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INVITED PAPERS

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THE USE OF DIAGNOSTIC METHODS IN THE FIELD OF AVIATION TECHNOLOGY

František ADAMČÍK[1] - Róbert BRÉDA[2]

Abstract: *Aircraft diagnostics forms the basis not only for aircraft control, but also for the passenger safety. The contribution describes various possibilities of the gas turbine engine diagnostics and focuses on the thermography, which is one of the methods of technical diagnostics. The aim of the contribution is to describe a possible connection or completion of gas turbine engine diagnostics on the ground and to extend this issue about new insights.*

Keywords: *thermography, diagnostics, aviation technology, aircraft turbo-jet engine*

1. INTRODUCTION

Aircraft turbo-jet engine is considered to be the basic building block of power units for medium and large aircraft. With smaller aircraft, reciprocating (piston) engines are generally in use. Diagnostics of aircraft engines is one of the basic ways how to avoid damaging problems during the operation of aircraft. Of course, in operation aircraft engines are exposed to different impacts depending on the type of environment, and, obviously, it results in their gradual degradation. For example, in a dusty environment, damages to compressor blades occur due to erosion. But it is also normal when damage is inflicted to the bearing case owing to engine use. However, not all damages put engines out of operation. It depends on their extent and type. For determining the specific fault diagnostics methods are employed to make it possible to predict potential failures. In the recent years, methods of diagnostics increasingly make use of thermography (thermal arrays imaging). The aim of this paper is to refer to its use in the diagnostics of aircraft turbo-jet engines in the chapter that will follow.

2. TYPES OF DAMAGES IN AIRCRAFT ENGINES

Fault or damages aircraft engines (Fig. 1) can be observed on their individual parts based on monitoring its parameters and observing various procedures of maintenance and diagnostic.

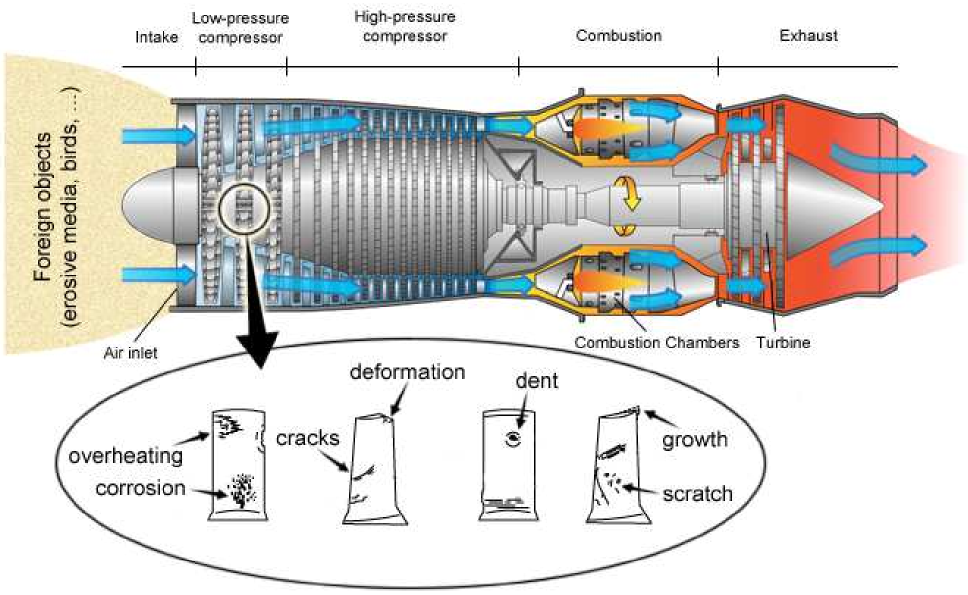

Figure 1 Composition of an aviation engine and types of damages on the compressor blades

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The inlet duct of the aicraft engine is the first part in its structural arrangement. Damages in this part, principally, are caused by foreign objects absorbed by the engine during its operation. Probably, birds are the most famous "objects" that can disrupt other parts of the engine and thus interrupt its overall running. Part of the compressor in which the air passes through the blades and is compressed is also susceptible to damages inflicted by foreign objects, since they can damage the overall structure. Most prone to them are the compressor blades, resulting in dents, cracks or total breakage of them.
Types of compressor blades damages (Fig. 1):

- deformation – the blade appearance is marlked with ragged or bent edges,
- overheating - damage is caused by exceeding the permissible temperature, blade surface is discoloured,
- corrosion - as major factors are the oxidizing and corrosive substances, particularly due to the humidity of the atmosphere,
- cracks - excessive vibration, overloading or incorrect processing of blades in the production may lead to the development of cracks and their subsequent rupture,
- dents - can be caused by foreign-object damages, for example birds,
- growth - damage is manifested by way of extended blades. Damage by growth is generated due to continuous or excessive temperature (heating) and the centrifugal force,
- scratches - narrow and shallow grooves are caused by sand or fine foreign particles.

The combustion of the air – fuel mixture takes place in the combustion chamber. The chamber is here exposed to high temperatures resulting in the risk of overheating the flame tube or the air casing. The flame tube is protected against high temperatures by anti-corrosive coating. Damages may be in the form of cracks, deformation, discoloration (removal of coating), missing material and erosion. The damages can occur when the operating temperature inside the chamber is different from that outlined in the operating standards. The engine turbine must be able to resist very high thermal stresses. This is the reason why the turbine inlet temperature is an important parameter and it should be checked frequently. Overheating of the turbine can damage the turbine blades, which is associated with the damages to bearings. Damage of the blades may be the same as the ones of compressor. For example, a damage caused by the release of a part from the combustion chamber takes the form of cracks, bending blades or blade corrosion, too. Types of damages in the output system (outlet nozzle) may be caused by high temperature of the output gases. Damages may take the form of overheating or releasing parts.
Another part of the engine, the damage of which can affect its operation, is the one of the lubrication system. The purpose of the system is the lubrication of rotating parts, but also their cooling (bearings). Lubricating oil is exposed to high temperatures, and overheating of the lubrication system is accounted for a typical damage. Another example is the contamination of oil by bearing materials (splinters), which gradually wear out. This may cause clogging of the oil filter. And, if there is an oil leakage, it may also result in damages to bearings due to a low pressure for their cooling.[2]

3. AIRCRAFT ENGINE DIAGNOSTIC SYSTEM

Aircraft engine parameters are the data by which we can estimate the possible damages of the engine and thus diagnostic its condition. Diagnostics forms part of the engine maintenance. It is through it that we are able to analyze and collect the necessary information for the subsequent evaluation of the possible behavior of the engine.
System of diagnostics can be divided into two parts - the board system and ground system (Fig. 2). The board system includes control of flow ducts made up by the thrust reversers, air inlet, blades, compressor, combustion chamber, turbine and the outlet nozzle. Rotating units require control of temperature, vibration and rotational control. The auxiliary systems include the fuel and oil systems. They include flow control, fuel and oil quantity checks, filter control and detecting chips in oil. The engine control system performs regulation of thermodynamic and electrical parameters, positioning regulation and executive elements.
The system of ground maintenance and diagnostics is based on vibration analysis, tribotechnical analysis and other checks using non-destructive methods (NDT). It is thermovision that can be classified a progressive method of diagnostics in the field of NDT methodology.

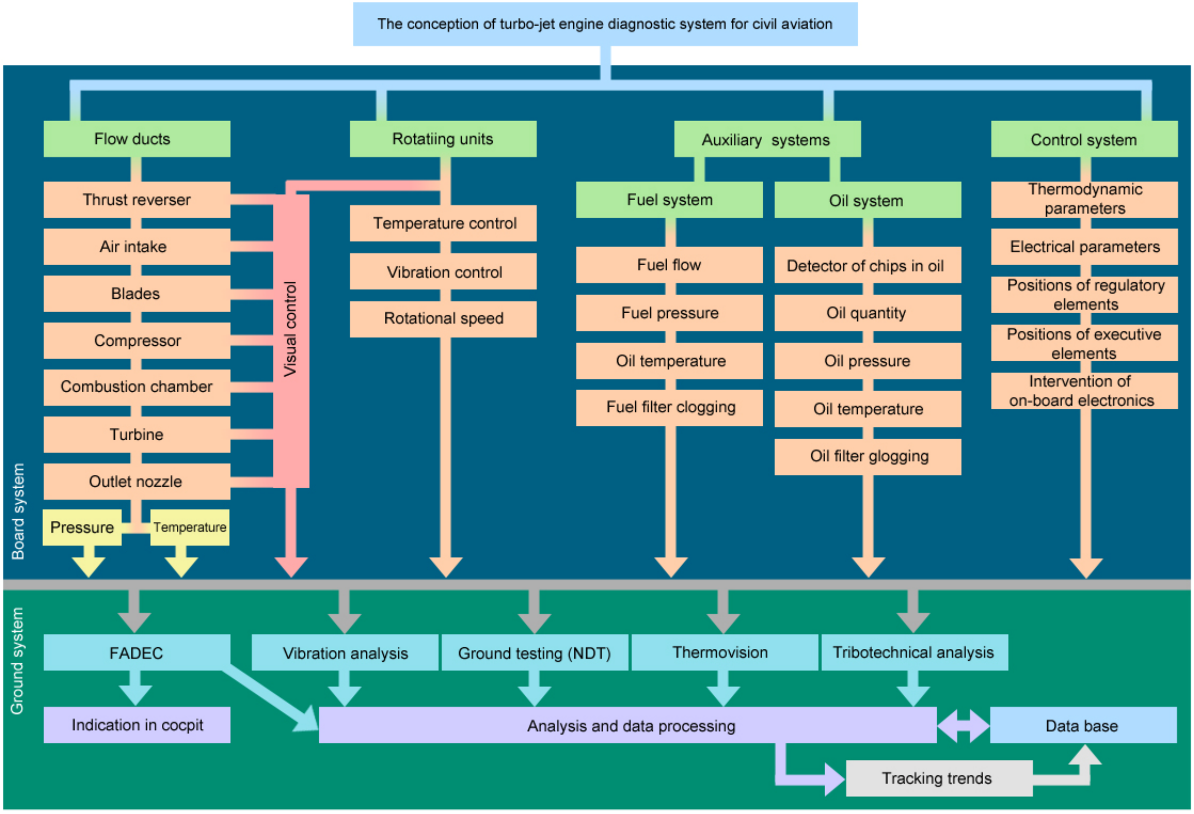

Figure 2 System of diagnostics of a turbo-jet engine in civil aviation

3.1 Thermovision

Thermovision is one of the methods on contactless measurement of temperature distribution on the surface of the analysed objects, which allows us to „see“, no mater whether lighted or not. The measurements are performed by thermovision camera, which operates on the principle of transforming electromagnetic (thermal) radiation into a visible image, in which each value of temperature is assigned a specific colour. In this case, the output of measurement is a colourful image showing the distribution of temperature over the surface of the object, called a *thermogram*.

Currently, thermovision is widely used mainly at airports when performing checks on aircraft parts, which include composite skins of fuselage, wings, landing gear, etc. As for fairings, they are employed in checking the so-called cool places. They are places where water is collected, which freezes at high altitudes and might cause deformation of composite parts.

In the area of aviation engines, thermovision, especially one of its methods – the Lock-In thermovision is used checking the condition of turbine compressor blades (Fig. 3, Fig. 4).

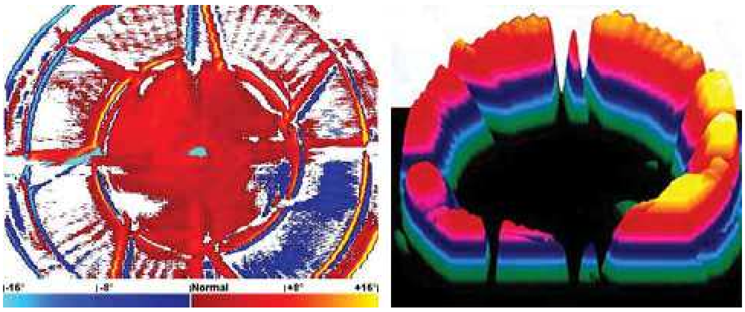

Figure 3 Example of the thermogram at a helicopter jet engine turbine[2]

When using thermovision for diagnostics, it is necessary take into account several factors that affect the overall measurement (scanning). The main factor is the emissivity of the monitored surface.

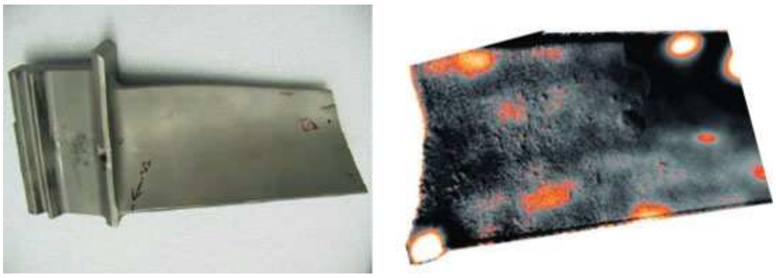

Figure 4 Detection of cracks in blades through the Lock-In thermography [3]

During measurements, a relatively precise adjustment is required, because the results can present significant deviations in tens of degrees of Celsius in depending on the selected surface. Further parameters include ambient temperature, reflected temperature, humidity and distance of thermal imaging camera from the object.

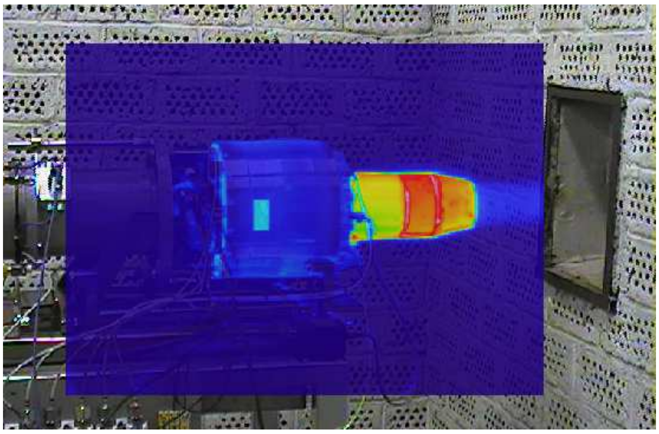

Figure 5 Thermogram of an aircraft engine

Figure 5 shows a typical thermogram (picture of thermal distribution) of the TJ 100 engine. We can see that the highest temperature, at an average of 200 degrees of Celsius, was detected by the camera on the outlet nozzle of the engine. Camera parameter settings were: 0.8 emissivity, reflected temperature 20 degrees of Celsius.

4. CONCLUSION

Thermography thanks to their advantages of the thermal imaging camera, such as speed of measurement, non-destructive of the objects and surface thermal imaging of radiation, belongs to diagnostic methods, which greatly facilitate the processes of operation and maintenance.

Although it is currently used in several areas, thermographic applications on the specific objects of research may bring new insights into the development of methodologies and practices for resolving issues. Accordingly, implementing thermovision diagnostics has been proven as one of the proper ways of ground testing of engines while also searching for correlations with other methods and findings of repair plants in the field of engine disassembly.

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[3] http://www.movitherm.com/thermography-products/ir-non-destructive-testing/crack-check-ndt-metallic-ceramic-composite-inspection.html

APPLICATION OF PROGRESSIVE ALGORITHMS IN THE AREA OF SMALL TURBOJET ENGINES' CONTROL

Rudolf ANDOGA[1] - Róbert BRÉDA[2]

Abstract: *The aim of the presented article is to describe the current architectures of the current full authority digital engine control systems (FADEC) and apply these concepts for control of small turbojet engines. The article also deals with implementation of complex situational control algorithms using methods of artificial intelligence for a small turbojet engine MPM-20 in laboratory conditions. The results of the research in this area are formed by the designed adaptive modular framework of complex situational control system for the small turbojet engine MPM-20. This framework has the potential to increase the safety and efficiency of control systems of turbojet engines and is tested in real-world laboratory conditions.*

Keywords: *turbojet engines, adaptive control, situational control, neural networks, full authority control systems*

1. INTRODUCTION

Present state of technological development and growing complexity of systems offers many challenges and also opportunities to achieve better results. In the area of jet propulsion, terms like safety, economic profitability and at the same time high efficiency come into foreground. The traditional systems of control are becoming obsolete and a with the need to satisfy the mentioned terms it is needed to incorporate the newest technologies of control even for use in older systems to bring them up to nowadays standards. It wouldn't be economically favorable to test such technologies within expensive and also very complex big turbojet engines also with regard to safety of such testing. Therefore a special class of turbojet engines designated as small turbojet engines (usually used to start normal sized engines) can be used as an ideal test-bed for differently aimed experiments in this area.
Our research is headed towards three basic aims.

1. Digital measurement of turbojet engines, which means digital real-time measurement of different state and diagnostic parameters of such engines.
2. Design and implementation of new progressive control algorithms for turbo-jet engines, especially the situational control algorithms incorporating methods of artificial intelligence complying with modern FADEC systems and philosophy.
3. Design and implementation of progressive digital diagnostic/back-up algorithms.

All these aims comply and put emphasis mostly on safety issues of turbo-jet engines. Other special feature resulting from our third aim is direct use of old obsolete small turbojet engines as sources of energy with use of cheap alternative fuels. We have to take in consideration that there exist a huge number of such small turbojet engines in old aircraft that are in non flying condition. Such engines can be refurbished and used again for other purposes. All knowledge obtained by experiments with such engine can be expanded to higher levels and certain principles may be used for design of particular algorithms of control that could also be used in normal class turbojet engines.

2. MODERN CONTROL SYSTEMS OF TURBOJET ENGINES

2.1 The aims of the modern engine control systems

The main global aim of control of turbojet engines is similar to other systems and that lies in increasing their safety and effectiveness by possible reduction of costs. This requires application of new technologies, materials and new conceptual solutions. One mean to achieve that is the

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development in systems of control and regulation of the engines themselves and processes ongoing in them [1].
Demands for control and regulation systems result mainly from specific properties of the object of control – a turbojet engine. The basic functions of control systems of a turbojet engine are the following ones – manual control, regulation of its parameters and their limitation. Manual control and therefore choice of regime of the engine is realized by a throttle lever according to a flight situation or expected maneuver. By regulation of a turbojet engine we understand such a kind of control where the chosen parameters of the engine are maintained on certain set levels, thus keeping its regime [1].
From the point of view of use of electrical and electronic systems in controls the turbojet control systems can be roughly hierarchically divided into following sets [2]:

1. Electronic limiters,
2. Partial Authority Flight Control Augmentation (PAFCA,
3. „High Integration Digital Electronic Control“ (HIDEC); „Digital Engine Control“ - (DEC); „Full Authority Digital Engine Control“ – (FADEC)).

The division of control systems into these three levels is not absolutely distinct, as systems on higher level as for example HIDEC system can utilize control mechanisms as electronic limiters. For example FADEC systems are often realized as single or double loop control systems with utilization of PI control algorithms or electronic limiters with estimation filters [3,4].

2.2 Full authority digital engine control systems

Full authority digital engine control system is aimed at control of an engine during it operational states without special pilot interventions. This means that the system keeps the engine's thrust on the desired level in all environmental conditions. The basic the digital engine control system is presented in the Figure 1 [10].

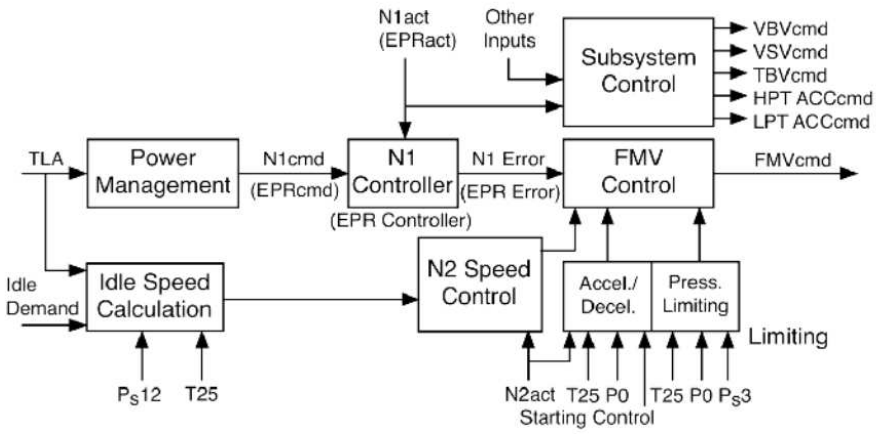

Figure 1 The model based engine control system[10]

Progressive control algorithms are used in power management control that transforms the commanded thrust according to atmospheric conditions into the speed (N1) or the engine pressure ratio (EPR) commands. The other area of use of progressive control algorithms lies in the area of N1(or EPR) controller that calculates the commanded fuel flow that is processed in the fuel metering valve (FMV) control system. Special algorithms are used in control of acceleration and deceleration of an engine. Usually N_dot control algorithms are used that keep the derivation of engine's speed on a constant level. Expansion of this concept by intelligent algorithms will be further presented in the following chapters.
In the algorithmic implementation of the previously presented FADEC control system design two basic approaches can be used [3]:

- Centralized architecture
- Decentralized architecture.

Both approaches are presented in the figure 2 [3]. Centralized architectures are usually used with some decentralized elements in aircraft engine control.

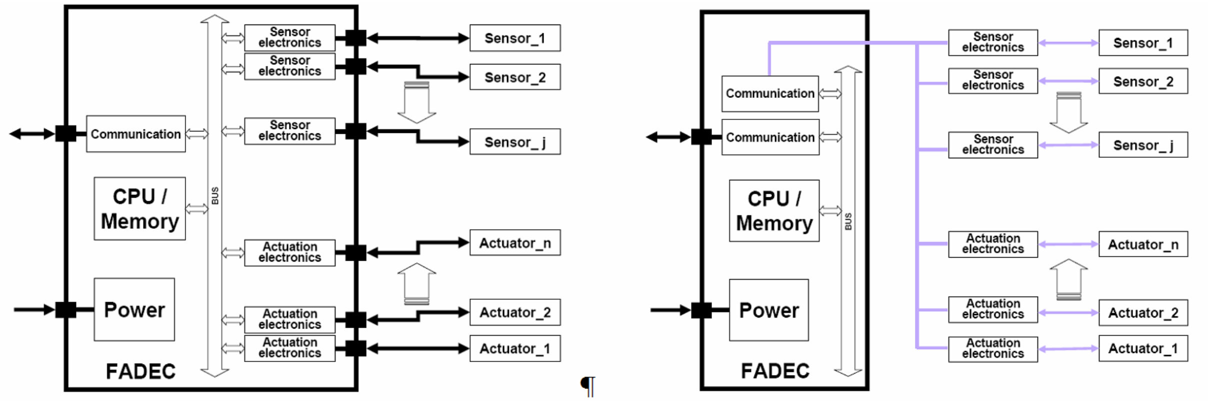

Figure 2 Centralized (left) and decentralized (right) FADEC architectures [10]

3. PROGRESSIVE CONTROL SYSTEM FOR A SMALL TURBOJET ENGINE

3.1 The methodology of situational control

Situational control was designed for the control of complex systems, where the traditional cybernetic models weren't sufficient. Situational control systems are suitable for systems, which are characterized by features like unique dynamics, incompleteness and indeterminacy of description, ambiguity and presence of a free will. These all properties are present in turbojet engine control, where also great focus is put on increasing safety. The methodology is aimed at control of complex systems under all operational and atypical conditions. This means its design is directly related to increasing of operational safety of engine control systems. This is reflected in approach of designing a situational control system. For the design of a system respecting the requirements of situational control system under all conditions, the following algorithm is proposed [6]:

a) description of the structure and function of the controlled complex system,
b) global goal designation,
c) classification of erroneous operational states and their causes,
d) classification and description regimes functions of the control, that are assigned to individual erroneous states,
e) design of algorithms for the individual regimes of control,
f) implementation.

From algorithms point of view the situational control is composed of two phases:

- The decision making phase, where the actual situation of the controlled complex system is classified into one of the situational frames
- The action phase where the actual situational frame is paired with appropriate controller selected from a set of prepared controllers

This is illustrated in the following Figure [6]. The central element of the situational control system is a formatter that uses all inputs to execute both control steps (classification of actual situation and decision making). These inputs are represented by:

- Input (environmental)system variables
- Output system variables
- State system variables
- Commanded variables

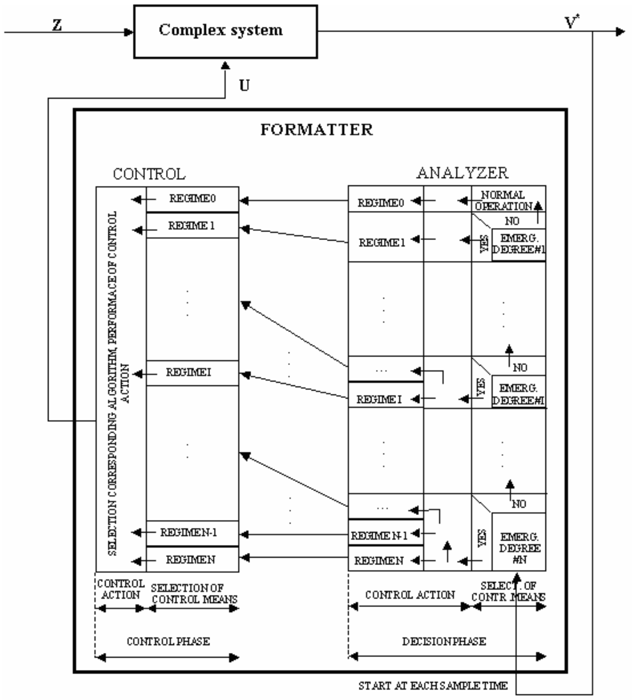

Figure 3 Situational control system of complex systems algorithms [6]

The resulting structures show that situational control system represents an ideal framework for applications of intelligent algorithms and complex progressive controllers.

3.2 The methodology of situational control applied to a small turbojet engine

The methods presented in the previous chapter are applied in the following manner on a laboratory object of a small turbojet engine MPM-20, which represents an ideal laboratory object for testing of new methodologies in real-world laboratory environment. The engine is a single shaft small turbo-jet engine derived from turbo-starter engine TS-21 by adding an exhaust nozzle instead of its output transmission. The engine is shown in the Figure 4.

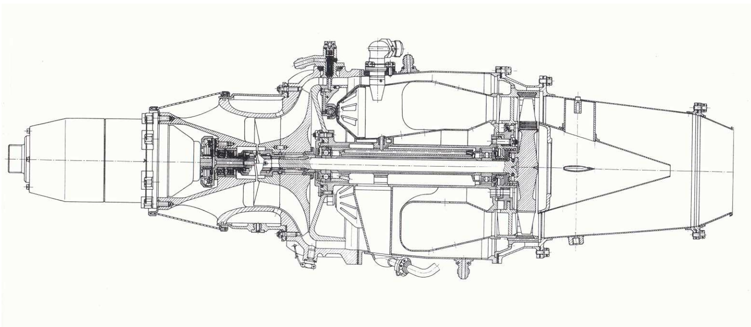

Figure 4 A small turbojet engine MPM-20 [7]

The proposed structure of situational control system uses paradigm and schemes described in [3] and in [7]. The whole concept of the situational control lies in decomposition of operational states into time spaced situational frames (classes) and every situational frame has one corresponding control algorithm (or controller) assigned to it. The basic architecture of such control system is shown in the following Figure 5. This designed system represents a basic algorithmic framework for design of a complex intelligent engine control system. The Figure 5 shows only 4 controllers, however any number of controllers can be used. The other elements of the control system are represented by the diagnostic module and predictive module that are used to adjust controllers, thus creating a complex adaptive control scheme.

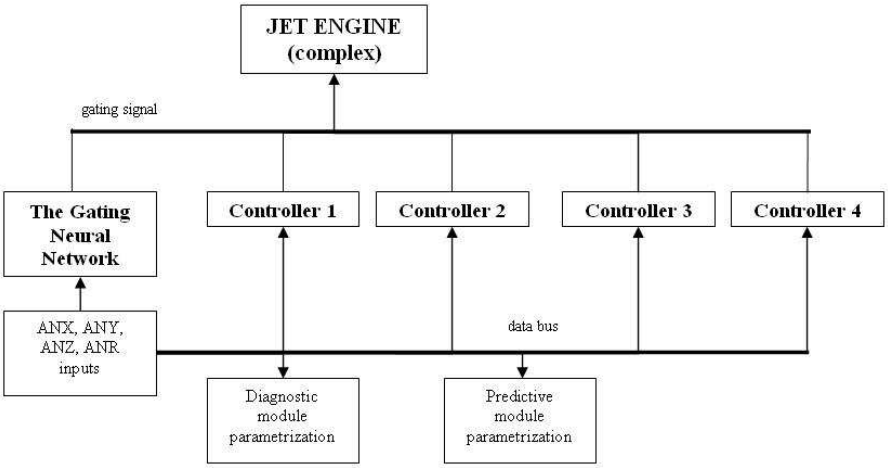

Figure 5 An adaptive control system for a small turbojet engine [6,7]

In application of the previously shown framework for a small turbojet engine MPM-20 the following architecture has been designed. The resulting physical architecture including analyzers of input (X), state (Z), output (Y) and desired (R) parameters is shown in the Figure 6.

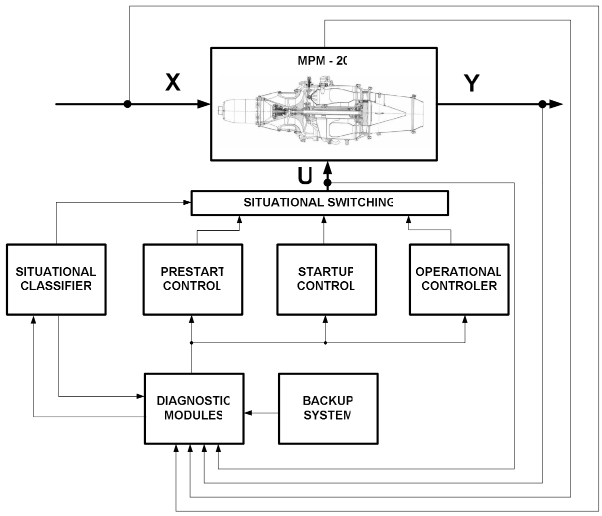

Figure 6 Situational control system concept design for the small turbojet [8]

From algorithmic point of view the control system is decomposed into the following 3 basic situational frames, where operational control is further decomposed into another 3 situational frames:

a. Pre-start control
b. Startup control
c. Operational control, which is further decomposed into:
   i. Steady state controller
   ii. Acceleration/Deceleration controller
   iii. Atypical state control

Individual elements of the complex adaptive digital control system are designed as follows.

Controllers that are used to handle realtime control**:**

- Relay expert system controller used for pre-start control and shutdown
- Fuzzy inference system for start-up control
- PSD controller as a steady state setpoint controller
- Fuzzy inference system for acceleration/deceleration control
- Model based controller for atypical control under overheat conditions

The situational classifier is used to determine which situational frame has occurred**:**

- Multi layer perceptron neural network trained with SCG algorithm with time delayed inputs.

The diagnostic module is used to allow any of the situational frames to occur and communicates with situational classifier, for example if an error during prestart control occurs shutdown control strategy is executed. The system is also used as a backup system and uses [8]:

- The modified voting method using neural networks as sensor models.

4. CONCLUSION

The presented framework designed for a small turbojet engine MPM-20 represents a FADEC control system incorporating progressive control and diagnostic algorithms in a complex situational control system. The system is implemented and being tested in laboratory conditions in the Laboratory of intelligent control systems of aircraft engines (www.lirlsm.fei.tuke.sk). Its potential is to increase efficiency and safety of turbojet engines' control. The system is modular and can be expanded by further modules that can further expand its capabilities. Use of the methods of artificial intelligence and concepts used in normal sized engines control make the system suitable for implementation not only for a class of small turbojet engines, but it can also be expanded for normal sized engines.

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AIR TRANSPORTATION SAFETY & SECURITY AND IMPACT ON THE OTHER TRANSPORTATION MODES

Ladislav BÍNA[1] - Helena NOVÁKOVÁ [2] - Jindřich PLOCH[3] - Zdeněk ŽIHLA[4]

Abstract: *Air Transportation Safety & Security is the long term monitored area. Following September 11, 2001, the Transportation Security Administration (TSA) was created to strengthen the security of the nation's transportation systems and ensure the freedom of movement for people and commerce. Today, TSA secures the nation's airports and screens all commercial airline passengers and baggage. From the air transportation these proceedings were implemented to the other transportation modes. Similar actions were done for ships, maritime facilities, containers and High speed train systems. Such methods will be accepted in other country as well. Special project in the area of Air Transportation Safety & Security has been started in the Czech Republic headed by expert team on College of Business Studies in Prague. Real situation in Air Transportation Safety & Security and impact on the other transportation modes is described including project of College of Business Studies in Prague.*

Keywords: *air transportation safety, air transportation security, passenger security control, baggage security control*

1. INTRODUCTION

Thanks to the specific nature of air transportation and the necessity to prevent potential accidents, from the outset of air transportation, maximum attention was paid to air transportation security problems. For example in the year 1928 there was established in USA a special committee [4] with the sole aim to analyze the cause of air accidents and prepare corresponding information about this.

Considerations concerning the following factors in the chain of events, which could be the cause of potential accidents, were published by H. W. Heirich in 1931 year [5]. The first official ICAO step in the area of operational safety was finalized by the National Safety Council NSC in the spring of 1946. On the basis of this initiative there was published the Accident Prevention Manual, with the main idea being: "*The basic tool, how to prevent accidents and to detect and analyze their reasons*" [5] which is still in existence to this day. Standards and requirements for the air transportation accident detection process was then dealt with by the Committee of ICAO and accepted as the ICAO Annex 13 to the Convention on International Civil Aviation. Results from the combination of all continuous legislative, organizational and technical arrangements, which came from the knowledge of new scientific and technical applications and together with the exploitation results of all world air transportation accidents in (Fig. 1), describe the noticeable decrease in frequency of air transportation accidents between 1959 - 2011.

A totally different style of arrangement connects the security protection programs of civilian air transport against any unlawful acts. These acts, connected to air transportation, can be considered as an unfavourable process due to the political and economical situation, in some parts of the world in the first half of the last century. Airplane hijacking, which was not so typical at the start of air transportation, grew in the sixties it grew to the state of air piracy where (hijackers started pushing their demands) and then into the seventies to the state of political terrorism (hijacking connected with political demands). Political groups connected with terrorism used civilian air transportation as a means to an end and so arose the "modern terrorism" phase.

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Terrorists began to demand things by using force and their activities culminated on September 11th 2001 with a civilian airplane attack against civilian targets with the aim to destroy a great number of people's lives and to create huge material losses and in the final analysis to create a feeling of fear.

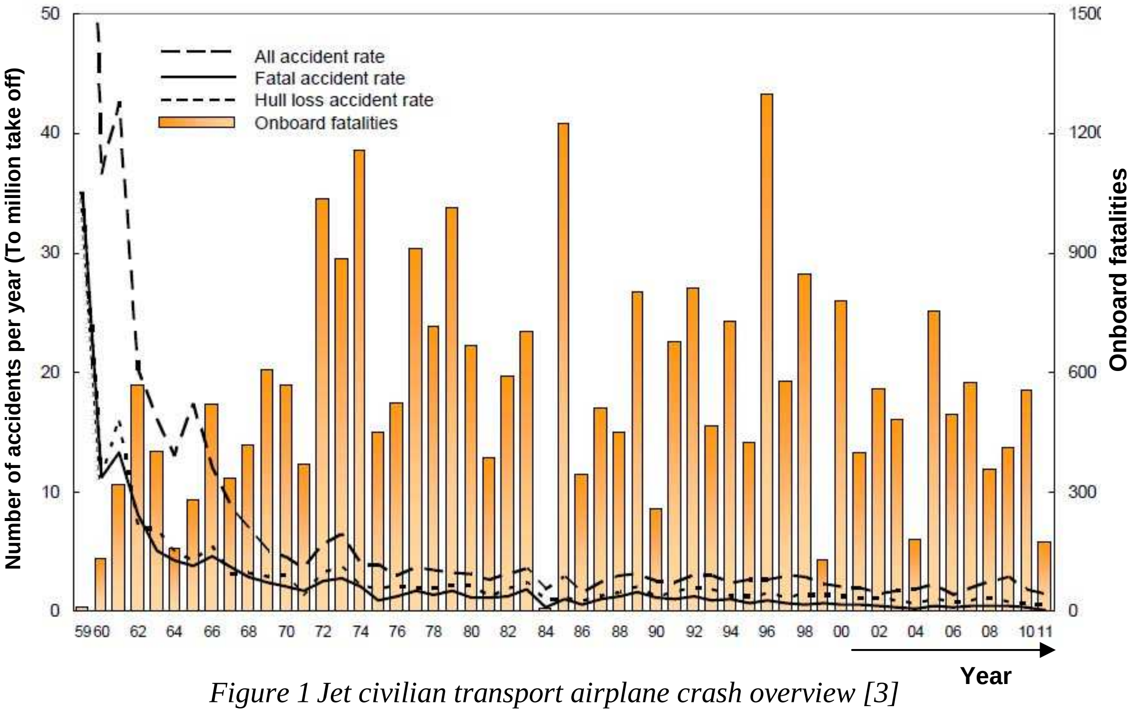

Figure 1 Jet civilian transport airplane crash overview [3]

The international community in the long term reacted to this situation by adopting a number of legislative, technical and organizational measurements, with the aim of ensuring a certain level of security [4]. But after the incident on September 11th 2001, there started to be many basic changes in the defence against unlawful acts in regard to the civilian air transportation area, especially in the USA. The described tragedy, together with other forms of terrorist acts against air transportation and ground transport, was the start of a coordinated and carefully considered universal standard, by introducing technical and organizational arrangements and other forms of defence. Nevertheless the statistical information, which informed us about the decrease of real or intended unlawful acts against civilian air transportation (Fig. 2), introduced potential acts of terrorism and meant a dangerous situation could arise at any time. The reason for this is connected with the existing financial assistance given to terrorists, their ability in advance to choose the type of attack, which would exceed most defences and finally terrorists have the possibility to use chemical, biological or any other forms of mass destruction.

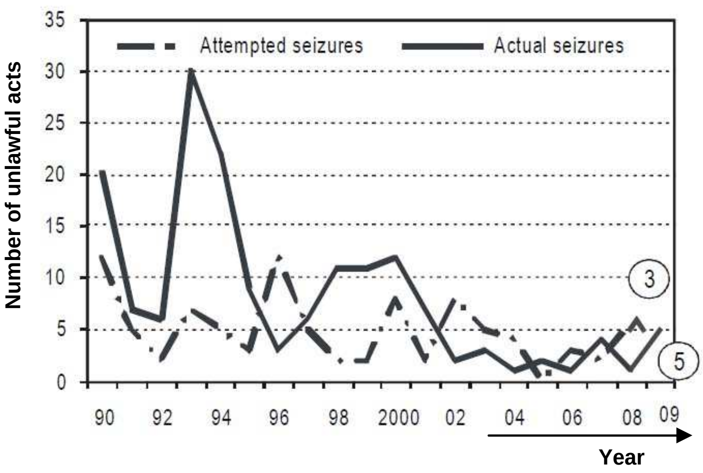

Figure 2 Evolution of unlawful acts again civilian air transportation [9]

2. SECURITY LAWS INTRODUCED AFTER 2001 YEAR

Reaction in the USA to the September 11th 2001 terrorist act was the creation of the Transport Security Administration or TSA, which the main aim was to introduce a defence system for all types of transportation in the USA, but especially for ensuring that the required parameters for air transportation security and defence against airplanes being hijacked were covered. TSA together with national, regional and local partners would supervise the underground, railway, bus, tube transportation security, but their primarily role was air transportation security.

During the last ten years, 450 US airports have established more then 25 000 stations equipped with airport security scanners Walkthrough Metal Detector and x-ray machines for passengers and their luggage at the security control. On the basis of Umar Faruk Abdulmutallab and Nigerian islamists transporting explosives on board the plane in their underwear, TSA decided to apply from the beginning of 2010 a new security control check, by using a new type of x-ray system. This equipment is able to detect metal and non metallic objects, hidden under clothing. These systems are able to view parts of the body and body cavities, which are normally difficult to check. Use of these types of machines have caused strong reactions, because the "Whole Body Imaging Technology" abuses the principle of the individuals human rights. Because of this situation there arose a new style of detector on the "milivize" principle. Software of this system is arranged in such a way, as to not present a detailed picture of a real person`s body, but only an anonymous figure with colour coded points, where it is possible to see hidden object on a person`s body.

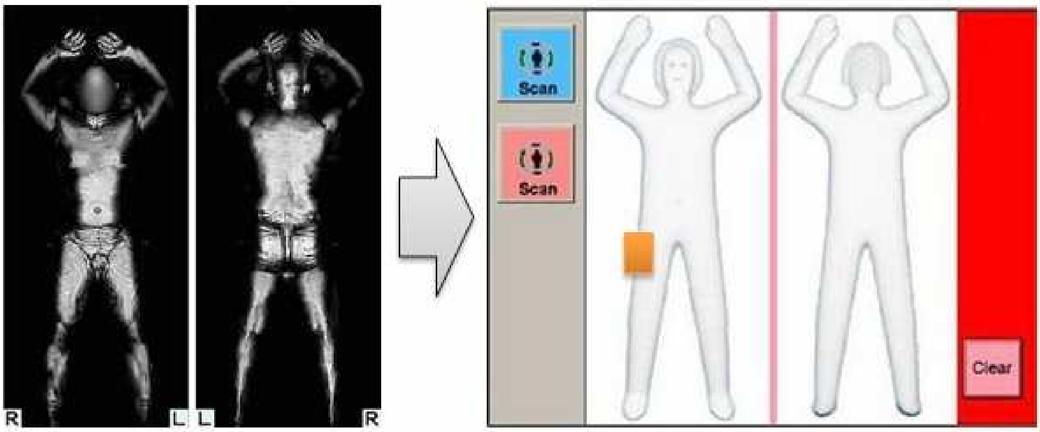

Figure 3 Example of the final presentation when apply milivize principle

During passport control, passengers travel documents are accepted, if their biometric figures are identical. This means that during the security control passengers have their fingerprints taken, a picture of their eye iris done or a digital photo taken of their face. Obtained digital biometric information is then compared with the dates, which are safely stored in a database. Great attention is devoted to the safety control of registered baggage from the point of view of explosives and other materials which are viewed as dangerous for air transportation. According to the law, TSA personnel are allowed to take physical control of any kind of baggage. If the baggage is locked by a TSA lock, then TSA personal can unlock the baggage by means of a special key and after they have checked it they can insert a special ticket with information about the control check and then the baggage is locked up again by TSA. When the baggage is not locked with a TSA lock, it can be forcibly opened and TSA personnel are not responsible for any damage, lose or destruction of the contents.

It is known, that many new security arrangements and requirements can be overcome by potential terrorists and often without them having any clear, logical or required strategy. This was typical in the case of supplementary prohibitions and additional control measures (for example imposing a ban on liquids for personal use when boarding the plane, or having to take off your shoes to have them x-rayed), which created many difficulties for travellers. Also the results of research nowadays has made security personnel realise the dangers of over reliance on the technical aspects of any system for scientific control with respect to the position, readiness, personal attribute and role of operators, who must make the final decision during the security control [1].

The reason for introducing the Machine Readable Travel Documents or MRTD’s was the necessity to improve the procedures during check-in, together with utilization of all resources, which can guarantee passenger identification and enable authentication. The new ICAO standard 9303 has been from the year 2003 required to be applied to all travel documents without chip card technology, asymmetric cryptography and some level of biometry. According to an EU decision all member states must have put this into practice no later than August 28th, 2006. The aim was to increase security by automatic passenger identification but the problem arose as to how to apply this with acceptable volumes of information from travellers.

Digital passenger name record or PNR is specific for all airlines. All PNR information is collected by the global distribution system or GDS, where the PNR is collected together with air ticket reservations. As a result of existing threats and possibilities, there is the supposition that at any time there can be some form of terrorist act, some states (USA, Israel), have made it their aim to effectively detect potential criminal offenders, by acquiring additional passenger information or API. As a result of this requirement the EU Council Directive No. 82/2004, stated that all transporters have a duty to provide from every passenger, 9 pieces of basic information. In the Czech Republic this Directive was passed into Law in 2006.

The ability to gather complicated passenger identification details in the shorter term, together with verification of their security characteristics, which are collected in air companies computer databases, plus national or international computer security databases, brings the next practical consideration which is about possible passenger differentiation for the security control. With this idea, can be connected a new security control (check point) solution, which can together help the check-in facility process and maximum security procedures [11]. This conception will revolutionize air transportation, which is based on reality, not fiction. Prospective check points must not only take into account security requirements increasing, but also there is the possibility for passengers to obtain a better feeling during the security control process, including respecting their privacy and human rights. The main of aim of these types of check points is to not only discover “problematical passengers”, but also to detect undesirable things and objects. Between the main features of such prospective check points must be the ability to positively identify potential risks arising from any evaluation, based on available information, without creating problems for passengers. The next requirement is the possibility to solve real problems of security control in real time and allow the continual flow of larger number of passengers through the check points, together with increasing the security control levels.

On the frame of any electronic identity verification at the front side of any prospective check point will be the possibility to place two input evaluations – “to board”, or “not to board”. Then there will be for passengers, according to an electronic evaluation or random selection, assigned a certain form of placement for scientific control. It means, the system will make a note of the passenger`s information for the next part of the control process according to the notation: ***known traveller, normal*** or ***enhanced lanes.***

For the start of any real solution there will be needed a broad international collaboration and especially the starting point for work connected with the design of such a system which can be discussed and accepted from the ICAO side. Irrespective of time is the acceptance that it is necessary immediately to begin finding a possible technological solution of the control systems. According to IATA sources there are in existence serviceable state technologies for analyzing traveller`s behaviours, metal detection and shoe security control. Continuity should be introduced to normal operational biometrical technology and passenger information systems. In the short term there will be available highly effective technologies for detecting explosives while going through security control.

The possibility of finding „problematic passengers“ depends not only on the quality of the actual equipment used but also it depends on the level of readiness, the personal character of the security person, brought into the security control system and their knowledge of how to use the security equipment. Nevertheless long term studies have been made concerning the sphere of human behaviours, up to now it has been difficult to evaluate the perfect personal behaviour of real people. These situations can be confirmed by the problems, which we can find in the behaviour and in the decision-making process of employees, who are working in different positions in security control systems at many European airports [1].

Project BEMOSA (Behavioural Modelling for Security in Airports), which was solved in the frame of 7th Framework Programme for Research and Technological Development of the European Union [1], represented an expirement to show, how modern technology can be negatively influenced by not corresponding with the results from the security control employee side. Published analysis has showed, how important the role is connected with the level of readiness, personal character and working conditions of every employee. The second conclusion brought information about how important it is to evaluate how effectively employees work with modern security technology, how capable are they working alone, or together in a working group and be able to interpret or understand the results, obtained from the control process from modern control technology.

3. SECURITY MEASUREMENTS ACCEPTED BY OTHER TRANSPORT MODES

The bomb attack at the Bologna railway station in 1980, the chemical attack by sarin in Tokyo underground in 1995, the same style bomb attack on the railway line in Madrid in 2004 and in 2005 on the London underground, brought a great loss of life and simultaneously great material loses. It is clear from this situation, that all forms of mass and goods transportation will in time adopt and apply the experience, obtained during security measurements taken against unlawful acts at airports.

Important logistic problems during the last decade can be categorized in the Supply Chain Security as such. On the one side there is the problem of strategic security applications, which can be interpreted for example by acts of sabotage, thefts, or by smuggling, terrorist attacks, or pirate attacks etc. Together with this exists the second requirement, it means minimizing time delays, which should be a source for the requirement of additional security measurements. The European Union, USA and other economic world regions of course also have their own different security arrangements, too. With respect to practical knowledge it is clear, that it is necessary to realize, like for instance in air transportation, to adapt for each different region a highly effective and mutually acceptable supply chain security control system.

Supply chain security control systems are part of a Supply Chain Management (SCM) system. SCM is the management of the network of organizations where the movement of people and goods from start to finish takes place. The network includes logistics of goods and transportation of people and looking at the processes such as research and design of systems, information, financial, legislative etc. An important part of SCM is transport on a local and global scale. Measures taken in the area of transport Security was inspired by procedures in air transport and has been carried out in other transport modes. According to Wikipedia (21.6.2013) and other sources **Airport security** refers to the techniques and methods used in protecting passengers, staff and aircraft which use the airports, from accidental/malicious harm, crime and other threat. This definition is valid also for other segments of air transport and other transport modes.

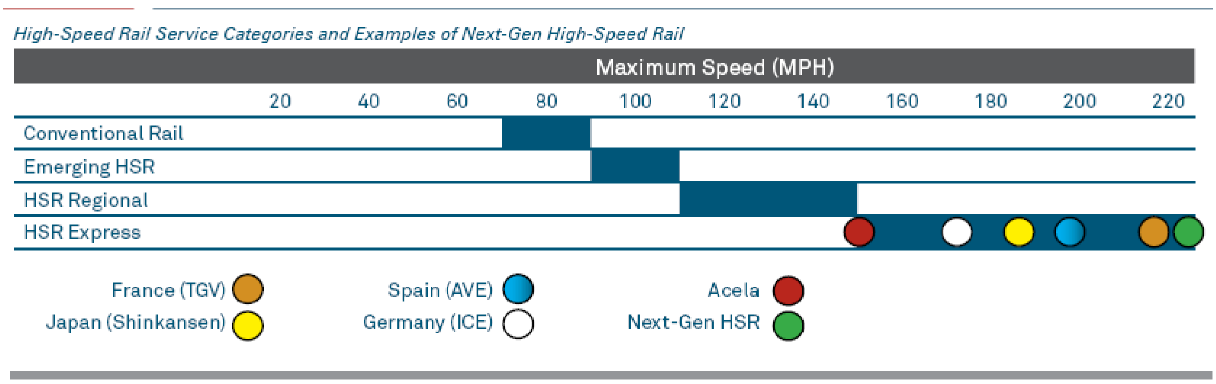

Figure 4 Speed Comparisons for Various Rail Categories, Source: Amtrak

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Currently when developing and carrying out the supply chain security control systems the following areas are highlighted:

- High-speed railways for passenger transportation,
- Urban and conurbation systems for the underground and railways,
- Logistic chains which focus on sea container terminals and sea transportation of containers.

Apart from air transport, high-speed railways are another transport system, which will gradually apply security systems. According to www.psmag.com high-speed rail's weakest link is security. Speed Comparisons for Various Rail Categories are shown on Fig. 4.

The problem, particularly in Europe, is how to ensure security (which requires similar procedures as in air transport) and freedom of movement of passengers. Unlike air transport, high-speed railway transport is of a flow character which includes changes, where security restrictions would slow down this process. The Deutsche Bahn high-speed rail in Germany has opted not to conduct passenger/baggage screenings.

The main reasons being that Germany has not completed a network of high-speed trains and it is not possible to ensure passenger/baggage screenings on standard trains due to changes. According to the same source there is no political will in Europe to play havoc with the current free movement of passengers using the rail network. There are different possibilities in countries that have a developed network of high-speed trains as for example in France or Spain. In the USA the situation is different. According to Mineta Transportation Institute's terrorism expert Brian Michael Jenkins as high-speed rail (HSR) planning in the U.S. comes closer to reality, issues regarding security have become more critical. To help identify and address those issues, the Mineta Transportation Institute (MTI) has just published a research report, *Formulating a Strategy for Securing High-Speed Rail in the United States*. MTI is a transportation policy research centre created by congress in 1991 and affiliated with San Jose (CA) State University. The report's principal investigator Brian Michael Jenkins and his team offer an analysis of information relating to attacks, attempted attacks, and plots against HSR systems. Brian Michael Jenkins directs MTI's National Transportation Safety and Security Centre, which focuses on research into protecting surface transportation against terrorist attacks. Maurillo Donna R. (2012 - Mineta Transportation Institute) described in her research report „High-Speed Rail in the US: Will It Be a More Attractive Terror Target than Inter-city Rail?" the problems and solutions concerning the security High-Speed Rail in the US.

According to other source materials quoted: "The difference between America and Europe, at the moment, is that the security theatre carries no political reward in Europe: No mainstream politician wants to inconvenience a lot of voters for security that will never be airtight. Europeans have lived with bustling, open-plan train stations for centuries; they know the odds. In America, though, good rail travel stands to become something new and unknown — all over again! — and if U.S. politicians start crowing for airline-style security theatre, the trains' usefulness will disappear."

On the web page of TSA (Transportation Security Administration) it is described that – quote: "The mission of TSA´s Rail Passenger Security group is to protect the nation´s railroad passengers, employees, and properties. Since the terrorist attacks of September 11, 2001, the 7/7 (July 7 2005) London subway bombings, and the Madrid rail bombings (11.3.2004), the Department of Homeland Security (DHS) has taken several steps to manage risk and strengthen our nation´s and transit systems by:

- Providing funding to state and local partners;
- Training and deploying manpower and assets for high risk areas;
- Developing and testing new technologies, and;
- Performing security assessments of systems across the country."

These measurements are also connected with planned extension of high-speed railway network in the USA.

Figure 5 US High Speed Rail Network Maps [12]

We can expect bigger problems when introducing security procedures at urban and conurbation systems on underground and suburban trains due to the obvious slow-down of passenger flows. However on new underground systems the questions of security have been solved. An example might be the “closed” underground of the new non-serviced no 9 line on the underground in Barcelona. From the point of view of security and protection of passengers against illegal activities the underground is “closed” by using turnstiles preventing unauthorized passengers getting on and off. The superior system of Siemens which is used by Barcelona on its underground is controlled from the central control TMB and besides the non-serviced operation of the trains the system has many other functions (station lifts connected with the location of trains, monitoring of the location of trains, observing the situation on board them and at stations, emergency situations etc).

In the area of logistic chains security and particularly in the section concerning container security there are many government and non-government programmes. On 22 April 2004, an agreement was signed with the United States on container security within the scope of the existing EU/US customs co-operation agreement (The Agreement between the European Community and the United States on customs cooperation and mutual assistance in customs matters (CMAA) was signed on 18 May 1997). EU signed similar documents with Switzerland (29.6.2009) and Norway (30.6.2009). Another agreement between EU and China came into force on April 1 2005 and it was primarily focused on sea containers. The pilot project initially involves the ports of Rotterdam (NL), Felixstowe (UK) and Shenzhen (China). Similarly the collaboration within the area of container security between EU and Japan was started on November 2, 2008 by a meeting of experts. The final result of these agreements was the decision by the US Congress to require 100 % scanning of U.S. bound containers at their last foreign ports by the year 2012. This term was then prolonged till July 2014. The impact of 100% scanning of U.S. bound containers on maritime transport is in the final report of The European Commission, Directorate General Energy and Transport Policy Research Corporation dated April 24th 2009. Authorities in Hong Kong expect to start providing radiation detection and imaging capabilities on a limited capacity in the fourth quarter of 2013 as part of a pilot scheme aimed at determining the impact of radiation scanning at large volume ports. In this year eighty-nine per cent of containers arriving from overseas ports are scanned as they enter the US, up from 37 per cent a year ago.

From the point of view of container security GPS systems monitoring position and state of containers during the over-sea transportation are also important. According to [12 – 22.6.2013] the DB Schenker company it offers a very interesting solution by the use of its product “smart box“.

4. NATIONAL KNOWLEDGE SECURITY CENTRE CONCEPTION

In connection with the increasing volume of air transportation, the natural acceptance of security measurements and the decreasing number of security employees (due to an airports financial situation), the security management require maximum connection to airport operational practice. In such a situation there is not enough time to deal with all the new information, recommendations, standards and regulations. With respect to this situation it is logical, that from the practical side of things that there is a requirement to build a national security knowledge centre, which will be able to collect all available information and materials, related to air transport security in the world. Together with this information and materials, the national knowledge centre role should be a collection of published theoretical works and practical applications, connected with potential risks, their detections, analysis and removing or restricting their influence. The next area of interest for material collecting would be the role of personal behaviour in air transport system, firstly in relation to security. Such obtained information and material must be analyzed separately, stored and as soon as possible used for practical use. For such a purpose the results must be obtained in a qualified and acceptable way. In this situation it is possible with the support of national authorities to publish these results in printed or electronic form.

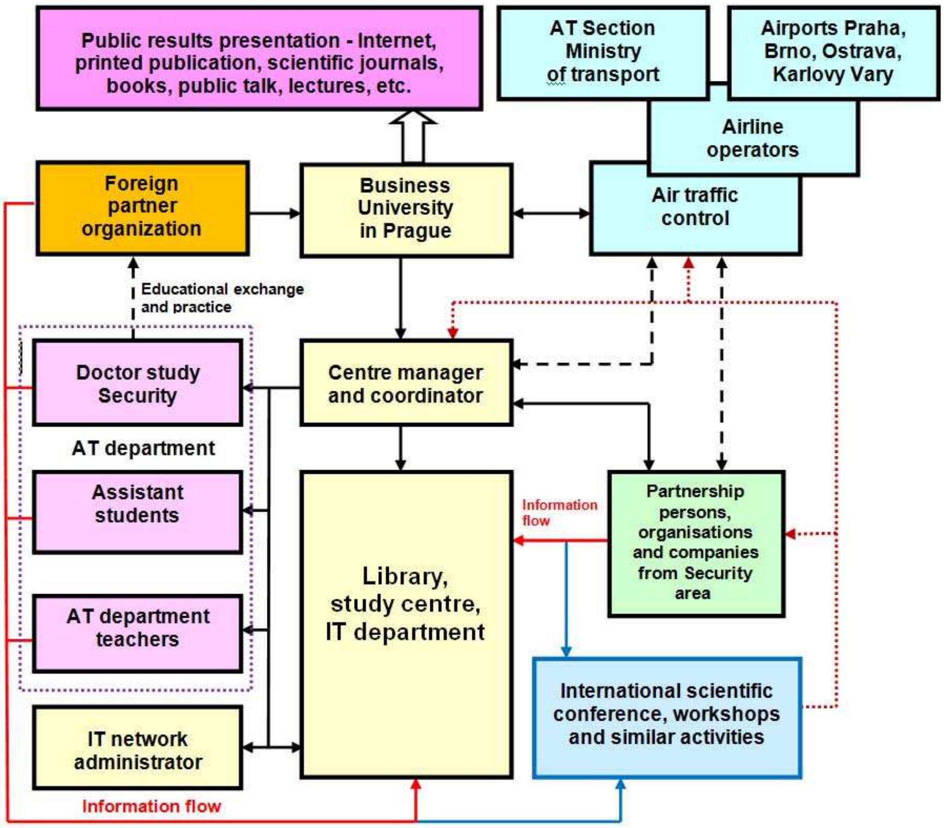

Figure 6 Block scheme of national knowledge centre

Trials to solve similar problems can be found in the Ministry of Transportation's allocation from 2008[5], with grants to SGS[6] solved at DF ČVUT Prague in 2011, or in one of the previous scientific works at Letecký ústav TU VŠB Ostrava[7].

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[7] - CZ.1.07/2.4.00/17.0080 "Rozvoj spolupráce formou stáží a odborných praxí v oblasti řízení letového provozu"

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A new initiative in this area from 2012 was an internal scientific project named “Influence of Human Factor in Transport System to Security area”, which will be solved by the Chair of air transport at the Business University in Prague (next CLD VŠO). During the first phase of this project CLD VŠO together with a group of external co-workers from different areas of air transportation and in collaboration with Airport Prague – Ruzyně and some other organizations will elaborate on a proposed structure for this type of national security knowledge centre (Fig. 6).

By the actualization of security, in an air transport integrated knowledge centre there arises the institutional base for an effective and complete actual information in a highly regulated, complex and hazardous branch of security against unlawful acts concerning civilian air transportation . The benefit of cooperation with collaborated subjects will be not only a help in increased cooperation with different institutions, but prevent duplicity in activities and create one common voice when there will be questions relating to defined areas. The basic form of this knowledge centre work will be collaboration with companies, national authorities, high schools and other institutes, which have a minimum partial orientation towards the security sphere in air transportation. Important tasks will be coordinated between the activities of these institutions in air transport security and so prevent unnecessary duplication. This project was continued in the 1st International scientific conference “Air Transport Security 2012”, which was held under the auspices of the VŠO Prague and Airport Prague – Ruzyně and will continue in periodical and non periodical scientific conferences and workshops for information exchanges between institutions. Output from this project should be the completion of the classical and electronic library for security in civilian air transport knowledge and all involved organizations will be given a chance to use this library.

Increasing security requirements for the next transportation modes, which was noted in chapter 2, creates the necessity to obtain more information from the security branch.

5. CONCLUSION

In the paper there are presented the basic principles of the air transportation security and the last technological solutions. New initiative in this area is from 2012 year internal scientific project “Influence of Human Factor in Transport System to Security area”, which will be solved by Chair of air transport at Business University in Prague (next CLD VŠO). During the first phase of project CLD VŠO together with a group of external co-worker from different areas of air transportation and in collaboration with Václav Havel Airport Prague and some other organizations elaborate conception proposed structure of such type a national security knowledge centre. This project idea is to continue in idea of the 1st International scientific conference “Air Transport Security 2012”, which was realized under auspice of VŠO Prague and Václav Havel Airport Prague and continue in realization of periodical and no periodical scientific conferences and workshops for information exchanges between institutions.

In chapter 3 the security measurements accepted by other transport modes are presented. Currently when developing and carrying out the supply chain security control systems the following areas are highlighted:

- High-speed railways for passenger transportation,
- Urban and conurbation systems for the underground and railways,
- Logistic chains which focus on sea container terminals and sea transportation of containers.

Apart from air transport, high-speed railways are another transport system, which will gradually apply security systems. In the area of logistic chains security and particularly in the section concerning container security there are many government and non-government programmes.

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UAV OPERATIONAL SAFETY ENHANCEMENT USING EMBEDDED MICROWIRES

Josef BLAŽEK[1] - Katarína DRAGANOVÁ[2] - Pavol LIPOVSKÝ[3] - Miroslav ŠMELKO[4]

Abstract: *Magnetic microwires are very perspective materials with a wide range of application possibilities. Thanks to their specific electric and magnetic properties they can be used as a sensitive part in microwire-based sensors for measurement of magnetic field, temperature or tensile stress. These measurement results can be consequently used for example in inertial navigation systems to increase navigation information precision, or for monitoring of other physical quantities to increase operational safety. Microwire-based sensors with their small dimensions and weight are very suitable also for application on unmanned aerial vehicles where they can be used as magnetic field sensors, tensile stress sensors, temperature sensors or power plant current sensors. The article deals with utilization possibilities of mentioned kinds of sensors during new UAV type research and development and during UAV operational safety.*

Keywords: *unmanned aerial vehicle (UAV), microwire, microwire-based sensor*

1. INTRODUCTION

Amorphous magnetic microwires exhibit a number of unusual properties [1] suitable for various technical applications. Their unique magnetic and electrical properties can be used for example in sensorics [2], where they can serve as sensing element of a magnetic sensor. But due to the microwire sensibility to the applied mechanical stress, these sensors can be used also for the tensile stress measurement. Additionally microwire temperature dependence can be used for ambient temperature measurement. With regard to the small weight, dimensions and low manufacturing costs, these sensors can be used to increase the operational safety especially on the small Unmanned Aerial Vehicles (UAVs).

2. MICROWIRE-BASED SENSORS

2.1 Theory

Our research is focused on the amorphous magnetic microwires. Magnetic properties of these microwires with a high and positive magnetostriction constant are related to the domain structure of microwires originating from stresses induced in the wire during the fabrication procedure. The domain structure consists of one axial magnetic domain in the middle of the wire, radial domains and closure domains at the end of the microwire (Fig. 1). Very important characteristic for utilization in sensorics is orthogonal hysteresis loop that is the result of the fact that the magnetization can switch between the states of positive and negative saturation through the single Barkhausen jump at the value of field called switching field. This field is a carrier of information about several physical quantities such as external magnetic field, tensile stress, temperature etc.

As it was mentioned, the sensor principle is based on the measurement of the switching field H_{SW} at which the magnetic state is switched from one magnetic state to another and can be calculated as a sum of an ambient magnetic field H_0 and a critical switching filed H_{CSW} of the microwire:

$$H_{SW} = H_0 + H_{CSW} \quad (1)$$

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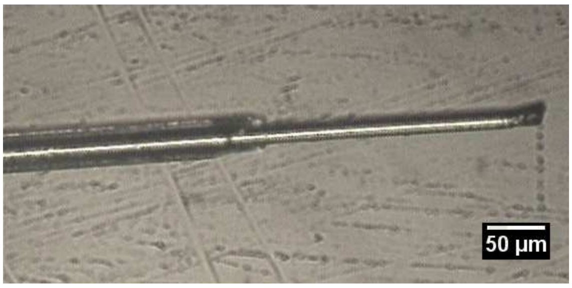
The switching field H_{CSW} comprises of two contributions. The magnetoelastic contribution H^{σ}_{SW} is induced by an internal stresses whereas the relaxation contribution H^{r}_{SW} arises from the structural relaxation of amorphous microwires:

$$H_{CSW} = H^{\sigma}_{SW} + H^{r}_{SW} \tag{2}$$



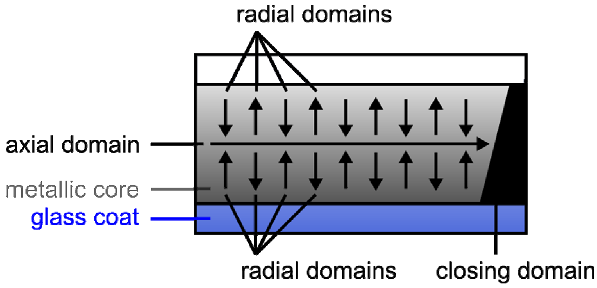


Figure 1 Amorphous magnetic microwire with high and positive magnetostriction constant and its domain structure schematics

2.2 Measurement method

Our contribution to the magnetic testing methodologies has been driven by the need to measure the critical switching field of the microwire. To determine the microwire properties it is appropriate to use such a method that allows a direct switching field component separation to determine the value of the critical field H_{CSW} directly. Result of our solution is a modified induction method which uses an exciting coil supplied by the precision triangular-shaped current and the sensing coil for the domain wall motion detection, which is represented as induced voltage peaks. The switching field is then proportional to the time at which the peak appears. For the time interval measuring the controlled electronics based on the CPLD (Complex Programmable Logical Device) with the resolution of 10 ns had been designed. Exciting and sensing signals can be consequently displayed on the oscilloscope screen.

3. POSSIBILITIES OF UAV SAFETY ENHANCEMENT USING MICROWIRE-BASED SENSORS

In aviation accent is always put on the safety. The basis of the operational safety is prevention and can be increased not only through the regulations, education and training of the aviation personnel but also through the failure prevention. Microwire-based sensors can be used especially on the small UAV board to increase the operational safety in several ways that are overviewed bellow.

3.1 Navigation

UAV have to operate at the equivalent level of safety like manned aircraft. But there is a problem especially with the small UAVs, for which many currently certified navigation systems are often too heavy. Microwire-based sensors in the role of magnetic sensors can be used as magnetometers for the navigation purposes for example as a replacement of compasses. Other possibility is their utilization together with accelerometers and gyroscopes in inertial navigation systems with 9 DOF.
Hence magnetic field is closely associated with the electrical field these sensors can be used also for the current sensing. Considering for example multirotor UAV conception, in such a way it is possible to monitor the current flowing from the UAV power source to every power plant separately and according to the UAV power consumption or performance calculation it is possible to determine the optimal operational mode. This information can be also used for compensation of the disturbing magnetic fields and so to increase precision of the navigation information. Sensor output data can be used both in real time applications and in post processing.
Magnetic microwires are sensible to the temperature, too and in the role of temperature sensors could also increase the precision of the navigation information. Again they can find their substation mainly on small UAVs that often uses low-cost sensors without the temperature compensation, whereby the temperature dependence of many sensors can be significant.

3.2 Collision avoidance

The requirements for a UAV operational safely in civilian airspace have not been formally defined to date except of the idea of equivalent level of safety to the manned aircrafts. Existing sensors that can reliably sense other non cooperative aircraft are not feasible for many UAVs because their weight, size and power requirements exceed constraints for a small UAV by a large margin. Of the sensors available that do meet the weight, size and power requirement, none have been shown to be reliable at target detecting within the necessary specifications.

In this area microwire-based sensors do not offer a complex solution but can be used as an augmentation to the sense and avoid systems for transmission power lines detection and avoiding because even vision-based sense and avoid systems are not usually able to detect transmission power lines and many UAV types are predetermine to operate in low altitudes and low terrain and missions are more and more often performed also beside the line of sight. In this case the sensor principle is based on the industrial 50 Hz frequency measurement.

3.3 Construction monitoring

Research at our Department of aviation technical studies is focused on the tensile stress sensors development. The first measurement results confirmed the theory that magnetic properties of amorphous microwires are determined by the magnetoelastic interaction of magnetic moments with the mechanical stresses causes switching field sensitivity to the applied mechanical stress [3].

Microwire-based tensile stress sensors can be used for example for construction monitoring or material structural health estimation and so to increase the UAV operational safety. Operational load can be also monitored. These sensors can also prove their worth in fatigue testing or crack detection.

Measurement of the tensile stress can be performed either on the material surface as in case of conventional strain gauge measuring methods or inside of the material because microwires can be thanks to their small dimensions easily integrated directly under the surface of the tested nonmagnetic construction without structural violations and without changes in material characteristics. For this purpose a new improved contactelss induction method placing the sensing and excitation coils outside the sensing microwire has been developed. If a remote sensing technique is applied, very fast monitoring could be done periodically, needless of complex and costly installations. In case of the structural monitoring of an UAV in operation it is satisfactory to embed magnetic microwires into the UAV structure and to use a reading device that have to be placed on the UAV board in the microwire vicinity (Fig. 2).

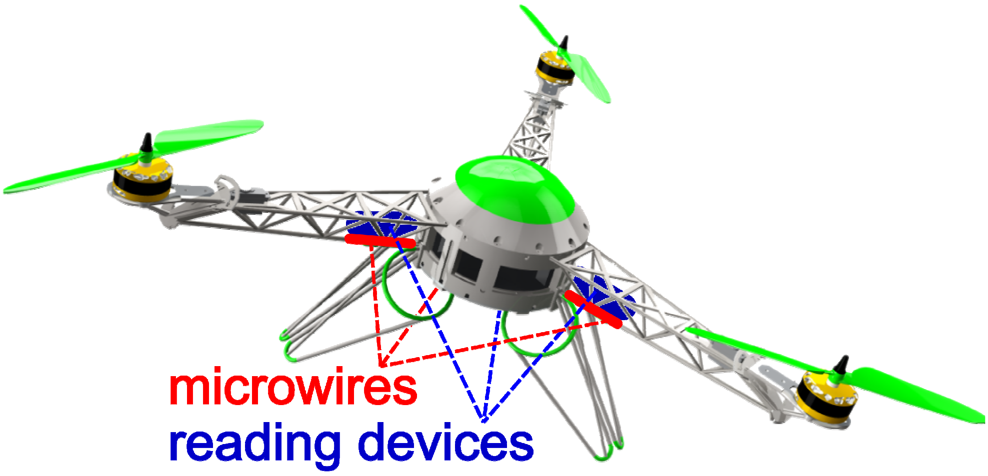


Figure 2 Example of microwire-based sensors placement on the UAV arms

Microwire-based sensors after their development completion in a relatively short time replace currently used tensometers. Thus they can become primary sensors for new composite parts, construction elements or whole UAV structures testing. In case of the composite material testing it is possible to choose layers between which will be the microwire implemented and so to measure internal tensile stresses in the composite material profile.

Other possible significant utilization possibility of microwire-based sensors we can see in the monitoring of the material manufacturing quality in for example such way that in the each manufacturing series there is one testing sample with an embedded microwire produced. These samples would be convenient for a manufactured composite reproducibility or endurance testing. Samples can be also archived for monitoring of material ageing and its influence on the material structure. In case of the construction problem or even UAV accident the archived samples of the specified series can be used for structural analysis.

4. CONCLUSION

Magnetic microwires and their application possibilities have been studied during the last two decades very extensively. The article reviews the microwires application possibility in the sensor design where they can be used as a sensor sensing element. Thanks to the microwire-based sensor weight and dimensions the utilization on the UAV boards seems to be a very perspective alternative to the currently existing heading determination devices. They can also replace magnetometers used as a part of inertial measurement units or to increase the navigation information precision thanks to the disturbing magnetic field or temperature dependence compensation. In the collision avoidance systems they can be used as an augmentation for transmission power lines detection. In the role of tensile stress microwire-based sensors have wide application possibilities in the UAV construction contactless monitoring.

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THE VISUAL GLIDE SLOPE INDICATOR WITH LED LIGHT SOURCES

Radim BLOUDÍČEK[1]

Abstract: *The Visual Glide slope indicators are except runway edge lights the most important part of the airport lightning system. Currently are realized with PAPI (Precision Approach Light Indicator) system or VASIS (Visual Approach Slope Indicator System). Both of them mostly use serial method for their supplying and currently use only halogen bulbs as the light sources. The paper shows new using of LED light sources in the Precision Approach Path Indicator (PAPI) light. It describes the power LEDs, which are usable for this, the way of the LED control and presents real technical solution of the PAPI LED control unit which is based on an eZ80Acclaim microprocessor. In additional presents a LED chip cooling in the very small space and control and diagnostics in the Android environment. At least the paper shows the method for PAPI supplying with the parallel supply network.*

Keywords: *visual slope indicator, modern light sources, PAPI*

1. INTRODUCTION

The visual glide slope indicators are inseparable parts of every airport lightning system. They provide information about the right approach path and use simple and easy understandable way of indication. The first glide slope indicator was PVG (Precision Visual Glidepath), which indicated as same information as current glide slope indicators.

Currently there are two basic types of glide slope indicators. The most spread is PAPI (Precision Approach Path Indicators), which is placed on most of classical airports and heliports. The second one is VASIS (Visual Approach Slope Indicator System). We can see it mainly with CALVERT system (but the most of airports use CALVERT system use PAPI). Both of these indicate same types of information and they have a lot of variant, e. g. CHAPI or T-VASIS.

All types of visual glide slope indicators are in 24/365 mode and their reliability must be high enough. Both of them are defined with aeronautical standards (ICAO ANNEX 14, ANNEX 14H).

2. PAPI – PRECISION APPROACH PATH INDICATOR

Basic PAPI indicator consists of one or two cross bars with four lights. PAPI os placed on TP (Touch down Point) level. The colours of lights depend on the angle of view. The right glide slope angle is indicated with two white and two red lights. The way of PAPI indication is shown in Figure 1 on the left side. On the right side of figure 1 is shown reduced PAPI (APAPI – Abbreviated PAPI) for small airports or some helipads which consists of one cross bar with two lights. Glide path angle is set to 2 – 4 degrees according to the others navigation and surveillance systems at the airport (ILS – GP, PAR). The other type of PAPI indicator is CHAPI (Charles Helipad Approach Path Indicator), which is designed only for helipads. It consists of two lights placed behind helipad. The pilot sees two green lights if he is on the right glide slope, else he sees white or red lights – depends on glide path angle (upper glide path white, lower red lights). It is shown in figure 2.

Unlike the others visual glide slope indicators (PVG, VASIS) PAPI is easier for installation and for indication. But on the other side the reliability of every light of PAPI must be very high because shown information depends on every light of PAPI. That is why every light of PAPI is composed of two or three light sources (halogen bulbs) and every bulb can be supplied with different loop of the serial CCR (Constant Current Regulation) system. The failure of bulb can be indicated at TWR with airport control and monitoring system (e .g. AMS-1 at the Czech Air Force airports).

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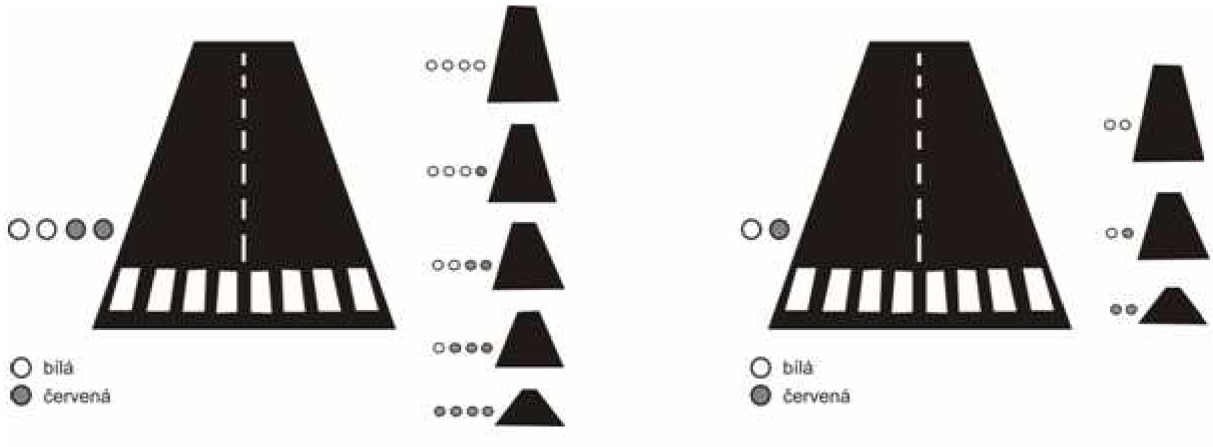

Figure 1 PAPI and APAPI indication

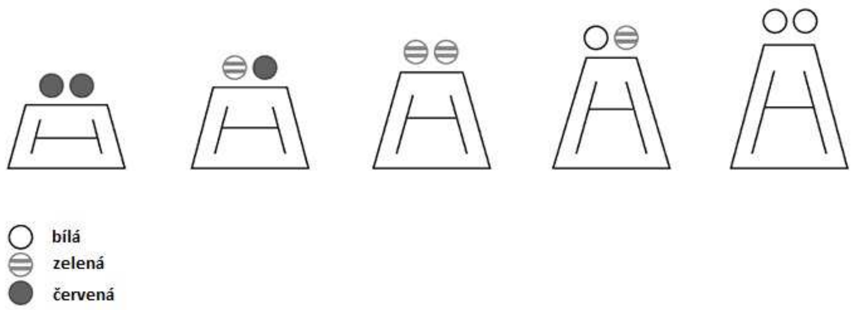

Figure 2 CHAPI indication

3. THE LIGHT SOURCES IN PAPI LIGHTS

High demands are placed on the visual glide slope indicators, as the airport lighting system, especially halogen bulb life cycle, since PAPI lights are in operation around the clock and their visibility (typically 20km). Therefore, as light sources in light PAPI lights slope indicator system cannot use the commonly used light sources.

There are various types of the light sources which are used in airport lights, but the most of them use classical halogen bulb with pk30d lamp cap. Two 200 Watts halogen lamp is used in one PAPI light and it is enough for 2x4800 lumens luminous flux. The light, which is emitted by PAPI, consists of two sectors – upper white sector and lower red sector. White sector light is emitted by halogen bulb without filtering and red filter (made of special glass) filtrates red part of halogen bulb light. Spectrograms of white and red lights emitted by PAPI are shown in Fig. 3.

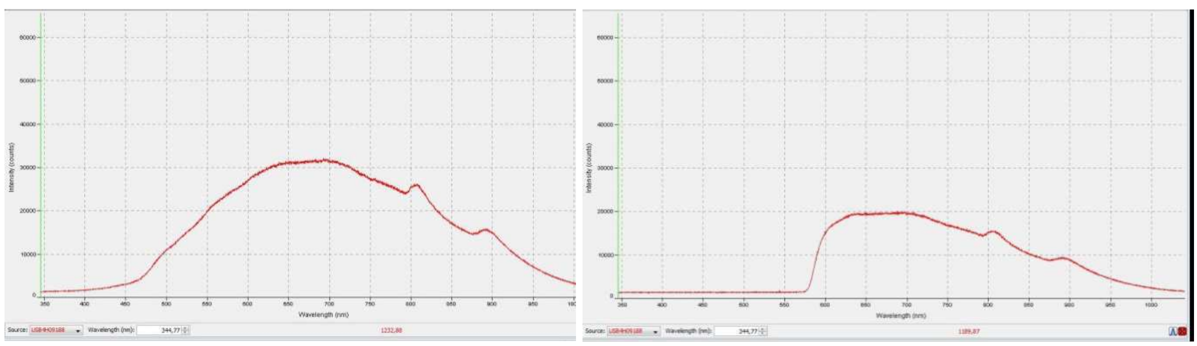

Figure 3 PAPI light spectres (left – white sector, right – red sector)

There is the optical system in the PAPI light for correct operation and this system is shown in Fig. 4. Light source is placed at focus of parabola (6), which directs emitted light. Red filter (5) filters red spectre from light and output lens gives a direction for most of luminous flux precisely in the approach area and turns over white and red sector.

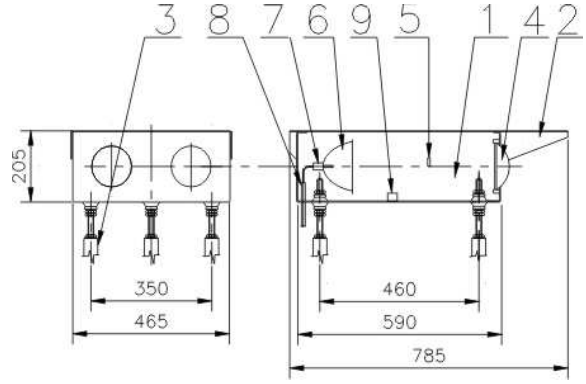

Figure 4 Typical design of PAPI light [4]

PAPI light must have very high reliability and that is why they are supplied by CCR (Constant Current Regulators) by at least two independent loops. Typical design of PAPI supplying is in Fig. 5. There are three loops which supply independently various light sources in the PAPI lights and when the one of filament is blown or one of CCR is out, the PAPI light unbreakable will emit the light information.

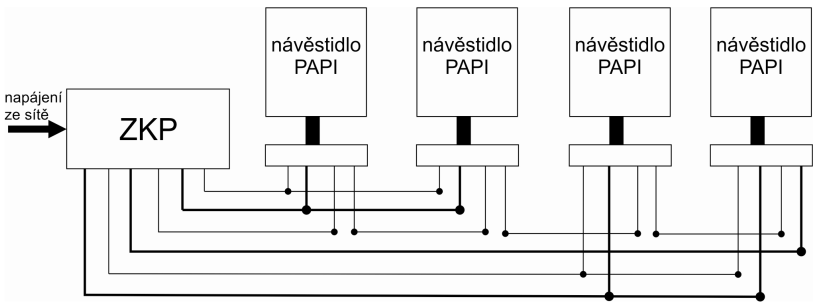

Figure 5 PAPI supplying

4. LED PAPI LIGHT

PAPI lights are one of the most important lights at the airport and that is why the PAPI light was designed. There was not only the change of the light source, halogen bulb to LED, but the design was based on the parallel methods of the light power supplying and the luminance control. Finally the light was built according to international standards and recommendations.

The first solved problem was a visibility of the light. The light source will be probably visible if the luminance causes illumination at the retina which is higher than eye edge illumination E_0. Eye edge illumination depends on lots of factors, mainly on colour of the light, brightness, physical condition of pilot etc.

If the light source is small enough it will be taken as a point source and we can use Allard equation [1]:

$$E = \frac{I}{R^2} K^{\frac{R}{D_{met}}} \quad (1)$$

Where: E is the eye illumination,
I is the luminosity of the light source,
R is the distance between pilot eye and light source,
K is the eye edge contrast,
D_{met} is the meteorological visibility.

If we use RVR (Runway Visual Range) as a main variable of the visibility in the equation (1) we write:

$$E = \frac{I}{D_{met}^2}\left(\frac{E_0.RVR^2}{I_0}\right)^{\frac{D_{met}}{RVR}} \qquad (2)$$

The second problem of the design is power supplying. Serial distribution circuit is a most frequent way for bulb-lights, because the constant luminous intensity is guaranteed of all lights in information group. Serial distribution circuit contents single-wire circuit, so-called loop, all light of information group is connected in.

Of course we cannot connect the light into simple serial loop, because when the one of bulbs is broken, the whole light in the loop is going out. That is why the bulbs are connected in coupling-isolation transformers. It ensures that the loop is closed when the bulb filament is broken. The cable for loop is the single-wire, high cross section (c 10mm^2), 6kV tested conductor.

It stands to reason that the loop must be powered with constant current, i.e. the voltage in the loop is depend on number of connected lights. So, the loop is powered with Constant Current Regulator (CCR). The basic work principle of CCR is a thyristor current regulation and the current in the loop is adjustable in 5 or 7 levels. [2]

The LEDs in the PAPI lights need alternative methods of powering than the halogen lamp. Serial loop is typical for airport light with incandescent lamp, but for LED we can use all advantages of parallel methods of supply and the luminous intensities will be constant in whole power network. The group of parallel powered lights can be interpreted like a distributed PTO (power take-off) network. It defines specific load in a system $\alpha[Am^{-1}]$.

Constant current supply is typical for LED as a component, but LED PWM regulation sort constant current out. Airport light control system can receive the remote data and generates a PWM modulation for the LED modules. And that way guarantees the constant luminous intensity in every light although the percent line drop is tens percent.

There is a block diagram in the Fig. 6. The light can be controlled with the remote controller which is based on 4DGL or Android technology and it transmits control data through the radios or cables at the RS232 format. Microprocessor eZ80 receives these data and controls LED constant current regulator which supplies LED chips. 100W LED chip by SnowDragon Industrial Co., Ltd was chosen as the light sources. These chips emit high temperature white light beside 5000 lumens and red light beside 3000 lumens . Every LED of the chip can be supplied with 32 Volts and 3.2A current. Finally the light is directed with the lens. The cooling is a very important part of the light because the temperature of the LED chip must not exceed 90 degrees of C. The LED chip power dissipation is up to 100W that is why it is necessary to use passive and active fluid cooling. For the design of cooling part of the PAPI light was taken the temperature at the airport in summer (up to 60 degrees). Microcontroller controls active part of fluid cooling.

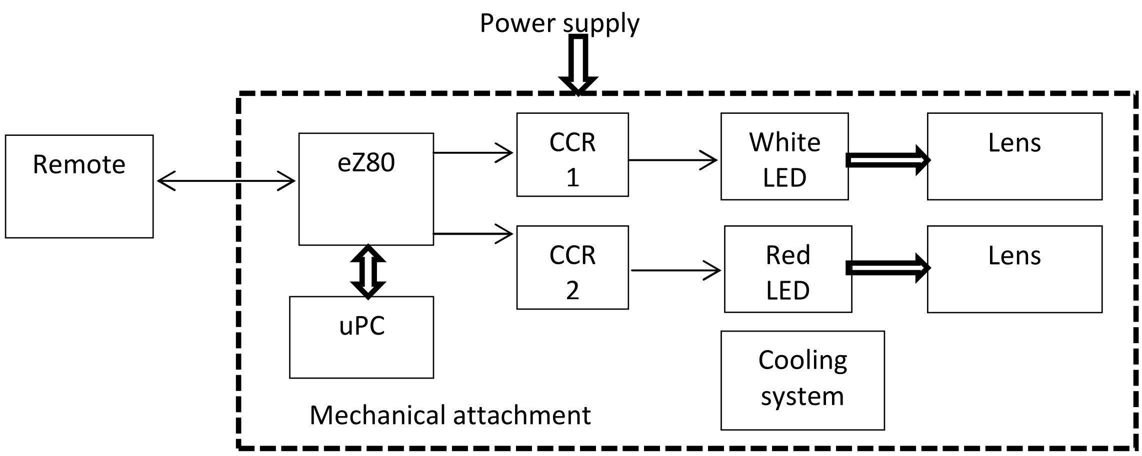

Figure 6 LED PAPI block diagram

There are two spectrograms in the Fig. 7, which show us the light spectres in the white and red sectors. We can see enormous difference between halogen bulb and LED light in the red sector and that is why it guaranties us that red colour will not change in long distances.

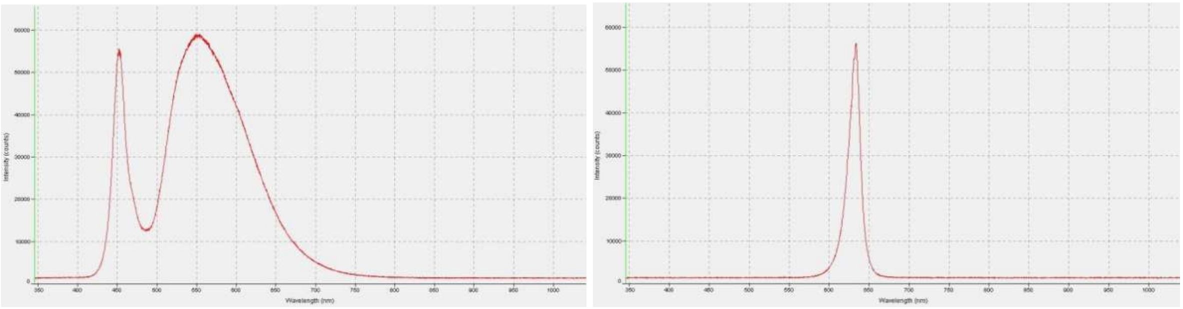

Figure 7 White and red sectors emitted by LEDs

5. CONCLUSION

LEDs are the light sources for the future and we can see them in many fields of the lightning (industry, automotive etc.) Only a few companies offer airport lights with LED but they do not use all LED advantages and only change classical halogen bulb to LED. This contribution showed us a new method of the airport lightning and introduces us the real technological solution of the PAPI light where all LED advantages were used. The designed PAPI light is more effective and contents modern control and diagnostics circuits. It can use parallel power supply network.

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INFLUENCE OF ELECTROMAGNETIC FIELDS IN THE ENVIROMENT ON COMMON COMMERCIAL RECEIVERS OF SMALL UAV´S

Róbert BRÉDA[1] - Marián MIĽO[2] - Marek ČEŠKOVIČ[3]

Abstract: *Small UAVs have been employed to operate at built – up areas, where on the present the environment is literally overfilled by various radio signals. Besides of the common radio and TV broadcast signals, we can find there also other signals. There are mostly signals from Wi-Fi nets, the internet wireless channels (point to point), radio signals from the mobile phone providers, signals from security wireless cameras etc. Independence of the amplitude of these signals, all of them or a part of them has income also on the input circuits of receivers of the UAV, sub served its role in that zone. In this article, authors analyse the negative phenomenon, which has tendendency to happen if in the area, there is too high intensity of electromagnetic field from various sources. If UAV is flown in that area, subsequently of the high level intensity of the field, the close receiver antenna field start to rise very steeply. Receiver even more, during the suitable conditions evaluates that signal as valid control signal from the pilot or ground station. By this fact, take up an incongruity between the desired control signal and the real value of modulated signal assumed by the receiver. Due to this fact the pilot virtually loses the control over the overall aircraft. The safety so-called "FAIL SAFE" system is also not activated, because the evaluation logic is not capable to find out of faulty values of that type.*

Keywords: *interference of signals, input circuits of receivers, small UAV, control system DSM and HOTT.*

1. INTRODUCTION

The control of small UAVs is nowadays usually handled with usage of multichannel RC kits. The present state in this area is on so high tech level that the possibility of jamming or management failures due the insufficient reliability of transmission of control data is not even considered. However the practice is nevertheless showing that vehicle becomes uncontrollable either for short time or definitely and its flight results to an accident. Apart from the subjective reasons, we remain only to take into account the interruption of the coupling channel due to its interference with signals in the surrounding environment, or due to overloading of preselector circuit, which is the input of each receiver. In most cases the vehicles is autonomously putted into failsafe mode while it receives relevant control signal or it will automatically land at previously programmed place. From this, the most dangerous situations occurs in case, while the receiver will handle the control signal on its input but this signal would not be the valid control signal but neither the false pseudo signal. The common case of all failures of control systems was the flight in proximity of mobile phone operator's antennas. Fortunately the cases those are known resulted only to small material costs and little UAV damage.

2. CONTROLLING THE SMALL UNMANNED FLYING VEHICLES

In the current increase of the usage of small UAVs we can meet with a number of radio sets that allow controlling of these vehicles, but also activation, respectively disabling some vehicle features. The number of control channels varies depending on the difficulty of vehicle and the average count is from 6 to 14 channels. In normal commercial vehicles, such as those used by police and fire departments we are faced with RC kits which are wide available. They frequently work at 2.4 GHz frequency band. As a method of signal transmission is used either DSM 2, DSM X, or HOTT system. Radiated performance of these kits can vary around of E.I.R.P. < 10mW.

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The situation in the frequency - spectral area is shown in the following figures. Figure 1 shows the broadcast of RC transmitter in the DSM2 system.

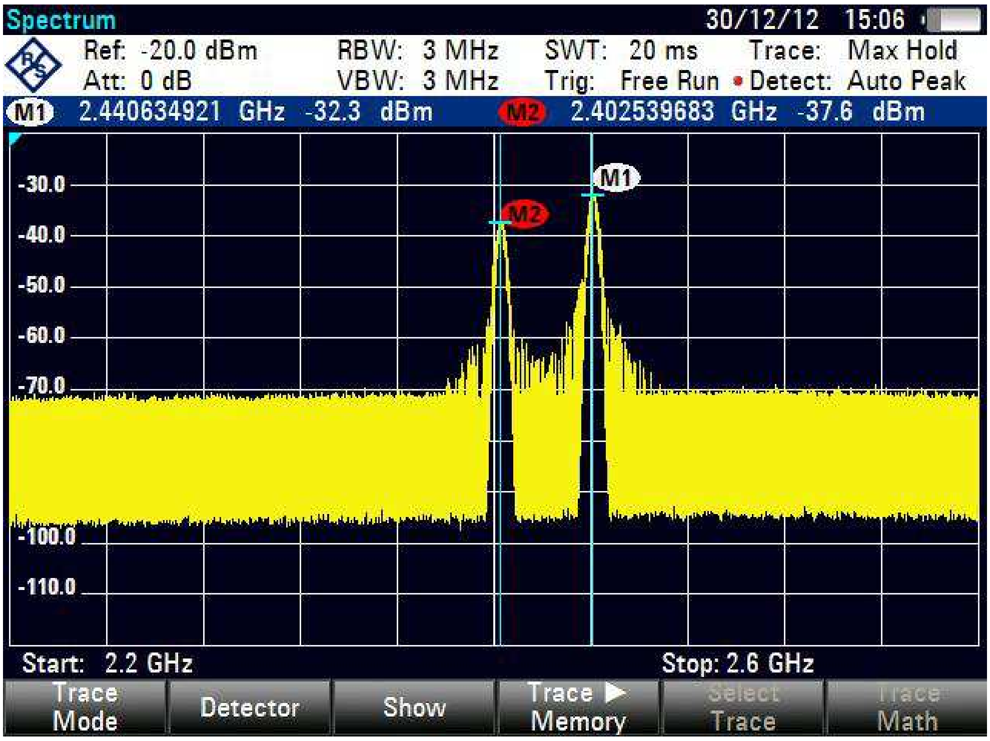

Figure 1 The broadcast of RC transmitter in DSM2 system.

We can see that the system itself "locks" the two free channels of frequency band, on which it is working at. Figure 2 is showing the situation in the transfer system DSM X. It is clear that the system is using a much larger number of channels, what should be more secure and reliable.

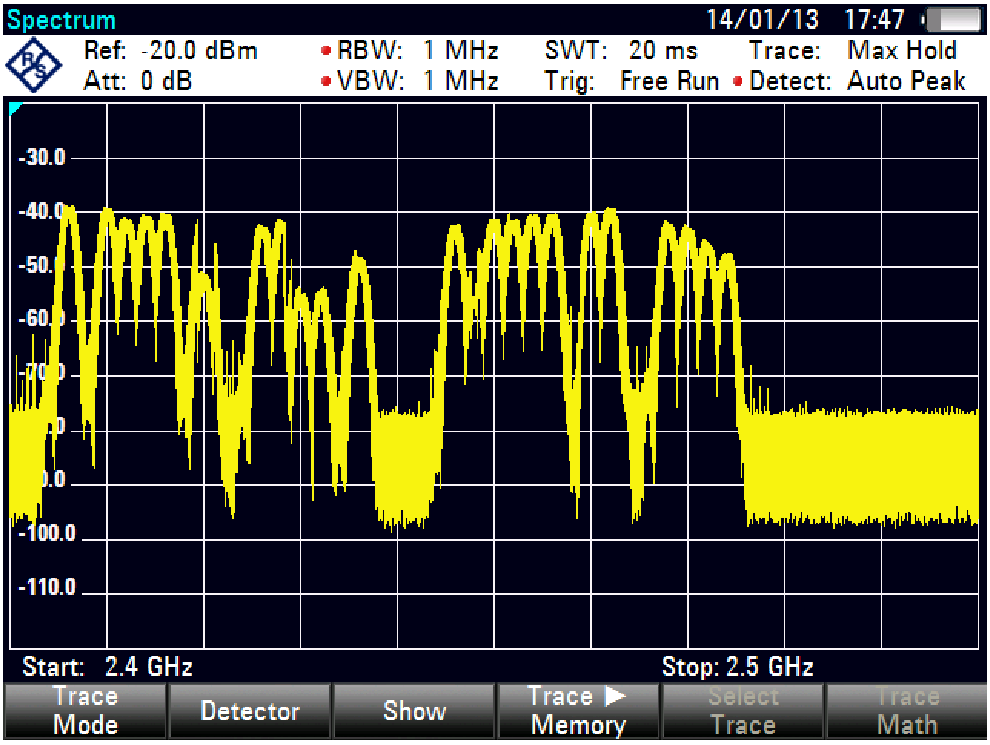

Figure 2 The broadcast of DSM X transmitter

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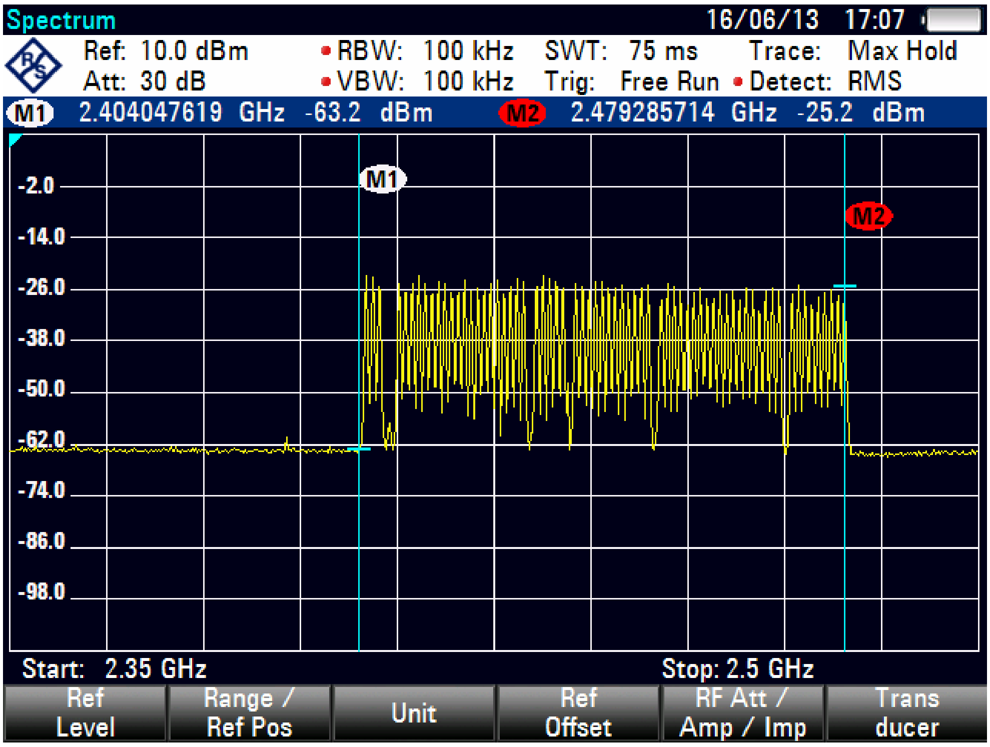

Figure 3 The spectrum of HOTT system

Figure 3 is showing the spectrum of HOTT system. All the methods listed above have one common feature, which is frequency hopping and thus automatic scanning of free channels to establish reliable - available communication channels.

3. THE LEVEL OF ELECTROMAGNETIC FIELD IN THE VICINITY OF MOBILE OPERATORS ANTENNAS

In urban areas such as cities and towns it is necessary to ensure smooth and reliable coverage of GSM/PCN systems. This can only be achieved by using of large amounts of cellular antenna units, mounted mainly on the top of tall buildings. These cells units are made up mainly from 2 to 8 antennas deployed on the building so that their radiation patterns are overlapped at fixed angles.

The requirements on the antennas needed for the ever expanding networks are becoming continually higher: strictly defined radiation patterns for a most accurate network planning, growing concern for the level of intermodulation due to the radiation of many HF-carriers via one antenna, dual polarization, electrical down-tilting of the vertical diagram and others.

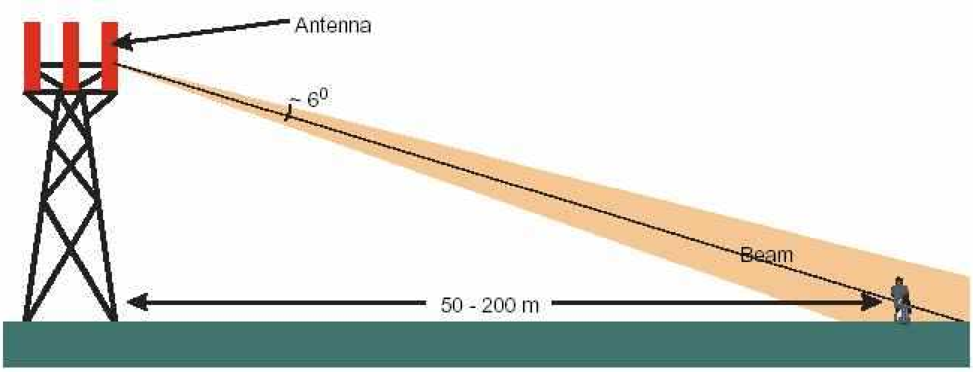

Figure 4 The typical angle of emitting of GSM signal

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By the realization all of above mentioned requirements is being increased the risk of flying in the vicinity of the antennas with that characteristics. Various type of modulation, emitting characteristics and polarization, which are using, take the huge potential for interference of signals with signals received by the receiver of flying vehicle. The typical angle of emitting is shown in Figure 4.

Figure 5 The simulation of flying at distance of 20 meters from antennas

By the accomplishment of the experiment we verified our expectations and procured the better projection about the situation in which the receiver of UAV works in real conditions, in the vicinity of such a heavy electromagnetic energy. The measurement we execute on the flat roof of high building in the simulated distance of the flight of UAV from the antennas equals 20 meters (Figure 5).

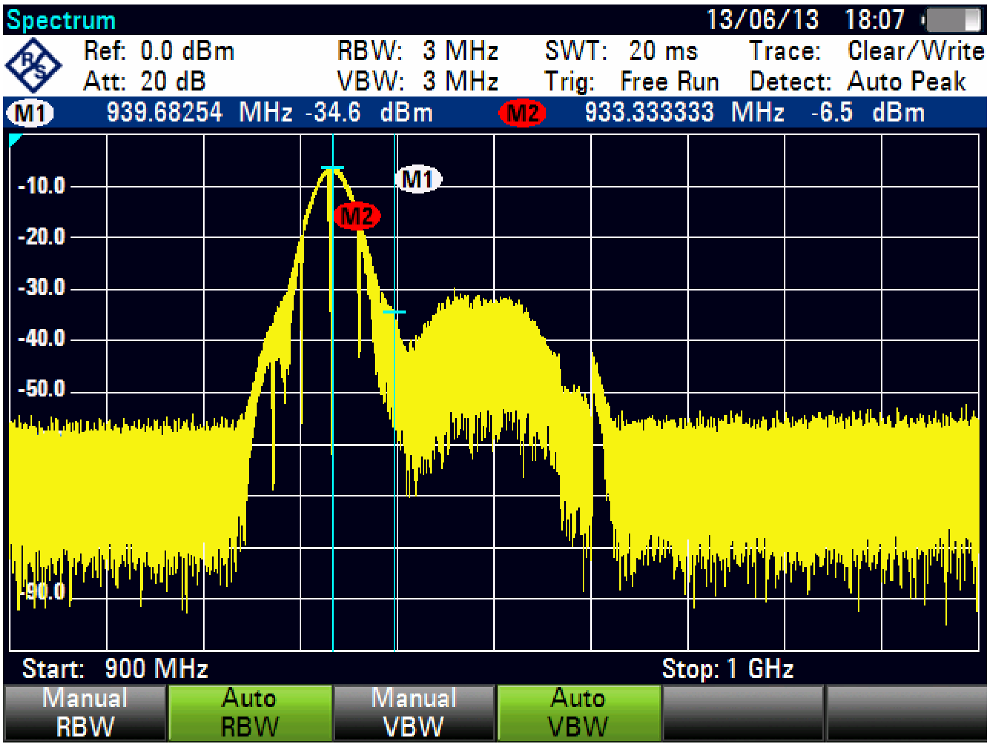

Figure 6 The spectrum of emitted GSM signal at distance of 20 metres

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To objectify our projections about emitting of that kind of antennas we used the spectral analyser Rhode & Schwarz, which is capable directly on its display to visualize the electromagnetic field in the vicinity of its antenna. As an external antenna we choose the special screening antenna for wide spectrum of the frequency 0,5 – 7,5 GHz. Firstly we set the range of the scanning at 800 MHz to 2000 MHz. After we found the signal from mobile operators ORANGE and O2 we reduced the range at 900 MHz to 1 GHz. At the 20 metres distance was the situation of emitted signal such it is shown in Figure 6. From the Figure 6 is clear, that analysed electromagnetic field is held relatively at high value, subsequently of that also the level and density of EM field is very high. Introduced phenomenon we had expected of course. Whilst almost 400 MHz wide of the band by that level of signal gave us the information, that such a signal is really able to covers and overbuilds overall band as our 2,4 GHz, which we use for controlling the UAVs. The interest point is the fact that we are in different frequencies and the spacing is bigger than 1,5 GHz. Actually the density of EM field, higher harmonic frequencies and different reflections of the signal causes, that the logic circuits of the common receivers are not able to reliable evaluate that signal or suppressed it and thus, such a signal is following on the next processing in the receiver parts as so-called right control signal. That “false” signal is composed of the interference of origin signal and GSM signal. We claimed that problem rests in the fact that high value of EM field enters directly into the receivers.

4. THE IMPUT CIRCUITS OF RECEIVER AND POSSIBILITIES OF IMPROVING THEIR ELECTROMAGNETIC ROBUSTNESS

We think, the main reason of that is based on high level intensity of electromagnetic field, which is intervening directly into the internal circuits of receivers. For the better understanding, the situation is captured in the simple Figure 7.

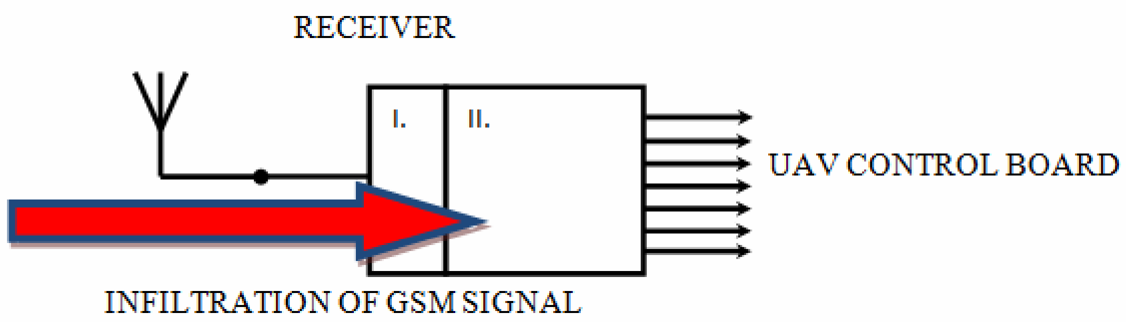

Figure 7 Demonstration of infiltration of GSM signal

As we can notice in Figure 7, the high level of intensity of GSM signals acts by as on the antenna also as on the input circuits (I.), and simultaneously on the other circuits for next signal post processing (II.) Whereas the receivers are covered just by plastics, or rubbered boxes, there is no problem for the signals for infiltration of stronger signals directly to elements of receivers, skipping the antenna, without following the antenna lines.

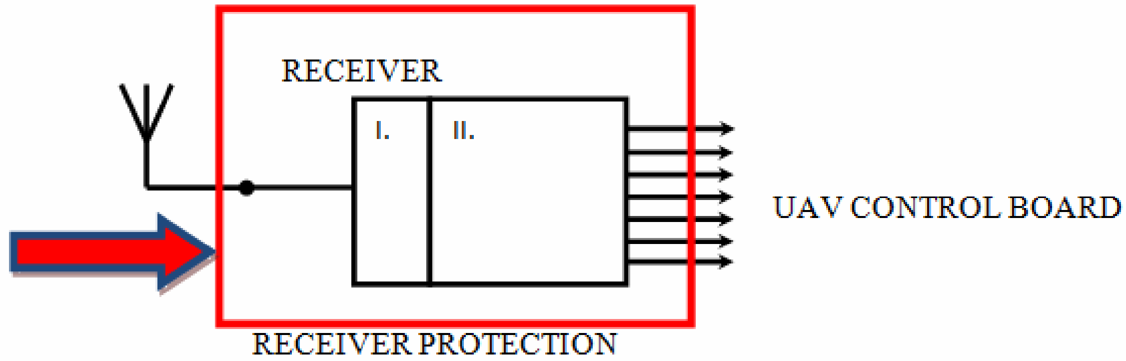

Figure 8 The possible protection against infiltration of GSM signal

One of the possible solution how to ensure the passing of the signal to receiver just by the antenna is to make such a most perfect separation and shielding the receiver against the environment. Of course the antenna is dropped out of shielded box. The theoretical presentation is in the Figure 8.
Such a shielding, by our expectation should get reduces the volume of undesired electromagnetic energy under the level, which is safety and do not problems for any receiver.

5. CONCLUSION

The main goals of the article have been to foreshadow also one of the negative sides of each radio controlled flying vehicle. The mover of our debates have been the numbers of crashes of small UAVs, which operators lost due to some reason the overall control and simultaneously partially or totally failed the system of emergency mode or fail safe mode. Those accidents happen during the common using of the UAVs, in ordinary environment of towns or villages.
Prime analyse of the situation drove us to realize the existence of the foreign electromagnetic fields in the area of interest of the flight the UAV. By the deeper analyse we came to concrete factor – the aerial systems of GSM nets, which attracted by their relation by our finding causes. In the present time there is still a long way in front of us to say the exact hypothesis and the numbers of experiments, but despite o fit, we are able to point out that for low flying UAV is the presence of the antennas of cellular phones and their EM fields the risky factor.
Our further steps will be focused on improving the receivers of UAVs, measuring their parameters, verification of the resistance against the interference and adjusting of antennas for UAVs. In this article, there is just several information about this issue in short order, however we deal with that problem just in the internal sphere of department of avionics.

This work was funded by the European Regional Development Fund under the Research & Development Operational Programme project entitled "Construction of a research & development laboratory for airborne antenna equipment, ITMS: 26220220130."

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POSSIBILITY OF ESTABLISHING MULTI-PILOT LICENCE TRAINING IN THE CZECH REPUBLIC

Jan BŘEŽANSKÝ[1] - Věra VOŠTOVÁ[2]

Abstract: *The beginning of the article is focused on the advantages of Multi-Pilot Licence (MPL) training program against standard forms of training. The core of the article is a possibility of establishing MPL Training in accordance with Part FCL and its acceptable means of compliance in the Czech Republic.*

Keywords: *Multi-Pilot Licence (MPL), competency-based training, advantages, actual training aeroplane, Flight Simulation Training Device (FSTD)*

1. INTRODUCTION

The global civil aviation training community now accepts that the traditional, inventory and hours-based training regulations for ab-initio pilot training are out of step with the requirements of multi-crew operation in modern transport airplanes [1].
The importance of replacing the old hours-based training concept by the new competency-based training concept have already understood airlines such famous names such as easyJet, Swiss, Air Berlin, Air China, Thai Airways, Flybe and many others.
The issuance of a Czech MPL will follow the completion of four phases of the course designed specifically for ab-initio (zero flight time) candidates. The privileges of the MPL are limited to co-pilot duties operating a specific aeroplane type that appears on the holder's MPL. Holders wishing to operate aircraft outside of the constraints imposed on the MPL will also need to obtain one of the traditional licences and the appropriate ratings such as Commercial Pilot Licence with Instrument rating (CPL/IR). The graduate is expected to be able to successfully complete a normally structured line indoctrination training program, also referred to as Initial Operating Experience (IOE) [2].

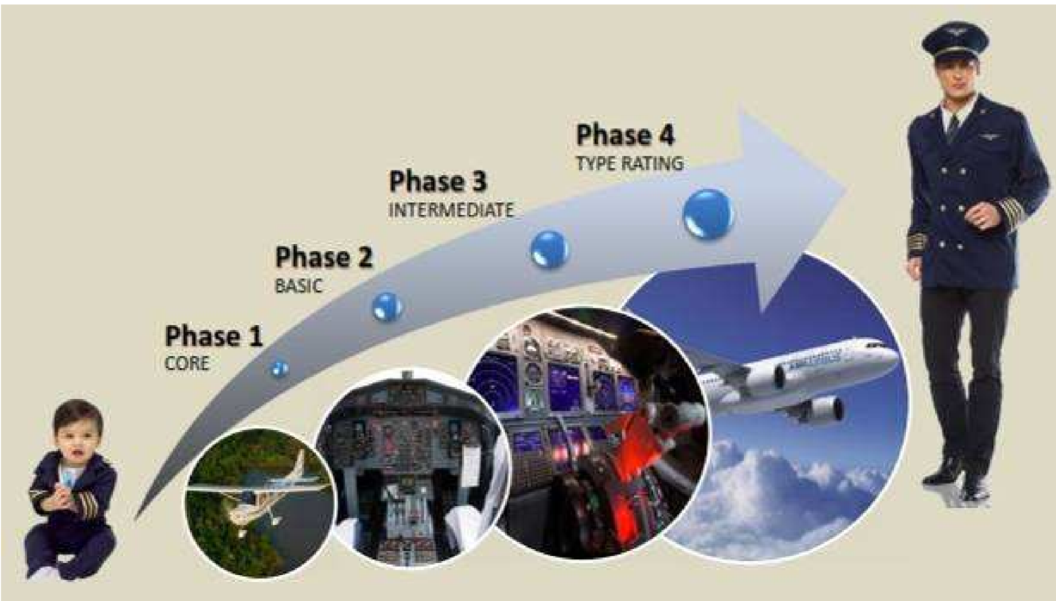

Figure 1 MPL Course Process

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Currently there is, unfortunately, only one appropriate company, Czech Airlines Training Centre (CATC) which is able to provide the MPL training in modern transport airplanes such as A320 or B737 in the Czech Republic and which will be probably suitable for the CAA.

2. ADVANTAGES OF MPL TRAINING

There are several major advantages against traditional forms of training. But of course, if there are advantages, there are certainly also some disadvantages. But it is important that the advantages prevail over the disadvantages.

Compared to current ab-initio training schemes the MPL training course provides 4 times more instruction time in multi-crew environment thus producing a better prepared co-pilot.

Table 1 Advantages

A thorough selection process	***Close connection with the airline***	***Embedded CRM/TEM & MCC***	***Higher quality & relevance of instruction***	***Continuous competency assessment***	***Upset recovery training***

More optimized training promises to save training costs, and safer pilots will become a measurable cost saving over time.

3. STRUCTURE OF THE COURSE

3.1 Screening

Prior to commencing the program, trainees should go through a careful screening and selection process provided by the ATO to determine if they have the attributes believed to optimize the chances of success. Area that must not be overlooked at this early stage is the assessment of each candidate [3]. Attributes, qualities, motivations, and attitudes of new generation pilot pools are changing and job requirements have also changed since earlier selection processes were established. Since every operator have their specific requirements so it is not possible to establish just one screening model to meet them all.

But generally we can say that assessment of their aptitude should include at least the following:

- Medical examination (AMC/AME)
- Psychological aptitude
- Language proficiency
- Test of common sense
- Flight-simulator check
- Freestyle interview

Professional aptitude testing for airline pilots, if correctly implemented, can contribute considerably to cost savings and enhanced safety for an airline [4].

3.2 Theoretical Knowledge Instruction

According to Part-FCL, an approved MPL course shall comprise at least 750 hours of the ATP theoretical knowledge instruction.

The theoretical knowledge instruction includes classroom work, interactive video, slide or tape presentation, learning carrels, computer-based training, e-learning method, and other media as approved by the competent authority [5].

To be competitive with others, it is necessary to find a suitable compromise between classroom learning and e-learning. It should be borne in mind that in an integrated course there is not permitted a distance learning method. On the other hand, the CAA can allow a crediting of ATP theory.

The theoretical knowledge instruction as well as the whole MPL course can be divided into 4 phases:

1. Phase 1: CORE
   - ATP Theory and Examination

2. Phase 2: BASIC
   - Crew Resource Management & Threat and Error Management (CRM/TEM)
   - Multi-Crew Cooperation (MCC)

3. Phase 3: INTERMEDIATE
   - Type Rating Theory

4. Phase 4: ADVANCED
   - Differences Course Theory (if appropriate)

3.3 Practical Training Instruction

In the practical training which should be divided into 4 phases as well as in the text above and there are just few things which shall be followed:

- Training in actual training aeroplane shall not be less than for a PPL.
- Total training time (the sum of aircraft and FSTD) shall be at least 240 hours.
- At least 12 take-offs and landings are performed in base training on the aeroplane for which the type rating is sought.

Somebody would say that it is a great thing for the course designers if there are just few directives but the opposite is true.

3.3.1 Phase 1

Although this phase will mostly be flown in small single-engine aeroplane and covers the content of a PPL, it is important that it is not confused with pure PPL training. MPL courses should be clearly differentiated from modular PPL training by applying professional techniques and structures from the outset [1].

3.3.2 Phase 2

Now it is time to start flying in a FSTD as a pilot flying or monitoring (PF or PM). In this phase, the pilot learns how to fly multi-engined aircraft and how to fly by instruments already in multi-crew environment.

3.3.3 Phase 3

MPL Phase 3 learning outcomes are not designed to be specific to type, and can be generic [1].

Since MPL course is designed for operator’s purpose only and with such an operator shall be a signed cooperation agreement, for this reason I suggest using a specific type of the airplane for which the type rating is sought. It could be said that this phase is a jet oriented course (JOC) and teaches students how to fly a jet and some normal and abnormal situations.

3.3.4 Phase 4

This phase follows up on the previous one. Now it is a “real” type rating which is extended against classic one, so there is time to practice more difficult abnormal and emergency situations which would not be possible to practice in the normal training for lack of time.

4. CONCLUSION

It is clear that the MPL training is not suitable for everyone and depends entirely on what you expect from flying. It is a big difference in whether you want to be a pilot of a large commercial aircraft or you want to fly just for fun. If you decide for the first option so in my opinion MPL training is the best way how to become a first officer (F/O) in a relatively short time and for reasonable price in comparison with the traditional way of training.

If pioneering companies providing training of this kind are nifty and manage to attract clients, especially the foreign ones, it may start the beginning of cooperation among ATOs and so revive our moribund market.

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SELECTED ASPECTS OF DIESEL FUEL ASSESSMENT

Štefan ČORŇÁK[1]

Abstract: *The basic sort of fuel of diesel engines is diesel fuel. With regard on the rock-oil origin, is it mixture of alkaline, cyklaline and aromatic hydrocarbons with 12-22 atoms of carbon in a molecule, boiled between 180- 270 ˚C, whose mutual relative substitution depends on the quality of the rock-oil and used technological processes. Further the additives are added to improve usable characters (depressants, detergents, lubricity additives, inhibitors of corrosion, anti-foaming additives, biocomponents in the form of methyl-esters of aliphatic acid etc.) To using of diesel fuel like fuel for diesel engines must fulfil line of qualitative indicators which is possible divide into several groups: physical -chemical characteristic, low-temperature characters, chemical structure, detonating characters, lubricity, parameters characterizing cleanness other parameters. The values of diesel fuel qualitative parameters and methods of their valuation are strictly defined by norm EN 590. Signal that everything isn't right in this area are results of fuel quality inspection which accomplish Czech business inspection. Author of article deal with problems of infrared spectrometry application with Fourier's transformation during evaluation of diesel fuel. Several samples of different age were evaluated. According to results, the modern apparature IROX DIESEL making use of methods FTIR is a suitable apparature for service evaluation of diesel fuel qualitative characters (change of choice parameters approve as decline of absorbance values and change spectrum width). The goal of this elaborate was to accomplish possibility of using of infrared spectrometry to evaluation of diesel fuel.*

Keywords: *diesel fuel, FTIR, IROX DIESEL, Michelson's type interferometer, vehicles*

1. INTRODUCTION

Fuel for combustion engines can be divided into two basic groups, where an essential one is petrol/gasoline and diesel and an alternative one (propane butane, natural gas, esters, ethers, alcohols, biofuels, hydrogen and others). An essential type of fuel in petrol engine is petrol and for diesel engines diesel [1].

In the Czech Republic 4,8 billion litres of diesel and 2,2 billion of petrol was sold in 2012. [2]. Consumption of such a big amount of fossil fuels has serious economic and ecological impacts.

This is the reason why the quality of fuel in the Czech Republic is prescribed by legislation:

- ČSN EN 228 (Czech State Norm EN 228) motor fuels (unleaded petrol),
- ČSN EN 590 (Czech State Norm EN 590) motor fuels (diesel),
- ČSN EN 589 (Czech State Norm EN 589) motor fuels (liquefied petroleum gas),
- ČSN 65 6507 (Czech State Norm 65 6507) Biofuel for diesel engines (methyl ester of colza oil),
- ČSN 65 6508 (Czech State Norm 65 6508) Motor fuels (diesel blend containing FAME),
- ČSN 38 6110 (Czech State Norm 38 6110) Natural gas.

These norms strictly state the parameters and methods of identification. In case of combat and special vehicles diesel is preferred because of its combustibility. General requirements, limits and methods for testing and assessment of diesel according to the ČSN EN 590 (Czech State Norm 590) is given in the Table 1 [2].

Assessment of these parameters in a laboratory is lengthy and relatively demanding from the point of time and money needed [2]. This paper presents opportunities how to use infrared spectroscopy for assessment of type, contents and some essential parameters of motor fuels.

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Table 1 General requirements and methods of assessment according to the ČSN EN 590 [2]

Quality	Limit values min	Limit values max	Units	Method of testing
Cetane number	51		-	EN 15195
Cetane index	46		-	EN ISO 4264
Density (15 °C)	820	845	kg/m^3	EN ISO 12185
Polycyclic aromatic hydrocarbons		8	% (m/m)	EN 12916
Content of sulfur		10	mg/kg	EN ISO 20884
Content of oily acids methylesters		7	% (V/V)	EN 140078
Point of outburst	55			EN ISO 10370
Oxidative stability		25	g/m^3	EN ISO 12205
	20		h	EN 15751
Lubricity (60 °C) (wsd 1,4)		460	um	EN ISO 12156
Viscosity (40 °C)	2	4,5	mm^2/s	EN ISO 3104
Content of ash				EN ISO 6245
Content of water		< 65	% (V/V)	EN ISO 12937
Total content of impurities	85		% (V/V)	EN 12662
Corrosive operation of copper		360	^oC	EN ISO 2160
Distillation test				
at 250° C it is distilled		< 65	% (V/V)	EN ISO 3405
at 350° C it is distilled	85		% (V/V)	
95 %(V/V)		360	^oC	

2. THEORETICAL BASE OF SOLUTION

Infrared spectrometry as a non-destructive optical analytical method belongs to a group of methods of molecule spectroscopy, which is based on an interaction of electromagnetic radiation with a tested sample and as a result of excitation of appropriate chemical groups and chemical bonds in molecules radiation of certain energy values is absorbed. Thus characteristic spectra are created and they consist of so called vibration absorption lines.

The principle of infrared spectrometry is based on the Lambert-Beer law [4]:

$$I = I_0 . e^{-\varepsilon . c . l} \qquad (1)$$

where: I_0 - incident radiation intensity; I - passing radiation intensity; ε_0 - molar absorb coefficient; l - absorb medium thickness; c - concentration of monitored substance.

The interferometer principle, most frequently of Michelson's type, is clear from Fig. 1.

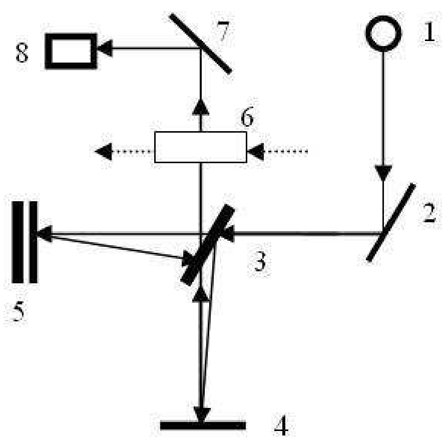

Figure 1 Michelson type interferometer principle diagram
1 - infrared source; 2, 7 - mirror; 3 - ray divider (semi-permeable mirror); 4 - fixed mirror; 5 - moveable mirror; 6 - measuring cuvette; 8 - infrared detector

The light from infrared Source 1 is divided by Mirror 2 into two equivalent rays with the help of Ray divider 3. One ray is reflected by a fixed Mirror 4 and the other ray is reflected by a Moveable mirror 5. Both rays are put together in a divider of ray 3 and then are routed to Measuring cuvette 6, which is filled up by an unknown sample. Because a Moveable 5 mirror moves along a definite track, in each moment of a spectrometer activity other wave lengths are magnified and reduced.
If the distances of mirrors 4 and 5 are identical, rays on the semi-permeable ray divider are added. If the distances are not identical, there is interference between both parts of ray. This variable light passes through cuvette 6, which is filled by an unknown sample and turns out over the Mirror 7 on the Infrared detector 8. The interference diagram (dependence incident radiation intensity in time) is consequently recalculated on spectrum with the use of Fourier's transformation.

3. MATERIALS AND METHODS

At the Department of Combat and Special Vehicles tens of samples of operating fluids were analyzed. From the analysis an extensive database was created. In this paper, just for an illustration, only results of 3 samples of fuels are presented. It is a sample of diesel, gasoline and a mixture of unknown/mixed fuel. For the evaluation of the quality of diesel, an IROX DIESEL analyzer was used with an in-built infrared interferometer of Michelson's type.
IROX-Diesel has been upgraded to determine the content of mono-alkyl esters of long chain fatty acids (or FAME/Biodiesel) in a mixture with normal diesel fuel. FAME (Biodiesel) is produced out of vegetable oils like rape seed and soy bean, mixed with methanol and a catalyst to accelerate the reaction to form fatty acid alkyl esters. Low concentrations of FAME (Biodiesel) in diesel fuel (≤ 9 % m) show a strong absorbance peak at 1747 cm^{-1} in the IR-spectrum while higher concentrations (9 to 40 % m) produce a weaker signal response at 1195 cm^{-1}. This allows accurate measurement of the content of FAME (Biodiesel) by calculating the second derivative of these parts of the IR-spectrum. The revised method and software modifications also resulted in a significantly improved precision for the determination of the Cetane Improver, Polynuclear Aromatics (PAH), Cetane Number and Cetane Index: calculating the second derivative of the additional peaks of Cetane Improver and PAH resulted in measurement data with an increased accuracy compared to the official methods and better repeatability. In the lower range (0,2 -> 7,0 % v): the peak at 1747 cm^{-1}. In the higher range (7,0 -> 30 % v): the peak at 1195 cm^{-1}. Recalibration with known standards is easy and the calibration constants are calculated automatically. The quality of these samples was checked at the Department of Combat and Special Vehicles, at the University of Defence, Brno. The analyzer IROX DIESEL was used for diesel fuel evaluation, in which there is a built-in Michelson's type interferometer.
Before the first measurement, the apparatuses calibration was accomplished with the use of calibration fluid 99+ % n-hexane. The calibration library included 180 samples. The recorded evaluation of measured values was accomplished with use of program MINIWIN 2.2.4.

4. RESULTS AND CONCLUSION

The general measuring results are in the graphs in Figure 2 - 3. From the results obtained it is clear that there is a typical infrared spectrum for each fuel.

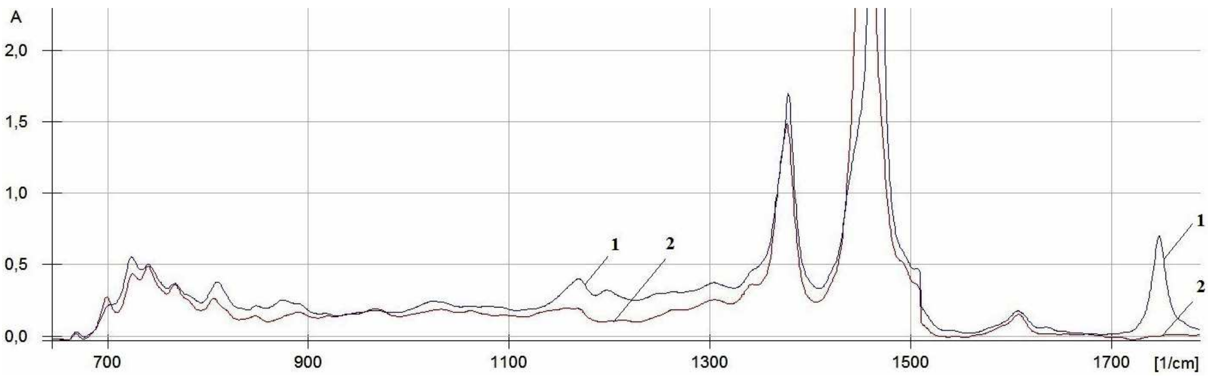

Figure 2 Infrared spectrum (finger printer) diesel fuel
1 – civilian diesel fuel, 2 – military diesel fuel (F54)

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This spectrum in the extent of 650 to 1800 cm^{-1} is called "an area of fingerprint" in which a position (wavemeter) of lines represents characteristic groups contained in fuel. By these lines it is possible to identify positively and unmistakably the majority of mixtures.
It becomes clear from Figures in this paper that for diesel there are typical wavemeter peaks 1377 cm^{-1} and 1377 cm^{-1}. Moreover, wavemeter 1747 cm^{-1} is typical for the contents of FAME, which is added into diesel.
In Figure 3 there is a spectrum of an unknown mixture (unknown/mixed fuel). From the Figure it becomes clear that we have a mixture of diesel (typical wavemeter 1377 cm^{-1} and 1466 cm^{-1}) containing FAME (typical wavemeter peak 1747 cm^{-1}), which is mixed with gasoline (typical wavemeter peaks around 727 cm^{-1}, 1087 cm^{-1} and 1204 cm^{-1}. From the absorbance values it can be deduced that diesel is represented by approx. 90 % in the mixture and gasoline by approx. 10 %. Such contamination may occur during transportation in tanks when medium is changed. In real life even a small contamination of fuel can have serious consequences for the engine.

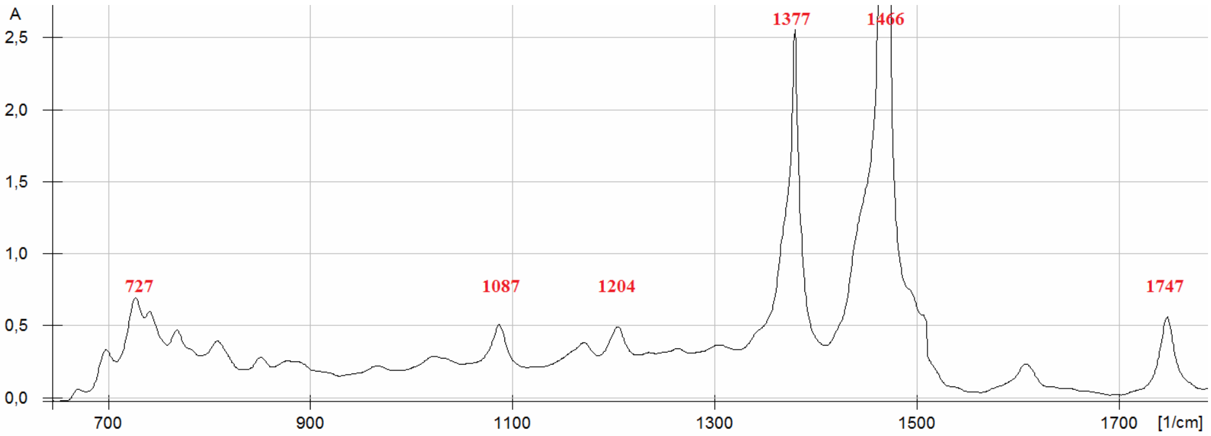

Figure 3 Infrared spectrum (finger printer) mixfuel

5. CONCLUSION

In this paper the author deals with the evaluation of fuels. Samples of civilian diesel fuel, a military diesel fuel and a mixture of unknown fuel were analyzed and evaluated. For the evaluation an analyzer of Michelson's type was used with an in-built infrared interferometer.
The results obtained proved that in the range of wavemeter 650 to 1800 cm-1, there is a unique typical unmistakable infrared spectrum, which can be compared with human fingerprints. By the use of these spectra it is possible to identify unmistakably the majority of fuels. Moreover in case of unknown mixtures, it is possible by the use of these spectra fingerprints to analyse and state their mutual ratio.

The paper has been written within the research project of the workplace development in K-202 department, University of Defence in Brno.

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SAFETY EQUIPMENT AND EMERGENCY PROCEDURES FOR UAV CONTROL

Katarína DRAGANOVÁ[1] - Václav MOUCHA[2] - František KMEC[3]

Abstract: *The key factor that influences integration of unmanned aerial vehicles (UAVs) into the airspace is safety. The first part of the article gives an overview of existing safety equipment that can be used on UAV board including sense and avoid systems, parachutes, airbags, nets, flight termination systems, emergency locator transmitters and data loggers. The second part of the article deals with the current state of emergency procedures including engine failure, mechanical damage and electrical or electronic component failure procedures, loss of communication and hijack procedures. Forasmuch as there is a lack of standards specific to UAV safety systems and operations, both safety equipment and emergency procedures can be, but don't have to be used by the UAV or by a UAV operator and that leads to the situation that UAV equipment and operation can vary according to the UAV type and mission.*

Keywords: *unmanned aerial vehicle (UAV), UAV safety equipment, emergency procedure*

1. INTRODUCTION

The safety measures should be taken so that undesired consequences are kept to a minimum during a hazardous event. Risk of personnel injuries or material damage due to hardware, software, procedural or environmental hazards must be at acceptable levels.

To increase safety of UAV (Unmanned Aerial Vehicle) operation different types of UAV safety equipment are used, including parachutes, airbags, nests, flight termination systems, emergency locator transmitters and data loggers.

Despite many preventive actions during planning, sufficient attention must be given also to the possibility that an in-flight emergency may occur. For the emergency situation planning many types of emergency situations have to be taken into consideration. An emergency recovery procedure that is implemented through UAV crew command or through autonomous design means in order to mitigate the effects of critical failures with the intent of minimising the risk to third parties. This may include automatic pre-programmed course of action to reach a predefined and unpopulated forced landing or recovery area.

Emergency system can be then defined as a system, procedure and/or function that aim to end the flight in a safe manner. The main requirement is that emergency recovery capability must be activable in the whole flight envelope protection, safeguarded from interference leading to inadvertent operation.

2. SAFETY EQUIPMENT

Safety equipment is a comprehensive designation for equipment that is used to increase the safety during the UAV operation during the normal but also emergency operations.

2.1 Sense and avoid system

The ability of UAVs to operate safely in civilian airspace is conditioned by the sense and avoid system utilization. This ability is currently limited by their insufficient ability to sense, detect and avoid airborne hazards. While larger UAVs might effectively implement radar or other existing system, such a solution is problematic for smaller UAVs. Therefore many new technologies have been developed,

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using for example small passive electro-optical [1], infrared or acoustic [2] sensors to search and detect the traffic.
But choosing of the sensor and detecting method is not the only problem. Also the way of avoiding manuever has to be standardised, because now many avoidance methods have been developed and used. But in fact, two complementary approaches are proposed. One approach promotes the idea of a dedicated controller using a specific display at the control station for performing the collision avoidance function. The second approach is the development of a fully autonomous sense and avoid system.

2.2 Parachute safety system

UAV parachute recovery system is equipment that relies on the deployment of a parachute to aerodynamically decelerate an aircraft allowing a safer touchdown [3] that can be used for routine landing or for emergency only [4].
Principally, UAVs can use three different **canopy shapes**:

- **cruciform or cross-type canopies** – consist of two pieces of rectangular cloth overlaid and sewn together. These canopies have the smallest drag coefficients and low oscillation opening forces leading to gentler parachute inflation and in precision airdrop systems are often used as drogue stabilizing parachutes;
- **hemispherical canopies** – have high drag and opening force coefficients, offer good reliability on opening and simplicity in construction and packing;
- **parafoils** – gliding parachutes, designed to be steerable, allowing for a small level of navigation after deployment. Their internal cell structure is ram-air inflated which forces the parafoil into a classic airfoil shape constructed out of a low porosity fabric and a complex reefing mechanism is generally needed.

Parachute activation refers to the method of deployment prior to inflation. It can be assumed that a key factor of parachute deployment systems is reliability. Three principal deployment methods are

- **Forced ejection systems -** are common extraction methods due to their simplicity. The mortar, catapult, and pressure bellows are examples of mechanisms designed to produce a forced ejection of the packed parachute. These systems tend to be heavy and they also produce high reaction loads, which is important when considering the platform in which the system will fire.
- **Drogue or pilot parachute systems -** have numerous advantages. The system is quite flexible since the parachute extraction force is applied continuously over the entire deployment sequence, and the system is also lighter. This system relies on aerodynamic force to extract the main parachute, thus problems may arise due to pilot chute interference with the wake turbulence of the descending body (known in skydiving as 'hesitation'). Used in tandem, individual extraction systems increase their effectiveness as demonstrated by the Gemini Spacecraft, which used a drogue gun to launch a drogue parachute to stabilize the re-entry vehicle, until a height at which the pilot chute was extracted, pulling out the main chute
- **Rocket extraction systems -** has all the advantages of a drogue parachute system, but does have a slight weight penalty. Furthermore, the rocket extraction system produces very light reaction loads, and is only slightly dependent on the characteristics of the vehicle wake. The rocket extraction does however increase the risk of damaging the parachute fabric on extraction, and has the added complexities of dealing with pyrotechnics.

Parachute filling distance is defined as the distance required for the parachute canopy to open, taken from the point of initial line stretch to full inflation. Sometimes the canopy filling time is also given.
The **attachment** of the parachute to the UAV directly affects the operation of the system. The attachment points determine the behaviour of the aircraft during canopy inflation, and also the attitude at which the UAV will fall once inflation is complete and the PRS is in the steady state condition. Conventional parachutes are placed in such a way that enables to protect the airframe (conventional or upside down landing), to remain the centre of gravity to keep the system balanced and to place the attachments in regard to the aircraft fixtures, able to handle the large forces that can be experienced due to the rapid deceleration during canopy inflation.
Also several concepts of a parachute releasing can be used:

Uncontrolled deployment releases the parachute into the free-stream and the forward moving airflow does the work in opening the parachute to full inflation. This method is effective for small UAVs with parachutes less than 5 feet in diameter

Ballistic deployment refers to the deployment of a parachute by the use of some kind of pyrotechnics.

Spring release method uses a high powered spring internally mounted to eject the main parachute into the free stream airflow.

UAV parachute recovery systems may comprise of the following main components:

- an **extractor parachute**, which may be connected to one of the doors of the vehicle or extracted by means of a mechanical system or pyrotechnic mortar; its function is to deploy the deceleration system in the air;
- a **drogue parachute**, which is a ribbon-type parachute, whose purpose is to gain control of very fast descents, in order to enable the deployment of the main parachute without unduly stressing the parachute canopy fabric;
- a **main parachute** to slow down the vehicle's descent to within the pre-established speed; this can be of various shapes ("polifonico", ring-shaped, square) as needed;
- a **container** made of fabric, metal or a mixture of both, its function is to contain the deceleration system in the smallest possible space and to allow the proper deployment of the system.

Several parachute recovery systems for UAVs are provided with a device that separates the parachute from the vehicle on impact with the ground, to prevent the vehicle from being dragged on the ground, by the parachute, for example in the windy conditions. But there are many other factors that should be considered when choosing the parachute for the UAV, for example UAV type, configuration, weight, speed, rate of descent, operation conditions (rain…), place of landing (water, dirt…), landing attitude (right side up, upside down, nose up, nose down…). Important are also characteristics of the parachute safety systems, for example its dimensions, weight, opening limit, stowing (internal, external) and of course there is a question of parachute reusing – if so, which components will be recycled and where will be the parachute repacked (in the field or sent back to manufacturer). Other issue is to integrate system for parachute into the UAV control unit. Main problems that have to be solved are manual or automatic parachute activation and prevention from parachute opening into the propellers [5].

2.3 Airbag recovery system

The UAV recovery systems are often fitted with airbags (Fig. 1) too, to soften and cushion impact with the ground and protect the vehicle's electronics. The device is activated when a landing signal is transmitted.

Figure 1 UAV parachute recovery system fitted with airbags [5]

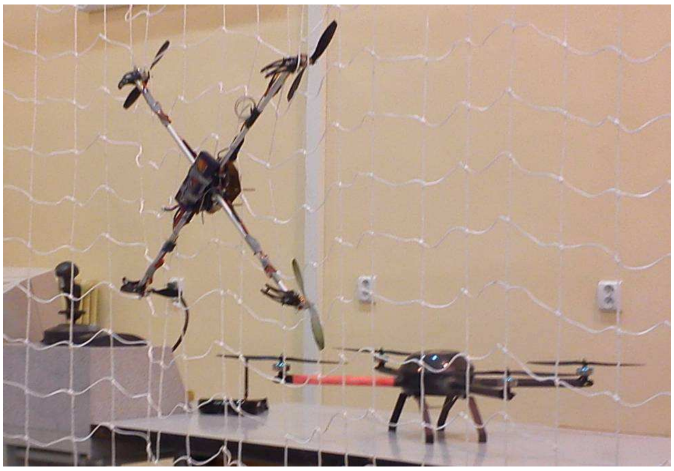

Figure 2 Nets in the Hall for UAVs testing

2.4 Nets

Many UAV are able to take off and land without using runways on airfield. One of the ways how to accomplish the emergency landing is to use a capture net, sized and designed according to the specific UAV characteristics.

Net can be responsible for arresting the vehicle and damage minimisation in the landing phase of flight. But there is also another possibility of using nets. If they are placed vertically they can serve as a safety element to separate viewers during UAV air shows or performances. Vertical nets can be useful also during trainings. This kind of nets is used also in our Hall for unmanned aerial vehicles testing. All planned and also accidental net reliability tests ended successfully without threat of persons and without property and even UAV damage (Fig. 2).

2.5 Flight termination systems

Flight termination systems are explosive devices that are used in specific situations, for example in the event of a system failure. These types of systems are used for the containment of UAVs within specific airspace under specific conditions. For certain missions or experimental tests, UAVs can be allocated a region of airspace by regulatory authorities that they are allowed to operate in. If the UAV has some kind of failure that threatens the breach of this airspace, ground operators can engage the flight termination system to destroy the UAV before it leaves the allocated airspace.

Nowadays only few UAVs have built a self destruct mechanism. It would be possible to put such a mechanism on most UAVs, but in some cases it could be very dangerous and also impractical. The flight termination could be programmed to either be manually commanded, or to occur in the event of communication loss after a predetermined time. The problem with this scenario is that UAVs loose link with their ground controllers frequently due to many reasons. Nevertheless, probably lot of UAVs would end up blowing up needlessly and that would make their use very expensive.

UAVs used in military, governmental and some safety, security, monitoring and observation application have built a self destruct mechanism more often and it is usually because of the fact that sensitive or secret information are stored on the vehicle.

Some of the UAVs have built only a function to erase data if a seal is broken on a component in an attempt to tamper or gather information held within.

2.6 Emergency locator transmitter

Emergency locator transmitter is a device capable of automatic or manual operation designed to withstand forced landing and crash environment conditions and survive in an operable condition, which transmits a unique identifying message with a unique ID. Other message types may be custom-programmed.

The inertia switch is designed to activate when the unit senses crash-specific longitudinal inertia forces. When properly installed, parallel to the line of flight, transmitter will not activate due to turbulence, normal operation, or aerobatics.

2.7 Data logger

Data logger is an electronic device employed to record any instructions sent to any electronic systems on the UAV. It is a device used to record specific UAV performance parameters and also for incident and accident investigation, as well as for analyzing air safety issues, material degradation and engine performance. Due to their importance in investigating, these devices are constructed to withstand the force of a high speed impact and the heat of an intense fire.

2.8 De-icing system

If all weather operation is required, the ice protection is desired and de-icing system has to be installed, the system and its components have to be designed to perform their intended function under any normal system operating temperature or pressure, and also the recommended procedures for the use of the ice protection equipment have to be set.

3. EMERGENCY PROCEDURES

Emergency recovery procedures are those that are implemented through UAV pilot command or through autonomous design means in order to mitigate the effects of certain failures with the intent of minimizing the risk to third parties. This may include automatic pre-programmed course of action to reach safe landing or forced landing area.

Emergency landing areas should be uninhabited areas where the risk to third parties can be considered as minimized and their location should be such that the UAV should be able to reach them, considering e.g. UAV gliding capability and emergency electrical power capacity.
Currently there is a lack of emergency procedures designed for UAVs. But principally several situations for which emergency procedures are required can occur:

- If **engine failure or power blackout** occurs, the emergency procedure depends on the UAV power plants equipment. If possible following actions should be performed (Barnard Microsystems Limited, 2012): the UAV should dump fuel if it is necessary, to reduce weight and the risk of fire on crashing. To slow the descent of the UAV air brakes should be deployed and to bring the UAV slowly to soft landing parachute or airbag(s) should be used. Since the engine failure is often the most probable failure mode, the UAV should have pre-programmed an engine-out landing procedures. Then if possible the emergency locator transmitter radio beacon should be activated.
- When **mechanical damage** is detected, the UAV should for example automatically increase the turn radius and prevent aggressive manoeuvres from being commanded. These new trajectory constraints are then incorporated into the trajectory planner to ensure the commanded trajectory is feasible. Exchanging the prevailing trajectory with the ground coordination functions, these revisions are communicated, so that the next coordination cycle will in fact account for any trajectory revisions resulting from, for example, vehicle damage.
  Another function that should be incorporated is the ability to provide contingency plans for emergency landings including trajectory planning in the emergency landing profile, substituting the nominal mission with a profile required by the specific situation.
- The UAV health monitoring capability should be used to detect and indicate **the electrical or electronic component failure or malfunction** of UAV electrical or electronic components. According to this information the UAV mission should be adaptively modified using back-up systems or terminated.
- **Loss of communication** can be defined as an operation in circumstances where vehicle cannot, or are not required to cooperate, such as in case of system failures where vehicle is unable to share the required data, or when the UAV senses a significant delay or loss of the command up link and if the vehicle is able to fly autonomously, the autonomous operation should be expanded using suitable technology (sensor equipment, navigation systems, sense and avoid systems etc.) and the UAV should automatically enter into a return home mode of flight using the pre-approved route at a pre-approved altitude to its pre-approved return home site. During this emergency, if the UAV pilot is able to re-establish communication with the UAV the pilot can decide to terminate the mission and return to base or continue in planned mission.
- **Hijack** can be divided into jamming of the command and control signal by the simple scrambling or muddling of the signals and spoofing, which means manipulation with signals used for UAV navigation and control using false information that, for all intents and purposes, looks real to the UAV. During this emergency, the UAV pilot should attempt to re-establish connection with the UAV. If contact is re-established, the mission commander may choose to terminate the mission and return to base or continue with the mission as planned and if is not and it is possible, the hijack code 7500 has to be used. UAV pilot has to notify supervisory personnel of the situation.

The most important factor that influences emergency procedure performance is training. The UAV pilot or operator should know certain emergency procedures well enough to perform the required procedure from memory. The UAV pilot or operator should know how to perform at least uncontrollable flight emergency procedures, engine failure, recovery and glide emergency procedures and control unit failure procedures. The UAV pilots and operators should also have information about mission planning and coordination, about UAV systems, their limitations and maintenance and also about weather limitations.

4. CONTRIBUTION OF OUR DEPARTMENT TO UAV SAFETY

Magnetometry has been studied at Department of aviation technical studies on a long-term basis. Magnetometers that have been developed, tested and calibrated on our department can be used for example in navigation, more specifically in conjunction with accelerometer and gyroscopes in inertial measurement units or directly in the role of magnetic compasses. Forasmuch as these sensors are sensible to the temperature, too, they can be used for temperature measurements for meteorological or environmental purposes or for the temperature-dependence compensation. But there are also other possibilities how to use magnetometers on UAVs that can lead to increase in the UAV operational safety. Due to the small dimensions, weight and low manufacturing costs can be microwire-based sensor used also for example as an augmentation of sense and avoid systems to initiate warnings to pilots or operators if the UAV approaches electric power transmission lines. This information could be useful in many applications that require flights in low altitudes and behind the line of sight or using autonomous navigation systems. Another possibility how to use microwire-based sensors is in the health-monitoring systems to monitor UAV construction and to detect risks or even damage in the mechanical construction either directly during the flight or during the pre-flight or post-flight inspections or during the UAV construction development. Furthermore microwires as sensing elements can be embedded into many types of materials, using the improved induction method sensing and monitoring of the constructions can be contactless.

5. CONCLUSION

Nowadays more attention is also paid to minimisation of the UAV damage because UAVs became more sophisticated and expensive and can carry important payload or valuable information.

For these purposes UAV safety equipment and whole systems including mainly sense and avoid systems, parachutes, airbags, flight termination systems has been developed. But the issue of emergency landings and safety equipment has to be solved from the both technological and also legislative point of view.

UAV operations are still very restricted in terms of where the UAV can operate. The vision for the future is that UAVs and manned aircrafts will be integrated into the same airspace, flying over populated areas, with the assurance that both people and property will be safe. But there is a long way to achieve this state. One of the main barriers that has to be solved is the UAV safety. The issue of emergency procedures has to be solved from the both technological and also legislative point of view.

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LED LIGHTING FOR AIRPORTS

Daniel DRAXLER[1]

Abstract: *LED lights are known to be as Light Emitting Diodes. The diodes are in fact the semiconductors that conduct the current only in one direction. Such lights use diodes rather than heated filaments or gas to produce light. This kind of lights happens to be the most energy efficient form of illumination. In comparison to the halogen and incandescent lights, such lights can be expensive but cost-effective as well. They do not require regular changes and are environment friendly as well. Within a research project, Martyn Cartledge explains how Manchester Airport is leading the way with recently approved LED lighting technology. In comparison to the LED lights, the halogen lights emit maximum heat. In order to compensate the heat, your cooling system would need to work harder and it might add to your electricity bill. If you happen to take an incandescent lamp, it would work for 1,000 hours in average thereby making regular replacements. This not only adds to your maintenance costs but also very tough to reach certain places to fix it. If you make the comparisons and the benefits of LED versus halogen lighting, you will find that LED lights are always a simple yet best alternative to any florescent or halogen lights. On August 17, 2012, a NOTAM was issued by the UK CAA approving the use of high-intensity LED (light-emitting diode) inset lighting. It has opened the door for many UK airports to introduce LEDs for both runway centreline and touchdown zone lighting. However, there is quite a story behind this decision. [1, 2]*

Keywords: *LED technology, airport lighting*

1. INTRODUCTION

Manchester Airport (MAN), UK, has been one of the driving forces in getting high-intensity LEDs approved for use by the UK regulator.

Back in 2008, owner and Operator Manchester Airports Group (MAG) decided that the existing approach and runway lighting System on the airport's principal runway (05L/23R) - which was more than 20 years old and reaching the end of its design life - required complete replacement to ensure continued safe and efficient Operation.

The contract to refurbish the runway was awarded to construction group Costain, with atg airports as the successful electrical contractor to install above ground level (AGL) constant current regulators (CCRs), approach masts, and new AGL circuits, among others. A major programme of works was required to refurbish and renew the original 05L/23R runway.

MAG decided that simple replacement of the lights was not enough and the engineering department was tasked with finding innovations and Systems to reduce both the electrical energy and the carbon footprint of the airport. Mike Curry, External Engineering Manager for Manchester, who headed up the trial and eventual Programme of installation, spoke with Airports International [3] to give background on the story.

2. SELECTION OF LIGHTS

Although low-intensity light units for taxiways and runways have been quickly adopted by the industry following a short trial at London Heathrow, high-intensity LEDs were not available at the time. A series of NOTALs were issued for the Civil Aviation Authority (CAA) to maintain control over the equipment critical to runway safety. The last one, 5/2006, effectively ring fenced high-white lights until the industry could demonstrate compliant fittings.

Such a product became available in late 2010 and the Aerodrome Operators Association (AOA) Technology Working Group commissioned an evaluation trial of LED runway centreline lighting.

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Facilities were provided by Manchester Airport and supported by the CAA, utilising products from lighting technology Company ADB Airfield Solutions. The trial lights were supplied for no cost by ADB, which was the original supplier of MAN's lights explained to Airports International the engineering principles and challenges created by such an Installation.
Unusually, Manchesters runway and taxiway Systems run at 12 amps, rather than the routine industry norm of 6.6 amps. It means that all of the fittings were constructed at 6.6 amps and an isolating transformer was sourced to step down from the 12 amps, against the normal 1:1 ratio.
The cost for the units, which are available from only one supplier, is rather high in relation to Standard versions available from a number of other sources. The trial lights were pre-production units, which became Standard by the time they were required for the full length of 23R/05L.
The trial LEDs, installed on February 16, 2011, lasted up to the end of that year, employing pre-production units on the first 3,281ft (1,000m) of the runway with existing fittings.
This particular runway was chosen as it is presently CAT 1 only. It yielded valuable Information that pointed towards compliance being attainable with the next iteration of the light units. A second phase on runway 05L/23R began at the end of 2011 using final production light units supplied by ADB.

Figure 1 HELLA Centerline LEDs [4]

The trial had now expanded - in addition, the centreline of runway 05L/23R and touchdown zone lighting were changed to LEDs, with similar checks, measurements and inspections repeated as happened in the first phase.
Information was drawn from a number of sources and a considerable amount of testing and readings were taken. The CAA undertook a series of test flights, the first of which occurred on the day of installation.
In addition, operational aircrew provided 'real-time' feedback, which demonstrated a high degree of acceptance, with both sets of LED light units underlining the progress made in harmonising the brightness with halogen lamps at lower settings.
Previous trials in the US had not been as positive and feedback from there came at just the right time for the MAN trial. In the US trials (in particular at Raleigh Durham), despite set tolerances and actual brightness, it became clear that the human eye perceived the lights as brighter than they really were.
To solve the problem, ADB created what was described as a human perception-dimming curve. Mike Curry and his team linked up with Manchester University to study the issue further.
The university conducted tests in its cloud Chamber to see how different lights penetrated in low visibility conditions, using Standard metering equipment and the human eye. This ongoing work could set new Standards and even change regulations in the future as there are massive possibilities for enhanced capabilities when low-visibility procedures (LVPs) are used at airports.
At this time, FedEx had developed an "enhanced vision System" to assist delivering crews to remote airports.
But the System did not 'see' the LEDs, and modifications took time to develop.
However, FedEx was not keen on releasing its self-developed specification, making it difficult to alter LEDs in this way.

Figure 2 HELLA LED Approach Light [5]

Results drawn from both phases demonstrated that high-inset red and white LED units could be installed in an operational environment and meet compliance satisfactorily.

The AOA Technology Working Group submitted its report with supporting evidence and a draft Information Notice to replace NOTAL 5/2006, requesting a change of policy. The Submission satisfied the Aerospace and Defence Industries Association of Europe (ASD) that the inset LED light units were compliant with the requirements set out in CAP 168, Chapter 6, and demonstrated an equivalent level of safety and dependable serviceability to that provided by similar incandescent sourced light units.
There were no unintended consequences from the trial, nor any failure modes that would have highlighted unsafe conditions.

3. LEDS AND HALOGEN COMPARED

LEDs use less power and have lower maintenance levels than halogen lights, lowering bottom line costs.

Halogen lamps tend to grow more yellow with lower intensity while LEDs remain the same colour.
As halogen lamps degrade there is further colour change, which does not happen with LEDs. MAN is now looking to replace the runway edge lights and any new lights are expected to show a return on investment within one or two years.

Approach lights were also replaced during the major refurbishment of 23R/05L, but CAA regulations State that halogen and LED cannot be mixed in the same Service so the diodes could not be used.

Due to the re-profiling of the approach and alignment of 23R, the new lights were also placed on new masts and poles along with complete rewiring. Elevated LEDs are currently available but the technology to produce them as inset approach lights does not yet exist because the small aperture in the fittings prevents the required 20,000 candelas being produced.
Therefore, as MAN - along with 90% of the UK - has such a requirement due to its displaced runway threshold, a Solution is awaited. Halogen technology has also been evolving and a 200W unit, which might have been previously required, is more likely to take a 150W unit, saving 25% on power.

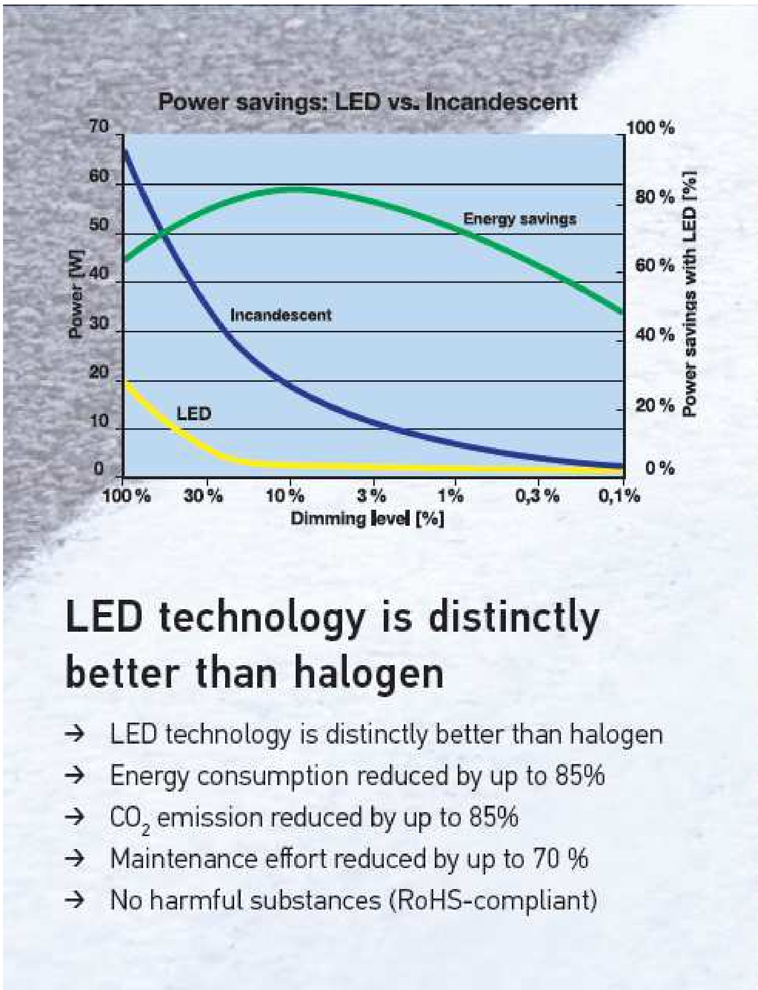

Figure 3 HELLA; LED vs. Halogen [6]

4. CONCLUSION

The coming year will see ADB focus on runway lighting, utilising the latest generation of products that incorporate low harmonic regulators using pure sine wave at the to create further savings. The state-of-the-art units use 30% less power and last longer as the LED forms a better fitting within the structure. LEDs have taken MAN along the road to success - a journey that is likely to continue.

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[3] Airport International January/February 2013 issue, first published there. Editor in charge Mr.Tom Allett approved (March 2013) to have it reprinted.

[4] Hella, Lippstadt-Germany; LED for airports, here shown Centerline Lighting

[5] Hella, Lippstadt-Germany; LED for airports, here shown Approach Lighting; The LED Approach Light is available in red as siderow, or white as approach.

[6] Graph of Hella, Lippstadt-Germany; LED for airports, Hella Airport Lighting Catalog Page 2

GLARE IN STREET VIEW IMAGES MAY SIGNIFY UNSAFE ROAD LOCATIONS

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Abstract: *In a recent study, various features of braking locations were investigated for trucks of a small commercial fleet. The trucks were equipped with on-board measurement, computing, data storage and data communication devices capable of sensing, identifying and recording braking events. Especially features of forceful braking events were examined in depth. As a supplemental data gathering step, each geographical location where such an event had occurred was visited in a virtual manner using Google Earth and/or Street View. In the course of this activity, it was observed that a number of forceful braking events had taken place during the monitoring period at locations where considerable disturbances in imaging process were present at completely different times, namely at the times of taking panoramic images for Street View. As a consequence of these disturbances, low-quality image-sections appear in the corresponding Street View images. Assuming comparable circumstances, sudden disturbances in illumination can dazzle drivers at these locations in the same manner as they could have dazzled the drivers of the monitored trucks. Though dangerous traffic situations that occur much later in time cannot be predicted based on Street View images, Google's vast panoramic image database is a splendid resource for assessing road safety; apart from many other possibilities, it could be searched for extensive glare regions and dynamic glare. The corresponding road locations could be identified as unsafe, or conditionally unsafe, and appropriate traffic risk mitigation steps could be taken.*

Keywords: *Road safety assessment, image databases, truck braking data, imaging artifacts.*

1. INTRODUCTION

In a recent pilot study, trucks negotiating their normal daily freight trips were used as probe-vehicles [1] for assessing the traffic safety of motorways and other major roads, i.e., roads used by trucks, see Fig. 1. Data recording the trucks' braking events – detected by their respective on-board electronic vehicular safety systems – were then analyzed in a retrospective manner [2], [3]. The recorded forceful braking events (see Fig. 1b), particularly the ones characterized with considerable initial vehicle speed, can be seen as surrogate safety events and can be processed by the internationally used surrogate safety assessment methodology [4], [5]. As an extension to the braking data gathering, the surroundings of the braking locations were displayed with Google Earth and Street View, and were then inspected and classified into various surrounding types by a human evaluator for further analysis [6]. In the course of this activity, it was observed that a number of forceful braking events had taken place at locations where considerable disturbances in imaging process – e.g., glare effects – were present at the times of panoramic image recording for Street View.

The glare effect is most obvious at night when the driver is adapted to a lower brightness. Examples of glare effects of different types, as well as, a method to detect them in night time road images are presented in [7]. As we know from our own experience, the sudden appearance of bright headlights can temporarily blind. The disturbing effect of glare increases with age greatly and is a major problem for elder drivers [8]. Herein, however, daytime glare cases are focussed on, such as shown in Fig. 3c. A good collection of Street View images with glare can be found in [9]. Most of the images presented there are static, but one dynamic image – an image sequence from Lawrence, KS, USA compiled from "neighbouring" Street View images – is also included there. The Lawrence scene with its road and bridge is vaguely similar to the one presented in Figs. 2a-b and 3a, but its glare effect is far less

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pronounced and far less extensive than in Figs.3a-e. The glare problem can be addressed from another viewpoint, as well: sun and shadow position modelling services related to traffic collisions due to glare is described in [10]. The glare effect is not limited to the human visual system (HVS) and to Street View. The robustness of a shadow-based real-time, monocular vehicle detection system [11] was demonstrated for daytime scenes using frames – taken with the vehicle detection system's on-board camera – of an under-bridge image sequence similar to Fig. 3c.

The motivation for investigating Street View road images with extensive and dynamic glare is the analogy between the behaviour of HVS and of the automatic gain controlled (AGC) cameras, such as the ones used for taking panoramic snapshots for Street View, in case of sudden illumination changes.

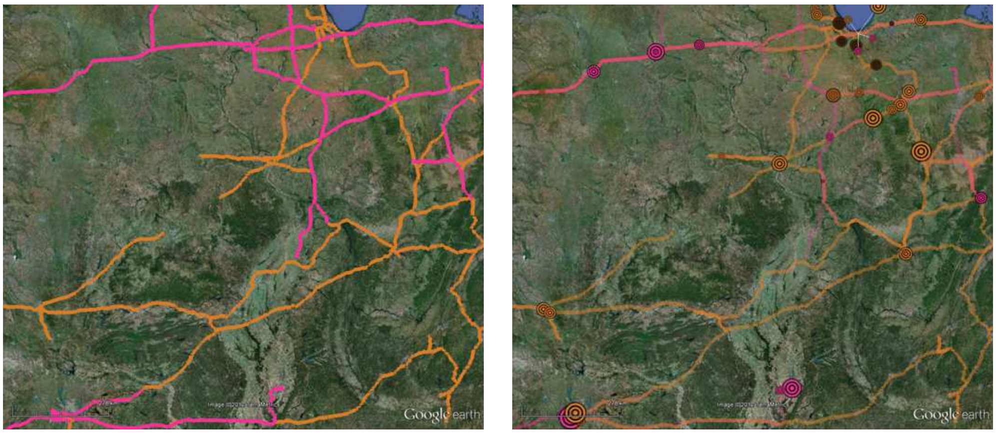

Figure 1 Two truck trajectories, marked magenta and orange respectively, are displayed with Google Earth. The trajectories of several thousand kilometres each are displayed in opaque (left) and in transparent (right) modes, respectively. The locations of abrupt braking events are marked in the right image.

Humans, as well as the AGC cameras mimicking the HVS, adapt to the light levels around them. When a very bright light, one that is far above current adaptation level, suddenly appears, it reduces visibility for humans and results in considerable image quality degradation in case of AGC cameras. In the latter case, it results in large low-quality image sections characterized by either maximum or close to maximum grey values, or by minimum or close to minimum grey values.

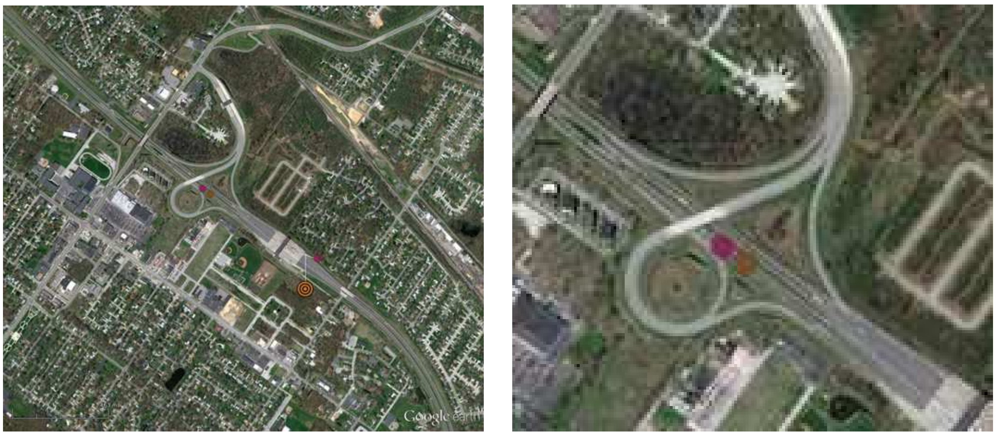

Figure 2 Area around four truck braking locations displayed with Google Earth. Two of these braking locations are very close to the road bridge over the motorway. The corresponding Street View images are shown in Figs. 3a-e.

The small dynamic range of the glare regions (e.g., dark region in the upper part of Fig. 3b, the bright region in the middle part of Fig. 3c, and the upper half of Fig. 3d) results in image blocks (e.g., 8*8 pixels) with low visual information content. It manifests itself in several close-to-zero singular values for each such block, and a high ratio between the largest singular value and the second largest singular value for each such block, see [12].

Figure 3a and e: Street View images of the daytime road scene near – in temporal sense shortly before and shortly after the bridge, respectively – the braking locations shown in Fig. 2b.

Assuming comparable circumstances to those apparent from Figs. 3a-e, particularly in respect of weather, season and daytime, sudden change in illumination can dazzle drivers driving their vehicles at this location later in time in the same manner as it could well have dazzled the driver of the monitored truck immediately before the recorded forceful braking. The statement can be generalized to other forceful braking events for which Street View images – taken at the corresponding braking locations – are degraded by glare. Though dangerous traffic situations that occur much later in time cannot be predicted based on Street View images alone, searching Google's panoramic image database for similar image degradations in a targeted manner could be a worthwhile exercise for identifying unsafe or conditionally unsafe road sections.

In the rest of the paper, firstly data gathering, data management and data visualization carried out in conjunction with the mentioned pilot project is summarized in Section 2. In Section 3, an unsafe driving situation – and corresponding road location – identified from the recorded braking data and confirmed by the imaging artifacts found in Street View images is presented and analysed. In Section 4, the main steps of a targeted search for similar image degradations and corresponding road locations are outlined and motivated. In Section 5, conclusions are drawn.

2. TRAJECTORY AND BRAKING DATA SET

The trucks taking part in the data collection mentioned above carried out their normal commercial freight transport assignments mostly within the USA, with a small percentage of the trips extending to Mexico. The data collection period lasted between November 2009 and February 2010. In this period, the monitored trucks covered around 100 thousand kilometres in total. The trucks involved in the study were equipped with up-to-date on-board electronic vehicular safety systems, as well as, on-board measurement, computing, data storage and data communication devices. The resulting compound system was capable of sensing, identifying and recording braking events and various other safety critical vehicular events [3]. Two different data sampling regimes were used during data collection: an on-going, relatively infrequent (2 sample/ minute) sampling of GPS-based geographical positions and wheel-based vehicle speed; and an event-based sampling of a wider set of the measurement and control data including also the anti-blocking system (ABS) and roll-over prevention activities. The data collected with these sampling regimes can be clearly identified within the truck trajectory and braking data – displayed with Google Earth – in Fig. 1. Based on the collected data, a database was set up and its data was analysed in an offline retrospective manner. Especially the forceful braking events were analysed in depth as these were considered relevant to traffic safety assessment and were seen as probable traffic safety incidents.

2.1 Using Google Earth and Street View for visualisation of the dataset

With up-to-date and publicly accessible geographical/navigational databases and visualisation applications, such as Google Earth and Google Maps, the visualisation of trajectory and vehicular emergency actions and events data has become fairly straightforward. The data concerning the actual geographical positions and vehicular activity need to be first converted into a Keyhole Markup Language (KML) representation; a KML file, or indeed several KML files, can be opened with the Google Earth program [13]. Using Google Earth program, one can zoom onto the individual braking locations; furthermore, one can follow a given truck in a virtual manner. Another useful facility of the Google Earth program is Street View. Photos of geographical locations are synthesised from panoramic photos taken nearby and stored in Google's massive 360º-view image database. The virtual modality comes very handy in assessing traffic safety problems. Based on the photos provided by Street View, the locations can be walked around, explored and checked in a virtual manner. As a supplemental step in truck trajectory and braking data gathering outline above, each geographical location where forceful braking had occurred – in conjunction with the monitored trucks during the data collection period – was visited in a virtual manner using Google Earth and Street View by a human evaluator, and was then categorised according to socio-cultural features of its surroundings, as well as, according to the presence of significant road features in the vicinity. The established location features were entered in the database [2] and analysed using different approaches, see [1], [3], and [6].

3. UNSAFE DRIVING SITUATIONS CONFIRMED BY PRESENCE OF GLARE IN STREET VIEW IMAGES

In the course of the supplemental step mentioned above, it was observed that a number of forceful braking events had taken place at road locations where considerable disturbances in imaging process – e.g., sudden illumination changes between consecutive Street View snapshots – were present at the time of the panoramic image recording. In the particular Street View sequence already referred to in the Introduction, the Street View car equipped with a panoramic AGC camera was driven along the motorway – shown in Fig. 2 – in broad daylight. Its camera took snapshots of the surroundings at regular temporal/spatial intervals. Among other vehicles, a truck with a trailer moving in the inner lane of the motorway in the same direction was also recorded, see Figs, 3a-e. Perhaps, it should be emphasized that this truck – most probably – does not belong to the fleet that was monitored in the pilot-project. The Street View car was then steered into the exit lane. Moving in the exit lane – as evident from the yellow Street View marking – it approached the road bridge crossing over the motorway (Fig. 3a), it entered (Fig. 3b), moved along (Fig. 3c), and somewhat later came out (Fig. 3d) of a dark shady road section under the bridge and turned off the motorway (Fig. 3e). The sudden shadow of the bridge produced extensive glare regions in the individual Street View images (Figs. 3b-d) and a dynamic glare in respect of the image sequence comprising these images. It is quite possible that a sudden change in illumination – similar to the one recorded by the panoramic camera mounted on the Street View car – dazzled the driver of the monitored truck, or more precisely, dazzled the drivers of the two trucks (the trajectory of these two trucks are indicated with magenta and orange lines, respectively, in Figs. 1.a-b, while their braking locations are marked in Figs. 1b, 2a-b and 3a-e) of the monitored fleet. Forceful braking events – suggesting unsafe driving situations – following the drivers' unpleasant and frightening experience in live and possibly busy traffic were detected by the on-board measurement systems, logged, stored in the database and later its location inspected in a virtual manner.

4. TARGETED SEARCH FOR DYNAMIC GLARE IN STREET VIEW IMAGES TO LOCATE UNSAFE ROAD LOCATIONS

There can be hundreds of road locations in Hungary alone, which could be characterized as unsafe, or conditionally unsafe because of quick change of illumination that could dazzle drivers. Many of these locations are unsafe either during daytime, or during the night. There are also places which are unsafe only for short periods of time at particular hours.

Major structures, such as road bridges, tunnels, can be located from a road database and then their locations could be checked with applications like SunCalc, which computes sun movement and sunlight phases at a particular time and location [14], and Street View.

Figure 3 b - d: Frames with sudden change in illumination recorded by the panoramic camera mounted on Street View car near a truck braking location recorded in the trajectory and braking database at a different time.

The critical computing step in using Street View image data for finding unsafe road locations characterized with dynamic glare is the handling of Street View cars' contiguous trajectory-segments (CTS's), or if this information is unavailable, then the identification of the CTS's from Street View image data via tracking road features for the road to be assessed. For example, the Kálmán filter based approach – combining the car's ego-motion with the road homography – proposed in [15] could be used for this purpose.

A CTS is the sequence of road locations where Street View snapshots were taken – with the same panoramic camera in a sequential manner – within a relatively short period of time. The illumination conditions, therefore, are – mostly – similar within a CTS. For each CTS of road to be assessed, Street View images taken at consecutive road locations can be searched for glare regions and for dynamic glare (i.e., consecutive images with extensive image regions where drastic and sudden changes in the luminosity take place).

5. CONCLUSIONS

In conjunction with a recent study investigating truck braking locations, it was observed that a number of forceful braking events took place at locations where considerable glare was present at completely different times, namely at the times of taking images for Street View. Assuming comparable circumstances, sudden changes in illumination can dazzle drivers at these locations at other times.

An approach was sketched in the paper for a targeted search of the Street View image database. Extensive glare regions and dynamic glare are sought following a Kálmán-filter based tracking, which identifies the CTS's of the assessed road. The corresponding road locations could be identified as unsafe, or conditionally unsafe, and appropriate traffic risk mitigation steps could be taken.

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ENHANCED FUNCTIONS FOR ATM SYSTEMS BASED ON AIRCRAFT DERIVED DATA

Jiří FREI[1]

Abstract: *More than 4000 aircraft per day within the coverage of air traffic control radars in the Czech Republic provide positional data. Many of them are currently equipped with Mode S technology allowing download of BDS registers from aircraft transponders. Aircraft derived data (ADD) integrated into current ATM systems bring enhanced functions supporting safety and efficiency for end users especially in ATC environment. Downlinked Aircraft Parameters (DAPs) from commercial aircraft allow calculation of dense fields of wind and other meteorological parameters usable for 4D trajectory or refinement of numerical weather prediction. Examples of potential applications in the Czech Republic are given.*

Keywords: *aircraft derived data, downlinked aircraft parameters, Mode S technology, safety nets, wind, trajectory*

1. INTRODUCTION

The Czech Republic has become recently one of the countries with the Mode S covered airspace. In other words it means that the air traffic control radar beacons installed within the Czech FIR are capable to operate with Mode S technology. Mode S has been around for many years but for various reasons its implementation as a surveillance technology and ATS support tool has been a long time coming – too long for many people in the ATC world. However we are now seeing the technology come on line in many European States and the benefits are beginning to be realized. Some examples of the specific function based on Mode S technology already implemented by ANS CZ[2] are presented in the following paragraphs.

The text is divided into 7 parts. Paragraphs 2 and 3 describe the “aircraft derived data” generally and specify its categorization and origin. Following part is dedicated for the presentation of already implemented data to current ATM system in the Czech Republic. Paragraph number 6 introduces new possibilities which are under research what else can be gained from the ADD for the ATM systems. Last part of this text summarizes benefits of ADD in general and shows future direction.

2. AIRCRAFT DERIVED DATA (ADD) IN GENERAL

Generally could be said that ADD is a surveillance application in which avionics data are transmitted from the aircraft to the ground station, and possibly other aircraft.

Many parameters could be obtained by using mode S technology – today reported parameters in many European countries are:

- Aircraft identification/equipage/equipment status,
- Aircraft configuration (flap settings, de-icing etc.),
- Current state measurements (position, bank angle, ground/airspeed, meteo, etc),
- Pilot ‘set’ parameters or targets (short term intent - selected altitude, heading, airspeed and next waypoints; these parameters are commonly called downlink aircraft parameters = DAP and some of them are already implemented in currently used ATM systems in ANS CZ)
- Avionics flight path data/calculations (intermediate waypoints and estimated times of arrival (ETAs)) and many others.

Supplied data may be displayed to air traffic controllers and used in ground processing functions and decision supported tools.

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ADD could be generally delivered by several mechanisms such as:

- ADS – B (1090 MHz extended squitter / VDL [3]– 4 / UAT[4]),
- Enhanced Mode S Radar Beacons (this is way used in the Czech flight information region; technology is based on Mode S air traffic control radar beacons interrogations and aircraft transponders replies)
- ADS – C[5]
- ACARS[6]

2.1 Transponders and BDS registers

According to the AIP [7]CR (paragraph 1.5.1.1.1) is the carriage and operation of Mode S transponders with EHS[8] functionality mandatory in FIR Praha for fixed-wing aircraft operation IFR flights with maximum approved take-off mass exceeding 5,7 tones or with maximum true air speed exceeding 250 knots (463 km/h).

Based on it each commercial aircraft has to be equipped by secondary radar transponder (abbr. from transmitter responder) at least at level 2 operating in EHS. Such kind of the transponder maintains avionics data in 256 different 56-bit wide Binary Data Store (BDS) registers that can be loaded with information and read-out by the ground system (e.g. secondary radar). These BDS registers are also known as Ground Initiated Comm B (GICB) registers. Information contained in register is updated within a defined fixed period. Not updated registers are cleared automatically by transponder. It means there should be only current data.

Following illustration demonstrates the organization and basic data flows for the transponder registers used in ELS (yellow) and EHS (red) applications. For easier understanding notation of the following figure – each BDS register is identified by a two digits hexadecimal number. In relation to the text above, aircraft equipped for EHS have to provided data from registers $(40)_{16}$, $(50)_{16}$ and $(60)_{16}$.

Figure 1 illustrates the organization and basic data flows for the subset of the registers used in the ELS, EHS, ADS-B, and military applications.

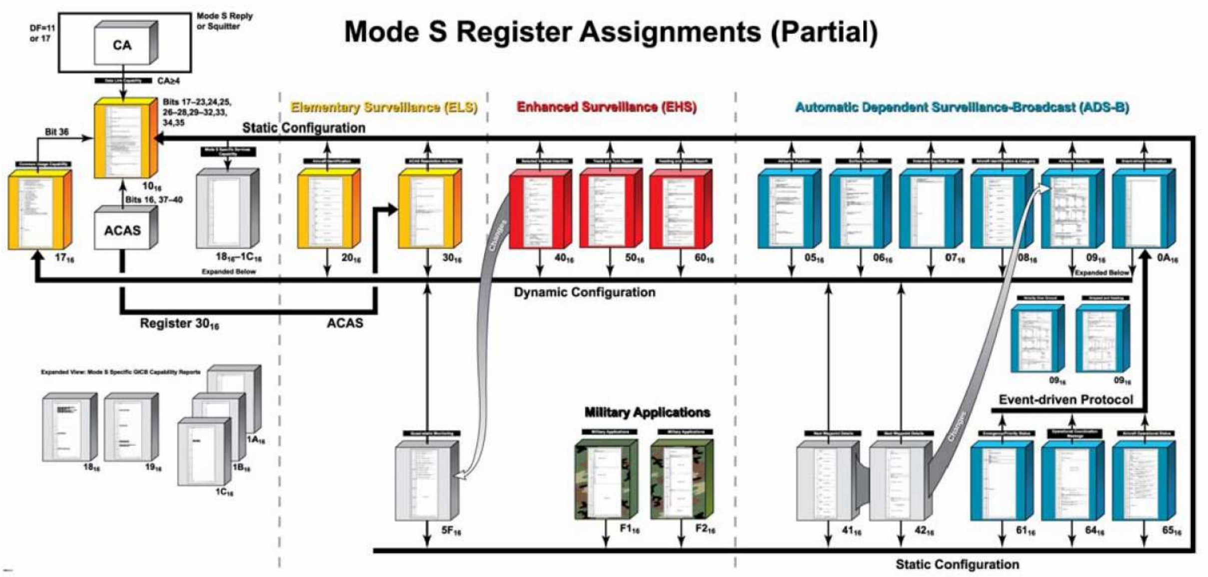

Figure 1 Mode S Register Assignments (Partial)

[3] VDL – VHF Digital Link
[4] UAT –Universal Access Transceiver
[5] ADS-C – Automatic Dependent Surveillance - Contract
[6] ACARS – Aircraft Communications Addressing and Reporting System
[7] AIP CR – Aeronautical Information Publication of the Czech Republic
[8] EHS – Enhanced Surveillance

Color-coding is used to group the registers by application:

- ELS (yellow) – for details see paragraph 2.2,
- EHS (red) – for details see paragraph 2.3,
- ADS-B (blue) and
- Military (green).

Registers shown in gray are indirectly involved with these applications, but are not directly called out by the application specification. The figure employs thick arrows to denote the transponder static and dynamic configuration data flows and the ADS-B event-driven protocol. Complete list of GICB register number assignments can be found in [3] – Table B-2-1 in Appendix B, page B-1 or in [10]. In [3], there are described also the general conventions on data formats (validity of data, representation of numeric data and alphanumeric character encoding, etc.).

ADD are transmitted from the aircraft to the ground station as the reply on the mode S radar interrogation. These data may be after processing and decoding displayed to air traffic controllers or used for further processing in ATM system functions.

The main differences between ADD and conventional surveillance techniques (such as radar) are:

- ADD are measured (or computed) by the aircraft sensors (avionics); radar data are measured by the ground radar station (e.g. ground speed, speed vector prediction)
- Much more data available from ADD than from radar (ground station, e.g. tracker) [4]

2.2 Elementary surveillance (ELS)

ELS support is required by the European Mode S mandate. Support of ELS consists primarily of populating and maintaining four Mode S transponder registers:

- $(10)_{16}$ Data Link Capability Report;
- $(17)_{16}$ Common-Usage Ground-Initiated Comm B (GICB) Capability Report;
- $(20)_{16}$ Aircraft Identification Register; and
- $(30)_{16}$ Airborne Collision Avoidance System (ACAS) Resolution Advisory (RA).

There are several other registers used to configure a Mode S transponder for varying levels of data link applications, but the two basic transponder registers $(10)_{16}$ and $(17)_{16}$ are sufficient for the application set. The last two of the ELS-required transponder registers provide the aircraft flight identification $(20)_{16}$ and information about the state of the on-board ACAS equipment $(30)_{16}$ (for more detail about ACAS/TCAS indication see paragraph 4.3). The definition, specification, and content of the ELS application data are well defined and quite mature.

2.3 Enhanced surveillance (EHS)

EHS support is required by the European Mode S mandate as well as ELS. Support of EHS consists of populating and maintaining three Mode S transponder registers beyond those required for ELS:

- $(40)_{16}$ Selected Vertical Intention;
- $(50)_{16}$ Track and Turn Report; and
- $(60)_{16}$ Heading and Speed Report.

These Mode S registers are intended to support improved ATC systems where knowledge of the aircraft's intended flight path can be used to supplement surveillance tracking. The data fields in these registers are simply a reformatting of values expected to already exist in the aircraft on its ARINC 429[9] data buses or equivalent information from data buses on aircraft not equipped with ARINC buses. The register definitions provide a status bit for each data field.

Register $(40)_{16}$ is the most complex of the EHS register set, since it uses a wide variety of data sources. Different aircraft configurations (e.g., Boeing versus Airbus) may need to set the data fields in this register differently, depending on the particular data sources and pilot control inputs available in the particular avionics. It should be noted that the definition of the contents of register $(40)_{16}$ has been redefined from an earlier version that sought to provide 3-dimensional intent information in a single register. The current register $(40)_{16}$ definition has been limited to vertical intent only as this is the data with the most immediate ATC application. [2]

[9] ARINC 429 – Term stands for Aeronautical Radio, Inc. It is a privately copy-written specification developed to provide interchangeability and interoperability of line replaceable units in commercial aircraft [14].

In the Table 1 below, there is the list of parameters used in ATM surveillance systems (IDP – made by company ICC (UK) and E2000 made by company Thales (France)) in ANS CZ.

Table 1 List of downlink/download aircraft parameters (DAP) from Mode S EHS (DAPs are comply with the EASA AMC 20-12)

BDS register	Basic DAP set
BDS 4,0	Selected Altitude
BDS 5,0	Roll Angle
	Track Angle Rate
	True Track Angle (TRK)
	Ground Speed (GSP)
BDS 6,0	Magnetic Heading (MGH)
	Indicated Air Speed (IAS)/ Mach no.
	Vertical Rate
	True Air Speed (TAS)

2.4 Data obtaining and extraction

For this research of ADD was selected and set up group of the ATC radar beacons: Prague and Písek (see Figure 2 below) for specific registers interrogation. Excluding mandatory registers for ELS (see paragraph 2.2) and EHS (see paragraph 2.3) were interrogated also following registers:

- $(44)_{16}$ – Routine meteorological reports

It contains information such as wind speed, wind direction static air pressure, relative humidity, air temperature.

- $(45)_{16}$ – Hazardous meteorological effects

This register contains information about dangerous meteorological effects such as windshear, microburst, turbulence, wake turbulence and icing. (For results of this research work see [6]).

- $(54)_{16}$ and $(45)_{16}$ - Waypoints 1 and 2

These registers serve to provide information on the next two waypoints. They contain waypoints name and estimated time over fix, estimated flight level over fix and time to go to the fix. (Unfortunately it was proved that during approx. 1 month of interrogation for registers with waypoints, there was no one aircraft within the coverage of the radar beacons which sent the reply).

Figure 2 SSR radars Prague (right) and Písek (left)

In Table 2 below, you can see the extraction of received data from aircraft avionics via Mode S radar beacon (Prague and Písek, SIC[10] 130 and 135). First and second column is the extracted content of BDS registers in hexadecimal notation. Decoded values (based on register structure described in [3] on page B-32 for register $(50)_{16}$ and page B-38 for register $(60)_{16}$) of some parameters are in following columns (column header: TRK = track angle, MGH = magnetic heading, GSP = ground speed, TAS = true airspeed). The usage of these parameters in current ATM systems is described in paragraph 3 (aircraft derived data).

Table 2 Example of BDS registers $(50)_{16}$ and $(60)_{16}$ in hexadecimal form and its decoded values (TRK and MGH in degrees, GSP and TAS in knots)

BDS $(50)_{16}$	BDS $(60)_{16}$	TRK	MGH	GSP	TAS
80 52 F3 3E 80 04 EE 50	97 1A 6F 34 60 0F FF 60	66.27	64.86	257.22	244.87
FF D4 2F 3D FF F4 EF 50	A0 CA 41 34 FF CF FF 60	94.04	92.10	254.13	245.90
FF DC F5 34 60 0C D9 50	E7 69 F3 2F 20 0C 01 60	291.44	290.74	215.04	223.26
FF D0 A7 39 7F FC E1 50	83 EA 1F 30 FF F7 FF 60	14.58	10.89	235.62	231.5
FF FD 2F 37 60 04 E8 50	E9 09 FD 32 3F EF FF 60	296.54	295.31	227.38	238.70
FF D4 43 3B E0 04 DE 50	A1 B9 EB 2F BF F4 00 60	95,80	245,9044	94,74	228,41
FF 5C 57 2D BF FC D6 50	E1 09 D7 2E 3F 37 E4 60	277,56	187,25	272,81	220,18
80 3E 3F 31 3F FC DE 50	EE 69 E9 30 60 04 01 60	320,45	201,66	310,42	228,41
FF FC 35 2E A0 04 D7 50	E0 49 DB 2E BF 17 E6 60	274,57	191,37	270,70	221,21
FF 93 13 3D E0 04 D5 50	96 FA 33 2D A0 DC 1B 60	69,08	254,13	64,51	219,15
80 5C 69 31 60 04 E8 50	E1 BA 45 32 20 0C 00 60	279,14	202,69	274,74	238,70
FF 97 CD 38 FF FC E3 50	BF 3A 11 30 E0 4C 01 60	175,43	233,55	177,71	233,55
80 7D 67 32 60 0C E3 50	E8 3A 01 31 B F7 FE F60	301,46	206,80	293,02	233,55

In Figure 3 below are depicted trajectories of aircraft (within the coverage of air traffic control radar beacons Prague and Písek) which sent replies for radar interrogations for mandatory BDS registers $(50)_{16}$ and $(60)_{16}$ (EHS). Figure was created in software Matlab (version 7.1) as interpolation of reported aircraft positions consisting from coordinates (latitude, longitude) and altitude. In the picture is captured time period of 2nd April 2013, 5:30 – 09:00 UTC (duration 210 minutes).

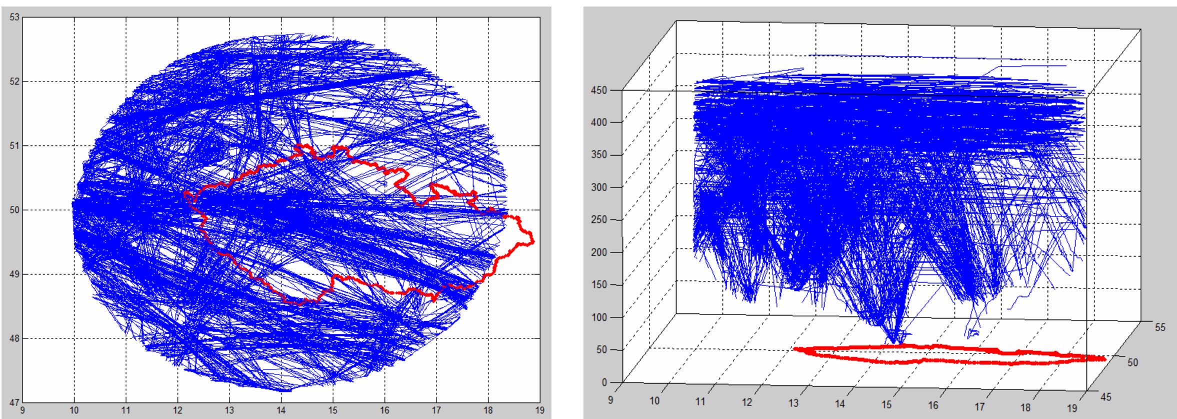

Figure 3 Aircraft trajectories of aircraft provided replies on radar interrogations (left: graph axes – latitude, longitude; right: graph axes – latitude, longitude, flight level)

[10] SIC = System Identification Code; This is the unique identifier for the radar beacon/sensor using ASTERIX (ATC standard = All Purpose Structured Eurocontrol Surveillance Information Exchange).

The Figure 4 shows the trajectories of aircraft within coverage of Germany Mode S air traffic control radar beacons. This picture covers time period of 12th May 2012, 10:00 – 11:00 (duration of 60 minutes).

Figure 4 Trajectories of aircraft provided ADD in Germany

3. DONWLINK AIRCRAFT PARAMETERS (DAP)

This category of BDS registers is often called also as *Controller Access Parameters* (CAPs). This is based on its end users – air traffic controllers. These data DAPs (or CAPs) are determined to be displayed for air traffic controllers on their surveillance screen. See the Figure 5 for practical usage of DAP in ATM system.

3.1 Visualization of DAPs to air traffic controllers

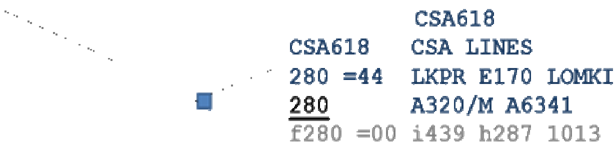

Figure 5 Extended label with DAPs in the very last line

This is depiction of the radar target of Airbus A320 with destination Prague (squawking code A6341) currently maintaining flight level 280 moving with ground speed 440 knots proceeding to waypoint LOMKI (information derived from flight plan, filed 15). All these information can be read from shown radar label. It contains mixture of data from current flight plan (system database in general) and also data obtained from the aircraft avionics (derived via Mode S radar beacon). When focus on very last line of the label in Figure 2 above, there are 5 parameters very useful for air traffic controllers (detail of DAPs in Figure 6).

f280 =00 i439 h287 1013

Figure 6 Downlink aircraft parameters from Figure 5

The following text will describe in brief the meaning of above shown numbers and symbols.

- **f280 –** Final State Selected (FSS)
  This is the value of altitudes which is set by the pilot in the cockpit of aircraft
- **=00** – Barometrical Vertical Rate (BVR)
  This is the value of vertical speed provided by aircraft avionics (in other words – rate of climb/descent)
- **i439** – Indicated Airspeed (IAS)
  This is the value of indicated airspeed

- **`h287`** – Magnetic Heading (MGH)
- **`1013`** – Barometrical Pressure Setting (BPS)
  This is the value of pressure set on aircraft altimeter (QNH[11]). In this situation the value is 1013, because aircraft is at altitude 28000 feet, flying above transition altitudes where the pressure has to be set to standard atmosphere pressure (1013).

Based on these information are generated specific warnings (or safety nets could be said) for air traffic controllers on their surveillance screen (see paragraph 4).

3.2 Origin of data

All data presented in radar labels (as shown in Figure 5, resp. Figure 6) are downloaded from aircraft to ground station. In rectangles in Figure 7, there are highlighted the parts of avionic from which are the data downloaded.

Figure 7 Aircraft cockpit; in rectangular marked pilot’s AP/FP Mode Control Panel (detail in Figure 8) and pilot´s primary flight display = FPD (detail in Figure 9) [5]

The pilot selects the altitude cleared by air traffic controller in the following panel (see Figure 8). This selected altitude is presented on the pilot´s FPD and downlinked to the ground station where is the information presented to air traffic controllers on the surveillance/radar screen.

Figure 8 Altitude window and altitude selector [5]

[11] The pressure 'reduced' to mean sea level, assuming ISA temperature profile from the station/airfield to MSL. An altimeter set to the airfield QNH reads the elevation of the airfield when on the ground.

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Magnetic heading (MGH) and indicated airspeed (IAS) are “measured/computed” by the aircraft. In other words, there is no pilot interaction for deriving the data. IAS and MGH are presented on the pilot´s PFD and downlinked to the ground station as well.

Figure 9 Pilot´s primary flight display (FPD) [5]

4. WARNING GENERATED BASED ON DAPS

4.1 Selected Flight Level Warning (SFLW)

Air traffic controllers are supposed to be very careful when issuing listening and reading-back[12] the instructions from the pilots. The situations when controllers are under heavy workload, they can lead very easily to misunderstanding between pilots and controllers.

One of the model situations can be issuing the clearance for climbing or descending. When the pilot read-backs the cleared level wrongly and the controller mishears it, it can lead to very dangerous situation. By using downlink aircraft parameters (BDS register $(40)_{16}$. – altitude set in control panel (see Figure 8)), the ground station of surveillance system can recognize discrepancy between cleared flight level given by controller and selected level set by the pilot in aircraft. If it differs, the warning is generated on controllers screen in label of the affected aircraft (see Figure 10).

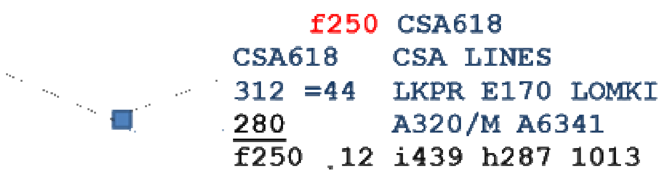

Figure 10 Indication of Selected Flight Level Warning (SFLW)

Principle of selected flight level warning: the underlined value (280) is the flight level cleared by the controller. In the reality the pilot set FL250 to descent (as can be seen in the very last line of the label – DAP = values of parameters downloaded from aircraft). The system recognized the difference and indicated the wrong set value by appearing wrongly set values by red colour in label.

No doubt it rapidly reduces the level busts or mishears on the frequency and together with it decreases the number of events leading to a loss of separation.

---

[12] Read-back - to repeat some information to the person who has just given it. In this context it means pilot’s confirmation of the issued clearance by controller

4.2 Wrong QNH

Notification of controllers about wrongly set QNH by the pilot (especially during the approach phase of the flight) is eminently important. It can be listed several aircraft accidents caused by wrongly set QNH.(E.g. 19.8.1975, flight OK540 from Prague to Teheran via Damascus and Baghdad, aircraft IL-62 crashed near Damascus; 30.10.1975, aircraft DC-9 with registration YUAJO crashed close to the Prague airport). Both mentioned accidents had probably the same reason – wrongly set QNH.
Due to Mode S technology can air traffic controllers check the QNH value set on altimeter by pilot in the cockpit nowadays. To be correct, the system checks it – it compares the value of aerodrome QNH derived from METAR[13] and the QNH value downloaded from aircraft. If the values differ, warning is shown in the label of affected aircraft.

In the Figure 11 is shown the warning in the radar label of aircraft (registration YUBUU, Cessna 525 Citation), during approach phase to Karlovy Vary intl. airport (LKKV). The system identified discrepancy and generated warning.

Figure 11 Left – surveillance screen with QNH warning; right – C525, reg. YU-BUU

4.3 Resolution Advisory (RA)

The Traffic Alert and Collision Avoidance System (TCAS) provides a solution to the problem of reducing the risk of midair collisions between aircraft. TCAS is a family of airborne systems that function independently of ground-based air traffic control (ATC) to provide collision avoidance protection. The basic principles of this system can be found in [8].

Air navigation service providers in the Czech Republic and in Hungary, they both implemented so called "RA" warnings in its surveillance systems. When the pilot receives an alert from system ACAS/TCAS, it is also downloaded from the BDS register $(30)_{16}$ (mandatory in ELS). The format of the TCAS Resolution Advisory Register content is defined in [9] or [10].

In the Figure 12 there is shown RA indication on the controller´s surveillance screen during near miss. System ACAS/TCAS detected intruder and issued RA in the cockpit of affected aircraft to the pilot. Via Mode S radar interrogation is this information downloaded to the ground station and shown also in radar label to air traffic controller. Nowadays, it is quite often discussed topic because the depiction (RA indication) on controllers screen can be about 15 seconds delayed (depends on the radar turn latency). The captured situation shows two test/calibration flights of the Czech ANSP[14] (Cessna 56X, identification CBA40 and Turbolet L410, identification CBA41) at flight level 100 in the area of responsibility of the Brno approach and teheir TCAS generated "RA"..

[13] METAR - is the international standard code format for hourly or half-hourly intervals surface weather observations which is analogous to the SA coding currently used in the US.
[14] ANSP – Air Navigation Service Provider

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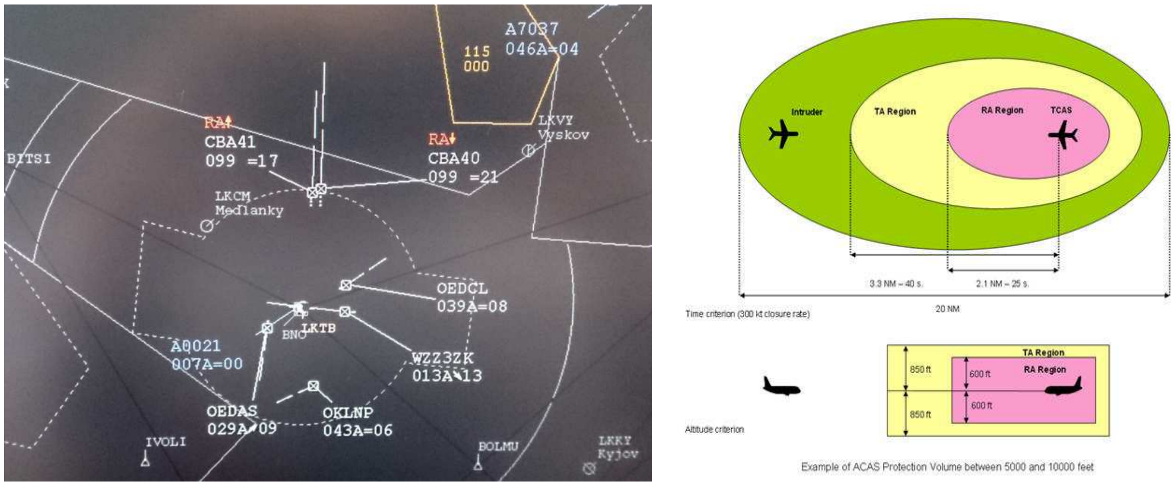

Figure 12 RA indication in radar labels
left – surveillance screen with RA indication, right – simple scheme of advisory regions [7]

5. PROPOSAL OF FURTHER USAGE OF ADD

5.1 Trajectory prediction (TP)

Very hot and discussed topic nowadays is to predict the most precise aircraft trajectory. In [11] is presented the effect of aircraft derived data to trajectory prediction[15]. In [12] are presented basic results of the research aimed for the topic "what is the difference in trajectory prediction when taking into account wind conditions" (speed and direction). The wind data were downloaded from the meteorological BDS register $(44)_{16}$ in the research. But from all aircraft within the radar coverage (approx 4000 per day), there were only in average 400 aircraft per day providing data in meteorological register.

Very often is nowadays computed trajectory prediction very different from the real flown path of the aircraft. The main sources of TP errors are:

- Weather forecast uncertainties
- Turn dynamics
- Aircraft performances modeling fidelity

(Simplifications, omissions and uncertainty in mathematical models used to estimate the trajectory)

- Erroneous assumptions on aircraft characteristics

These vary dynamically (for example aircraft weight) but usually assigned values derived from flight plan data and/or performance databases)

- Tracking and flight mode errors
- Pilot and controller intent uncertainties

Finally has to be said that ADD can reduce most of these errors.

5.2 Current wind condition in airspace

Generally automated weather reporting from commercial aircraft has very big potential. Wind condition may be not only downloaded but also computed from the parameters contained in BDS registers $(40)_{16}$, $(50)_{16}$, $(60)_{16}$ (mandatory in EHS). By using principle of wind triangle can be based on track angle, magnetic heading, true airspeed and ground speed computed wind speed and wind direction. Values can be computed for each aircraft within mode S sensors coverage (approx 4000 per days). Based on that (computed wind condition in the vicinity of each aircraft) can be created online 3D wind model. From that will benefit not only controllers (easier provision of air traffic service) but also the airliners (flying in more efficient altitude, less fuel consumption) but also the passengers (shorter flight duration) and environment as well (less harmful substances in the air). More about the wind model created from the reported data from commercial aircraft can be read in [1] and [6]. In the Figure 3 above is shown the potential area of coverage so called on-line or current 3D wind model.

[15] The process of trajectory prediction is a kernel function in modern Flight Data Processing Systems (FDPS) and the ATM tools that provide controller and system support [EUROCNOTROL´s definition of TP]

5.3 Other applications using ADD

ADD slowly infiltrate nowadays almost into each ATM application when perfect and precise results and outputs are expected. In many EUROCONTROL documents (for example [13]) can be found that ADD are generally useful not only for direct using by controllers (DAP) but other relevant information from BDS registers could be used for ATM system support functions. Such tools as Medium Term Conflict Detection (MTCD), Short Term Conflict Alerts (STCA), Arrival Manager (AMAN), Minimum Safe Altitude Warning (MSAW), Area Proximity Warning (APW) and others could eliminate its false warning by using ADD.

6. BENEFITS FROM ADD AND CONCLUSION

ADD quality depends on aircraft equipage but it tends generally to be more up to date and accurate than information extracted from flight plans and other ground data stores.

Operational benefits from ADD are foreseen in the following areas:

- Strategic and tactical planning, through MTCD;
- Optimization of airport resources;
- Collaborative decision making i.e. prioritisation;
- Increased predictability;
- Increased quality of data;
- Enriched ATM data (DAPs in labels) and even using of meteorological data (when approved by CAA)
- Saving unique SSR codes (by using aircraft identification (BDS reg. $(20)_{16}$). The intent of this register is to provide a means for applications to correlate surveillance data (containing the Mode S address and the Mode 3/A code) with the flight plan (containing the aircraft identification). The aircraft identification register contains an 8-character text string that is to be set equal to the flight plan identification (if one is available) – otherwise, it should be set to the aircraft's registration marking;
- Safety nets should benefit from ADD because of the more accurate tracking and short term trajectory prediction resulting in lower false alert rates and improved conflict warning times for the air traffic controllers; In paragraph 4, there are shown some of warnings increasing the safety and reduces many kind of the risk (midair collision, wrong QNH, level bust, etc.)
- Arrival management should benefit from ADD through the improved reliability and performance of conformance monitoring and the increased accuracy of ETA[16] estimates.
- Efficient real time fleet management is a key to successful airline operations. The critical requirement is to maximise the usage of the aircraft in combination with minimum time on the ground. Fleet management not only needs accurate ETA but would also benefit from more accurate and frequent weather reports (As mentioned before, ADD can be used to collect weather data in order to improve meteorological forecasts for ATM).

Mode S has been a long time coming, but now it's here, it's showing its worth. Using of BDS registers as the important ATM data source brings huge potential for further research and development. ADD are beneficial not only to the air traffic controllers but also to airline operations, and airport organizations. ADD are a contributor in the air transport cooperative case, which should enable increased predictability for the whole system and hence allow for safe and cost efficient operations.

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COMPUTATION OF STEADY STATE POSITION OF THE LONG LINE TOWED BEHIND A HELICOPTER

Peter GAŠPAROVIČ[1]

Abstract: *A long line suspended below helicopter and used for the transport of external cargo presents safety risk for helicopter when towed unloaded between the phases of the flight with a cargo loaded. The paper presents the results of the computation of steady state position of the long line at various cases. Auxiliary loading of the free long line doesn't create higher safety at higher air speed. The only measure able to separate the long line from a tail rotor is slower flight speed.*

Keywords: *helicopter, long line, tail rotor, CFD*

1. INTRODUCTION

Large and heavy cargo is transported by helicopter usually as a external load, i.e. suspended on a long line below a helicopter. When the cargo is unloaded, and helicopter is flying to the site of next cargo, the shape of unloaded long line is affected by aerodynamic forces. Under some condition, towed free long line can get very close to the tail rotor of helicopter – very dangerous situation. In the recent accident [2, date 2012-08-03] the long line tangled into the tail rotor. It would be helpful to examine the shape of the long line at various scenarios, but there are no generally applicable and published data on position of long line towed behind helicopter, and the whole issue is still not settled [3].

The shape and position of the free long line behind helicopter results mainly from the balance among aerodynamic, gravitational and inertial forces. Interplay between aerodynamic and inertial forces has a consequence of non-stationary dynamics of the line movement. Even the equilibrium state of the line is complex. In the presented article, only steady state solution to the shape and position of the long line is examined to identify most dangerous scenario.

2. STEADY STATE MODEL OF LONG LINE

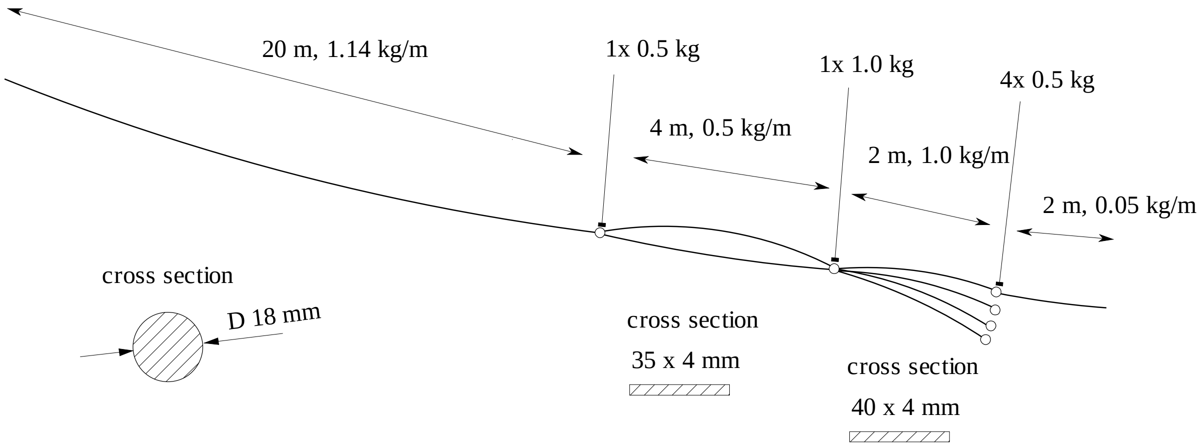

Figure 1 Construction of long line

The construction of the chosen long line is on the Figure 1. The part of the line which is closest to the helicopter is made from steel cable (diameter 18 mm) which can be aerodynamically modelled as a flexible cylinder of infinite length. The next parts of the line are formed by textile belts with the cross section of high aspect ratio (35 to 4 mm and 40 to 4 mm). In the second part, there are two parallel belts and the last part contains four parallel belts. The parts of the long line are connected by metal

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shackles which are modelled as an isolated mass. The long line is attached to the hook inside a fuselage of helicopter and it is leaded outside through the opening in the floor of fuselage. The small radius in the shape of the line through the opening is replaced by simplified hinged constraint of the fixed end of the line end in the floor of the helicopter.

Because of non-homogenous construction of the long line, the numerical solution will be employed. The whole long line is divided into line elements, and size of the element is chosen such way, that a small radius of the shape of the last part of the line can be modeled. This results in 144 line elements. The shape of the long line is determined by the position of the nodes between line elements. Numerical scheme is very simple, because the position of the nodes can be determined by successive integration of forces on line elements from the free end of the line towards the fixed end of the line and by the following integration of the resulting angle in opposite direction.

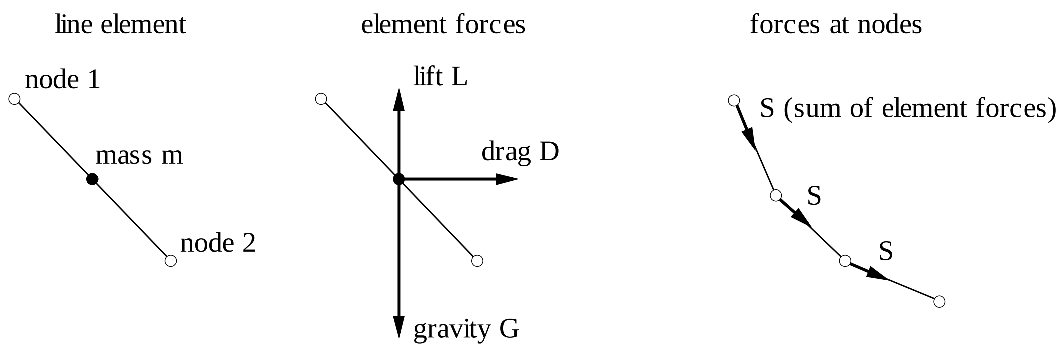

Figure 2 Numerical model of the line (elements, nodes, forces)

There are only three forces on line elements in steady state solution: gravitation G, aerodynamic drag D and aerodynamic lift L (see Figure 2). Resulting force R on the line element is the vector sum of these forces:

$$\vec{R} = \vec{G} + \vec{D} + \vec{L} \tag{1}$$

The resulting angle alpha of the line element is driven by the angle of force at the second node of the element, which is the sum of all line element forces from the node to the free end of line:

$$S_i = \sum_{j=i}^{end} R_j \tag{2}$$

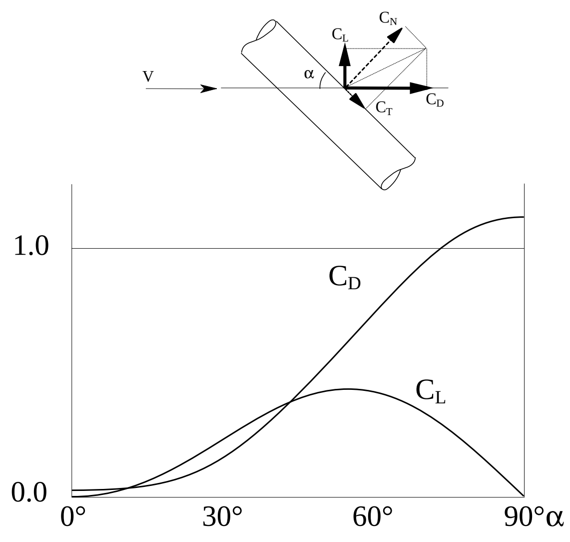

Figure 3 Dependence of aerodynamic forces on the angle of cylinder (by Hoerner [1, p. 311])

The actual value of aerodynamic forces depends on the local angle of incidence between the axis of the line and the airspeed vector (see Figure 3). The dependence is highly nonlinear and experiment data for cylinder can be found in Hoerner's reference [1, p. 311]. My mathematical model of dependence of aerodynamic forces on the angle of incidence alpha is independently derived from the basic experimental data on perpendicular flow past the cylinder and trigonometry of normal and tangential velocity components. It is simpler than the fit expression published in Hoerner's reference and shows similar agreement with the published data. My model is described by equations:

$$C_D = 0.02 + 1.0 \sin^2 \alpha \tag{3}$$

$$C_L = (1 - 0.02) \sin \alpha \cos \alpha \tag{4}$$

The experimental data for belts are also published in Hoerner's reference [1, p. 325], and based on the data for fluttering belt with high aspect cross section the value of drag coefficient for perpendicular flow is estimated to be 0.78. (My estimation make provision for partial mutual covering of parallel belts and twisted shape of individual belts.) Estimated value is substituted in expression for circular cylinder.

3. RESULTS AND DISCUSSION

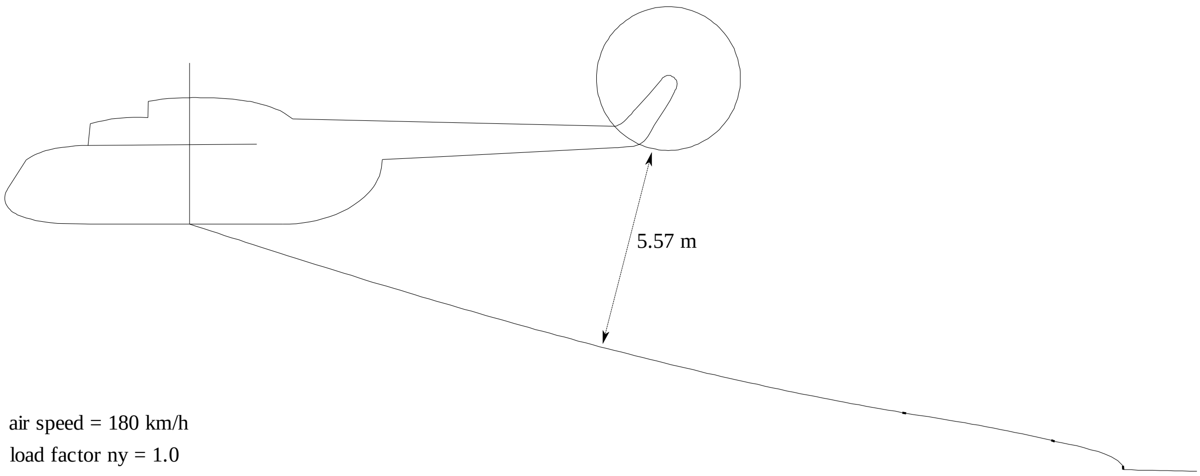

Figure 4 Initial case for computation of steady state position of the long line

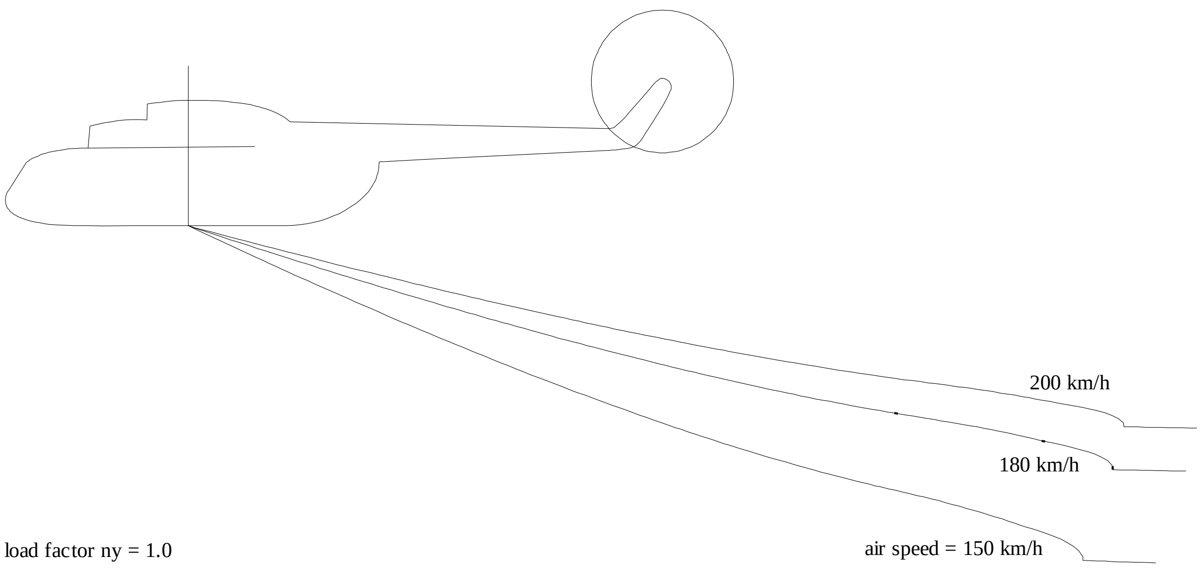

Figure 5 The change of the line position with the speed

The results of the solution for the initial case is in Figure 4. The initial case is described by expected normal condition at the steady flight (airspeed 180 km/h, vertical load factor 1.0). The computed separation between the line and tail rotor is 5.57m.

The results in Figure 5 displays the change of the long line position at higher and slower airspeeds. It is evident that the consequences of 20 km/h higher speed is not very dramatic. It is also evident, that the change of the line position at lower airspeed is more distinctive.

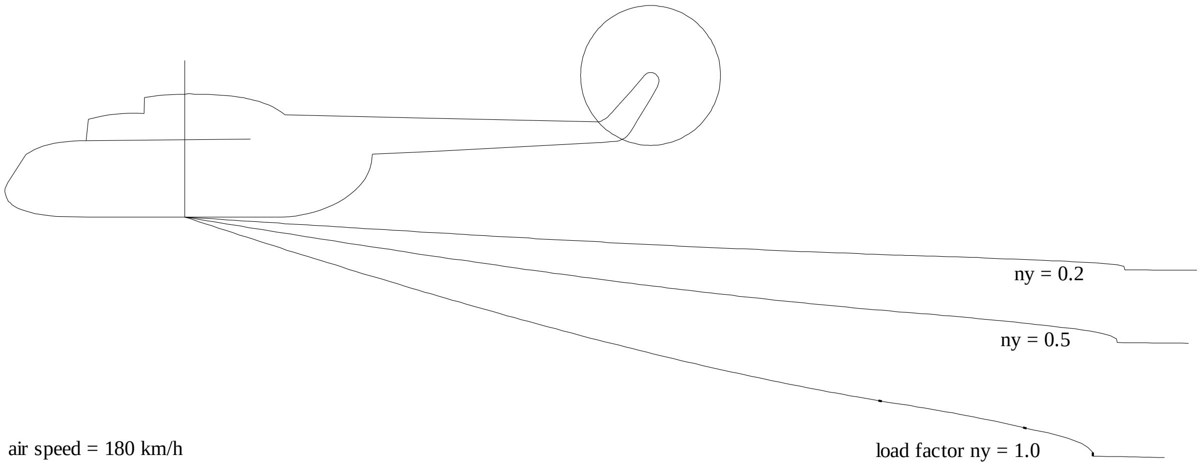

Figure 6 The change of the line position with the load factor

The second examined effect on the position of the line was that of the vertical load factor ny (see Figure 6). It is shown that even +/- 0.5 change of load factor has greater impact on the position of the line than the slight increase of the airspeed.

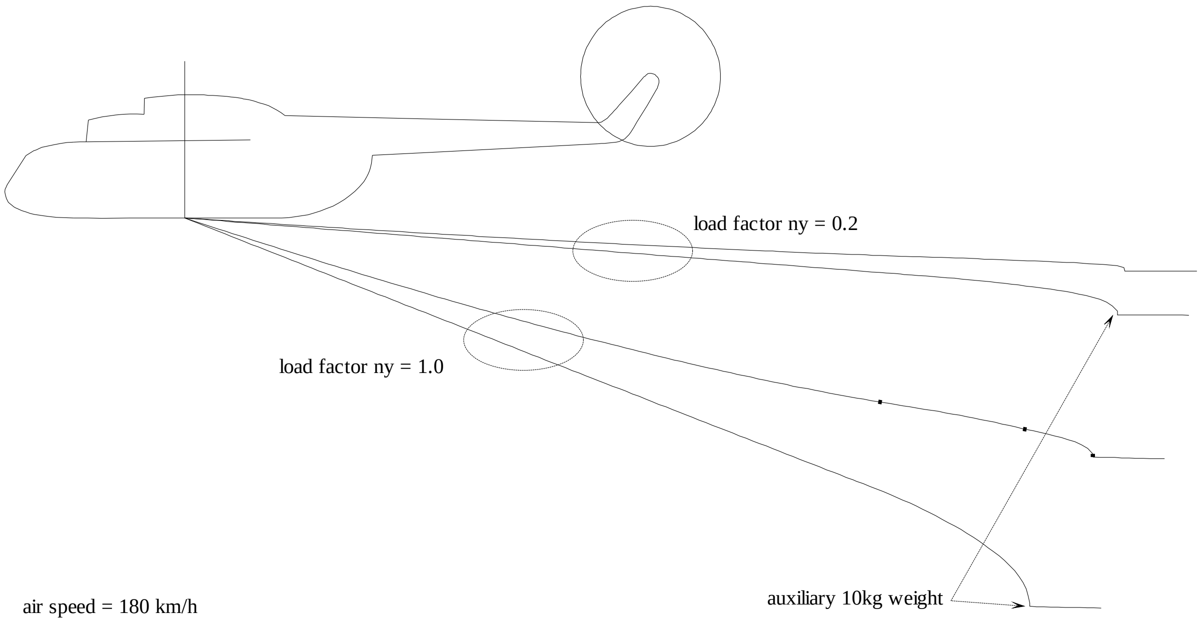

Figure 7 The effect of auxiliary weight combined with the load factor

The last examined scenario was the use of auxiliary 10 kg weight on free end of the line (Figure 7). Although it increases the separation between the line and tail rotor at normal condition (load factor = 1.0), the auxiliary weight doesn't have much sense in worst scenario at lowered load factor. Moreover there is risk, that additional mass at the free end of the line may increase aeroelastic oscillations. However the question cannot be answered by present steady state model.

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4. CONCLUSION

Presented solutions of the line position suggest that the increased airspeed doesn't represent such risk as the temporary lowered vertical load factor. Even the auxiliary weight at the free end of the line is not able to alleviate the problem at lowered load factor. The only viable measure to increase the safety remains the slower flight speed.

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INTEROPERABILITY OF THE EUROPEAN RAIL SYSTEM

Peter IHNÁT[1] - Jozef MAJERČÁK[2]

Abstract: *This paper presents a summary of EU initiatives for creation the rail traffic management system as part of interoperability of European railways. The most of existing rail traffic management systems has been developed and implemented on the basis of requests of national markets that steps led to generation of the different and incompatibles rail traffic management systems on the European rail network. These different barriers for continuously moving of the trains through borders and increasing the needed time for hand over the trains between railway undertakings. The common rail traffic management system can remove the limitations of previous systems as well as key area for creation of interoperability of the European railways. It's full-area implementation on European rail network increase competitiveness of rail sector.*

Keywords: *Rail transport, interoperability, ERTMS, TSI TAF, cooperation*

1. INTRODUCTION

The commercial operation of trains throughout the rail network requires in particular excellent compatibility between the characteristics of the infrastructure and those of the vehicles, as well as efficient interconnection of the information and communication systems of the different infrastructure managers and railway undertakings. Performance levels, safety, quality of service and cost depend upon such compatibility and interconnection, as does, in particular, the interoperability of the rail system.

European commission passed for support railway transport, a lot of decisions, decrees and recommendations, which significantly contribute to increase European railway transport at the European railway network. But time shows, that in railway sector is appear the whole ranks open questions, which need immediately deal with. One of them are national procedures for the approval of locomotives are currently regarded as one of the biggest barriers to the creation of new railway companies in the freight sector and a major obstacle to the interoperability of the European railway system. Since no Member State can decide on its own that the authorisation for placing in service which it issues will be valid on the territory of other Member States, a Community initiative is needed to harmonise national procedures, simplify them and apply more systematically the principle of mutual recognition.

Central to the work of the Commission in Europe is the aim of simplifying and modernising the regulatory environment in Europe and exactly meeting this cross-cutting strategic objective has led the Commission to develop and pursue a far-reaching Better Regulation agenda, with a view to making further progress towards the Lisbon objectives for jobs and growth. It is in this framework that the consolidation and merger of the Directives on railway interoperability are proposed.

The proposal is part of a wider initiative designed to improve the technical part of the regulatory framework for rail, namely the Railway Interoperability Directives, the Railway Safety Directive and the Agency Regulation.

Thirdly, with its ten years' experience of implementing the Interoperability Directives, the Commission has a duty to propose several improvements to the technical part of the regulatory framework.

This proposal concerns the consolidation, recasting and integration of the Railway Interoperability Directives. It should be read with the joint proposals on amending Regulation (EC) No 881/2004 establishing a European Railway Agency (hereinafter referred to as "the Agency") and Directive 2004/49/EC on safety on the Community's railways.

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2. INTEROPERABILITY

Interoperability is fundamental condition for function Trans-European conventional and high speed railway systems. It represent ability of transport system allow secure a uninterrupted movement means of transports, which reach specific levels of performances determining for system on the traffic infrastructure. This ability resides in implementation control, technical and operational conditions by preserve basic requirements at the individual systems.

Trans-European railway network were based on Directives 96/48/EC and 2001/16/EC divided into two systems:

- **Trans-European High speed railway system**

Trans-European high speed railway system consist of infrastructure included routes and stable equipment's Trans-European transport network, which were constructed or reconstructed for high speed and from means of transport appointed at the moving along these infrastructures.
For booked of required performances, safety, service quality and minimalization costs must by booked our reciprocally compatibility at the high level.

- **Trans-European conventional railway system**

Trans European conventional railway system consist of infrastructure Trans -European transport network, which were introduced in Decision No.1692/96/ES European parliament a Council from 23.july 1996 together with devices for transport management, navigation systems, monitoring systems, technical installation for data processing a telecommunications for distance management passenger and freight transport.

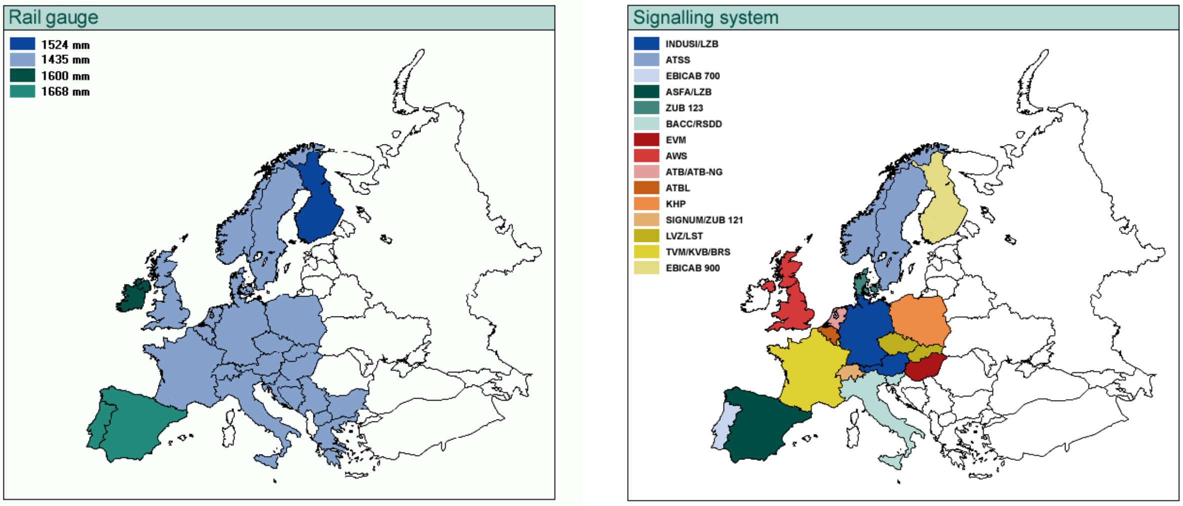
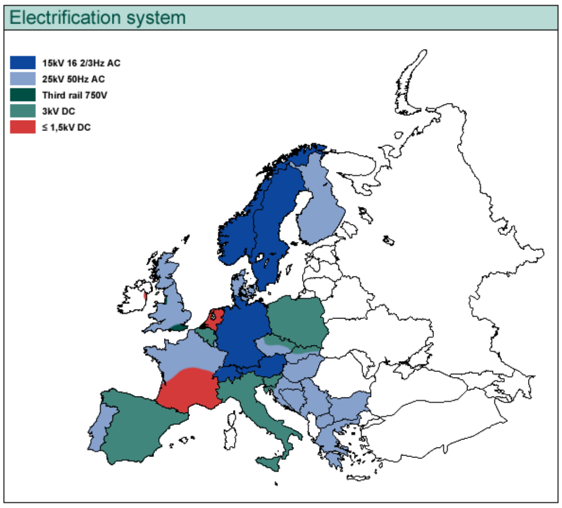


Figure 1 Non interoperable European areas (picture left – rail gauge, picture right – signalling system

The experiences show that high-speed rail system and a conventional rail system are similar and not require two separate directives. The procedures for developing technical specifications for interoperability are the same for both systems, as are those for the certification of the interoperability constituents and the subsystems. The essential requirements are practically identical, as is the subdivision of the system into subsystems for which technical specifications have to be prepared. Moreover, since trains have to be able to move freely from the high-speed network to the conventional network, the technical specifications for the two systems overlap to a large extent; Work on developing the TSIs has shown that, for certain subsystems, a single TSI can serve for both systems. It is therefore appropriate to combine Directives 96/48/EC and 2001/16/EC into directive on the interoperability of European rail system 2008/57/EC from 17.july 2008.



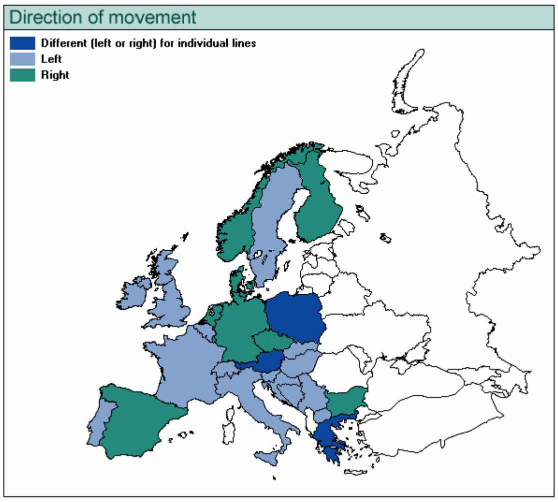


Figure 2 Non interoperable European areas (picture left – electrification system, picture right – direction of movement

In accordance with Directive 2008/57/EC was European rail system divided into following subsystems:

- Subsystems of the Structural areas:
    - Infrastructure – consist of the track, points, engineering structures (bridges, tunnels, etc.), associated station infrastructure (platforms, zones of access, including the needs of persons with reduced mobility, etc.), safety and protective equipment. Infrastructure to which the public has access must be designed and made in such a way as to limit any human safety hazards (stability, fire, access, evaluation, platforms, etc.),
    - Energy – consist of the electrification system, including overhead lines and on-board parts of the electric consumptions measuring equipment. Operation of the energy-supply systems must not impair the safety either of trains or of persons (users, opening staff, trackside dwellers and other parties),
    - Control-command and signalling – consist of the all equipment necessary to ensure safety and to command control movements of trains authorised to travel on the network. Used must enable trains to travel with a level of safety which corresponds to the objectives set for the network,
    - Rolling stock – defined structure, command and control system for all train equipment, current-collection devices traction and energy conversion units, braking, coupling and running gear (bogies, axles, etc.) and suspension, doors, man/machine interfaces (driver, on-board staff and passengers, including the needs of person with reduced mobility), passive or active safety devices and requisites for the health of passengers and on-board staff. The electrical equipment must not impair the safety and functioning of the control-command and signalling installations. The braking techniques and the stresses exerted must be compatible with the design of the track, engineering structures and signalling systems. Trains must be equipped with a public address which provides a means of communication to the public from on-board staff.

- Subsystems of the Functional areas:
    - Traffic operation and management – consist of the procedures and related equipment enabling a coherent operation of the different structural subsystems, both during normal and degraded operation, including in particular training and train driving, traffic planning and management. Alignment of the network operating rules and the qualifications of drivers and on-board staff and of the staff in the control centres must

be such as to ensure safe operation, bearing in mind the different requirements of cross-border and domestic services.

- o Maintenance – defined the procedures, associated equipment, logistic centres for maintenance work and reserves allowing the mandatory corrective and preventive maintenance to ensure the interoperability of the rail system and guarantee the performance required. The technical installations and the procedures used in the centres must ensure the safe operation of the subsystem and not constitute a danger to health and safety,
- o Telematics applications for passenger services, including systems providing passengers with information before and during the journey, reservation and payment systems, luggage management and management of conditions between trains and with other modes of transport. Suitable levels of integrity and dependability must be provided for the storage or transmission of safety-related information.
- o Telematics applications for freight services defined procedures, messages and content of these messages, which must be transmitted between subjects involved in the transport chain (railway undertakings, infrastructure managers, logistic bodies, customers, keepers, etc.)

Each of these subsystems is covered by one or several Technical Specifications of Interoperability (TSI), where are defined main requests on safety, reliability and availability, health, environmental protection and technical compatibility. The first series of TSI´s on trans-European high - speed rail system were drawn up by AEIF (European Association for Railway Interoperability) in 2002 and most of them were subsequently revised in 2008. AEIF was acted as the joint representative body defined in the directive, bringing together representatives of the infrastructure managers, railway companies and industry (the AEIF was replaced by ERA in 2004). The second series of TSI´s for European conventional rail system was published between 2006 and 2011.

All of systems must satisfy main requests of the safety:

- design, construction or assembly, maintenance and monitoring of safety-critical components, and more particularly of the components involved in train movements must be such as to guarantee safety,
- parameters involved in the wheel/rail contact must meet the stability requirements needed in order to guarantee safe movement at the maximum authorised speed,
- parameters of brake equipment must guarantee that it is possible to stop within a given brake distance at the maximum authorised speed,
- design of fixed installations and rolling stock and the choice of the materials used must be aimed at limiting the generation, propagation and effects of fire and smoke in the event of a fire,
- any devices intended to be handled by users must be so designed as not to impair the safe operation of the devices or the health and safety of users if used in a foreseeable manner..

As already foreseen in the interoperability Directives currently in force, this legal framework is begin further developed by correcting errors and close open points in TSI´s, and extending the geographical scope of the TSI´s to the whole European Union´s rail system.

On this basis, the Agency (ERA – European Rail Agency) is currently revising the following TSI´s:

- Operation and traffic management (OPE),
- Freights wagons (WAG),
- Locomotives and passenger rolling stock (LOC and PAS),
- Control – command and signalling (CCS),
- Telematics applications for passenger services (TAP),
- Telematics applications for freight services (TAF),

- Accessibility for persons with reduced mobility (PRM),
- Safety in railway tunnels (SRT),
- Infrastructure (INF),
- Energy (ENE).

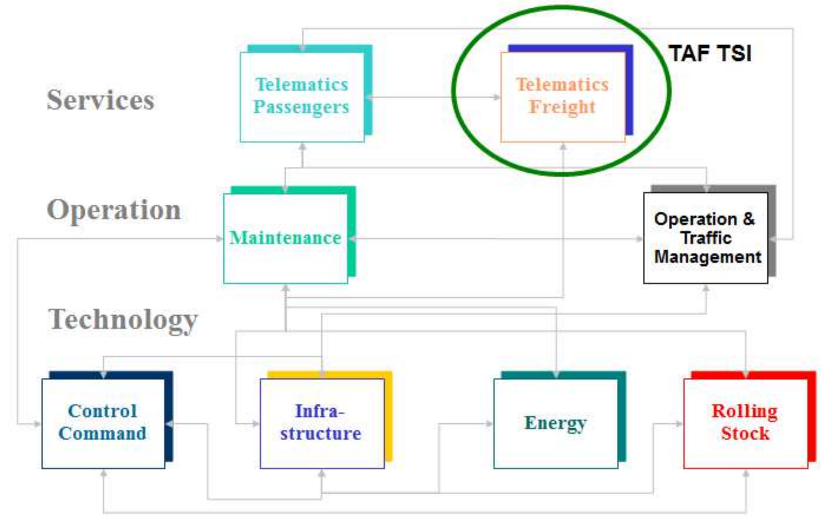


Figure 3 The dependence between TSI´s

3. CONCLUSION

A matter of central importance which still has to be improved in order to facilitate the free movement of trains is the procedure for approving locomotives. According to the manufacturers and the railway companies, often these procedures are still very long and very expensive; in their view, certain requests from the competent authorities have little justification on a purely technical level.

Simplification of the procedures for placing rolling stock in service makes rail transport more competitive. By reducing the costs of the transport chain, it contributes to the competitiveness of industry as a whole in the European Union. A dynamic rail sector also reinforces the European railway industry's position as world leader and safeguards jobs in the sector. More competitive rail transport will also contribute to the European Union's basic commitments as regards sustainable development and addressing climate change, which are results of excessive environmental pollutions.

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ANALYIS OF MEASURED PILOT RESPONSES DURING THE FLIGHT CONTROL PROCESS

Rudolf JALOVECKY[1] - Jan BORIL[2]

Abstract: *This paper evaluates both the long-term analysis of mathematical models and parameter identification of human behaviour during the flight control process. The Department of Aerospace Electrical Systems at the University of Defence has built a flight simulator. The simulator uses X-Plane 10 software. During the spring of 2013 some pilot students were tested, their responses to visual stimulus (altitude change) were measured and a statistical sample of these responses was produced. Also the used testing methods were evaluated and alternative models of human behaviour were created.*

Keywords: *Human Behaviour Model, Identification Algorithm, Mechatronic Pilot – Aircraft System, Flight Simulator, Human Factors, Nelder-Mead simplex method.*

1. INTRODUCTION

Human behaviour is so complicated that it can not be clearly and easily described by simple mathematical models. Variable human characteristics don't allow the formulation of one universal mathematical description that would fully cover all human dynamic responses during various activities. It is even harder to create a mathematical model of human/pilot behaviour whilst flying an aircraft. Human behaviour models, represented by automated aircraft control parameters, have been published for several years. Some of these early models were based on estimates of human behaviour while controlling a machine [1, 2]. Later on, as IT- especially the simulation tool MATLAB-SIMULINK developed, the early estimates could be verified. [3, 4, 5]. The lab used for these experiments has already been used for several years, for the analysis of human behaviour whilst flying an aircraft. The lab possesses a flight simulator and the authors have also created several test applications for measuring human response to a visual stimulus.

2. METHODS USED FOR PARAMETER IDENTIFICATION OF THE HUMAN BEHAVIOIUR MODEL, USING THE FLIGHT SIMULATOR

2.1 Using the Nelder-Mead simplex method with fminsearch function

The first mathematical method, suitable for parameter calculation of a transfer function for pilot behaviour model, is the already prepared algorithm of the smallest squares method utilising the *fminsearch* function in the simulation tool MATLAB. This function covers the Nelder-Mead simplex method and looks for the minimum of scalar function with more variables [5]. In the past, this function was used in the algorithm for parameter identification of a pilot transfer function as follows:

$$F_{ei} = \frac{a_1 s + 1}{b_2 s^2 + b_1 s + 1} \tag{1}$$

With defined criteria condition

$$f_{\min} = \sum (y_{id} - y)^2 \tag{2}$$

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This algorithm, however, can not cope with transport delay calculation. Therefore, the program was supplemented with a simple sub-program searching for the initial pilot response (the output value was not zero, i.e. higher than a small inputted value). After finding the time delay, the input pulse was (for the identification algorithm calculation) moved into the beginning of the response.

2.2 System Identification Toolbox

The second mathematical method for calculation of transfer function parameters, for the pilot behaviour model, uses a simulation MATLAB add-on tool System Identification Toolbox. This Toolbox designs mathematical models of dynamic systems based on measured input and output data. The input data was the measured altitude changes corresponding to the control yoke movement. The output data was the measured values of the control yoke in a longitudinal direction.

The Toolbox uses a graphical user interface, shown in Fig.1., making work and organisation of data and models much easier. The toolbox also provides identification tools ranging from regulator design and signal processing to time and vibration analysis. The interface window is split into three parts – data, models and the processing part.

One of the most important functions is the “Model output” function, comparing validation data with the simulation data of the designed model, showing results in a graphic and percentage form.

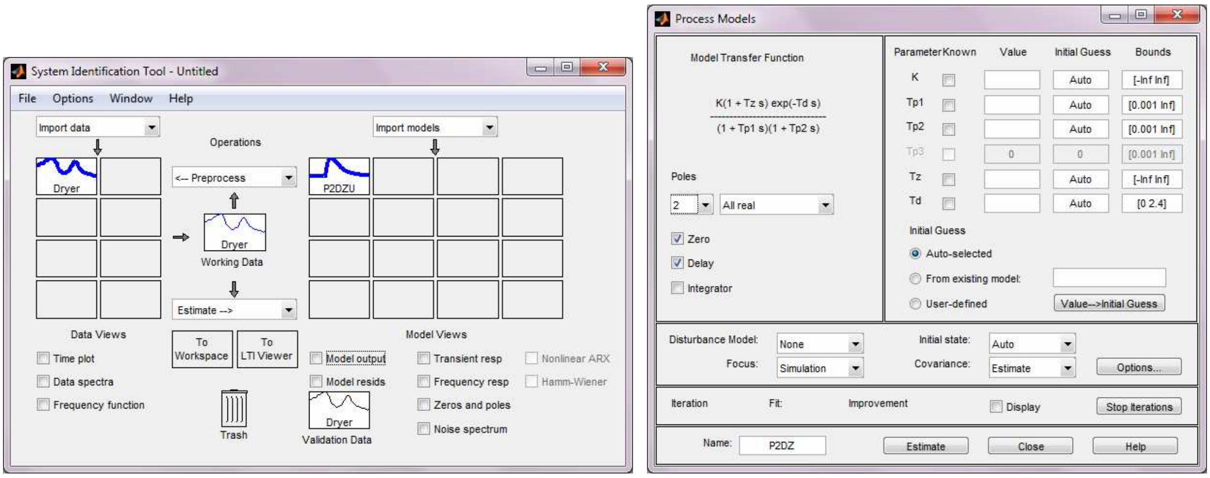


Figure 1 Graphic user interface (System Identification Toolbox) and the environment in which the transfer function is entered

After clicking on “*Estimate*”, a type “*Process Models*” should be selected. Then, a sub-window pops up giving options for transfer function forms. This sub-window offers many options such as transfer function form change, initial conditions input, iteration number, minimisation criteria and many others.

2.3 Software X-PLANE 10 – flight simulator

Nowadays, X-Plane Software is considered a complete, comprehensive and a highly effective flight simulator for PCs, offering state-of-the-art flight models. It is an engineering tool providing easy design of an aircraft flight model of all categories, including construction solution. The information provided from the mathematical-physical calculations in real time is extremely accurate – i.e. with minimum difference from the real pattern. The basic X-Plane software version contains dynamic information about 30 aircraft. For example a Bell 206 JetRanger helicopter, a Cessna 172 airplane, a King-Air C90, a shuttle or a B-2 bomber. The King-Air C90 aircraft (see Figure 2.) was selected for the following pilot response tests, responding to an unpredictable situation during a flight.

A very important feature of the X-Plane program is the option of recording the input and output data from the flight simulator into a *.txt file. These txt files were, for the purpose of parameter identification of human behaviour, imported into the simulation program MATLAB. For parameter identification of a transfer function for pilot behaviour, primarily three parameters needed to be saved – time, joystick movement values (output signal) and aircraft attitude in the space (input signal). Another important adjustable parameter was the sampling frequency, set to 20 Hz.

Figure 2 Cockpit screenshot and scenery of King-Air C90 aircraft consisting of four screens

3. ANALYSIS OF MEASURED RESULTS – HUMAN RESPONSES WHILE FLYING AN AIRCRAFT

3.1 A Mathematical model of human/pilot behaviour while flying an aircraft

It is very difficult to mathematically describe a human pilot as all the biological and physiological processes of a human brain are not known. Therefore, it is not possible to create a complete set of functions describing the processes of human thinking that all of the pilot's actions are based on. When considering a human as a part of an aircraft control system, it is necessary to take into consideration that all of his features are time variables and dependent on his current psychological state and condition, tiredness and ability to react to a new situation. Learned habits, knowledge and training play a big role in the pilot's response action. Thus, it is not easy to create a mathematical model of human behaviour in such a situation. Some experiments with human behaviour models use a linear model with transport delay [3, 6, 7, 8, 9] (which is not entirely correct, for example when considering output quantity limitations), represented by the transfer function as follows:

$$F_{(s)} = \frac{Y_{(s)}}{X_{(s)}} = K \cdot \frac{(T_3 s + 1)}{(T_1 s + 1) \cdot (T_2 s + 1)} \cdot e^{-\tau s} \tag{3}$$

Where

K - Pilot gain/amplification represents pilot habits for a given type of aircraft control.

T_1 - Neuromuscular lag time constant represents the pilot's delay in activity caused by the neuromuscular system.

T_2 - Lag time constant is related to the implementation of learned stereotypes and pilot routines.

T_3 - Lead time constant is related to the experience of the pilot.

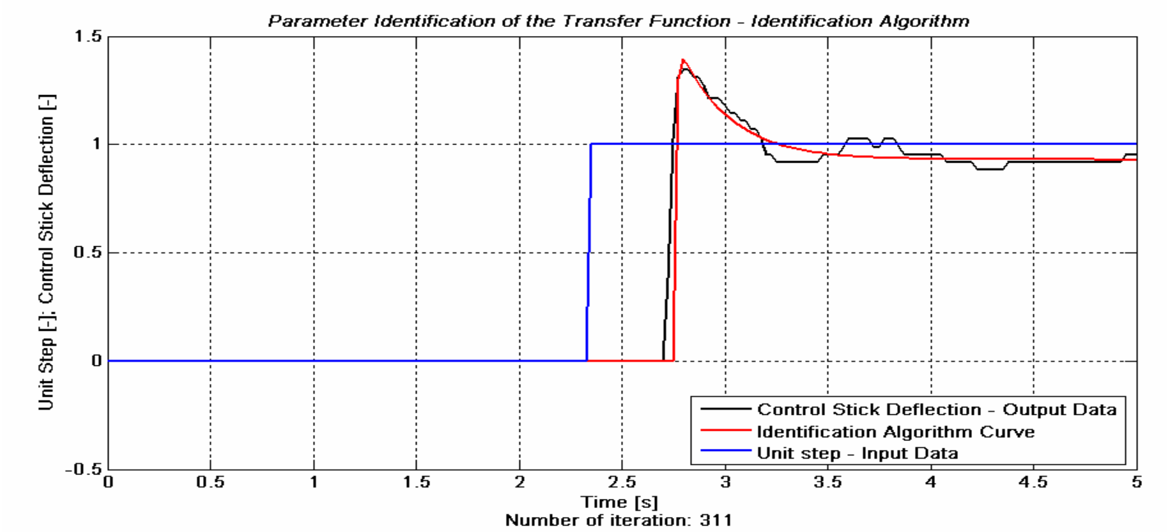
τ - This time constant indicates the delay of brain response to the pilot's musculoskeletal system and eye perception.

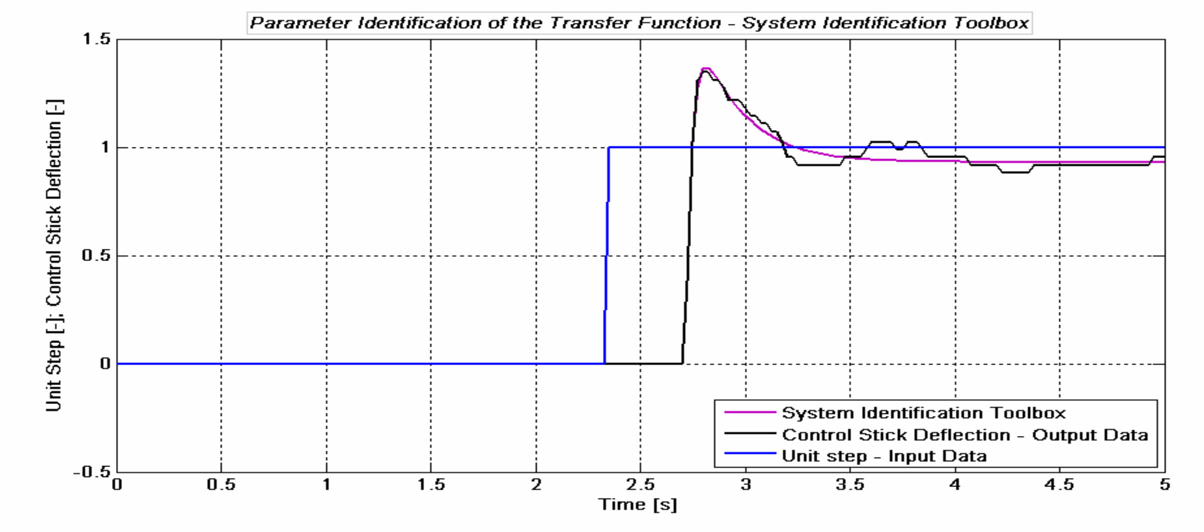
A more detailed description of time constants is in [10]. The variations of time constants and transport delays bring huge combination of results, i.e. huge amount of human response simulations. The main aim of this study was to improve the parameter identification algorithm for pilot behaviour by applying it to the measured data and determining the time constants, the travel delay and the amplification of the mechatronic system pilot-aircraft.

3.2 Results summary of human response to a visual stimulus – moving curve on a PC screen

Many tests for measuring human (future pilot) responses to visual stimuli were conducted. For the first set of tests, their own program **MOP** [11, 12] was used, utilising only a joystick and a PC for running the program. The tested person watched the PC screen where the external visual stimulus (the step change) was simulated, and then attempted to correct the sudden gap by reaching the "point" on the screen using the joystick. The input signal, that the human was reacting to, was a sudden step change to a curve created suddenly at a preset time. The tested person didn't know whether the step change would be positive or negative or when it was going to happen.

The aim of this study was not to show all the measured results, but to show possible methods of analysis of this measured data. The measured data was then analysed with both an identification algorithm and the MATLAB add on tool – System Identification Toolbox. After processing all of the data, both methods came up with the same results - graphically (curves) as well as numerically (as the individual parameters of the human behaviour model transfer function).



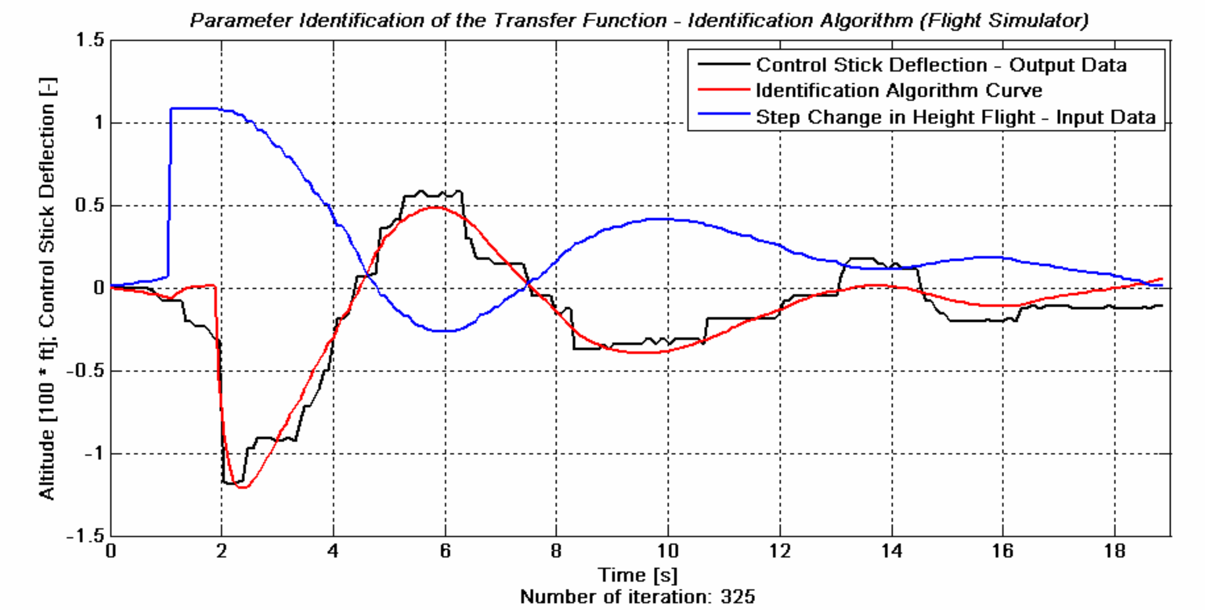


	Methods	Transfer Function Parameters					Probabilistic and Statistical Data			
		T_1 [s]	T_2 [s]	T_3 [s]	τ [s]	K [-]	σ [-]	Fit [%]	FPE [-]	MSE [-]
1	Identification algorithm	0,011	0,240	0,387	0,400	1,075	0,082	-	-	-
	System Identification Toolbox	0,032	0,211	0,370	0,366	0,930	-	94,630	0,00075	0,00072

From the graphs and the table it is clear that the results, obtained by two different methods analysing the same sets of measured data, are identical. For the authors, it was more convenient to use their own programmed identification algorithm as they can set and change many parameters unlike in the pre-programmed GUI (System Identification Toolbox) in MATLAB. The first thing that comes to your attention when you look at the graph is the first time constant – transport delay. For this type of test, the time constant is in the range of 0.3 – 0.55 sec, depending on the current physical and psychological state of the tested person. The other parameters of the human behaviour model were in the expected ranges. The next step was to utilise these parameters in a simulation program where the pilot model affects stability of the aircraft.

3.3 Results summary of the measured human responses to a visual stimulus – measured on a flight simulator

As for the above mentioned tests, many tests for measuring human (future pilot) responses to visual stimuli were also conducted for these tests. The above described simulator was used and the data analyses were done using both of the above described mathematical methods. The task of the pilots was to react as accurately as possible to a sudden altitude change of 100 feet (by watching an altimeter) and to return to the previous flight altitude by moving the control yoke (in this case moving only the aircraft elevator).The identification algorithm then calculated parameters of the transfer function for the pilot behaviour model.



Pilot 2 - Measurement 4	Method	Transfer Function Parameters					Statistical data
		T_1 [s]	T_2 [s]	T_3 [s]	τ [s]	K [-]	σ [-]
	Identification algorithm	0,173	1,688	3,961	0,730	-1,712	0,104

In the chapter 3.2., two methods suitable for analysis of the measured data were mentioned. In this case, an advantage of the identification algorithm method became apparent - the option of setting input parameters before running the identification. When using the flight simulator, it is difficult for the algorithms to determine the exact time when the pilot started to use the yoke to correct the sudden change of the flight altitude. Therefore, a zero zone was set up. After exceeding this zero zone limit, the algorithm started to calculate parameters of the transfer function for the human behaviour model. Nevertheless, this set up is not possible in the GUI System Identification Toolbox and thus this method is not suitable for analysing measured data from a flight simulator. Also, it is impossible for a pilot/human to keep an aircraft in a stable flight position within feet of accuracy.

If there is no assistance from automatic controls, the pilot keeps adjusting the flight altitude by continuous movements of the control yoke. That's why it is impossible to provide a stable and unchangeable input signal, needed for the System Identification Toolbox analysis.
What more, all the time constants in these tests were substantially higher than the time constants measured during the tests using only a joystick, where the pilot reacted to a visual change of curve on the PC screen. This was due to the fact that the pilot is simultaneously watching many parameters that are needed to be watched in the cockpit. The pilot watches not only the flight altitude, but also aircraft speed, aircraft attitude, engine parameters, etc.

3.4 Mechatronic system pilot-helicopter-autopilot

The matter of determining optimal time constants of inertia blocks was also tested on a model for helicopter stabilisation during hovering when the auto stabilisation systems have failed. Based on the mathematical description of human behaviour (3) and the mathematical description of helicopter dynamics [13], a simulation program was designed in the Simulink environment. Then time constants changes of the human behaviour model were analysed for a longitudinal helicopter flight, including transport delay changes and possible amplification changes.
One interesting and theoretically possible result is shown in Figure 3. If the pilot is quite experienced he can predict the oncoming situation much further in advance. However, this can negatively influence the helicopter flight. The reason is that the pilot compensates for the new oncoming situation in advance, but this expected situation doesn't have to happen or, if it happens, it can be slightly different or have different parameters than the pilot has predicted. According to the graph, the time constant T_3 should be in a range of 0.4 ÷ 1.2s. If the constant is outside of this range, the pilot could worsen rather then dampen the vibrations of the hovering helicopter.

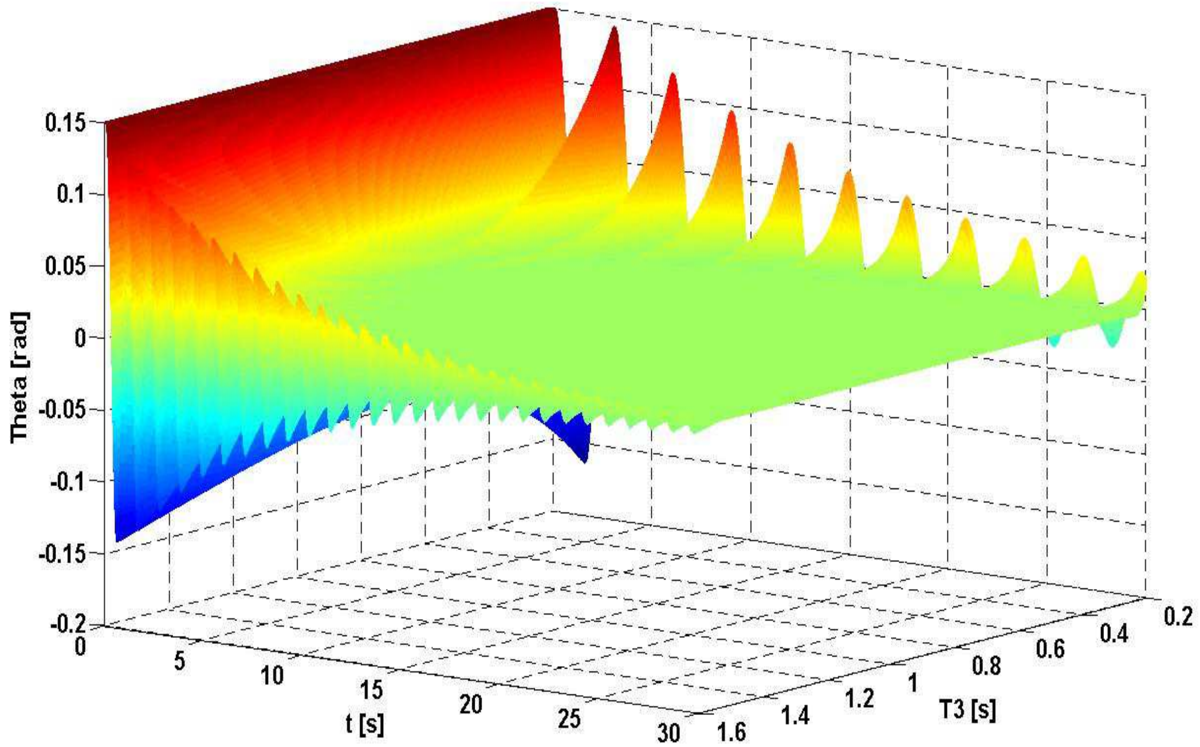


Figure 3 Longitudinal tilt when longitudinal channel of stabilisation system failed – stabilisation is done using pilot behaviour model (K=0.8, T_1=0.15s, T_2 =0.05s, T_3= 0.2÷1.6s, τ =0.1s)

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4. CONCLUSION

During many years of identifying parameters for alternative models of a human whilst flying an aircraft a MATLAB - SIMULINK environment was widely utilised and several testing methods were used. The dissertation thesis [15] describes this topic in full detail.

In the future, it is very likely that the existing algorithm of smallest squares method, utilising Nelder-Mead simplex method, will be further developed. Developing could bring the option of enriching the transfer function for the pilot behaviour model with more time constants. Then, equation (1) would have more time constant a_2 and may be also b_3. That would, however, make the human behaviour analysis even more complicated [12].

Future research will also include setting realistic limits to the parameters of the pilot behaviour model. These parameters could be used for eliminating so called PIO (Pilot Induced Oscillation) [14], oscillations caused by a pilot trying to compensate for the aircraft vibrations. But his interaction is with a certain delay and instead of stabilising the aircraft, the pilot actually causes more vibrations and in a worst case scenario it could cause frame damage or even cause the plane to crash.

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METHODS FOR DETERMINING THE POSITION MEASUREMENT ERROR IN MODERN AIR NAVIGATION

Jaroslav JEŘÁBEK[1]

Abstract: *This article describes a method for determination errors in navigation systems. It compares the method such as circular error probable, error ellipse and standard error. It compares their properties. It deals with the application of these methods in modern air navigation, such as RNAV and RNP. Article shows the use of ground based navigation beacons to enhance integrity on-board navigation equipment.*

Keywords: *RNAV, RNP, PBN, ATM*

1. PERFORMANCE-BASED NAVIGATION

RNAV and RNP are described in Performance-based navigation (PBN) manual. At present, RNAV and RNP requirements are similar and overlap. There are defined many navigation specifications.

Under PBN, generic navigation requirements are first defined based on the operational requirements. Civil aviation authorities then evaluate options in respect of available technology and navigation services. A chosen solution would be the most cost-effective for the civil aviation authority, as opposed to a solution being established as part of the operational requirements. Technology can evolve over time without requiring the operation itself to be revisited as long as the requisite performance is provided by the RNAV or RNP system.

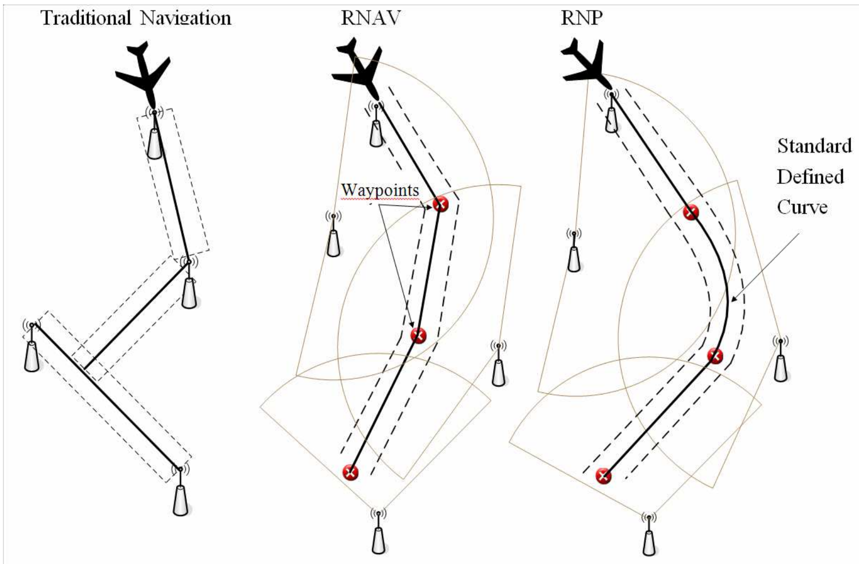

Figure 1 RNAV and RNP

2. USE OF TERRESTRIAL NAVIGATION BEACONS

Ground-based navigation beacons have an advantage over GNSS that their position in this field is fixed. Work area and navigation performance inside this area is defined by fixed and does not change depending on the movement of the beacon itself, like in the GNSS. Land beacons have less accuracy GNSS positioning accuracy, but the reliability and integrity in a given area are larger. Therefore, the signals of ground beacons can be used to improve navigation on the parameters of the aircraft. Work area air navigation system is the locus of points where aircraft position error with a given probability does not exceed the selected size.

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The working area is an area (space), in which point, the Δl ≤ Δlmax. Convenient way of determining its shape is finding its borders. Boundaries of the working area are the known species LNS consist of closed curves or surfaces, for which points are valid:

$$\Delta l = \Delta l_{\max} \tag{1}$$

The following methods can be used to determine the boundaries of the working area:

- method ellipse major half-axis errors
- method mean square error of aircraft position,
- method for error ellipse area,
- method of circular error (CEP).

Work areas are dealt two tasks.

- defines the location of ground beacons on the surface due to the aircraft's position accuracy,
- defines the shape and size of the space above the earth's surface where it is possible to use the navigation system.

The maximum allowable position error $\mathbf{\Delta l_{max}}$ aircraft is an important parameter that occurs in calculations of navigation system for measuring distance and angle or both parameters $\mathbf{\Delta l_{max}}$ value is determined based on required navigation performance (RNP). Due to the fact that the navigation system are placed on land, it is possible to omit the value RNP 4, which defines the maximum longitudinal and lateral deviation, thus $\mathbf{\Delta l_{max}}$ for flights over the ocean. For flights above Europe the desired value sufficient for two RNP flight routes over land, due to the high density of traffic above the a relatively small area of Europe is an effort to implement the value of the RNP1. This means that the area for navigation systems $\mathbf{\Delta l_{max}}$ = 1 NM.

2.1 VOR/VOR operational

VOR (VHF Omnidirectional Radio Range) is a quadrant system. Position of the aircraft can be determined in two VOR systems with their known location. To determine the working area thus created system (VOR / VOR) is valid for the following calculations:

- σ is the root mean square error (can be seen in TTD devices)
- P is the probability that measured position of the aircraft is inside (on the border) error ellipse (probability 95%),
- R is the topographical distance - this is a projection of the slanted distance r on a sphere or ellipsoid, approximating surface of the Earth (the projection of the map)
- d is the distance of finders,
- Δlmax is the maximum permissible error value of aircraft position (set according to the requirements RNP).

The devices are usually of the same type, so we can assume that σ1 = σ2 = σ. The border area of work, which is defined parameters P, d, and σ Δlmax can find a solution of equation driveshaft ellipse and the maximum allowable value of aircraft position errors:

$$a = \Delta l_{\max} = const. \tag{2}$$

For $\mathbf{\Delta l_{max}}$ applies:

$$\Delta l_{\max} = \sqrt{-2\ln(1-P)} * \sigma * 2d * Q \tag{3}$$

Where:

$$Q = \frac{1}{2}\sqrt{\frac{[(\frac{R}{d})^2+1]^2 - 4(\frac{R}{d})^2\cos^2\beta}{(\frac{R}{d})^2+1-\sqrt{[(\frac{R}{d})^2+1]^2-4(\frac{R}{d})^2\sin^2\beta}}} \tag{4}$$

To create a working area whose size is determined by the desired position measurement error, for the purposes of Article truncated. In addition, are not considered conditions of dissemination of radio waves. Given that the calculation is arduous, it is advisable to use a suitable tool (software applications) for the following calculations and display it in appropriate graph (see Fig.2).

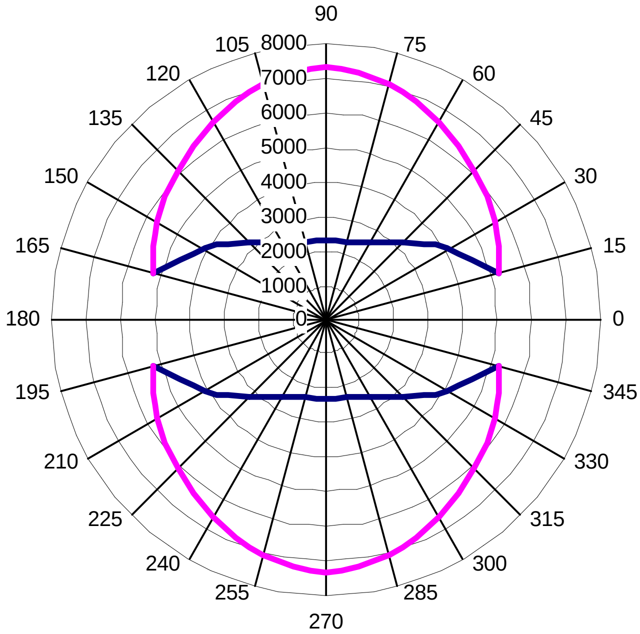

Figure 2 Two VOR systems working area

2.2 DME/DME operational

For accurate and unambiguous determination of aircraft position using DME should be three terrestrial habitats DME. In determining the work area must create base between all three means. We must make the calculations for each pair of DME separately. For DME / DME applies:

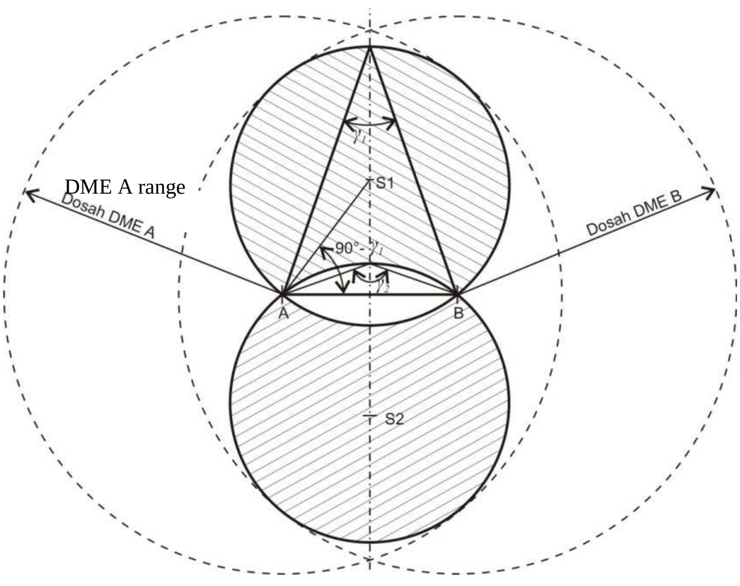

Figure 3 Two VOR systems working area

- positional error lines does not depend on the distance,
- in case of using airborne or ground rangefinder of the same type is medium square error of measure distances the same:

$$\sigma_{\delta_1} = \sigma_{\delta_2} = \sigma_{\delta} = \sigma \tag{5}$$

To calculate the half-axis and b error ellipse using the following equation:

$$a = \frac{\sigma\sqrt{-\ln(1-P)}}{\sin\frac{\gamma}{2}};\ b = \frac{\sigma\sqrt{-\ln(1-P)}}{\cos\frac{\gamma}{2}} \tag{6}$$

Border of work for measuring distance area systems can be determined from the equation:

$$a = {}_{\Delta}l_{\max} = const. \quad \text{for } b \le a \tag{7}$$

$$b = {}_{\Delta}l_{\max} = const. \quad \text{for } a < b \tag{8}$$

The procedure is not complete, but the resulting work area can be plotted (see Fig. 3).

2.3 Title Material

VOR/DME is the most commonly used combination of ground navigation stations. Both systems are installed in the coaxial installation. When calculating the work area of VOR / DME are mostly used equation of error ellipse semi-major axis:

$$a = \Delta l_{\max} \quad \text{where:} \quad \Delta l_{\max} = \sigma_1 R\sqrt{-2\ln(1-P)} \tag{9}$$

Equations for axes error of ellipse **a** and **b** has the form:

$$a = \sigma_1 R\sqrt{-2\ln(1-P)} \ \text{and}\ b = \sigma_2\sqrt{-2\ln(1-P)} \tag{10}$$

Continue:

$$\Delta l_{\max} \ge \sigma_2\sqrt{-2\ln(1-P)} \tag{11}$$

If you start from the previous equation, the boundary of the working area of the system, which also measures the distance and angle, is the curve:

$$a = \Delta l_{\max} = \sigma_1 R\sqrt{-2\ln(1-P)} \tag{12}$$

The only variable parameter of the previous equation is the distance R. Therefore, limit the working area of the system, which at the same time measures the distance and angle of a circle is radius centered at the point location of the antenna system VOR/DME. Subsequently created the work area is shown in Fig. 4.

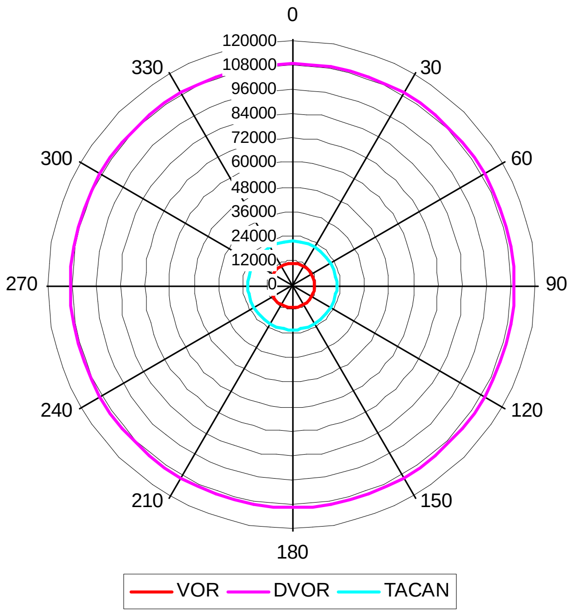

Figure 4 Working area of VOR/DME, DVOR/DME and TACAN systems

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3. CONCLUSION

The article describes the basic problems of using existing (traditional) air navigation facilities, originally designed for route navigation to support new methods and ways of navigation such as RNAV and RNP. The article describes how to create working areas by half-axis error ellipse method by simple way. Does not take into account the distribution terms of radio waves used.

In the future, as long as these devices will be used has to be created a database of such equipment and maps of their work areas for each category of RNAV and RNP. The crews of these airplanes information will be saved to board FMS (flight Management System) due to automation of this process.

The article describes how to create working areas by half-axis error ellipse method by simple way.

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THE USE OF NFC IN APPLICATIONS FOR HANDICAPPED PERSONS

Michal JERABEK[1] - Jan KRCAL[2]

Abstract: *Traveling can pose a particular challenge to the handicapped. Persons with disabilities, including the visually impaired, must overcome a series of barriers. This needs to be taken into consideration when designing transportation information systems. This article outlines the use of the NFC technology, commonly used in the banking industry, in the information systems, with the aim to increase the accessibility of these systems.*

Keywords: *information systems, visually impaired, NFC technology*

1. INTRODUCTION

Today, modern information systems in transportation are widespread and constitute an indispensible support of transportation processes for both the carriers and passengers. However, it is necessary to bear in mind already in the design phase that the transportation system should be designed so as to serve the highest possible number of users, not leaving any group of citizens behind. In case of people with limited movement and orientation capability, this is not an easy task, since each person faces special circumstances and has own special needs. What is suitable for one group may not fit another. When designing transportation information systems, it is therefore necessary to understand the requirements of the different groups and offer complex solutions suitable for all. The process should include continuous consultations with the representatives of the handicapped. When choosing such a consultation partner, it is necessary to exercise prudence, since "Diagnosis is not a qualification." (Viktor Dudr, Czech Blind United).

A whole array of adjustments and expansion of information systems was created for persons with visual impairments to ease their independent movement and reinforce their safety. The available solutions are far from perfect and there is room for improvement. This is the reason why the authors of this article want to make a contribution in this area.

2. LEGISLATION IN CZECH REPUBLIC

Rights of the handicapped persons are firmly anchored in the Czech legislation in the form of laws, norms, and methodologies. The legislation, however, does not offer a definition of a "handicapped person." Rather, it uses the term "persons with limited ability of movement and orientation," referring not only to persons with physical, visual, hearing or mental impairments, but also to seniors, pregnant women and children younger than three years old and their accompaniment. [1]

The chief legislative norms are as follows:

- Act No. 183/2006 Coll., about local planning and construction regulations, as last amended on January 1, 2013;
- Regulation No. 398/2009 Coll., about general technical requirements guaranteeing barrier-free use of buildings.

The Czech Republic has additional rules and regulations governing special situations, such CSN 73 6110 – Design of Urban Roads, whereby proposals for design of local routes must ensure that they are safe for all its users.

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Regulation No. 398/2009 Coll. [1] applies to the following situations:

- processing of documentation for issuance of territorial decisions;
- processing of simple technical descriptions of plans for issuance of territorial agreements;
- processing of project documentation;
- approval, announcement, and realization of construction;
- issuance of final approval agreement;
- use or removal of buildings or installations;
- building inspections.

Buildings covered by this regulation include those containing civil equipment. All new or reconstructed buildings belonging to this category should therefore have the parameters for barrier-free use in order to be suitable for persons listed in paragraph one of this section.

The legislation does not sufficiently cover the area of information systems for persons with reduced movement and orientation capability. While it does cover certain elements, such as the height of control buttons or displayed information, taking into consideration the needs of the persons bound to a wheel chair, better care needs to be taken to address the needs of the blind or otherwise visually impaired by providing audio information or the possibility to change the size and color of letters and background. Unfortunately, solutions that would create friendly environment for a whole range of handicapped groups are practically missing.

3. ACOUSTIC ADJUSTMENTS FOR VISUALLY IMPAIRED PERSONS

Hearing and touch are crucial senses for the visually impaired. Acoustic information can guide the blind and otherwise visually impaired to walk in the right direction or to safely cross the street.

3.1 Acoustic signalization on pedestrian crossings

Acoustic signalization on pedestrian crossings indicates whether or not a street can be crossed. The emitted sound has a form of sound beats and their frequency allows to detect the instruction. The sound beat with repeating frequency 1.5 Hz signals “red – stop” and repeating frequency 8 Hz (faster) signals “green – go.”

The SZN 01 device, which is so far most widely used in the Czech Republic, makes the characteristic hammer-like sound of an electromagnetic relay. The more modern electronic mechanisms utilize an interrupted sound at the frequency of approximately 400-500 Hz, if it is used at the pedestrian crossing. An analogue device, used where pedestrian crossings and railroads intersect, utilizes an interrupted sound at the frequency of approximately 800-1000 Hz. Thus, the sounds cannot be mixed. None of these devices, however, allows adjusting the volume of the acoustic signal. [2], [3]

3.2 Acoustic orientation beacons

Acoustic orientation beacon identifies a specific significant orientation point, such as:

- entrance to buildings, typically public buildings, such as administrative offices, shops, banks, post offices, health care centers, or social services providers;
- entrance onto escalators and moving pedestrian belts;
- underpasses, bus and train stations, or hospitals.

Acoustic orientation beacons feature either a choice of a suitable trill, or a combination of the trill with a subsequent voice message and orientation tune. They can sound without an interruption in daily or weekly cycles or after activation by a command transmitter. The Czech Telecommunication Office has allocated for the entire territory of the Czech Republic a unique frequency of 86.79 MHz for the control by radio commands. They are typically placed in the height of 2.2-4 m and their sounds differ according to the purpose of their use.

Expansive underpasses, bus terminals or train stations, hospital complexes etc. can be equipped with a set of remote controlled acoustic beacons so that the blind or visually impaired person can be guided by their sound. Location of these beacons must be carefully chosen and their information message carefully formulated. It is important to take into consideration that beacons located close to one another would be activated by the transmitter simultaneously and thus disorient the user. [2], [3]

3.3 Acoustic orientation beacons

Clearance and information system of the public transportation vehicles (trams, trolleys, buses) and some trains is typically supplemented by a command system. Once activated by the visually impaired, a voice message containing information about the connection (vehicle number and direction) is sounded. By pushing an additional button, the visually impaired can signal to the driver the intention to board. This device can also announce the current and upcoming stops by activating the respective command [2], [3].

3.4 Electronic information systems with output for the blind

This category includes for example the so-called "intelligent stops," which reproduce, based on the signal from the transmitter, a voice message containing for example information about arrival of the next vehicle. Another type of such a device are information systems in terminal halls, such as airports, where the system can give information about arrivals and departures. The highest level constitute information electronic stands with voice output, which provide information about timetables, cultural events, accommodation, restaurants etc. [2], [3].

4. COMPENSATION DEVICE FOR VISUALLY IMPAIRED

Compensation device is a tool, apparatus or mechanism specially designed or adjusted so that its use would at least partially compensate the limitations caused by the impairment.

4.1 Remote controller

Acoustic orientation and information mechanism for the visually impaired on the territory of the Czech Republic are controlled by the VPN-type transmitters for the blind. There are six different encoded commands transmitted by the radio signal on the frequency 86,79MHz. Two types of transmitters with identical functions are available:

- Type **VPN 01** – pocket-size box with six buttons. The buttons are arranged in two columns with a tactile mark between button 1 and 2. The numbers of the buttons define the numbers of respective commands.
- Type **VPN 03** – white stick component. The transmitter is built into the handle of the white stick (the orientation five-part compact type) with three buttons, which can, however, give six commands, such as the box type.

5. TECHNOLOGY NFC

Technology NFC (Near Field Communication) is a wireless technology, which utilizes radio data transmission for short distances, allowing an easy and safe two-way communication between the electronic devices. The communication takes place on radio frequency 13.56 MHz.

The reach of the device, or in other words maximum distance for safe transmission of the data, is approximately 10 cm. The device has in most cases the reach of 15-20 cm. The safety of the communication is given by the short distance.

NFC has a backwards compatibility with RFID tags, which correspond to the norm ISO/IEC 14443. When utilizing the NFC technology, the device can communicate in two modes:

- active – both parties communicate with each other and switch the direction of the signal transmission;
- passive – device of one party is charged by an electromagnetic field of a transmitter/second party and therefore does not need its own charger.

6. INFORMATION SYSTEMS USING NFC

Acoustic orientation beacons are very useful for the visually impaired. They are activated by a command from the VPN-type transmitter and this command is transmitted by a radio signal – it is all-directional. Their main disadvantage is that the signal is not transmitted to the selected beacon only, but throughout the entire area that the signal covers (tens of meters in the open space), thus activating all the beacons in the area. The information from all the activated beacons can interfere with one another and instead of providing a guidance creates chaos. Visual sense has the ability to filter the unnecessary information, for example by closing the eyes, focusing on the desired information etc., but the sense of hearing does not provide for any such possibility. Another disadvantage of the acoustic orientation beacons is their ability to react only by pre-formulated reaction (trill, trill + voice message). Their reaction is therefore basically static and their adjustment for a new situation cause a delay in providing the right information. Information and communication technology is so advanced today that it is possible to remove these disadvantages. It would be a mistake not to promote the acoustic orientation beacons despite their limitations, since they require only low maintenance (they only require an electronic connection) and can prove to be very effective and practical.

At the Faculty of Transportation Sciences at the Czech Technical University in Prague, we are working on a proposal to expand the information system for bus terminals, which would help the visually impaired in their independent and safe movement in the bus terminal. The information electronic stands with the guidance trill and voice message provide information about arrivals and departures of buses, but they do not provide any guidance on how to reach a particular boarding point. The key feature of the proposed expansion of the information system is a simple electronic information stand, proposed as a thin client, when the main logistics is programmed in the transportation information system of the bus terminal. This information stand has a NFC reader and voice input only.

It provides two types of information:

- information about the required connection (arrival time or delay);
- information for independent and safe relocation to the required bus boarding point.

Should the path towards the boarding point be complicated and difficult to remember for the visually impaired person, the electronic stand would provide additional guidance to the next nearest stand in the desired direction. The path between the electronic stands reflects the need of the visually impaired persons and is dotted with tactile elements detectable with the white stick or distinguished by special surface stepping area. Since the bus terminals tend to vary in size and shape, they would have to be equipped with several electronic information stands, while each stand would need to have its clearly distinguishable identifier (S_ID), which would help to identify the position of the passenger who could thus receive the relevant information for further relocation to the desired bus arrival point.

For easy identification of the required connection, technology NFC is used. For the purposes of the passenger, it is sufficient if it is equipped with the NFC tag. For the information stand to provide the required information, the information system needs to know the connection which the passenger wants to take.

This process of data upload into the central database of the transportation information system can be done in two ways at the minimum:

- when purchasing the ticket;
- through a web application.

Using one of these two methods, a unique identification number is read from the NFC tag and deposited by the chip producer, along with the data about the required connection into the database. The passenger is not identified and can own several NFC tags. Given the consent by the transportation providers (and the passengers), the ticket could be uploaded directly onto the NFC tag or a ticket medium equipped with the NFC tag.

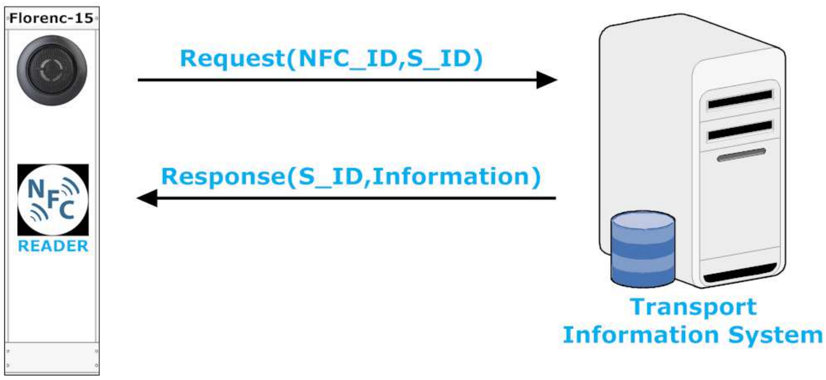

Figure 1 Scheme of communication between electronic information stand and the transportation information system

The request sent from the electronic information stand contains not only the identification number for the NFC chip of the passenger, but also identification number of the stand in order to determine the position of the passenger in the bus terminal.
Where possible, the connection between the information electronic stand and the transportation information system is carried out through Ethernet, but the method of choice is more typically WiFi due to the existence of the infrastructure and minimalization of costs. The transfer of data is being carried out by the protocol TCP/IP. No sensitive data is being transferred and therefore the communication does not need to be encoded.

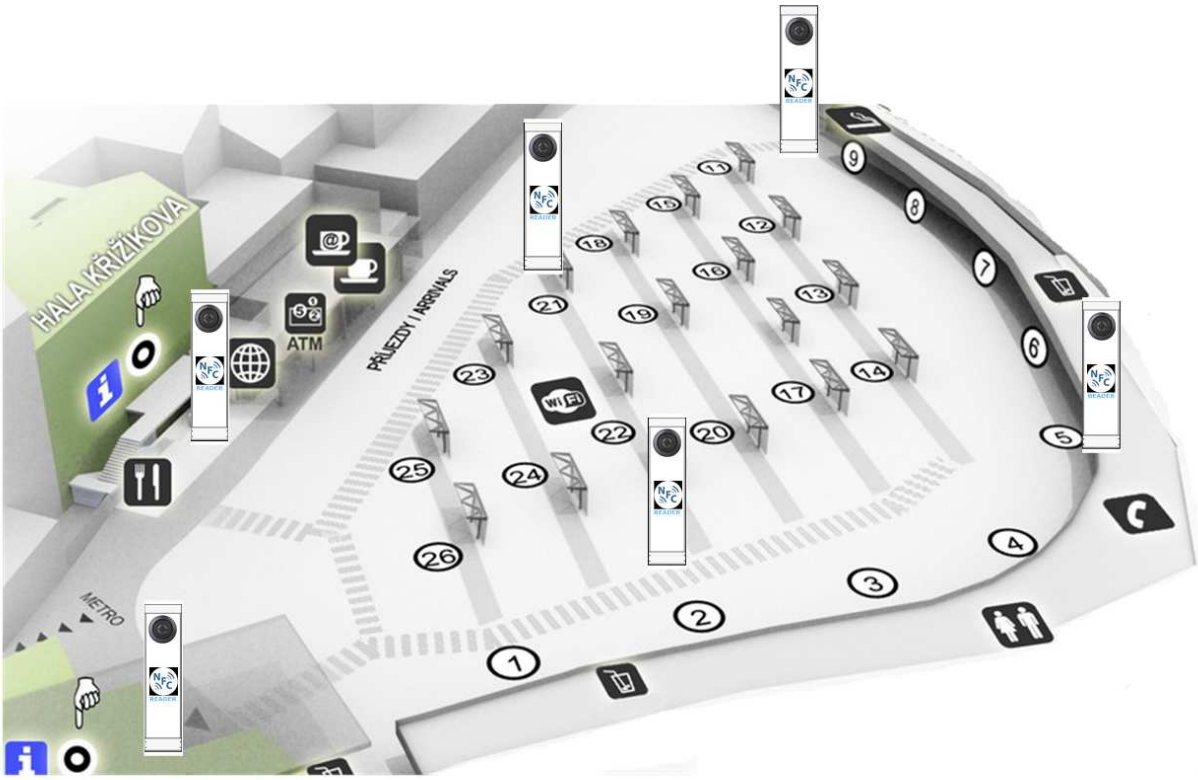

Figure 2 Proposed localization of electronic information stands at the Florenc Bus Terminal

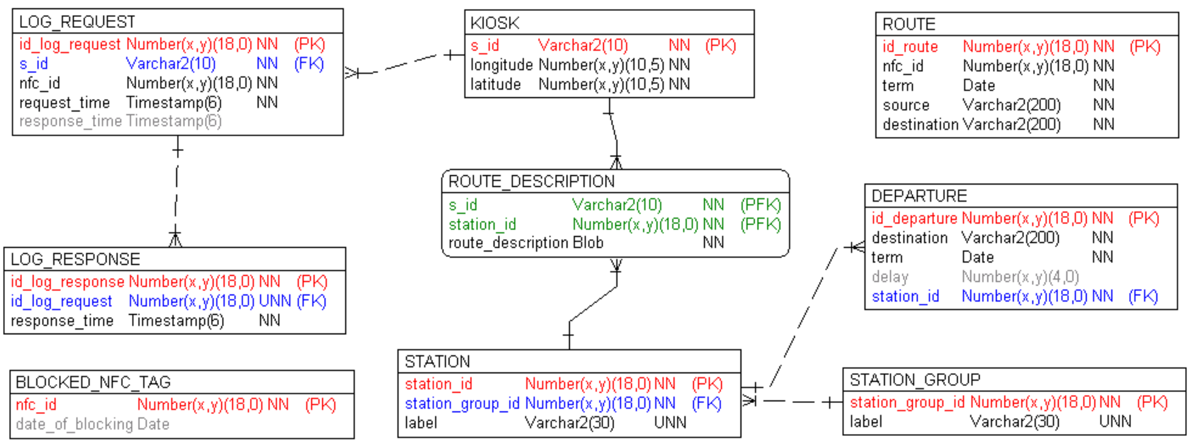

Figure 3 New part of the relation database scheme of the transportation information system

7. PERFORMANCE INDICATORS OF SYSTEM

7.1 Response duration

The response duration is the ability of the information system to serve request for navigation to a certain specified maximum duration that can be defined as the probability

$$P\left(\left(t_{Ri}-T_{R}\right)<\varepsilon_{RD}\right)>\gamma_{RD} \tag{1}$$

that the difference between the measured duration of ***i***-th response t_{Ri} and the specified maximum duration T_R will not exceed the value ε_{RD} on the probability level γ_{RD}.

A research study conducted by the (now defunct) Institute for Rehabilitation of the Visually Impaired of the Charles University in Prague revealed that three seconds is the maximum response time of the system that the blind person can comfortably accept. A longer response time is less acceptable, because the blind person cannot scan the environment to understand the delay. An acoustic signalization indicating that the system is processing the response would be a fitting solution in such a case. The total time of response is generally broken down into sub-periods:

- the period of generating the request (p_greq);
- the period of sending the request (p_sreq);
- the period of request processing (p_reqp);
- the period of generating the response (p_gres);
- the period of sending the response (p_sres);
- and the period of response processing (p_resp).

$$response\ duration = p\_greq+p\_sreq+p\_reqp+p\_gres+p\_sres+p\_resp \tag{2}$$

8. CONCLUSION

The visually impaired persons do not want to live in seclusion from the world, but want to live a full and meaningful life to the extent their disability allows them. At minimum, they want to be self-reliant. When designing an information system (or other applications) it is therefore necessary to respect this and adjust the design to the specific needs and abilities of the visually impaired. The aim of this article was to introduce a proposal for expansion of transportation information system of a bus terminal, which by utilizing modern information and communication technologies would afford the visually impaired an independent and safe movement. The technical proposal is supplemented by the performance indicator, which helps to determine if the proposed solution will operate at a sufficient speed.

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INFORMATION AND MONITORING SYSTEMS IN ROAD TRANSPORT

Alica KALAŠOVÁ[1] - Ľubomír ČERNICKÝ[2]

Abstract: *Road traffic, by its dimensions, weights and speeds of vehicles which is moving is a danger that requires precise deployment rules, advanced technical systems for safe movement, an appropriate infrastructure etc. Road safety is an issue of interest to all citizens, each of which can contribute to improving safety on public roads. Although the measures taken in this area have proven, road accidents remain unacceptably high. The main aim of transport management is to meet as many transport demands as possible with the least effort made up to required level. The main demand is to create transport information system that is a part of transport management. The objective of this contribution isto analyse various data recording and transfer of vehicle movement from the point of view of their economical and technological effectiveness in the area of the Slovak republic. All of analysed possibilities work on equal principles: mobile device which is capable of recording data of vehicle position and status and hereby able to communicate with outside world, and the fixed part which provide the capability of administration, saving and analysing of the obtained data and communication with the mobile devices located in the vehicle. This part can be parsed into two layers – system containing the application logic and data archiving system (database server). Simply it can be said that almost in all cases this is considered as three-layer architecture.*

Keywords: *information systems, tracking, localization, position, location, vehicle*

1. INTRODUCTION

Recently, an information system has been more and more discussed expression in various life spheres, whether in science or governmental or private sector. Also the question of their utilization for administration and data-manipulation of the car-fleet of companies which more or less use their vehicles for passenger, goods transport or another type of service comes to foreground. In all of cases, it is necessary – even by law (tax bureau) or for internal company requirement – to monitor the status and utilization of all vehicles – their running, repairing, servicing, etc.

The objective of this contribution is to analyse various data recording and transfer of vehicle movement from the view of their economical and technological effectiveness in the area of the Slovak republic. All of analysed possibilities work on equal principles: mobile device which is capable of recording data of vehicle position and status and hereby able to communicate with outside world, and the fixed part which provide the capability of administration, saving and analysing of the obtained data and communication with the mobile devices located in the vehicle. This part can be parsed into two layers – system containing the application logic and data archiving system (database server). Simply it can be said that almost in all cases this is considered as three-layer architecture, as is shown in Fig. 1.

For evaluation of suitability of separate alternatives it is necessary to respect specific needs of companies – some of them need vehicle movement information, obtained after its return to the car park; some of them need to be informed about status, location and motion of the vehicle in real-time; in some cases it is necessary to communicate with device in the car in duplex mode and actively deliver data into computer in the vehicle, to inform driver or to assign him various requirements.

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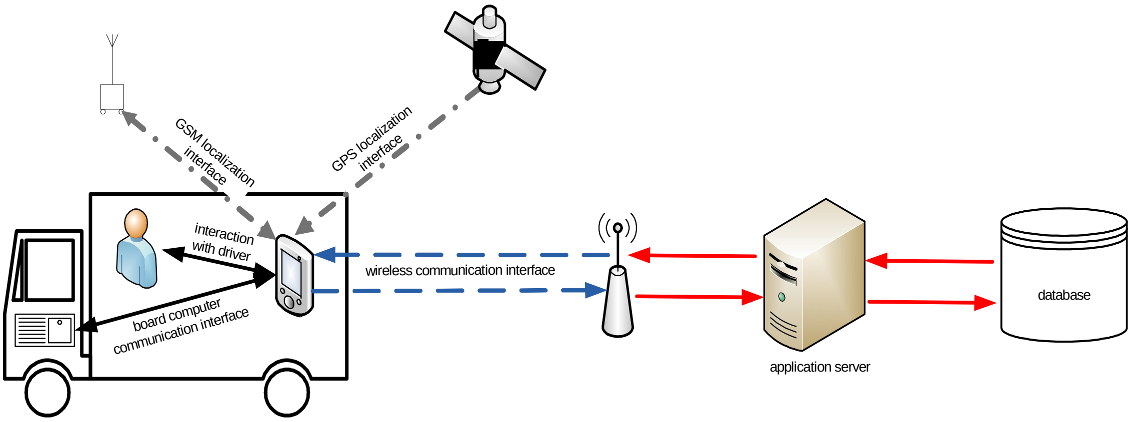

Figure 1 System architecture

2. SYSTEM ANALYSIS OF LOCALIZATION

The main part of entire system is vehicle localization. In present, there are in principle two most used technologies, which provide localization of vehicle – terrestrial and satellite.

At this time, 4 existing satellite navigation technologies are discussed. It is (in present fully operational) American system GPS, Russian GLONASS, Chinese Compass system and European navigation system GALILEO.

The GPS system provides very exact time-reference almost anywhere on the earth or earth-orbit. The advantages are absence of operating costs by user-view due to free receiving of GPS signal and low prices of receiver-purchasing [1].

GLONASS (Global Navigation Satellite System) is a global position Satellite System realized by ex-USSR at the same time with the United States's. All GLONASS satellites are launch from Baikonur Cosmodrome, or from the Plesetsk cosmodrome, the first release dates back to October 1982, the constellation was completed during the period of maximum efficiency with 24 satellites in 1995.

In the years succeeded because of the serious economic situation interns Russia has not had the possibility to maintain to assets the entire constellation.

But in 2002 with improving of the economic situation it has been given the way to the program of I throw again of the system to satellitare GLONASS that previews 18 satellites within 2007, and will have to newly catch up the number of 24 satellites within 2012.[3]

The Compass Navigation Satellite System (CNSS), also named BeiDou-2,[4] is China's second-generation satellite navigation system that will be capable of providing positioning, navigation, and timing services to users on a continuous worldwide basis.[5]Although the upgrade of its regional navigation system towards a global solution started in 1997, the formal approval by the Government of the development and deployment of BeiDou-2/CNSS was done in 2004 and it is expected to provide global navigation services by 2020, similarly to the GPS, GLONASS or Galileo systems. [5]

As of December 2011, the COMPASS system was officially announced to provide Initial Operational Service providing initial passive positioning navigation and timing services for the whole Asia-Pacific region with a constellation of 10 satellites (5 GEO satellites and 5 IGSO satellites). [6] During 2012, 5 additional satellites (1 GEO satellites and 4 MEO satellites) were launched increasing to 14 the number of satellites of the constellation. Until 2020, the system is going to launch the remaining satellites and evolve towards global navigation capability. [6][7]

Galileo is a global navigation satellite system (GNSS) currently being built by the European Union (EU) and European Space Agency (ESA). One of the aims of Galileo is to provide a high-precision positioning system upon which European nations can rely, independently from the Russian GLONASS, US GPS, and Chinese Compass systems, which can be disabled in times of war or conflict .[8] When in operation, it will use two ground operations centres near Munich, Germany and in Fucino, Italy. In December 2010, EU ministers in Brussels voted Prague, Czech Republic as the headquarters of the Galileo project.

Full completion of the 30-satellite Galileo system (27 operational and three active spares) is expected by 2019.[9]

3. ANALYSIS OF DATA TRANSFER EQUIPMENT BETWEEN VEHICLE AND ORGANISATION

Presently, for the wireless data-transfer it is possible to use the technologies which are described in the following rows:

- Data-transfer via Infrared technology. The advantages of data-transfer system IrDA (infrared radiation) are low prices of sensors and low absorption by passing the metallic glass, which are equipped with many of modern vehicles. Disadvantage of this solution could be the need of direct visibility between devices and limited working radius (about 1 – 3 meters).
- Data-transfer via bluetooth technology. The Bluetooth technology does not need direct visibility between devices. Signal strength provides communication possibility till 10 meters, but if there are barriers, accessibility decreases.
- Transfer of data through terrestrial mobile networks. As the mobile networks area-coverage is at this time at high-level, it is also possible to use this technology for remote wireless information transfer. Packet-switched technology GPRS based on GSM-standards is progressively replaced by faster third generation technology UMTS. The price for small data-volume is not enormous and also in case of short sending data-interval the total amount is not so high. This solution is interesting for company vehicles, used in inland, if it is needed to have on demand instant vehicle motion-information or to perform direct interaction with device in the car or to give the driver necessary instructions. Disadvantages are incompatible settings of different mobile networks, which causes potential malfunction after country boundary pass-over and network change (to roaming) – therewith the next disadvantage is related – the price for transferred data in case of roaming-using is incomparably – as many as ten times – higher against standard rates. But in unavoidable cases the information value of vehicle location, nevertheless, exceeds the financial value paid for data transfer.
- Transfer of data through satellite communication systems. Satellite communication systems like INMARSAT or IRIDIUM have almost unlimited signal accessibility under the same communication conditions all the world over (they cover about 98% of population). When crossing the frontier neither the configuration, nor the price for the services usage change. However, these are inaccessible in indoor and underground areas (closed park-houses, underground garages, tunnels, etc.). The next disadvantage is the price for transferred information. Besides obtaining information about vehicle location in real time, this type of service makes the interaction with computer or vehicle driver possible.
- Data transferring via technology of wireless fidelity. Technology of Wireless Fidelity is the standard-package for wireless local networks LAN (WLAN), in present based on specifications IEEE 802.11. It provides connection to the network in the Access-Point neighboring devices with wireless adapter (PC, notebook, PDA …). Frequencies Wi-Fi are not licensed, however only devices with broadcast performance until 100 mW are allowed, so they have limited accessibility. Typical Wi-Fi router could be reachable within 45 meters in the buildings and 90 meters outdoors. It appears from this that this technology does operate without usual operational costs but it is only able to inform about the vehicle movement after arrival to parking place or garage of the company. The new system called WiMax defined in the standard IEEE 802.16 will operate on the similar principles as the supplement of this technology with operational range of 40 – 70 km in outdoor environment.

4. POSSIBILITY-ANALYSIS IN MODEL EXAMPLES

4.1 Daily press distribution

A company which is concerned with this type of business does not need to use navigation system, because its drivers have driven their route already few times. The question of vehicle localization is not necessary to be discussed. But foreground there is a problem of localization-data transferring. This type of company does not need to have the overview of actual location of each vehicle but it is necessary to know which vehicles are on the way, which of them are in the parking place etc.

For such a company it is enough that the car-movement data are collected at the moment of its arrival to the parking place, like in the past as in “Driving-book” manually was, and this fact can spare relatively considerable finance-mass. Of course, the transfer as such has to be equally secured that the information-distortion through drivers or third persons does not occur. As the most suitable system for this type of company appears the combination GNSS (GPS) – localization and Wi-Fi/WiMax – data transferring.

4.2 Taxi service

For taxis it is already suitable to think not only about recording, eventually localization of exact route, but also about active navigation by software with loaded relevant map-details. The taxi-service with a big car park employs also its own dispatchers. After a demand they have to choose a vehicle, which is not busy and/or reserved and simultaneously is closest to the point of customer-pick-up point. All of these conditions indicate that the online vehicle localization is necessarily required. The point of view of customer pick-up driver can be informed about in two ways – by making use of two way communication with vehicle or by transmitter. In the first case the possibility of satellite data transfer is clearly eliminated due to high cost and consequently, it is obvious that advantages of satellite communication will not be utilized in this case, as the taxi vehicles are not usually crossing country frontier. In this case, the optimal combination of technologies is: GNSS (GPS) for localization and GPRS/UMTS for data transferring.

4.3 Emergency systems

During operating service, the emergency vehicles have absolute priority on the road communications. Also in this case, like with the taxi-vehicles, it is suitable to use the navigation system too. In addition to localization of the vehicle location, used by operator, it is in the interest of saving human life, to connect the navigation software (with the map details) with the mobile device (or to implement it) which performs the localization and data transfer. Hereby it is necessary to use the duplex transfer mode (in this case in the direction to vehicle) that the driver and crew of these vehicles have their shortest or fastest route already scheduled at the time of getting into the car. This solution clearly speeds up the arrival of emergency to the destination point and thereby increases the probability of people survival after serious accident or other events that need the action of emergency system. Next, after the arrival to the destination, in case of serious event, it is easy to report to the operator how the situation looks like, and to evaluate if the next emergency vehicle is necessary. The operator can see on the display where the car is located and he can manage and send the next emergency vehicle very easily and fast. Optimal combination seems to be the couple of technologies GNSS (GPS) and GPRS/UMTS. But as the human life is concerned in this case, any failure of such a system is allowable, and for that reason it is exceedingly needful that the backup system will be applied. Good selection for data transferring backup-system could be satellite communication system, although very financially consumptive, also the combination of GNSS (GPS) and GPRS/UMTS/SAT could be used.

4.4 Mass public transportation

In the age when every saved minute by travelling performs, it is very important for the travelling public to know where the public transport vehicle, which passenger would like to get in is situated. He needs to know the delay of vehicle if it occurs and to have the possibility to use an other alternative or to use the time reserve for other meaningful activity. Information system has to localize the vehicle, calculate the probable time of arrival to every following bus stop and to send information to the centre. In this section, it is possible to segment the transferring method to urban and interurban. Within the frame of operational costs minimisation the wireless Access Points around the transportation lines in the whole town will be arranged, which provide for the data receiving between vehicles and the centre. The side effect of this solution can be creation of many free hot-spots around the city, in case of adequate secured transfer. For this model example following combinations could be suitable:

- in case of interurban or long-distance transportation the data transfer through GPRS/UMTS is the optimal solution;
- in case of urban mass public transportation the data transfer can be solved via Wi-Fi hot-spots;

Localization by GNSS systems (GPS) is in both cases optimal. It is necessary to say that in the international mass public transportation this type of information system does not make sense.

5. CONCLUSION

Intelligent transport systems (ITS) are advanced applications which, without embodying intelligence as such, aim to provide innovative services relating to different modes of transport and traffic management and enable various users to be better informed and make safer, more coordinated, and 'smarter' use of transport networks.

An Information and Communication Technology (ICT) Infrastructure is a necessary condition for the deployment of ITS services, providing relevant and high quality data from systems that monitor the road situation. A connected European ICT infrastructure will enable cross-border continuity of services through the exchange of harmonised data. Monitoring infrastructure is a major enabler for traffic management and traveller information services.

The connected ICT Infrastructure consists of three dimensions:

- systems for collection of data (monitoring and positioning systems)
- systems and protocols for communicating data (e.g. between traffic control centres and to and from vehicles)
- quality of the data (accuracy, timeliness)

Accurate, reliable, high quality traffic data is a prerequisite for effective traffic management and information services. Today there is a lack of common European quality criteria for data and services, which is in turn a basic need for quality cross-border services using data from different countries. So far, only little evidence exists of the relationship between data quality and cost-benefits of the service.

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SAFETY FEATURES USED IN THE OVERSIZED TRANSPORT

Alica KALAŠOVÁ[1] - Jozef MASÁR[2]

Abstract: *This note is to explain the use of the MS Word in the automotive industry, where is nearly 85% - 95% of goods for production process transported by trucks & trailers, safety issue plays an important role in transport. Not only that, it is necessary to transport large volumes of goods with fewer trucks but also increase safety in transport itself due to larger volume of transportation goods by one truck brings with it an increased demand for safety features to ensure the goods and provide transportation. All transport oversized cargo represents a specific solution. These evaluation parameters can be classifying as oversized cargo. It is important to define the specific technical characteristics and oversized loads. Oversized loads may be excessive load on the dimensions, but also excessively heavy cargo. Possible solutions that can be applied at present in the Slovak Republic to improve transport safety, the deployment of such trucks that can flexibly change height and transport large volume of goods (raise the roof of trailer = raise of carrying capacity). This vehicle has a modified hydraulic pillars of which are technically adapted so that it is possible to increase the loading space that will raise the roof of trailer to requested height. In our contribution we describe possible solutions.*

Keywords: *safety, oversized transport, the cup system*

1. INTRODUCTION

The most frequent question within the transport processes is the question of SAFETY. This question is very complex and includes a lot of detailed questions and analyses which is necessary to conduct to answer the question of transport safety factually, precisely, simply but most of all on the basis of the real data. [1]

The question of safety plays a significant role in the transport process within the automotive industry where 85 per cent up to 95 per cent of goods for the production process is transported by a truck and trailer transport. It is not only necessary to transport bigger volumes of goods with fewer number of trucks but it is also necessary increase safety within the transport itself because the transport of bigger volume of goods by one truck also brings increased requirements for safety measures to secure the goods as well as to secure the transport itself. The only possible solution which we are able to apply within the Slovak Republic to increase the transport safety is to provide such trucks which can adjust their height flexibly and transport huge volumes of goods (to lift up the semi-trailer roof and thus increase to transport capacity of the semi-trailer). [2]We speak about a semi-trailer vehicle with modified hydraulic pillars which are technically adjusted to be able to lift up loading space by lifting of the complete roof of the semi-trailer for requested height. The current maximum height, for a semi-trailer, from the viewpoint of safety is 4.85 meters.

However, at the same time it is obligatory for the carrier to check and pay attention to construction options of the transport route to avoid the risk of contact between a vehicle and any construction which pass over the transport route including any cable or other wires. The key role in this process has The Slovak Maintenance Road Service as well as the town itself (in the case that the transport route goes through roads which are under competence of SMRS or the town itself). The benefit of such transport enjoys every side because roads where such transport is realized are damaged less (maximum limit of 24 tones have to be kept), there are fewer truck on those roads, there is a lower level of emissions as well as noise of traffic. However, there is a problem with the legislation [349/2009 about the biggest possible dimensions and weights, 286/2012 Collection of Laws about administrative fees (Item 80)] which increases the cost so much that the transport is financially unbearable for carriers due to an inconveniently setting of legislation which commands the requirement of fee for each transport route from point A to point B and does not pay attention at all repeated transport through the same or different transport route (see Supplying huge industrial companies of various field of production).[5]

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2. SAFETY COMPONENTS USED IN OVERSIZED TRANSPORT FOR INCREASING THE TRANSPORT SAFETY OF OVERSIZED GOODS

The basic component in truck transport for passive securing of goods against falling out from semi-trailer's space is wooden or aluminium boards which are set in the pillars along the edges of the semi-trailer's space. This kind of securing is necessary to increase in oversized transport. An aluminium board with wooden fill has proved as an effective way in practice. It is a practical modification of pure aluminium board which is not fully aluminium but inside space of the desk is filled with flexible wooden board.

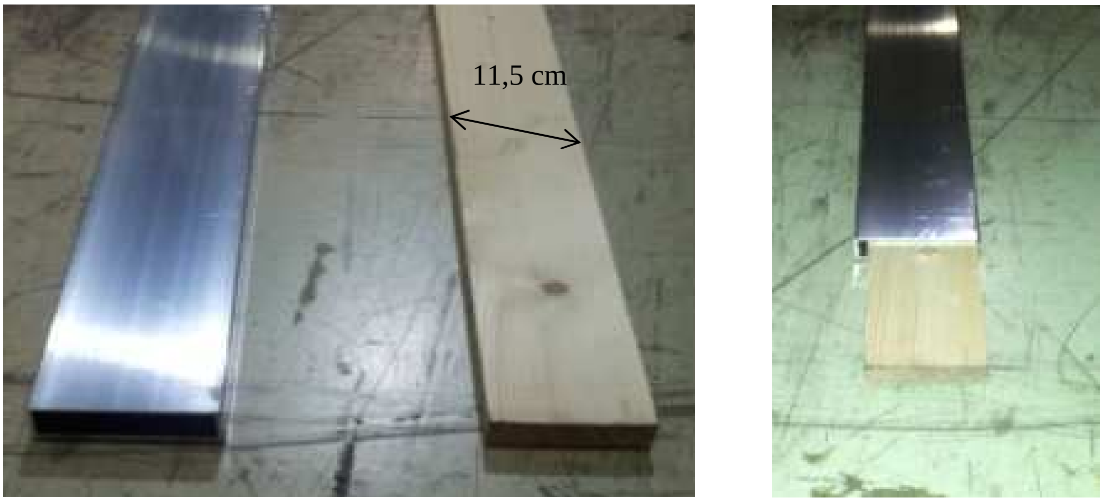

Figure 1 Securing of loading space with Flexi boards (an aluminium frame and wooden fill)

Another component which can be considered as an item which increases the safety within the oversized transport for supplying in automotive industry is an auto-palette made in a special way. It is a 'cup system' which provides loading of two or more auto-palettes on each other without necessity to use other safety items for securing the goods and auto-palettes themselves during the transport. This system provides stability for auto-palettes during the complete period of transport (loading space of semi-trailer have to be equipped by a special anti-sliding floor which is already a standard procedure nowadays).

Figure 2 Display of an auto-palette within the cup system

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3. SYSTEM OF CHECKING FOR TECHNICAL CONDITION OF VEHICLES, CAR PARK OF LOGISTICS FIRM/LOGISTICS DEPARTMENT AND DETERMINATION OF PRIORITIES WITHIN FOUND ERRORS

Regular and systematic checking of the technical condition has almost the most significant influence for increasing of safety. We need to distinguish three types of checking here. There is checking process conducted by specialized service at least once a year and the one conducted directly by a driver/employee at each beginning of a shift [continuous monitoring of technical condition of a vehicle]. There is also a complete checking process conducted by a driver/employee once a month where a detailed report is made as a result of this process. A company always has a current technical condition of a vehicle and is able to plan the most necessary repairs and service maintenance. An employee has accurate information about technical condition of a vehicle they are using for their job.

Checking which is done once a year in a specialized service is the checking which is important from the viewpoint of trouble-free process during the checking of technical condition of a vehicle and the level of emissions produced by it. A company have to eliminate unexpected losses because of idle time of vehicles from the car park caused by insufficient checking of the technical condition. Therefore it is necessary to check each vehicle of carries' car park in the specialized service at least once a year. The carrier has to receive exact and detailed checking report from each conducted checking process. On the basis of the report and after a consultation with the service management, the carrier will decide on following repairs which are necessary to ensure that a vehicle could pass successfully checking of technical condition and level of emissions [3].

Checking which is always conducted by a driver/employee before the beginning of a shift/drive is the checking focused on the most critical points and usually lasts from eight up to ten minutes. Mostly it is a checking process of brakes and steering of the clutch, lights of the vehicle as well as the tachograph and preset data. An important checking which is in fact critical is checking of the pressure in all tyres of the vehicle including random checking of pressure in the tyres. Any suspicion on any checked element is necessary to report to dispatcher who is obliged to conduct such steps to eliminate the technical problem completely and in the case that it is not possible to repair the found error immediately they are responsible to ensure that the error will be temporarily secured until the vehicle gets to a specialized service where the error will be removed completely.

The checking which is done once a month by a driver/employee is the checking which is planned with exact and determined procedures of checking together with a report in which all revealed flaws are recorded in details. It is necessary to sum up and determine the priorities of repairs for all flaws. It is important that the driver, who is employed by the carrier who has the earlier mentioned checking implemented into work duties of a driver, is able to classify the found error according to the priorities of repairs.

A driver who has gained this knowledge and thus attended the training from the carrier/employer knows how to divide the flaws into following priorities. Priority A means that the found flaw does not affect driving characteristics of a vehicle. Priority B means that it is not possible to repair the found flaw by a driver. However, the vehicle is able to get into the specialized service. Priority C means that the found flaw has a critical affect on driving characteristics of the vehicle and it is not possible to get it into the specialized service and therefore it is necessary to call an emergency specialized service. After subsequent summary of all found flaws, the management of the logistic company/logistic department has to set the accurate time plan when the priorities A and B are removed [The plan of maintenance and repairs]. Priorities C are always removed as first and immediately after the flaw is found and assessed as a priority C [a twenty-four hour assistance of specialized centre for service is immediately checked].

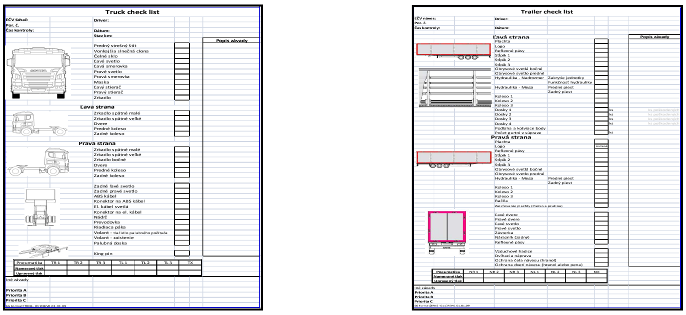

Figure 3 A checking form for a technical condition of a vehicle [checking conducted once a month]. Checking of the hydraulic system of a semi-trailer with adjustable height [maximum height is 4.85m]

The hydraulic system which is a principal pillar for lifting and lowering of the roof construction is the 'Achilles heel' for semi-trailers with adjustable total height. This system consists of more safety elements while the basic safety element are safety locks built in the load-bearing pillars along the edges of the semi-trailer as well as in the front and back of main construction of the semi-trailer [face and the doors of the semi-trailer].

Figure 4 A side movable pillar with the build lock for securing the height of the semi-trailer with hydraulic system with adjustable height [total height 4.85m]

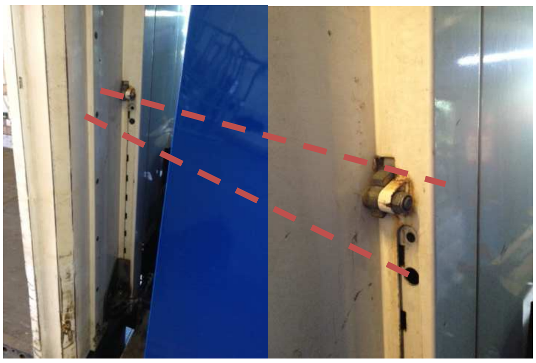

Figure 5 The main safety lock for securing the height of the semi-trailer built in the face of the semi-trailer.

Checking of the hydraulic system can be done only by a person who is delegated to do it [with specific training]. The procedure of the checking is determined accurately and can not be changed by the controlling person themselves because the block up of the hydraulic system can be caused [air is sucked into the system and thus the malfunctioning occurs]. The foundation of the hydraulic system is the hydraulic mechanical pump which is located on a good accessible place on the semi-trailer [usually by the extensible legs of the semi-trailer JOIST]. Hydraulic oil is subsequently pumped into all four shoulders of the semi-trailer through the hydraulic mechanical pump and distribution system with consequent securing of the height because of locks [which are described in details above]. The total tightness of the system and thus its functionality is determined by range of oil leaking from the hydraulic piston [while a little leakage so called 'weeping' is not the flaw] [4].

4. CONCLUSION

Experts perceive sensitively everything regarding to the transport safety whether it is only partial improvements of traffic signs or improvement of carriers for securing of the transported goods or increasing of efficiency and thus decreasing the intensity of traffic. Every improvement of traffic safety is the benefit for all participants in traffic.

Flexi system of aluminium boards as well as Cap system of car palettes has impact on the safety of transported goods. Both systems increase the protection of goods against an unprompted release during the transport.

Checking system of technical condition of vehicles of the car park is active element in the process of improving the traffic safety. It is the technical condition of the vehicle which has the most significant impact on the traffic safety. Avoiding the technical errors and technical problems of vehicles by systematic checking process within logistic companies is the most effective way in the area of safety. The checking system 'PRIORIT' is an effective and applicable in every logistic company. However, the transport manager has to realize the importance of the regular training for drivers/employees, so they can keep the level of knowledge of responsible drivers who conduct the checking directly.

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COMPLIANCE OF CERTIFICATION REQUIREMENTS FOR THE AIRPORTS OPERATION

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Abstract: *Operation and management of airports with public air transport must first ensure maximum safety of air transport. There are many legislative guidelines, regulations and requirements for the management of air traffic, resulting from various fields such as economic (trade), environmental, energy, security etc. And it's compliance with international requirements and reliability certification system is subject to both technical equipment of airports, but especially the management and organization of activities related to airport operations.*

Keywords: *certification requirements, compliance standards and recommendations of the ICAO safety management system of airport operations, airport operations specialist authorities.*

1. INTRODUCTION

The European Aviation Safety Agency - EASA gradually assumes more and more responsibilities for aviation safety in order to ensure a uniform level of safety in aviation in the member states of the European Union (EU). Following a substantial extension of its competencies, the Agency focused onto airports and air traffic management systems. As a result of its mandate, the EASA develops standardized, comprehensive and binding regulations dealing with airport design, its operation and equipment on the basis of Annex 14 to the Convention on International Civil Aviation - Aerodromes, Volume I Aerodrome Design and Operations.

This set of standards and recommendations is representing standardized application-specific international norms based on ICAO documents:

- Doc 9157, Aerodrome Design Manual,
- Doc 9774 Manual on Certification of Aerodromes,
- Doc 9184, Airport Planning Manual,
- Doc 9137, Airport Services Manual,
- Doc 9859 - Safety Management Manual,
- Doc 9476, Manual of Surface Movement Guidance and Control Systems,
- EUR Doc 015, European Guidance Material on Managing Building Restricted Areas.

However, the EASA but in their documents and applications being prepared must also allow sufficient flexibility of physical limitations and operational specifications (size and type of operation) of airports in the EU.

2. SAFETY OF AIRPORT OPERATIONS

The current management system of aviation safety in Europe is based on a set of rules issued by the EASA and the National Civil Aviation Authorities (NCAA). These organizations during the recent decades effectively ensured not only fair results in the field of aviation safety, but also their continuous improvement. To manage the organization of safety management system it is necessary to have a focal point, an organization possessing the resources and facilities that ensure the efficient functioning of the entire system.

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Due to the maintenance and enhancement of security at European airports, the EASA has decided develop a study on understanding the ICAO requirements by the aviation bodies of the member states. For this reason, a study was prepared to transpose ICAO Annex 14 into national law, the certification process specification of airports and airport facilities in these countries and implementation rules and principles of the Safety Management System (SMS) at EU member state aerodromes. The reason for this study is the Single European Sky - Package II, which contains amendment to Regulation EC no. 216/2008 of the EC Regulation 1108/2009 - the rules and standards of accountability for safety at public airports. Given that future EASA rules should replace national laws on airport safety, the EASA needs to obtain specific information on the current situation in the EASA member states.
In advance, collected and analyzed were the data from the various civil aviation authorities and airports via comprehensive on-line questionnaires to ensure extensive preparation for audit interviews. Then the individual monographs of countries were compiled. Using this methodology, an analysis of deficiencies was made of deficiencies in the member states, in essence when answering the question "Where professional sees major potential for improvement?" In addition, different national concepts were specified relating to the implementation of ICAO requirements, specific areas of national issues and the so called "best practices" [1, 2].

3. LEGISLATIVE FRAMEWORK

Following the implementation of the current Annex 14 in the national legislation, there is a great variety in the levels of congruence. Significant differences can be observed in some cases, especially due to delays in rulemaking at national levels.
The main differences in the implementation of ICAO requirements in member countries:

- Requirements of Annex 14 taken as fully binding;
- Requirements integrated into the different national laws, each of them having different legal claims;
- Requirements implemented into a single national law in combination with all the other seventeen ICAO Annexes;
- Implementing only standards;
- Recommendations declared as mandatory and more strict than national requirements as by the ICAO;
- ICAO (Annex 14) Requirements not yet implemented into the national aviation legislation at all.

The key role of two questions:

1. The first question can be related to the type of national legal and legislative system. In cases where an individual member states accede to the implementation of the provisions of Annex 14 to Regulation Ordinance or acquiring force solely under the auspices of the parliamentary session. Its introduction and update in itself is very complex, lengthy, and largely politically motivated. Political changes and choices can affect the ongoing application of the regulatory process. In contrast, in the case of direct implementation of law enforcement were fully allocated sufficient authority Civil Aviation Authority (CAA-Aviation Authority), which is able to issue binding regulations and update national legislation to change Annex 14, reflecting the rapid implementation and implementation at national level.
2. The second problem with the timely and full implementation of the specifications contained in Annex 14 is in the limited capacity of professional bodies. In almost all countries is noticeable shortage of professional staff. For this reason, the authority concerned is able, with difficulty, to achieve the introduction of national legislation in full, and mostly updates for nationally lengthen the time. The new EU member states have had to deal with particular problems. After creating a wholly new independent administration and legal structures, the also had to cope with complex legal and administrative changes in preparation for accession to the EU.

Very often, an important role in the quality and compatibility of national legal sphere is played also by state involvement in direct air services. If the state was the operator of all or most national airports and perhaps also the national air navigation services (Navigation Service Provider - ANSP), the legal field proved mostly inadequate. The lack of separation between state and airport operations and the lack of independence supervisory certification bodies results to less-developed rules [1, 2].

4. THE ROLE OF THE STATE IN IMPLEMENTATION OF THE REQUIREMENTS OF THE AERODROME CERTIFICATION

In some countries, certification of aerodromes (Licensing) follow the procedures that have been established decades ago. Although they introduced the term "certification" in each case the certification of airports, basically almost completely satisfy the requirements of the concept of "ICAO certification". In some of these countries were existing regulations subsequently adapted ICAO requirements. In other countries, applicable and appropriate legal support and implementation of aerodrome certification was unsuccessful for various reasons:

- legal and constitutional provisions have been subject to significant changes, which then do not ever facilitated really relevant legislative processes;
- introduction of regulations and legislative requirements were subjected to political and legal obstruction because of frequent political changes in the country;
- delayed implementation of aerodrome certification was associated with inadequate or delayed professional service supervision. The authorities were either not legally entitled, not accustomed to the challenges of a complex certification process or have become incompetent due to personnel issues;
- outside professional support had to be taken, just to get things started in the certification of aerodromes;
- main attention was paid to only the main (controlling) airports in the state and thus the associated compliance certification requirements, while other airports have been marginalized because of the low representation of international traffic and thus limited (modified) requirements for the certification process.

Regarding certification in related fields of aviation can be argued that the expected new European rules for the certification of airports in the countries a variety of regulatory influences can be expected. In particular, harmonization of existing national licenses in the certification of airports and land use planning practices could play a major role in the number of certified airports [2].

5. THE ROLE OF THE STATE IN THE IMPLEMENTATION OF SMS REQUIREMENTS

The biggest challenge for both airports and the governing bodies is undoubtedly the area of safety management system (SMS) in its entire scope.

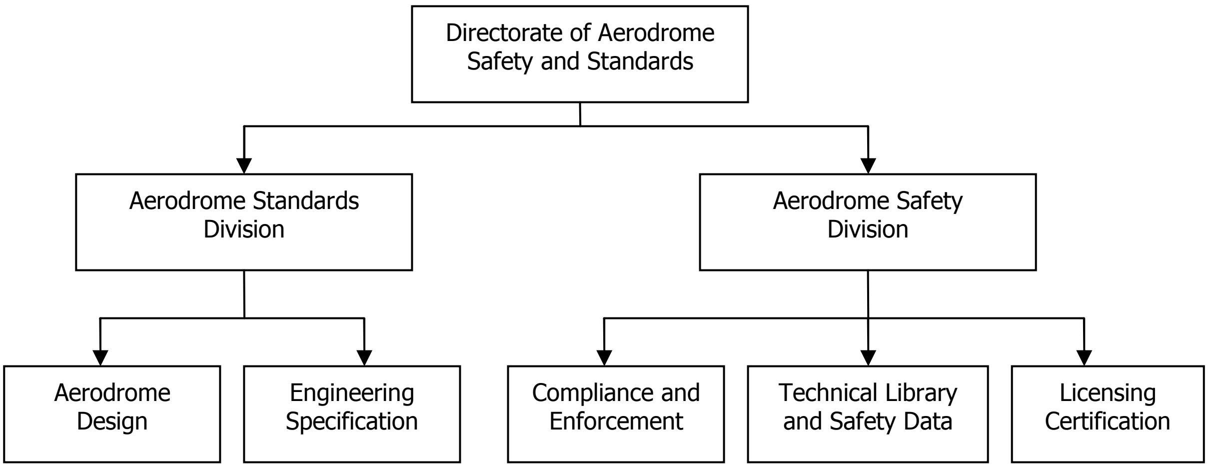

Figure 1 Organizational structure of a typical aerodrome Safety and standards directorate

In summary, we can say that only a few countries have seen development of the SMS and successful implementation at high level. In countries with airports in very difficult terrain and bad weather conditions very interesting approaches were taken to manage the urgent needs at a large number of necessary deviations from the actual standards. In other countries, there are basic standards and requirements, but real applications and real traffic SMS does not yet exist. There is a big range of different levels of compliance with the safety system, even different national views on the part of air traffic SMS (reporting, internal audit, risk management, accountability).

Only in a few countries there is a rapid and sustained enforcement of the requirements, promotion and monitoring of the effectiveness SMS airports by the aviation authorities. In addition to staff shortages the authorities often have to deal with a large number of new requirements, which require highly sophisticated knowledge and training. However, such training is available only in a limited extent and thus there are few specialists. This possibility is further limited due to the difference in earnings between industry and public services. Airport operation consists of various tasks of organizations such as the airport operator, air traffic control service providers at the airport, but the role of SMS should be based on a common source and directed towards one goal - to maximize the safety of air transport. These tasks should be managed by one manager with the relevant powers and responsibilities. Therefore, future EASA rules on SMS airport operations will grow in importance considerably. New rules will have to be accepted by a wide range of existing safety issues, such as the implementation of more and more integrated airport management systems. [1]

6. NATIONAL PROFESSIONAL BODIES

In most cases, total resources personnel authorities tend to be the lacking or rare. Authorities in the countries where they ICAO Annex 14 is directly used, have nothing or only a limited amount to do with law enforcement procedures, and may focus more intensively on the implementation of guidelines and oversight of airports.

Figure 2 Method of evaluating the implementation of Annex 14

Establishing rules for small airports (outside the EASA) remains at a national competence. In this regard, one can speak of a double load. To compensate for this disadvantage, the future European rules must be on a qualitatively higher level, clearly and comprehensively structured to provide support for activities by national authorities. To allow for a condensed overview of the respective areas the individual matrixes are summarized for the important structural and operational areas [1].

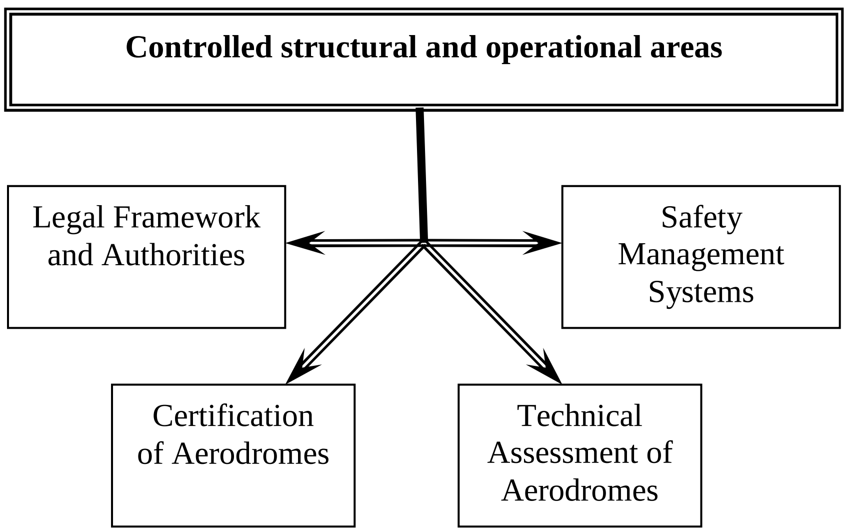

Figure 3 Controlled area

Technical assessment:

a. Use of ICAO documents in practice
b. Use of deviations from Annex 14
c. Handling deviations
d. Safety Management System
e. Change Management
f. Compliance with ICAO standards
g. Compliance with ICAO recommendations

7. CONCLUSION

The new legal framework EASA must fill in the gaps visible in the current state and must be based on a flexible approach to airport operations. Taking into account the wide range of variations in airports and their potential impact on operational safety, it is essential to establish clear rules for the management and particularly to the assessment of those variations. Although national certification (licensing) and procedures vary widely and in some countries to a certain extent do not exist at all. National authorities in some member states are not fully prepared for the professional duties of civil aviation, either because of their lack of mandate or staff vacancy. Within the EASA the l activities and responsibilities associated with the operation of the system are not performed in full. Systematic approach requires the cooperation of all subjects, partnership approach of the member states, EUROCONTROL and stakeholders aviation industry, as well as providing the feedback.
National SMS concept, where each step there is need for clear definition of detailed and appropriate requirements for SMS at airports, will most likely result in a major impact on the governing bodies at airports: a) Application of the safety management system to all interested components of air traffic at the airport. b) New rules and structure of the SMS to must be into account the integrated management systems of airports. These should support solutions and flexibility of rules for the airport operator.

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SOLUTION OF NAVIGATION TECHNOLOGIES FOR SCIENCE SYSTEMS ON MARS

Jozef KOZÁR[1] - František ADAMČÍK[2]

Abstract: *The article deals with the possibilities of using means of navigation based of global navigation for Mars mission. Research in this area should help to process the theoretical concept of a small satellite navigation system.*

Keywords: *navigation system, Mars, global navigation system, space probes, planetary navigation, GNSS*

1. INTRODUCTION

Current technological research of nearby planets with mobile or static planetary probes is one of the most expanding sectors of space and planetary research. This way of research of celestial bodies in our Solar System contributes to understanding of an evolution of the worlds on our neighbouring planets and also it helps to investigate the existence of conditions once suitable for life in the past or at present.

The probes used in this research require precise navigation and positioning system for recording of the position on the surface, for detail mapping and examination of the planet's surface and also for ensuring of the high-precise navigation and orientation in the areas usually unknown and even potentially dangerous.

2. SATELLITE NAVIGATION SYSTEM FOR PLANET MARS

Systems usually used for navigation and positioning are various, mostly depending on the primary science mission of the probe. These can be based on different principles of navigation and positioning. Whether it's a single inertial navigation, intelligent navigation, or comparative navigation system, in almost all cases, they have several disadvantages. These disadvantages are represented in various forms - high costs of development, reliability of the system, its accuracy, durability or the guaranteed time of correct functioning of the system and also the suitability or unsuitability of the system for geodetic measurements for determination of the exact position in desired area of the planet's surface.

Most of current planetary science systems are focusing on research and investigation of our very similar neighbour planet – Mars. Present and past Martian probes mostly used for their positioning the complex navigation systems, consisting from inertial navigation and various intelligent navigation systems. These systems are accurate, but their disadvantage is the limitation of use on small area. An every move away from the target research area must be mathematically computed and re-validated by ground control teams on Earth.

Another main disadvantage which should be mentioned is the high price of development of the complex navigation systems for these probes. Almost every probe or rover is different and its final price is limited by the mission budget. Part of the budget spent on development of the navigation system could be spent on scientific research of the probe itself and this way can be used more effectively in every such mission.

Solution for this trouble could be the design and use of the Martian own satellite navigation and positioning system. This system will be developed only once and it could be used for multiple missions - for static probes examining the desired target on surface, for mobile rovers on Mars investigating the conditions in larger areas and also for any possible flying probes or satellites on lower Martian orbits.

The technology of operation of orbital based satellite navigation systems is nowadays well known. The satellite navigation system can operate in two forms - like a global navigation satellite system or

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like a local satellite navigation system. Global navigation system would be able to cover the whole surface of planet with its navigation services and the local system would be able to cover the desired area. Correct functioning of the entire fleet of all satellites is necessary in the global satellite navigation system. In this variant, a correct synchronous activity of at least 24 satellites around a planet comparable to planet Earth in its size is therefore essential. Local satellite navigation system does not require such amount of satellites for its proper functioning. Only three satellites are necessary to determine the position on the surface of the planet. But for a potential use of the system in wider range, this number will increase accordingly.
One could say "Yes, the construction of the satellite navigation system and its operation will cost much more than use of traditional systems like before" – this opinion is correct, but unfortunately in one way only. The construction of the system would take some extra costs, also its operation would not be for free. That's true. But use of this system will allow us to reduce the costs of every scientific mission to planet Mars. The system would be fully autonomous and would be controlled by ground segment based on planet Earth. Satellite navigation system for planet Mars could later offer us more other features, for example the improved data communication channel based on relation principles. Each satellite in the system would be communicating with other satellites and this way it can also provide the communication coverage for rovers or probes in desired area. It could make the exchange of the scientific and technical data more effective and easy.

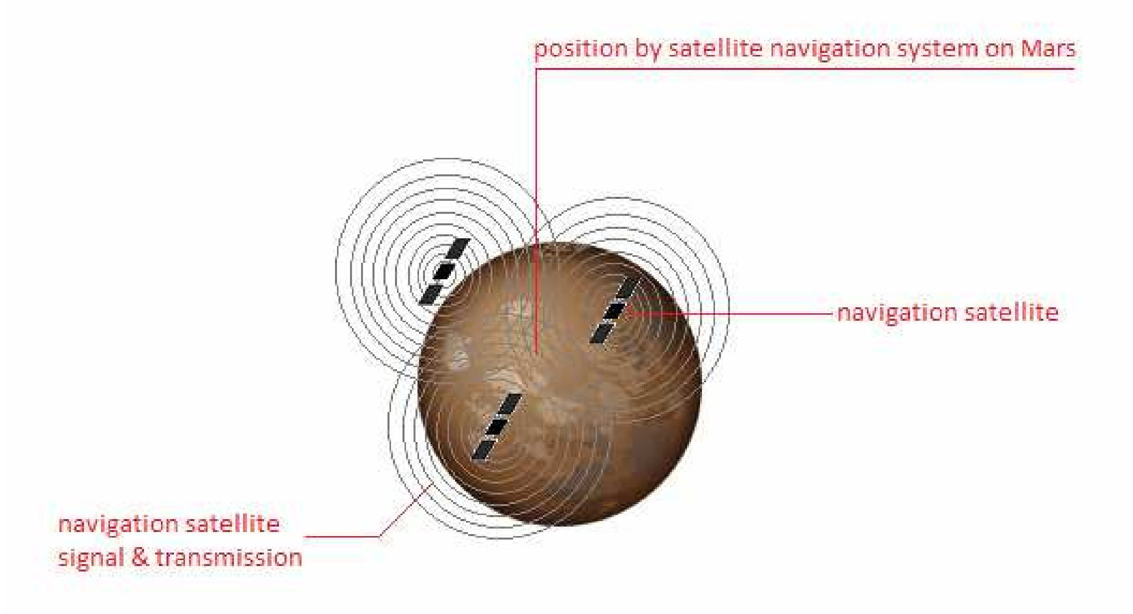

Figure 1 Position achieved by navigation satellites orbiting Mars (image credit Jozef Kozar)

3. CONCLUSION

Navigation systems are in today's world the integral part of the research devices on any celestial body in space. The current technological possibilities of mankind are practically allowing us to build and to use any positioning system anywhere. Although there are many conditions which need to be met, we can still see three of them – financial costs, precision in navigation and multiple usability in more missions. Therefore, it is very important to consider all of them, because they are one of the most important factors to guarantee the success of any mission in the space.

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THE ISSUE OF BIOMETRIC IDENTIFICATION OF SENIORS

Lucie KRCALOVA[1]

Abstract: *The paper discusses the use of perspective (most used) biometric methods for identification of older people (seniors). It compares the possibility of using different methods for this age group, and specifically focuses on the biometric identification method of users according to the structure of veins on the wrist.*

Keywords: *biometrics, identification, seniors, veins, wrist*

1. INTRODUCTION

Unambiguous identification of an individual is today, given the increasing security risks, a highly relevant topic throughout the world. For this reason, biometry is a field that is receiving increasing attention. Biometric features of each individual are unique, non-transferable, and inalienable and we carry them with us all the time. Popularity of biometric identification methods is influenced on one hand by increasing security risks, and on the other by technological advancements and improving financial accessibility. Biometric characteristics are sought after by private companies for identification of their employees and protection of property, and increasingly also by states' bureaucracies, for example in issuing of biometric passports. It is expected that biometry will replace traditional identification methods. [1]

Biometric methods most commonly utilized are: fingerprints, hand and face geometry, structure of vessels in a retina, and structure of bloodstream of a palm or back of a hand or finger. My research focuses on identification of an individual utilizing structure of bloodstream in a wrist, particularly of persons of age 65 or older.

2. DEFINING THE TARGET GROUP

Number of seniors, that is persons of age 65 or older, steadily increases. Longevity increases due to accessibility of medical care, medical prevention, growing living standards and other factors. Senior citizens remain longer professionally and socially active. They attend to administrative matters, use public transportation, travel abroad etc. At the same time, social pressure for independence is very high. Nevertheless, ageing is accompanied not only by health problems, but also every day symptoms, such as lower efficiency, decreased memory capacity, and challenge of making sense of information surge or accepting change.

Utilization of unambiguous identification employing biometry, or rather one concrete biometric feature, would simplify everyday tasks for this age group (as well as for others). Seniors (but not only) would not need to carry any identification documents, bank cards, or keys. They would eliminate worries about forgotten or lost items or passwords, as well as costs associated with their replacements.

3. COMPARISON OF POSSIBLE USE OF MOST FREQUENT BIOMETRIC FEATURES FOR SENIORS

As stated in the introduction, currently the most widely used biometric methods for identification and verification of an individual are: fingerprints, hand and face geometry, structure of vessels in a retina, and structure of bloodstream of a palm or back of a hand or finger.

3.1 Fingerprint

Advantage of identification of an individual using fingerprints is the ease of obtaining comparable samples, their availability from a high number of sample sources (10 fingers) and also the fact that they can be obtained from majority of population. If fingerprints are taken by a touch sensor, then

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shaking hands of older people can be problematic. Also, fingers must not move and optimal pressure must be applied – not too light but also not too strong as not to damage the sensor. In order to use a method of sliding a finger across a silicon sensor, the user must slide the finger in a very exact manner. This method is not intuitive and it can be generally said that older people are averse to following such methods. Fingers may not move either when using contactless sensor, which may be either optical or ultrasound.

3.2 Geometry of the face

Biometric method based on face geometry examines the shape of the face and location of optically significant features, such as eyebrows, eyes, nose, or mouth. The scanner then records the distance between the eyes, lips and nose etc. This method is considered to be user-friendly for seniors.

3.3 Geometry of the hand

Hand geometry does not capture one particular biometric feature and is therefore utilized for medium-level security needs. Reference sample of seniors might change though, for example due to swollen fingers, arthritis (deformation of joints or fingers) or change of fingers' thickness. On the other hand, laying the hand down into the scanning position can prevent shaking of hands.

3.4 Retina of the eye

Identification of an individual through a retina involves scanning of vessels structures in the optic fundus in the area of blind spot. If the senior wears glasses (which seniors commonly do) they must take them off. In addition, it might be difficult for them to focus on a target. Persons with astigmatism might also find it challenging to localize and fixate on a target.

3.5 Structure of bloodstream

Use of structure of bloodstream as a biometric indicator is relatively new and was enabled by greater accessibility of the required technologies. Bloodstream of a palm or back of the hand is the most commonly used identification feature. The most common technique utilized now in the private sector is scanning of the finger bloodstream. This is a user-friendly method, which at the same time offers a high level of security. This group of biometric methods includes also identification of user according to wrist bloodstream, which is described below. The challenge of this method, when applied to seniors, lies in occurrence of illness, bloodstream changes, or effects of medication (more in the next chapter).

The above analysis suggests that each method poses varying degrees of challenges when applied to seniors. Biometric feature least affected by ageing is face geometry. This biometric method is however not the most secure one – face can be changed by plastic surgery. Scanning of face also requires appropriate illumination.

4. USER IDENTIFICATION BY WRIST BLOODSTREAM WITH FOCUS ON SENIORS

4.1 Description of the method

Biometric method based on scanning of wrist bloodstream is highly secure. Veins are located beneath the body surface and their appearance cannot be falsified. In addition, acceptable sample can only be collected from a living human being. This method is user-friendly and comfortable and since it does not require contact with an apparatus, it is hygienic and non-invasive. This method also provides unambiguous identification of an individual. Even wrist bloodstreams on the left and right hands of one individual are not identical. This method is relatively new and not yet very widespread (first commercial systems were utilized in 2000). Wrist vein structure is an easily accessible biometric feature, offering high potential for administrators and user-friendliness for users.

4.2 Scanning method

Wrist vein structure can be scanned by special cameras using infrared light. Resulting scan displays black and white distinct pattern of veins. The infrared light scans the hand and as a result of differing reflection of veins and surrounding tissue produces an image. Contrast between the veins and surrounding tissue is accentuated by the infrared light. Blood carries oxygen throughout the body. It binds hemoglobin and produces oxyhemoglobin, which spreads through the veins' surface and carries oxygen to the surrounding tissue. This is what allows us to see the bloodstream image. Hence, only living persons can be screened. [2]

4.3 Use the device

In my research, in order to scan the bloodsteam I use apparatus called PalmSecure produced by Fujitsu, which contains LEDs emitting infrared light. It scans the desired area and at the same time captures the image around the infrared area. The second apparatus which I use is a reflex photo camera Nikon and infrared additional lighting. This camera obtains clearer results, as can be seen in Figure 1 and 2. Figure 1 shows bloodstream scanned by PalmSecure, while Figure 2 was obtained by Nikon. When these images are vectorized, they can be further worked with – they can be algorithmized. Their size is also lower.

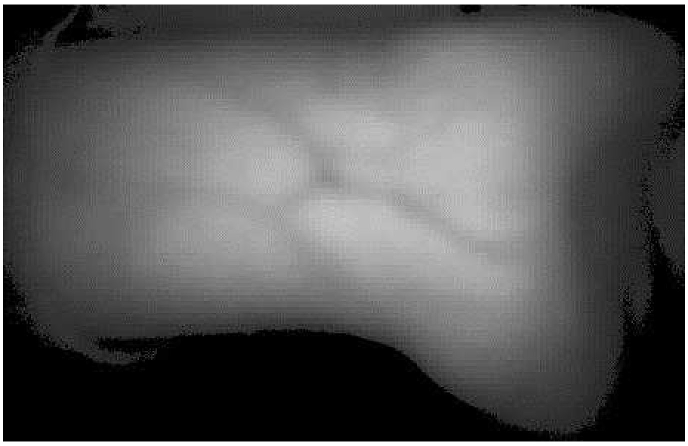

Figure 1 PalmSecure

Figure 2 Nikon

4.4 Seniors

Due to ageing, veins undergo degenerative changes, such as vein hardening, inflammation, blockage or clotting. These diseases are commonly treated or moderated. Medication intake can, however, negatively impact the resulting image quality, just like the degenerative changes themselves. Figure 3 displays wrist of an 83 year old man. He takes Godasal, medication to dilute blood and prevent clotting. Another medication, which this man uses regularly to lower the levels of cholesterol in the bloodstream, is Torvacard. Figure 3 clearly shows degenerative changes of the vein structure and negative impact of medication on the image quality. Changes in blood density (dilution) decrease the contrast between veins and surrounding tissue and their structure is therefore obscured. As a comparison, I also show a wrist of a 35 year old woman (Figure 4) which does not take any medication and does not suffer from any vascular disease.

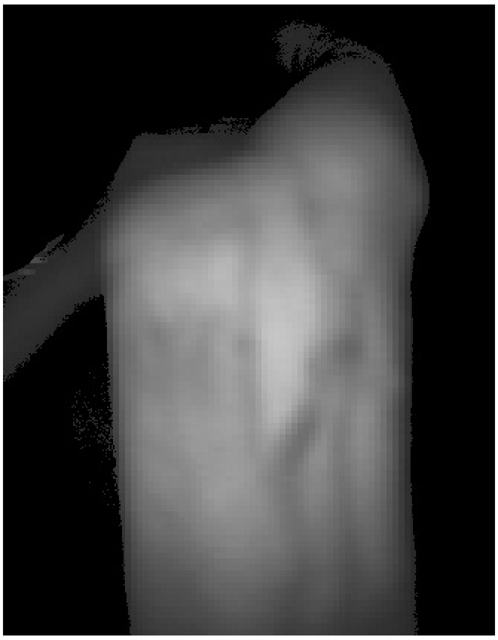

Figure 3 The structure of the veins on the wrist (man, 83 years)

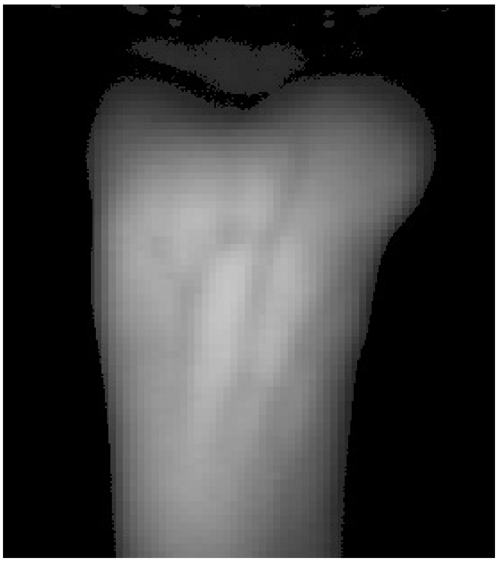

Figure 4 The structure of the veins on the wrist (woman, 35 years)

4.5 Collected data

Sample collection involved several stages. In the first phase, I measured reference samples. I noted the following parameters for each: age (65 and older in all cases), medication (especially for vein disease treatments), and other health-related information (for example smoking). Each individual was then scanned several times and each scan was accompanied by information concerning regular medication intake, presence of cardiovascular disease and whether or not verification took place. The collected data revealed that the verification success rate decreased substantially when the individual was taking medication for cardiovascular disease.

5. CONCLUSION

Treatment of deficiencies in venous circulation is common today. In order to contribute to a more widespread use of this biometric identifier, I will focus my future research on looking for a suitable algorithm that would compensate negative impact of medication on the process of verification of seniors.

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OPERATIVE DETECTION AND CLASSIFICATION OF IONIZING RADIATION SOURCES

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Igor ANTALÍK[5]

Abstract: *Searching of hazardous radioactive materials and equipment in transports, transport packages and suspected material is highly important in security and military operations. In terms of stationary control systems used to secure airports and border crossings, the problem appears to be sources of gamma radiation detection, or detection of neutron sources, as well solved. Operative detection of such materials in transports, or in containers, using portable detectors, is for military operations at least equally important. Detection of radioactive sources of gamma and neutron will be influenced in this case by the type of a detector, the time of the acquisition, the speed of the source, the distance between the detector and source and also the type of the material between the source and detector. It is difficult to determine the source of alpha and beta ionizing (not gamma) in suspected materials while they are protected by a suitable packaging. For the detection of the expected range of risks were used semiconductor detectors, Geiger - Müller sensors and gas proportional detectors. Using portable NaI (Tl) and HPGe spectrometers for an in-situ gamma spectrometric analysis, gives the possibility of a provisional identification or a selective searching on the basis of typical energies. Using measurements of the energy spectrum of neutrons N (E) for operational measurements also appear as significant. Application of the PFNS methods (Prompt Fission Neutron Spectra) may allow a classification of neutron sources as* ^{252}Cf *or* ^{239}Pu*, but also the detection of dangerous nuclear facilities at relatively large distances*

Keywords: *radioactive, detector, trafficking, transport*

1. INTRODUCTION

Nuclear technology for peaceful purposes is traditionally understood in context of nuclear power plants. Apart from the use of nuclear energy to produce electricity from power reactors, it has also been used extensively in agriculture, medicine, industry, biology and hydrology. Some of the more common radionuclides are listed in Table 1 [1]. Everyday use of radionuclides necessarily involves trafficking and transportation of radioactive material. In Slovak Republic transportation of such material must meet obligations under Nuclear Regulatory Authority of Slovak Republic ordinance no. 58/2006 [2].

A radioactive material trafficking outside of the regulatory and legal frameworks is becoming an important phenomenon in last decade. Illicit trafficking of radioactive materials may either be deliberate or inadvertent. Deliberate, illegal movements of radioactive materials, including nuclear material for terrorist, political or illegal profit are generally understood to be illicit trafficking. The more common movements outside of regulatory control are inadvertent in nature. An example of an inadvertent movement might be the transport of steel contaminated by a melted radioactive source that was lost from proper controls [3]. Experiences in last decade indicate that there is a significant probability of trafficking of radioactive material associated with terrorist activity.

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Terrorists have essentially four ways by which can they can exploit military and civilian nuclear assets:

- The theft and detonation of nuclear weapon,
- The theft or purchase of fissile material leading to fabrication and detonation of improvised nuclear device (IND),
- Attacks against and sabotage of nuclear facilities such power plants, causing the release of a large amount of radioactivity,
- The unauthorized acquisition of radioactive material contributing to the fabrication and detonation of a radiological dispersion device (RDD) or radiological emission device RED) also called dirty bomb [3].

Table 1 Some of the more common radionuclides

^{241}**Am**	in moisture gauges, smoke detectors,	^{85}**Kr**	to gauge the thickness of thin plastics and sheet metal,
^{133}**Ba**	in portable gauges to detect void spaces.	^{55}**Fe**	to analyze electroplating solutions and gauging.
^{109}**Cd**	to analyze metal alloys for checking stock and sorting scrap	^{32}**P**	in molecular biology and genetics research
^{47}**Ca**	biomedical researchers studying the cell function and bone formation of mammals	^{63}**Ni**	to detect explosives, and as voltage regulators,
^{252}**Cf**	frequently used neutron source for well logging in oil field exploration, moisture gauges,	^{210}**Po**	reduces the static charge in the production of photographic film,
^{14}**C**	in organic synthesis and biochemistry for labeling of compounds,	^{238}**Pu**	Used for pacemakers, space applications, radioisotopic thermoelectric generators (RTGs),
^{137}**Cs**	for gamma radiography, gauging, to treat cancer, to measure and control the liquid flow in oil pipelines,	^{147}**Pm**	to gauge the thickness of thin plastics,
^{51}**Cr**	for research purposes in red blood cell studies	^{224}**Ra**	in the past in many different applications such as luminous paint
^{90}**Sr**	in RTGs, thickness gauges, calibration, medical treatment (brachytherapy),	^{75}**Se**	in protein studies in life science research and in radiography
^{60}**Co**	teletherapy, gamma radiography, gauging, to sterilize surgical instruments and to preserve poultry, fruits and spices,	^{24}**Na**	to locate leaks in industrial pipelines and in oil well studies
^{67}**Cu**	when injected with monoclonal antibodies into a cancer patient, helps the antibodies bind to and destroy the tumor,	^{57}**Co**	in nuclear medicine to help physicians interpret diagnostic scans of patient organs,
^{244}**Cm**	in mining to analyze material excavated from drilling,	^{99m}**Tc**	the most widely used radionuclide for diagnostic studies in nuclear medicine,
^{67}**Ga**	for localization of inflammations and tumors,	^{3}**H**	for self-luminous aircraft and commercial exit signs; for luminous dials, gauges and wristwatches,
^{131}**I**	to diagnose and treat thyroid disorders,	^{235}**U**	for nuclear power plants , also used to produce fluorescent glassware,
^{192}**Ir**	for gamma radiography to test the integrity of pipeline,	^{133}**Xe**	in nuclear medicine for lung ventilation and blood flow studies,

1.1 Detection of ionizing radiation

The term detection means in the use of an instrument or device to determine the presence and level of radiation. The key factor for detection and identification of radioactive material is that this material emits ionizing radiation. This radiation is measurable using detection instruments.

There are five types of detection devices:

- **Fixed radiation portal monitors (RPMs)** are pass-through type monitors typically consisting of two pillars containing gamma radiation detectors and usually neutron detectors, and monitored from a display panel. They can provide alarm capability to indicate the presence of nuclear or radioactive material above a preset threshold. Portal monitors are used for personnel, vehicles, packages and other cargo in a variety of venues. Typically, all these applications use instruments that are either personnel or vehicle portal monitors.
- **Personal radiation detectors (PRDs)** are radiation detectors approximately the size of a telecommunications pager, which can be worn by front line officers. PRDs can provide a flashing light, tone, vibration or numerical display that corresponds to the level of radiation present.
- **Hand-held gamma and neutron search detectors (GSDs and NSDs)** are radiation detectors used to identify the location of radioactive material. GSDs and NSDs provide greater sensitivity than do PRDs.
- **Hand-held radionuclide identification devices (RIDs)** are radiation detectors that can analyze the energy spectrum given off by a radionuclide to identify it. They can be used also as survey instruments to locate nuclear and other radioactive material [1].

Two modes of operations are distinguished by this standard:

- Transient mode when the measured radioactive source is passing through the monitor's detection zone;
- Static mode when the measured radioactive source is in the detection zone and is not moving [4].

1.2 Identification of radionuclides in suspicious material

Meeting the IEC 62327 requirements for identification of an single radionuclide is divided into 3 ategories:

- unshielded radionuclides;
- shielded radionuclides by 3 mm of steel;
- shielded radionuclides by 5 mm of steel.

Shielding has been chosen to be representative of commonly used transportation equipment and does not comprise the whole variety of possible shielding. The following are the minimal criteria that instrument must meet for identifying single radionuclide within the times indicated after exposure to the radionuclide:

- unshielded, in 1 min: ^{111}In, ^{133}Xe, ^{99m}Tc, ^{201}Tl, ^{67}Ga, ^{125}I, ^{123}I, ^{131}I, ^{18}F;
- behind 3 mm steel shielding, in 2 min: Low Enriched Uranium (LEU), Reactor Grade Plutonium (RGPu), Highly Enriched Uranium (HEU), Weapons Grade Plutonium (WGPu), ^{57}Co, ^{241}Am, ^{237}Np;
- behind 5 mm steel shielding, in 2 min: (Highly Enriched Uranium - HEU), RGPu, HEU, WGPu, ^{133}Ba,^{40}K, ^{226}Ra, ^{232}Th, ^{137}Cs, ^{60}Co, ^{192}Ir [6].

From this point of view the detection, classification and identification of radionuclides, which have relatively low activities, but can present considerable safety risk associated with terrorist activity including criminal or unauthorized acts, can be very important for practice.

2. EXPERIMENTAL

2.1 Instrumentation

Instruments used for this experiment were portable gamma spectrometer DETECTIVE-EX (ORTEC) with electrically cooled HPGe detector with dimensions 50 x 40 mm and energy range from 30 keV to 3 MeV, portable gamma spectrometer IdentiFINDER (ThermoScientific) with NaI(Tl) detector with dimensions 35 x 51 mm with energy range from 20 keV to 3 MeV.

For detection and identification of ionizing sources in transport vehicles MDS-134A (TSA Systems) with two plastic scintillator detector with dimensions 121 x 30 x 3,8 cm was used. Ionizing sources of ^{133}Ba with activity 87,94 kBq (reference date 10.4.2000), ^{137}Cs with activity 333 kBq (reference date 5.6.2002) and source of natural uranium as 10 g uranyl acetate (Fluka). Isotopic composition of natural uranium was analyzed using alpha spectroscopy. Steel plates 3 mm and 5 mm thick and lead shielding block 50 mm thick were used for shielding purposes.

2.2 Measurements conditions

Measurements were realized in five phases to determine detectors efficiency under in-situ determination conditions of unshielded sources. Sources of ionizing radiation with relatively low activities were chosen for their somehow difficult detection and identification.
Detector effectivity to detect and identified unshielded source was realized under normal atmospheric conditions (20°C, 62 % relative humidity and 101,320 hPa o fair pressure). Levels of background gamma and Roentgen radiation were measured and expressed as dose equivalent rate of 0,036 µSv/h. Shielded radiation sources were measured at distance of 250 mm from detector. In – situ gamma spectrometric identification of radioisotopes was realized using GammaVision-32 software.

3. RESULTS AND DISCUSSION

Ability to detect gamma radiation of ^{133}Ba using MDS-134A behind steel shielding with 3 mm thickness was reduced with increasing distance of source from detector cap (Figure 1). Maximal distance where it is still possible to detect and identify low activity source (in our study ^{133}Ba with activity 36,77 kBq to the date of measurement) is 250 cm. At this distance it is also possible to distinguish the source from the background.
For identification of radionuclides the limiting factor would be energy resolution of detector. As seen from Figure 2 and 3, NaI(Tl) detectors have much lower energy resolution compared to HPGe detectors what can result in problematic detection and identification of mixed radioisotope sources with similar energies of emitted photons.

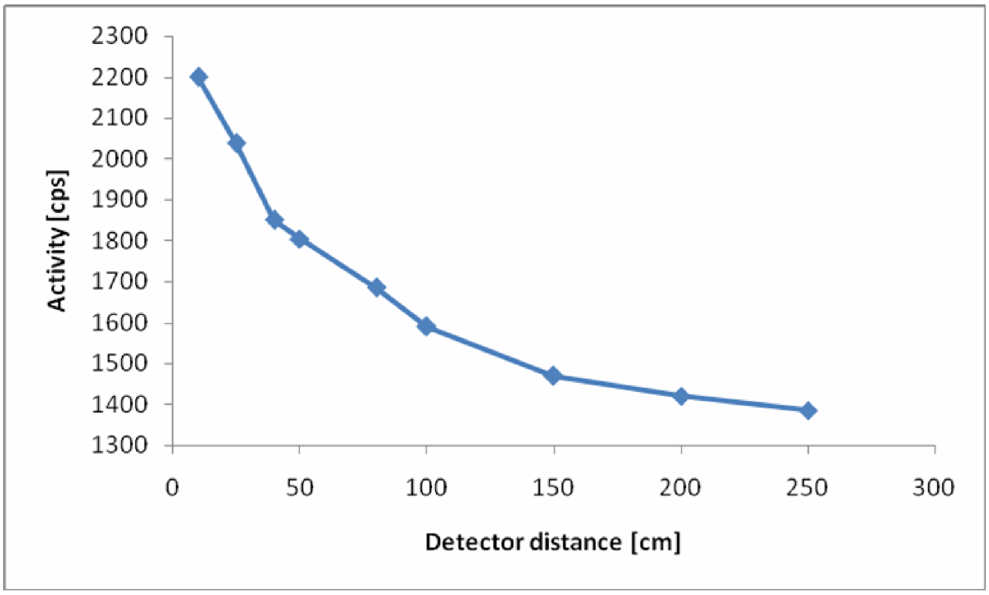

Figure 1 Dependance of activity of ^{133}Ba and distance from MDS-134A detector

For NaI(Tl) detector the limiting distance for identification of ^{133}Ba was 10 cm at 30 second long acquisition. For HPGe detectors the limiting distance of detector from source under same experimental conditions was 2000 mm at 600 seconds long acquisition. HPGe detector efficiency for several energies of point source of ^{133}Ba is shown on Figure 4. Dependence of the efficiency on distance to source can also be expressed as relative net peak count rate, where the count rate is normalized to the count rate at the center (or 0 distance). Figure 5 shows Relative net peak area vs. offset by energy of HPGe detector for ^{133}Ba.

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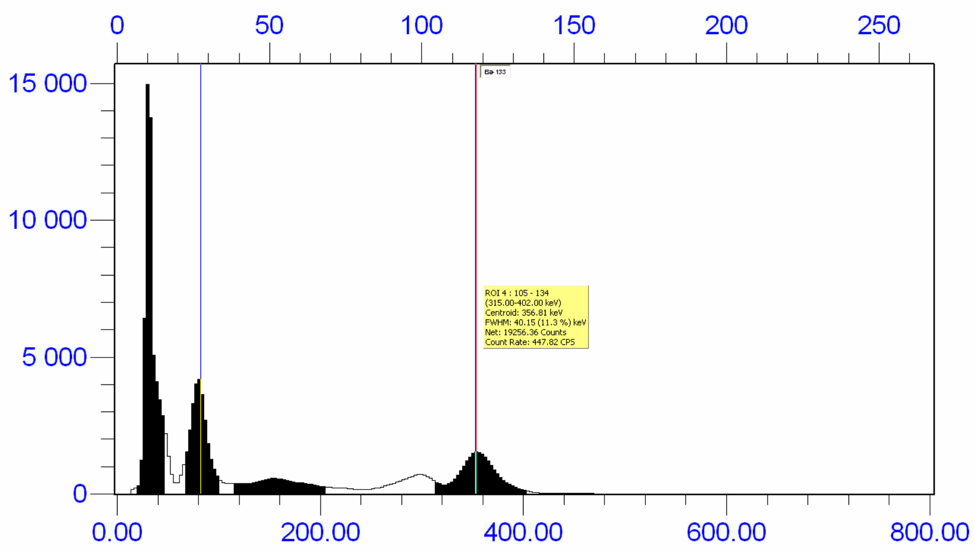

Figure 2 Spectrum of ^{133}Ba measured using NaI(Tl) detector

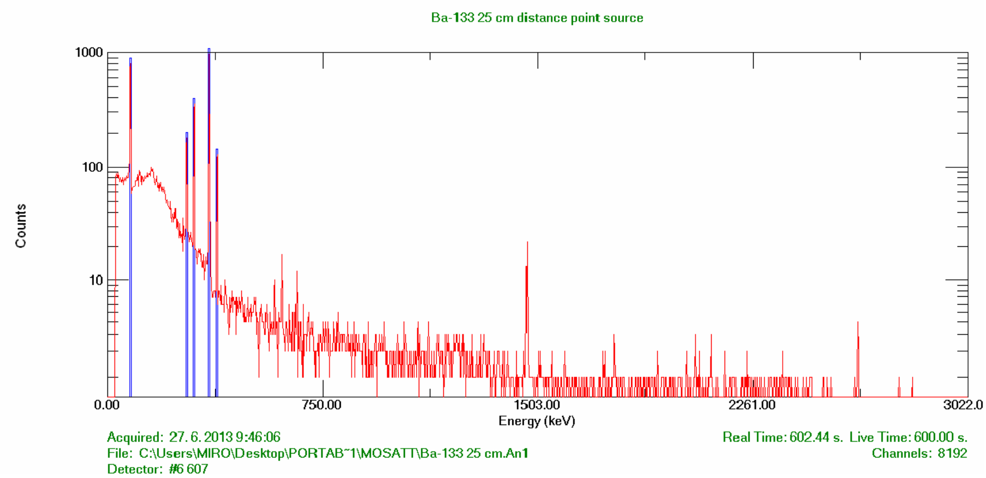

Figure 3 Spectrum of ^{133}Ba measured using HPGe detector

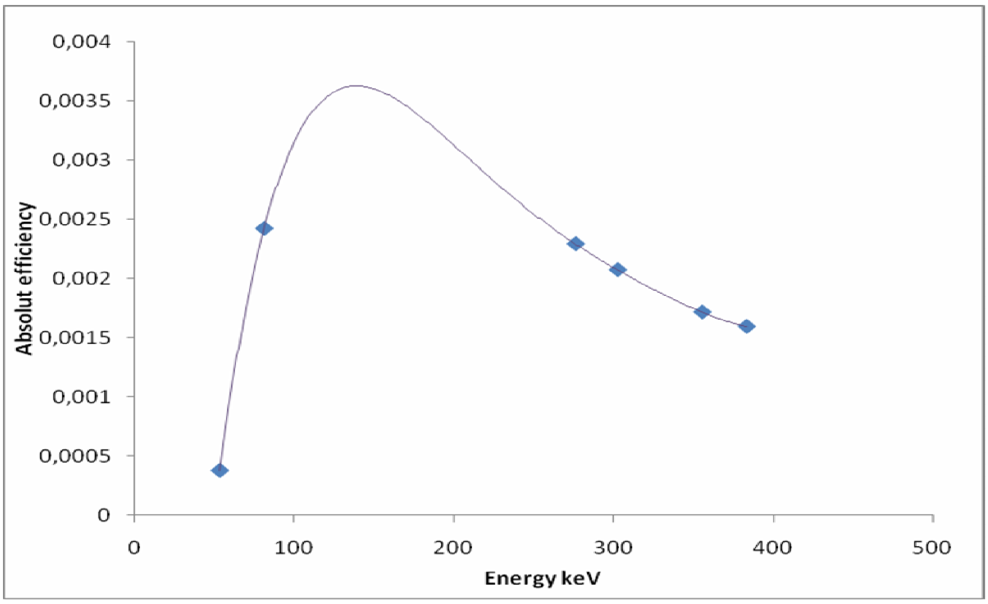

Figure 4 Absolute efficiency for point source of ^{133}Ba at 250 mm distance from endcap

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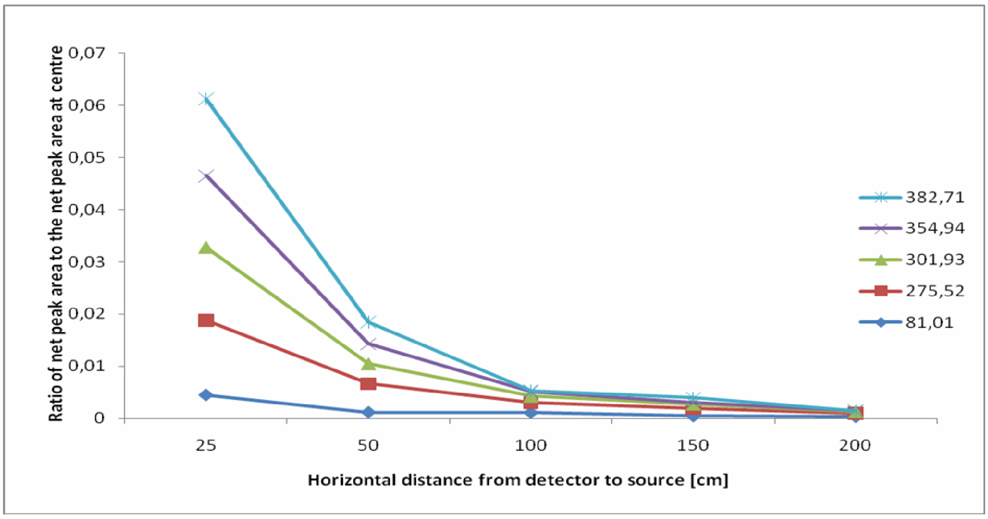

Figure 5 Relative net peak area vs offset by energy of HPGe detector for ^{133}Ba

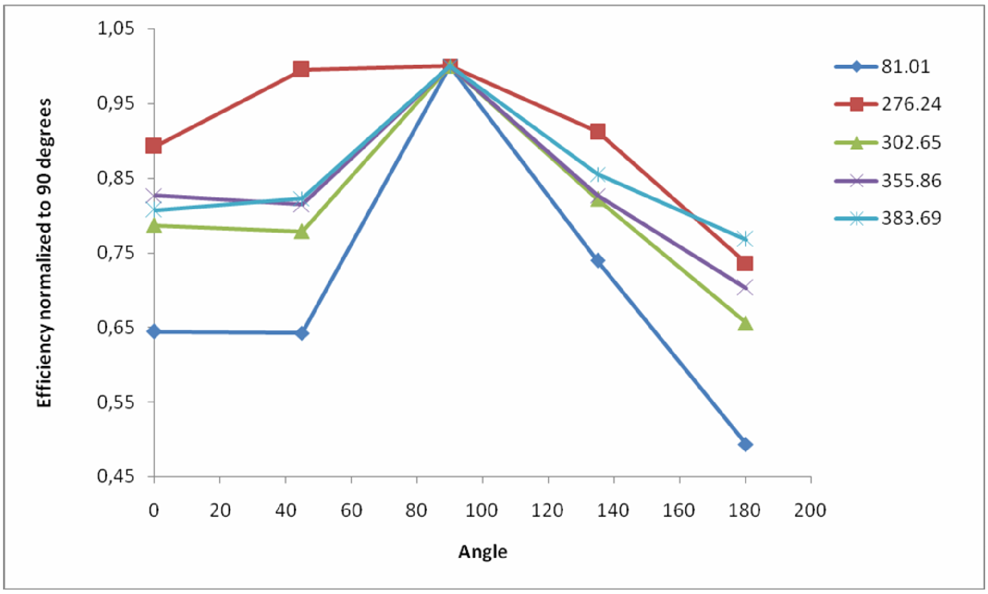

Figure 6 Relative efficiency of HPGe detector by angle

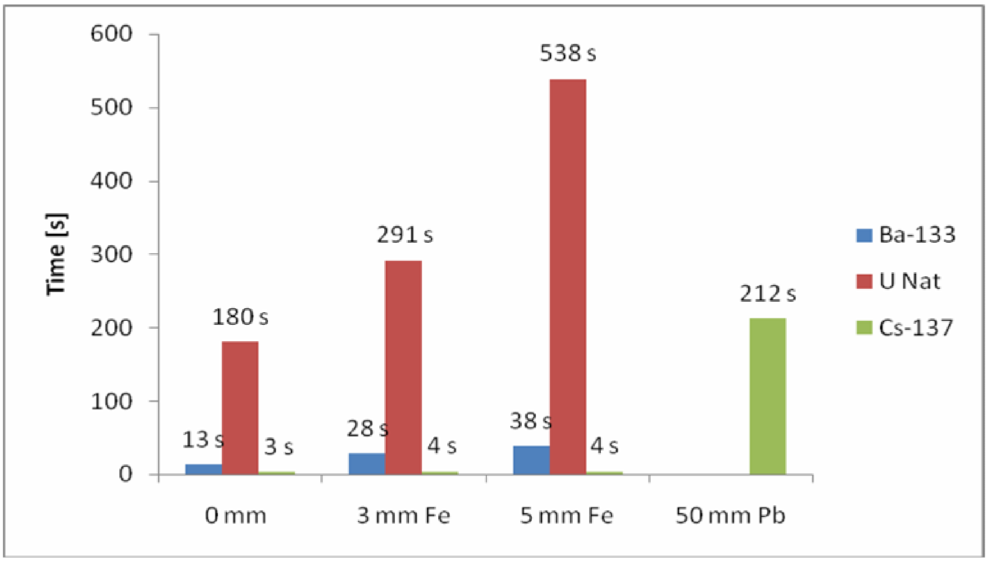

Figure 7 Time to identify several radionuclides using different types of shielding

Figure 6 shows dependence of geometry of measurement expressed as angular response of detector (range of 0 – 180°) at 25 cm source distance from detector endcap. The best detector response is when source is positioned on axis of detector as expected from detector construction.

4. CONCLUSION

Portable mobile handheld instruments for detection of roentgen and gamma radiation seem to be ideal for detection of all kinds of radionuclides which emit gamma radiation with energies between 30 to 2000 keV under field conditions including localization of all radioactive materials which can pose potential risk. Advantage of these instruments is their low weight, easy operation, relative fast preparation for measurement. The use of NaI(Tl) sensors is somehow limited for in - situ identification because of their low energy resolution. Answer to this limitation can be application of larger NaI(Tl) crystals what could increase capacity to detect and localize source of ionizing radiation but will not remove issues associated with interpretation of spectra of mixed radionuclide source. On other hand heavier and more expensive, portable and electronically cooled HPGe detectors are considered to be the best solution for in – situ identification of gamma radioisotopes. This field identification is sometimes comparable to gamma spectroscopy under laboratory conditions. Relatively high efficiency of HPGe detectors and sufficient energy range enables to detect and identify mixed sources of ionizing radiation in considerable short period of time with activities at background level. Evaluation of acquired spectra using software equipped with libraries is almost immediate and does not require special education of operating personal.

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LEGISLATIVE VIEW ON THE FLIGHT SAFETY USING METEOROLOGICAL RADARS

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Abstract: *Meteorological radars fulfil an important role in the air transport from the viewpoint of providing valuable information for the flight safety about the meteorological situation. There are two kinds of meteorological radars from the point of view of fair operation. Firstly there are ground radars, which follow and analyse meteorological situation within a certain area of a state or in the vicinity of an airport. Secondly there are aircraft board radars, which follow and analyse meteorological situation in front of the flying aircraft. While there are not so many ground radars in a certain limited area, board radars are a part of each transport aircraft. At the same time, one frequency band is legislatively appointed for those radars and board radars even work on the same frequency. Naturally, a question arises about a possibility of the mutual interference, mainly due to the safety during the most demanding part of aircraft landing. The paper deals with a legislative and technical securing of the use of those radars in relation to the safety of those flights from the viewpoint of the use of one frequency band.*

Keywords: *weather radar, radar, legislative*

1. INTRODUCTION

Radiofrequency band is world legacy and every state has to protect this legacy from incorrect and unwanted usage, or against jamming, or misusing. From this view of sight for usage of radiofrequency band are applied strict rules, which are watched, defined and assigned by the telecommunication bureau and the economical usage is also monitored. The assignments of frequencies for individual users are listed in “National table of frequency spectrum” of competent state.

The history is showing that the radiofrequency band is used in aviation for long time. For aerial radio systems the specific frequencies or entire frequency band are assigned. Those are the systems used mostly for radio communication, radio navigation, radio technical and radiolocation purposes. Aviation used radio systems working on “low frequencies” are in LF, MF, HF, VHF and UHF band precisely defined and specific frequencies are assigned. On “higher frequencies” in SHF and EHF rather specific frequency bands are assigned. This is neither an intention nor fulfilling the technical options or requirements for individual systems, which are working at so high frequencies.

Figure 1 The land based and airborne meteorological radiolocator

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2. THE FREQUENCY BAND OF WEATHER RADARS

Among the systems also used in aviation the meteorological radio locators (weather radars) are included, for which frequency band from 9 300MHz to 9 500MHz was allocated in NTFS. On first sight it is quite wide band in 200 MHz range. But weather radars are working in impulse mode and the frequency band width of one of their working channel is even 60 kHz. In aviation we can recognize the two types of weather radars, see Figure 1. The first type is the airborne weather radar which monitors the meteorological situation in front of flying airplane. The second type is the ground meteorological radio locator which monitors meteorological situation around the air field. From principle of operation and way of tracking the meteorological situation, this second type of weather radar is not only used at airfield, but also to monitoring the weather in wide area of competent country. Moreover those weather radars are mostly used onboard of ships and vessels.

From “National frequency spectrum table” of Slovak republic can be seen that frequency band in range from 9.3 GHz to 9.5 GHz is assigned into three sections:

a.) The radio navigation section.
b.) The radiolocation section.
c.) The section of public license.

Table 1 The national frequency band table of Slovak Republic in 9.3 to 9.5 GHz frequency band

Frequency band	Assumed in SR for	Civ/ mil	Used in SR for	note
9 300 ÷ 9 500MHz	radio navigation	civ.		
		mil.	Defense systems	
	radiolocation	civ.	Weather radars	9 345MHz
		mil.	Defense systems	
		civ.	Detection of motion and defense	9 200 ÷ 9 500MHz (public usage)
		mil.	TLPR	8 500 ÷ 10 600MHz

Frequency spectrum listed in **radio navigation sphere** is not used for civil application. It is used only in defense systems for military applications. Designedly the frequency band from 9.3 to 9.5 GHz is not listed in table due the usage in defense systems.

Frequency spectrum in **radiolocation sphere** is not used for military applications but it is used in civil applications for example for weather radars. The specific frequency 9 345 MHz is assigned for on-board weather radars.

In **sphere of public usage** it is possible to use listed frequency band in SR also for detection of motion and for security purposes. This is also the major domain of ground radar systems.
Listed frequency band is assumed also for specific usage in TLPR (Tank Level Probing Radar) systems. Those are radars with small radiation performance and small detection range and they are used for measuring the level in tanks.
This frequency redistribution is not significantly changed even by newest “Telecommunication bureau regulation” SR (VPR), “Decisions of the Commission of the European Union (EU) and even by “Recommendations of the European Frequency Management (ERC).

3. FREQUENCY BAND OF WEATHER RADARS IN LEGISLATIVE TERMS

Based on the previously listed facts, with focus on main operating frequency 9.41 GHz and band width of ± 30MHz of ground weather radar and operating frequency of airborne weather radar 9.345 GHz with band width ±5MHz (±30MHz) we are able to draw their frequency spacing in range from 9.3 to 9.5 GHz, as can be seen on Figure 2.
From Figure 2 is clear, that with width of frequency band of ±30MHz of ground weather radar and width of frequency band of airborne weather radar of ±5MHz their frequency spacing is B_1 = 30MHz.

Even if we assume that either one of the airborne weather radars bandwidth is ± 30MHz, the frequency distance B2 will be at least 5MHz.

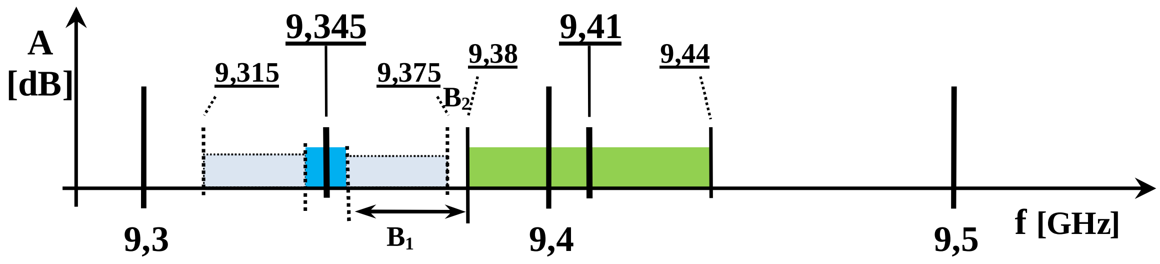

Figure 2 The frequency spacing of onboard and land based meteorological radars in Slovak Republic

The listed separation of 9.3 to 9.5 GHz frequency band was specified by NTFS in notes 5.427; 5.474 and 5.475 and then it was specified by World radio communication conference (WRC-07) in notes 5.475A; 5.475B and 5.476A. The individual annotations have the following character:

- Note 5.427 defines that the radar response from radar transponder in a given frequency band,
- Must not be changed with the answer from radar beacons,
- Must not cause interference to naval or airborne radars in the radio navigation service.

Since the ground or airborne weather radar is not being used as a radar responder, or radar beacon, this line does not apply to meteorological radars.

Note 5.474 define that the frequency band can be used for search and rescue transponders. Ground weather radar being is not used as a search or rescue transponder, therefore this line does not apply to meteorological radars.

Note 5.475 states that this frequency band is limited for use for:

- airborne aviation meteorological radio locators,
- ground-based radars, while radars for meteorological purposes are prioritized over other land-based radar installations.

That is to say a band in the range 9 300-9 500 MHz is intended for use on airborne aviation radio locators and ground-based meteorological radars.
Note 5.475 states that the frequency band may be also used for active satellite observation of earth and cosmos. Ground-based weather radar is not involved in active satellite earth observation and space research, so this section does not apply to it.

In the 5.475B note states that the ground radars which are used in the radiolocation service and are working in a given frequency band:

- must not interfere with the preferred radio navigation and radiolocation service,
- cannot claim for protection from harmful interference from the preferred radio navigation and radiolocation services.

In other words the land-based weather radars may interfere with other types of land based radars but the other types of land based radars must not interfere with airborne weather radars and land based weather radars and they also cannot request protection against their interference, see Figure 3.

The note 5.476 states that the active earth and space research satellite stations operating in a given frequency band must not cause interference to radio navigation and radiolocation service and they cannot request for protection from harmful interference from stations of this service. Land-based weather radar is not participating in the satellite and space research, so this section does not apply at him.

Of these notes, for the issue of determining the frequency band from 9.3 to 9.5 GHz for ground meteorological radar only paragraphs 5.475 and 5.475B are addressed. According to paragraph 5.475 the use of the band 9 300 to 9 500MHz is limited to:

- on-board aircraft weather radar,
- ground (land-based) radar.

Subsequently, in the note section 5.475 to ground radar is specified that the ground radars for meteorological purposes are given priority in this frequency band from the other radiolocation devices.

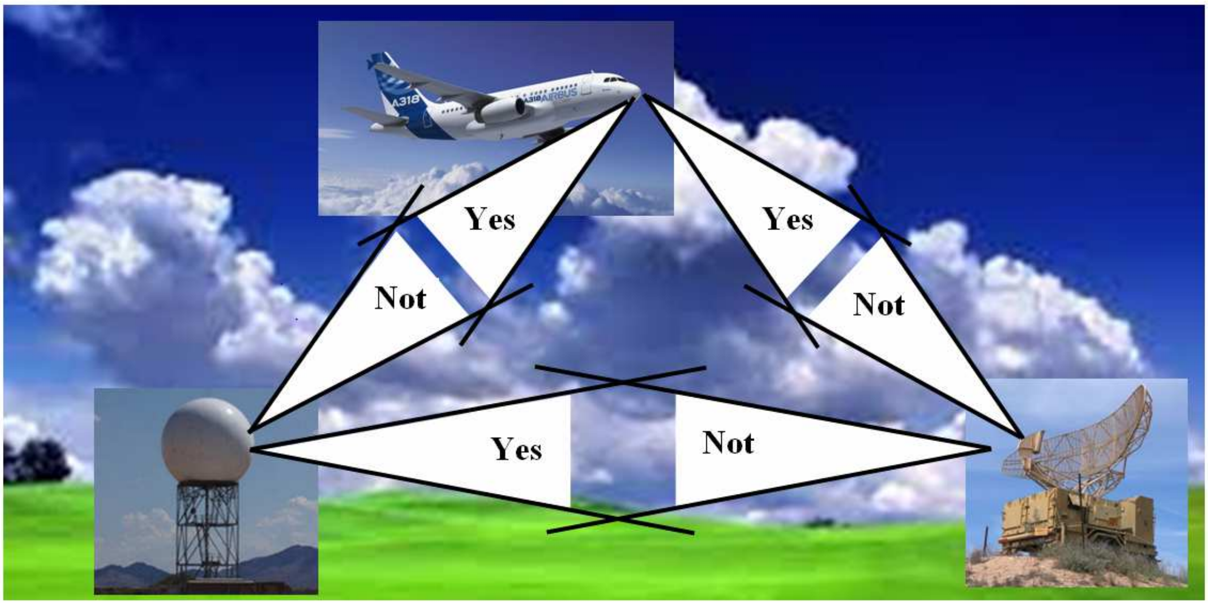

Figure 3 Possibility of mutual radar interference in 9.2 ÷9.5GHz band according to current legislation

Taking into account the above remark it is possible to specify point 5.475 like that the usage of the 9 300 ÷ 9 500MHz frequency band with aeronautical radio navigation service is limited to airborne weather radars and ground radars for meteorological purposes.
Due to the fact that the notes have the worldwide validity (WRC-07) and the allocation of the frequency band affects the maritime radio navigation service, in note 5.475B is referred that stations that are used in radiolocation service operating in the band 9 300 ÷ 9 500MHz they cannot cause harmful interference to radio navigation and radiolocation service. This notice is important because it requires that the ground weather radar should not cause the interference to on-board maritime and aeronautical radio navigation and radiolocation service.

4. CONCLUSION

By analysis of the frequency band in the range of 9.3 to 9.5 GHz with regard to specifying notes the following conclusions can be defined for the Slovak Republic:

- based on 5,475 note it can be concluded that the frequency range 9 300÷9 500 MHz is predetermined as for work for airborne meteorological radars, both for land-based radars for meteorological purposes,
- based on the same note, common (same time) operation of onboard and land-based meteorological radars is not excluded in the Slovak Republic,
- by analysis of values of working frequency of individual systems and their band width it can be concluded that the assigned frequencies are not overlapping,
- from frequency aspect there are such technical assumptions created that land based and airborne weather radars are not affecting each other.

From a global perspective, the meteorology sphere labelled in the English mutation as “Meteorological Aids”, what is representing the meteorological and radio communications aid service for meteorological and hydrological observations and examinations.
It is obvious that from a global perspective the land based meteorological radars have allocated frequency band of 9.3÷9.5GHz and their joint operation with airborne weather radars is not mutually excluded.

More detailed specification of the frequency band of 9.3÷9.5GHz from NTFS in the USA is set by "Manual of Regulations and Procedures for Federal Radio Frequency Management". From the listed manual of Federal Radio Frequency Management USA it is clear that the specific values for frequencies for land based and airborne weather radars are not set in U.S. NTF Stable. It is therefore clear that the producers after the agreement have set the second frequency 9.375 GHz for airborne weather radars, which fits between the initial frequency of 9.345 GHz of airborne weather radar and frequency of 9.41 GHz of land based meteoradars so that their activities are not mutually excluded.

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A MODEL-BASED DESIGN OF A DYNAMIC APPROACH STABILIZATION ADVISORY SYSTEM

Ivan LACKO[1] - Zdenek MORAVEK[2] - Frank RISTER[3] - Jan-Patrick OSTERLOH[4] - Andreas LUEDTKE[5] - Frederic DEHAIS[6]

Abstract: *This paper describes the model-based approach taken by the manned aeronautics vehicle (MAV) group of the EU-ARTEMIS JU project D3CoS (Designing Dynamic Distributed Cooperative Human-Machine Systems) to design an approach stabilization advisory system (AStA) with a strong cooperative, multi-agent perspective. Two experimental cycles were conducted on a Boeing 737 full-flight simulator. During these experiments we were able to induce unstabilized approaches and collect data about human-machine interaction, psycho-physiological and behavioural data. Outputs from the first experiment served as an input for development of AStA as well as for the definition of normative standard tasks, which have been modelled with a formal procedure editor (PED). The latter experiment demonstrated the usability of the developed approach stabilization system and was used as a comparative baseline for outputs of cognitive architecture utilizing modelled pilot behaviour. Based on this, we present the latest development towards an approach stabilization system, which monitors aircraft performance, human-machine-interaction and, subsequently, pilot behaviour or cognitive state.*

Keywords: *Cognitive Task Models, Human-in-the-loop, Flight Guidance, Dynamic Cooperation*

1. INTRODUCTION

D3CoS aims at improving the quality of system design and safety by application of a model-based development and testing. Human-centered system design and the application of agent modeling in early phases of the development improve the safety of cooperative human-machine systems. In order to achieve this, the traditional role of assistance systems is addressed from a multi-agent perspective: humans and machines inherently cooperate to achieve common goals or tasks.

1.1 Motivation/background

Unstabilized approaches are a major causal factor of approach-and-landing incidents and accidents (e.g. runway overruns, tail-strikes etc.). Poor aircraft handling, system control or crew resource management during approach and landing fuel the statistics: from the years 2001 to 2010, 49% of fatal accidents worldwide occurred during the initial or final approach, or in the landing phase in (Boeing, 2010).

For safety reasons, the authorities define values for a set of flight parameters, such as vertical speed, or airspeed (ICAO, 2006, Airbus, 2006, 2009) and pilots are required to follow approach.

profiles with respect to these values. If the criteria for stabilized approach are not met at the stabilization height (1000ft or 500ft respectively), a go-around is mandatory.

However, about 97% of unstabilized approaches are continued for landing. Continuation of an unstabilized approach has been found to be a causal factor in 40% of all approach-and-landing accidents and in 75% of runway excursions or overruns (Flight Safety Foundation, 2009). This covers 19% of all aviation accidents since 1988!

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1.2 Problem

The decision-making process may be degraded due to misunderstanding of human and machine in today's master-slave design. Mode confusion or improper system state awareness may arise from improper use of automation systems and contribute to approach destabilization (Sarter & Woods, 1995). Combined with the (super-) critical aerodynamic design of modern aircraft, the recovery of the operation may become very difficult.

Flight management systems calculate descent trajectories that seldom account for proper wind profiles and are based on the programmed flight plan distance. Whenever the tailwind component increases and/or the flight plan distance decreases, e.g. due to shortcuts, pilots have to make calculations on their own and often have to revert to heuristics, as workload levels during such a flight phase do not allow a qualitative higher cognitive reflection (Mioch, et. al., 2010).

Based on the assumption that pilots want to fly as short and as fast as possible, with ideally no application of engine power above idle, contributing factors of destabilized approaches, have been identified (e.g. system operation techniques, procedural deviations, good visibility, short final approaches).

2. EXPERIMENTAL DESIGN

During a descent, there are various competing factors: potential energy (altitude) has to be converted into kinetic energy (speed). However, this kinetic energy has to be lost at some point (deceleration) in order to configure the airplane for the proper landing state. As all approaches are ideally planned to make power application only necessary at the very late stage of the final approach, there is a narrow corridor allowing to trade altitude into speed, and vice-versa.

As the flight profile changes dynamically with the environmental conditions, the decision how to re-stabilize an approach has to be constantly re-evaluated by the pilot. There are navigational rules that enable pilots to compute the vertical path of a trajectory. However, increasing workload during the approach limits the use of such algorithms.

Instead, algorithms are replaced by less reliable heuristics based on experience (Wickens, 2003) with consequences on the performance during the approach. Here, the space opens for advisory tool supporting pilots in decision-making process.

A demonstrator of such a tool was developed in D3CoS. It monitors approach destabilizations and helps the pilot to overcome the "burden of biases" like confirmation, recency and availability but also learned carelessness (Frey & Schultz-Hardt, 1997, 2001). In this paper a method for evaluating such tool is described. The method has two aspects, ability to systematically induce unstabilized approaches and ability to evaluate change in performance of pilots when a supporting tool is offered.

2.1 Scenario Design

The predictability of pilot errors dictated the design of the scenario use cases. "Traps" for pilots were intentionally incorporated in three different scenarios (approaches) for three different airports. Destabilization factors differed from scenario to scenario, no counterbalancing or learning effects were neither expected nor measured during the trials.

The induction of workload was another contributing factor. All three testing scenarios contained one non-normal situation (different for every scenario: "display source," "EEC alternate," "FMC fail"). Such situations forced the crew to accomplish non-normal procedure. The intention of these malfunctions/non-normal procedures was to redraw attention away from the approach itself and to eliminate learning effects. However, to maintain the three scenarios different but still comparable, the workload had to be equally distributed to allow for an evaluation.

Therefore, the entire flight profile has been task-modelled with PED (see chapter 2.2).

Every scenario comprised of the descent phase, descent monitoring procedure, shortcuts, altitude interception, deceleration phase, final approach initiation phase and landing. These phases have common procedures that remain the same in sequence and timing. Thus, the simulation of these tasks shows similar to identical workload values with regards to workload peak values, workload peak timings and means (see Table 1):

Table 1

	Normal procedures (McCracken & Aldrich, 1984)			Non-normal procedures		
	MAX	SD	MEAN	MAX	SD	MEAN
Peaks	11.6	0.96	10.01	12.8	2.74	10.22
Means	6.68	0.96	5.04	3.6	0.75	2.76
Timing	-	-	-	0.62	0.18	0.39

The timing values show that the peak workload occurs in the first half of the respective procedure, assuring that no interference with subsequent tasks will accumulate workload unevenly (see Fig. 1).

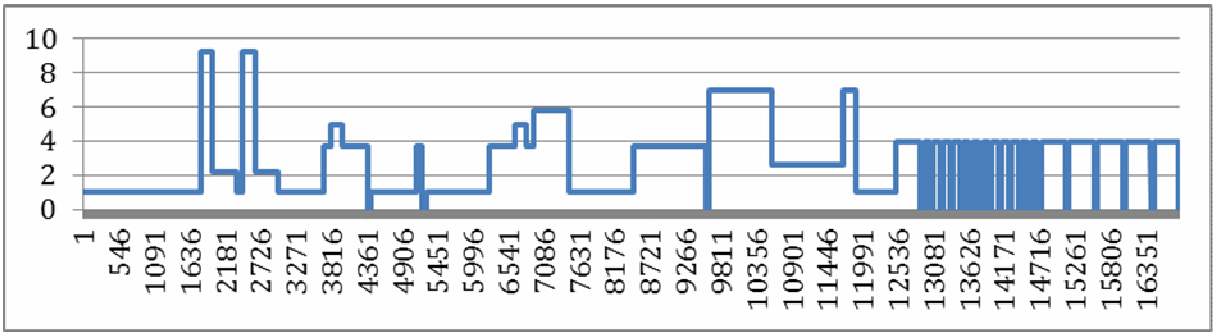

Figure 1 PED workload evaluation

2.2 Modelling Tools

Cognitive architectures are means for improving a human centred development process for assistant systems. CASCaS (Cognitive Architecture for Safety Critical Task Simulation) is an example of cognitive architecture used in D3COS (Luedtke & Moebus, 2004, Luedtke & Osterloh, 2009). It has structure similar to established architectures, ACT-R (Anderson et al., 2006) and SOAR (Wray & Jones, 2005), but extends the state of the art by integrating additional mechanisms to model the cognitive phenomena "learned carelessness," selective attention and attention allocation. In addition it has been built for easy integration with external simulators, like the flight simulators X-Plane and MS Flight Simulator, driving simulators, e.g. SILAB.

Cognitive architecture is a generic (task independent) processor of hierarchical procedures executed on task specific knowledge expressed in terms of production rules. These rules can be connected to task trees or networks that can be built graphically with instruments such as PED (Procedure Editor, dedicated to CASCaS). Unlike other instruments, PED has inherent simulation capabilities for logic validation and for evaluation of induced workload.

The workload computation of PED is based on the model of McCracken & Aldrich (1984). Workload has been divided into four categories: visual, auditory, cognitive and psychomotor. For each of these categories, different kind of actions have been defined, like visually monitor, trace or discriminate. All actions have assigned a pre-defined workload value between one and seven. The workload value has been specified based on expert judgement. For the assessment, the workload values are accumulated for a 10-second time frame

2.3 Psycho-physiological Measurements

Ocular measurement: A Pertech® head-mounted eye tracker was used to analyze participants' ocular behaviour. A dedicated software (EyeTechLab) provided data such as timestamps and the x,y coordinates of the participants' eye gaze on the visual scene.

An electrocardiogram (ProComp Infinity system, Thought Technology) was used to collect (sampling rate = 2048 Hz) the participants' cardiac activity during each flight. The BioGraph Infiniti© software was used to export and filter the heart rate variability (HRV) derived from the inter-beat interval. Ratio of LF/HF power int HRV spectrum reflects ratio of sympathetic/parasympathetic activity, which is directly connested to the mental workload of a subject.

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After each flight, subjective assessment of workload felt by pilots during the whole flight duration was performed using the NASA-TLX (Task Load Index) (Hart & Staveland, 1988). The NASA-TLX is a multi-dimensional rating procedure that provides an overall workload score based on a weighted average of ratings on six subscales: mental demands; physical demands; temporal demands; own performance; effort and frustration.

3. FIRST RESULTS

Data analysis shows that we were able to induce unstabilized approaches: 26 approach destabilizations and six completely unstabilized approaches with 4 unstabilized landings were detected.
The analysis of the TLX questionnaires confirmed that pilots considered the events selected to induce the re-evaluation of plans as stressful and the analysis of the ECG data shows the supporting tool reduces the overall workload during the approach, see Fig. 2.

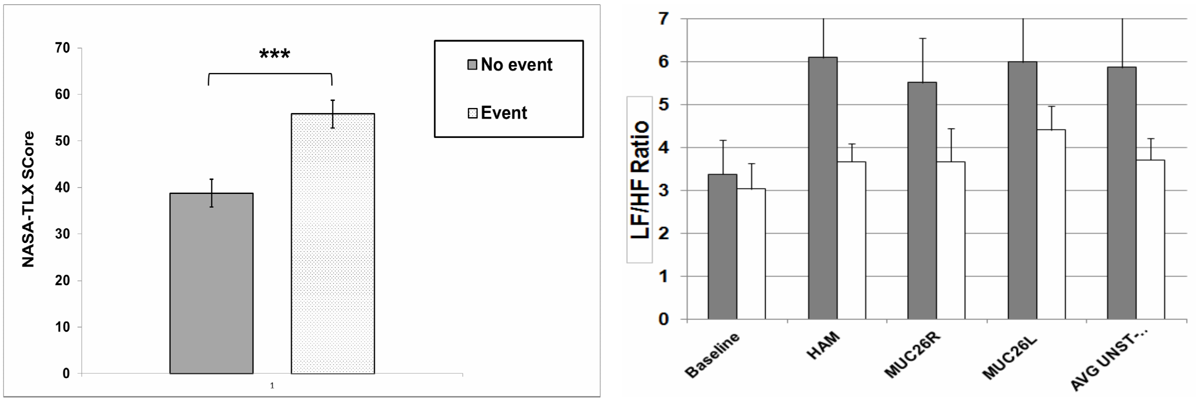

*Figure 2 Left - NASA-TLX score for scenarios without induced replanning and with replanning Error bars represent the standard error of the mean, *** p<.001ED workload evaluation, Right - ECG based workload estimates. White - with the supporting tool, gray without the tool*

Relative workload analysis showed an increase of the workload value shortly after the event happened, see Fig. 3. There is an obvious correlation for ECG data, eye-tracker data and event positions. The time series of relative workload derived from physiology measurements and from the computer analysis of SOPs correspond one to each other.

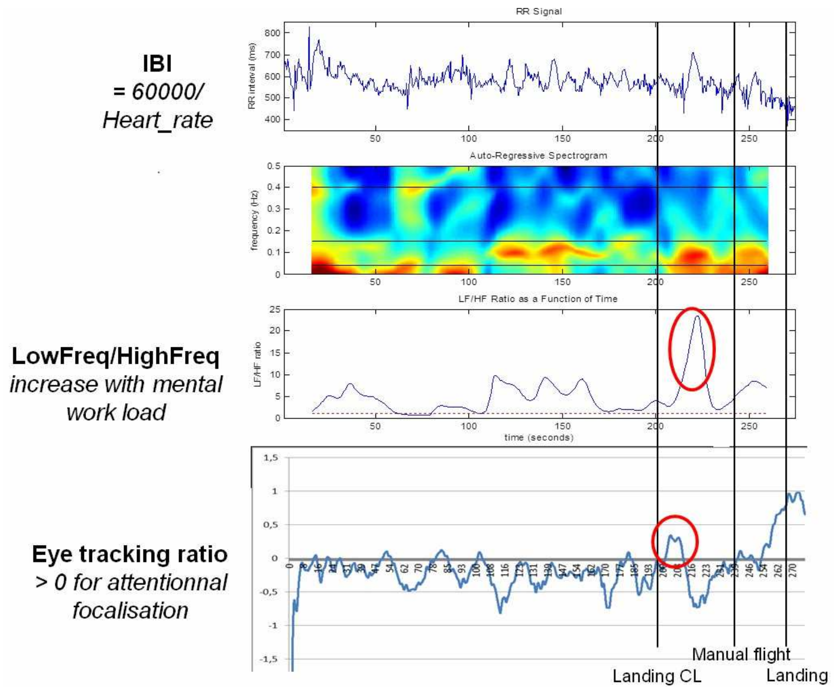

Figure 3 ECG, eye-tracker and event correlations

CASCaS processing of the scenarios is under progress with ambition to provide detailed insight in the workload structure of the approach. The ambition is to show a modeling can provide comparable and/or complementary data as the real experiment.

4. CONCLUSION

PED modelling allows for creating of comparable flight scenarios and for preliminary evaluation of the workload. Comparison of workload determined from the physiology measurement showed qualitative agreement.

Cycle 1 experiment supported our hypotheses that approach destabilization can be made predictable and that machine agents have the potential to counteract unstabilized approach in impending phases.

In Cycle 2 experiment, entire flight profiles were flown with two groups of subjects – first without a supporting tool, second with the supporting tool. Their performance was cross-evaluated and analyzed with respect to physiology data showing a better performance with group of pilots using the supporting tool.

The forthcoming work will demonstrate how modeling with CASCaS can facilitate the experiments and allow for deeper insight in the course of the flown approach.

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SPECIFICATION OF SUPPLY CHAIN SECURITY

Martina LÁNSKÁ[1] - Dana PROCHÁZKOVÁ[2]

Abstract: *Supply chain security is a tricky issue in today's globalized world. Risks concerning supply chains impede entrepreneurial interests of supply chain participants (companies, manufacturers, suppliers, forwarders etc.) and affect customers, i.e. citizens. Among damaging phenomena disasters that afflicted supply chains substantially you can also count corruption, outstanding liabilities of counterparts in supply chains, level of political stability in public administration, favouring competition from the public administration, acts of fraud among supply chain participants, sudden changes in political situation, sudden market changes, company reputation dishonesting, bad strategically decisions etc. This paper presents a summary of risks that have been derived from specific surveys in the EU and that sets requirements to improve security in supply chains.*

Keywords: *security, safety, supply chain, risk, risk management*

1. INTRODUCTION

Present human life is very influenced by globalisation; different networks, supply system, finances etc. are interconnected. This reality affects security and safety of humans, public assets that are indispensable for human existence and development. In last fifteen years two important items have showed gain ground, namely critical infrastructure protection and supply chains´ security. Because there are supply chains for different commodities, e.g. also for weapons, drugs, narcotics, the interest of governments of democratic states is to permit only safe supply chains, i.e. their aim is supply chains´ safety. For ensuring this aim the governments have been carried out an integral safety management [1] and in its frame they enforced the supply chain operators to respect rules of safe community [2], which means that supply chain operators will not operate supply chains with criminal commodities and in all activities they will respect protection of all public assets (human lives, health and security; property; welfare; environment; critical infrastructures and technologies). To ensure the given target all supply chain participants, i.e. suppliers, producers, shippers, distributors, sellers and customers need to know the own partial risks and the partial risks and the integral risk connected with the whole supply chain [3]. The reliability of several supply chains decreases with time due to globalization – suppliers and customers are located in different countries and the differences among countries cause unexpected risks.

The concept of problem solving given below is based on the strategic, systemic and proactive approach that lean on advanced cognition that reality is well described by model " system of systems (SoS)", i.e. system of several mutually interconnected systems [4].

The paper describes terms used in security and safety management, set of disasters that threaten the supply chain and main partial risks for supply chains. It also shows the targets of specialised research the aim of which is to upgrade security and safety of supply chains by help of co-operation of public administration and supply chain operators.

2. GENERAL TERMINOLOGY OF SUPPLY CHAIN SECURITY

With regard to data in the professional literature based on long term deep research of disasters, their impacts and human measures and activities directed to human protection [4], especially collected during the solution of research project FOCUS under the European Union auspice [5] the set of main terms, given below in a logic order, was specified.

Safe space (safe community) is a space understand as system in which the safety level is acceptable. The EU started this concept after the attack in Madrid on March 2004.

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The basic system asset is item of system (element, linkage, flow) that is necessary for system existence, stability and development.

Supply chain is system of systems, i.e. system of several mutually interconnected systems of supplies, products, shipping, distributing, selling and shopping. According [6] the term supply chain is a simplification of the supply web or network of suppliers, manufacturing plants, retailers, and the myriad supporting companies involved in design, procurement, manufacturing, storing, shipping, selling, and servicing goods.

Safety is a set of measures and activities for ensuring the security and sustainable development of assets.

Security is a forming the sense of safety, safe feeling, certainty, ensuring the public welfare, permanent development of sound environment and reliable operation of technological (physical and cyber) facilities. In research connected with the supply chain [7] **security** is used to describe protection against criminal acts, such as terrorist attacks, sabotage, robberies, smuggling, or illegal immigration. Within the area of security, we create a complex solution, which enables us to prevent said crimes. More specifically, security includes protection of machines, facilities, transported goods, but also buildings, cities, the environment and its inhabitants, against exposure to wilful dangerous influence of other people (terrorists, thieves, smugglers etc.).

Danger is a condition / situation at which it originates or can originate detriment on assets.

Harm/damage is a detriment on human life and health, property, environment and human society expressed in money.

Vulnerability is a predisposition to harm / damage origination.

Disaster is a phenomenon that leads or can lead to damages and harms on assets of the state (i.e. phenomenon which leads or can lead to impacts on protected assets of the state). From the view of cybernetics the disaster is one of the possible conditions of system including the human society and environment, which leads or can lead to damages / harms on one or more assets of the state. The term “disaster” is often used for phenomena with small number of victims; if number of victims is greater (usually more than 25), the term “catastrophe” is often used.

Impact is adverse effect / influence of phenomenon in a given place and time on assets.

Vulnerability is sensitivity of asset to impacts of disaster / threat. It is inherently complex entity of the system, the dynamic, i.e. not a static variable. In the scale of time and space (egging the projection into area), certain aspects dominate at different point in time and at a different location.

Scenario (model) of disaster is a set of isolated and interconnected disaster impacts in space and time that causes or can cause the given disaster in definite site, i.e. time sequence of events affected by disaster impacts.

Emergency situation is a situation caused by disaster origination. Usually, it is classified into 5 categories (0 - 5) that for simplicity are denoted by colours (upper-most by sequence of colours - yellow, orange, red).

Hazard is a set of maximum disaster impacts that are expected in a given place in specified time interval with a certain probability. According to technical norms and standards the hazard is determined by identified size of disaster.

Risk expresses the probable size of undesirable and unacceptable impacts (losses, harms and detriment) of disasters with size of normative hazard on system assets or subsystems in a given time interval (e.g. 1 year) in a given site, i.e. it is always site specific.

Threat is a measure of occurrence of attack (including terrorist) in a given place. It is a probability that originates or can originate an event or set of events, quite different from desirable (originally supposed) condition or development of protected interests of the state from the viewpoint of their integrity and function. It is determined by capability of attacker, vulnerability of protected interests of the state and by attacker intent.

Disaster assessment, hazard assessment and risk assessment in a given territory, site, time interval are the risk engineering operating methods.

Proactive management is a management type, in which there are in advance performed measures for averting or at least mitigation of some undesirable phenomena, and ensured preparedness for the effective response to undesirable phenomena.

Reactive management is a management type, in which there are solved problems when they occur.

Risk management is a planning, organization, allocation of work tasks and checks up of sources of organization so, that there might be reduced losses, damages, harms, injuries or deaths caused by various disasters. Risks are reduced by the reduction of vulnerability of objects, human population, environment, state etc. (in this connection there is used the term „impact mitigation“ for impacts that cannot be averted at disaster origin). According to majority of technical norms and standards there is performed the reduction of vulnerability at planning, designing, construction and operation of protected interests for all risks, the probability of which is equal or greater than 0.05. By this way there is formed the inherent safety of system including the human society, objects and environment (i.e. so-called design disasters ought to be get under control by design, regulations for land-use planning and construction, operating instructions, rules for response to emergencies and by instructions for response to critical situations, and therefore, their occurrence would not threaten sustainable development).

Safety management consists in a planning, organization, allocation of work tasks and check-up of sources of organization with aim to reach requested safety level. Enhancement of safety is reached by use (application, realization, and implementation) of technical, legal, organizational, educational etc. protective measures. They are also considered risks the occurrence probabilities of which are smaller than 0.05, but impacts are fatal (severe). Safety management belongs to a common practice at planning, designing, construction and operation of technical facilities and objects such as power plants, dams, nuclear facilities etc., and it is the basement of nuclear safety, radiation protection and protection against dangerous chemical substances that is introduced by the SEVESO II directive. In technical slang there is stipulated that this type of management considers beyond design (severe) accidents. Except of formation of inherent safety of system including the human society, objects and environment this management type also promotes so called principle of precaution, because it considers disasters or their sizes the occurrences of which are very low probable, that are unforeseen.

Crisis management is a management the purpose of which is to precede a possible critical situations, to ensure preparedness for response to possible critical situations, to ensure the getting possible critical situations under control in frame of power of crisis management authority and executing measures and tasks of line higher crisis management authorities (for getting situation under control there is used legal measure „declaration of crisis situation“ that temporarily enables to limit rights and civil liberties of humans and use beyond standard sources), to start renovation and next development. Fundamental phases are the prevention, preparedness, response and renovation. In some conceptions there is the crisis management a part of safety management, in others the crisis management is only used for the getting critical situations caused by disasters under control and for the getting current emergency situations under control there is used emergency management.

Supply Chain Security is a systematic and continuous process to enhance prevention, protection, preparedness, monitoring, detection, mitigation, response, and recovery from disruptive criminal and terrorist activities and incidents in the supply chain.

Supply Chain Safety is a systematic and continuous process to enhance prevention, protection, preparedness, monitoring, detection, mitigation, response, and recovery from disruptive criminal and terrorist activities and incidents in the supply chain and in supply chain vicinity.

Supply chain management [6] challenge facing retailers, distributors, manufacturers, and suppliers is to maximize customer service while minimizing cost. For most supply chain operations the service challenge can be expressed in terms of availability: having the right product at the right place when the customer wants it. The cost challenge is to make that happen at low cost.

Supply chain risk management [8] is the management of external risks and supply chain risks through a coordinated approach among the supply chain members to reduce supply chain vulnerability as a whole.

Safety performance indicator is a quantity that measures level of safety in a given subsystem / system. (Usually there are used types - outcome indicators and activity indicators).

Critical infrastructure are physical, cybernetic and organizational (service) systems, that are necessary for ensuring the protection of human lives and health, property, minimum function of economy and administration of the state.

3. LIST OF DISASTERS THAT THREATEN SUPPLY CHAIN

A disaster is a phenomenon that harmfully affects the human system assets, i.e. both, the public assets and assets of legal entities. According to the current knowledge these are phenomena that results from five following processes [1].

The first group of processes are results of processes running in and out of the Earth: natural disasters (natural disasters - earthquake, floods, drought, strong wind, volcanic activity, land slide, rock slide etc.); epiphyte; epizootic; land erosion; desertification; fundament liquefaction; sea floor spreading etc.

The other group of processes are results of processes running in human body, behaviour, in human society separated to unintentional (illnesses; epidemic; involuntary human errors) and intentional (robbery; killing; victimization; religious and other intolerance; criminal acts; terrorist attacks; local and other armed conflicts etc.).

The third group of processes are results of processes connected with human activities: incidents; near miss; accidents; infrastructure failures; technology failures; loss of utilities etc.

The fourth group of processes are results of processes that are reactions of the Planet or environment to human activities: man-made earthquakes; disruption of the ozone level / layer; greenhouse effect; fast climate variations; contaminations of air, water, soil and rock; desertification caused by human bad river regulation; drop of the diversity of flora and fauna (animal and vegetal) variety; fast human population explosion; migration of great human groups; fast drawing off the renewable sources; erosion of soil and rock; land uniformity etc.

The fifth group of processes are results of processes connected with inside dependences in human system and its surrounding separated to natural (stress and movements of territorial plates; water circulation in environment; substance circulation in environment; human food chain; planet processes; interactions of solar and galactic processes) and human established (human society management; flows of raw materials and products; flows of energies; flows of information; flows of finances etc.).

4. TYPES OF PARTIAL RISKS FOR SUPPLY CHAIN

A risk is a normatively determined damage or loss that disaster of a normative size causes onto protected assets (interests), namely of both, the public and the legal entities. We have got five groups of risks namely construction-technological and design risks, credit risks, market risks, external risks, operational risks and risks connected with management and decision making. Risk analysis and assessment is required at applications for the EU projects [4].

Construction-technological and design risks include construction and design risks, site risks and risks of defective technologies, networks and corresponding services. Construction and design risks contain risk connected with design documentation (right / wrong, errors); risk connected with construction / building; risk connected with exceeding the building costs; risk connected with site / site surrounding pollution during the project realisation caused by public administration; risk connected with site / site surrounding pollution during the project realisation caused by supplier; risk connected with project impact on environment during project realisation caused by wrong decision making by public administration, risk connected with project impact on environment during project realisation caused by wrong decision making during the project realisation caused by suppliers and operators. Site risk includes risk connected with a current entity; risk connected with site accessibility; risk connected with site conditions; risk connected with networks (utilities) found in a site (building venue); risk connected with the land-use plan; risk connected with a building permit; risk connected with cultural / archaeological heritage; risk connected with government protected areas. Risks of defective technologies, networks and corresponding services contain: risk connected with defect during the project realization; risk connected with defects during the project lifespan; risk connected with using the wrong technology; risks connected with technological insufficiency; risk connected with unexpected power outages, service outages and supporting systems outage provided by public administration.

Credit risks include liquidity risks and risks of outstanding liabilities / so called risk of accessibility of obligations, which can be further divided into: risks connected with accessibility (private sector outstanding liabilities); risk connected with counterpart failure and with loss for supplier; risks connected with concentration (all supplies are guaranteed by a single supplier); risk connected with partnership disclaim (public administration does not support the project).

Market risks include risk of demand in case that public administration is a supplier, risk of demand in case that private subject is a supplier, competition favouring risk and other market risks such as: currency risk, inflation risk, interest rate risk.

The need to make or order products before demand is known with certainty is one of the basic challenges of supply chain operators. Too much product means that it has to be stored for a long time, incurring inventory carrying costs and likely being sold at a discount or a loss, too little inventory means lost sales and lost customers [6].

External risks include political risks, act of God and other external risks. Political risks include: risk connected with national or international situation; default risk caused by government failure; multinational political risk connected with obligations of the Czech Republic in the EU and the NATO. Act of God risks include: risk connected with a natural disaster of catastrophic size; risk connected with terrorism; risk connected with war. Other external risks include: legislative risks / tax rate general risk connected with the actual legislation changes; risks connected with needs of additional permits; risks connected with sector situations / strikes.

Operational risks include risks related to equipment, risks related to personnel and risks related to human behaviour and intent. Risks related to equipment contain: risk related to equipment, inputs (materials; risk connected with maintenance, repairs, modifications and adaptations; and risk connected with a low residual value. Risks related to humans are: risk connected with non-corresponding workforce; risk connected with non-procuration; risk connected with a lack of human resources; risk connected with workplace oriented lawsuits; risk connected with a human factor failure. Risks related to human behaviour and intent include: risk connected with acts of fraud; risk connected with illegal action; risks connected with technology systems´ safety; risk connected with damages, thefts.

Risks connected with management and decision making include contractual risks and other risks connected with management and decision making. Contractual risks include: risk connected with responsibilities to the third party; risk connected with agreement change; risk connected with infringement the general statutory instruments. Other risks connected with management and decision making include: risk connected with strategic decision making; risk connected with reputation.

In terms of financial area we use further listed definitions of partial risks:

1. Financial risk represents an amount of value decrease by the observed object, i.e. company / property / critical infrastructure / technology which is caused by natural or other disaster or a likely interaction in human system. It is expressed by a probability of value decrease occurrence, which is expressed in money.
2. Credit risk represents an amount of value decrease by the observed object, i.e. company / property / critical infrastructure / technology which is caused by the fact that the counterpart does not fulfil existing liabilities (does not pay back a loan, invoice, does not supply a product etc.) It is expressed by a probability of value decrease occurrence, which is expressed in money.
3. Market risk represents an amount of value decrease by the trade-able financial claims, i.e. goods / property / critical infrastructure / technology which is caused by market changes. It is expressed by a probability of value decrease occurrence, which is expressed in money.
4. Currency risk represents an amount of value decrease by the foreign exchange which is caused by changes in banking markets. It is expressed by a probability of value decrease occurrence, which is expressed in money.
5. Exchange rate risk is a type of risk arising from changes in mutual exchange rates between two currencies. When investors and companies keep properties or make business in different currencies, they face exchange rate risk against they can insure themselves, however.

6. Interest rate risk represents an amount of property value decrease, i.e. goods, buildings, critical infrastructure, technology which is caused by changes in financial markets. It is expressed by a probability of value decrease occurrence, which is expressed in money.
7. Share risk is represented by an amount of share value decrease which is caused by changes in stock exchange. It is expressed by a probability of value decrease occurrence, which is expressed in money.
8. Commodity risk is represented by an amount of traded commodity value decrease which is caused by changes in the market. It is expressed by a probability of value decrease occurrence, which is expressed in money.
9. Liquidity risk represents an amount of loss to be capable to carry out certain business transaction at the time, which is caused by: insolvency (own non liquidity), non-existent counterpart (market non liquidity) and changes in the market. It is expressed by a probability of value decrease occurrence, which is expressed in money.

5. SECURITY RISK

Security risk generally includes risks connected with human community safety understand as human system safety without regard to human system vicinity safety, i.e. all partial risks and moreover risks connected with interconnections among the human system assets [1, 4, 9]. Public assets comprise of: human lives and health, human security, welfare, environment, infrastructure and technologies. Legal entities assets are: fulfilment of tasks given in document of its foundation; profit; and provision of accordance with the state, i.e. the proper fulfilling of protective measures that are determined by the state to support the public assets. There is an integral risk from its substance, because it is related to a human system in which it is more protected assets (interests) which are mutually interconnected. From a methodical point of view and based on current knowledge and experience the risk for safety management is determined correctly and has got correct and validate value if it reflected all defined protected assets (interests), has determined by defined procedure, is based on a qualified data file with a determined testified value and with homogeneity boundary or is based on qualified processing the qualified data file for a given assignment.

Risk connected with a human system security and development includes also risks in terms of objectives: safe state, safe territory, safe municipality and sustainable area development. Security risk represents an amount of violation of security of a followed system, i.e. the human system in general, the landscape, the human settlement, public or technological objects, infrastructures, human society, which are subjected to surveys. It is expressed by a probability of level of security violation occurrence, which in this case is represented by a summary of losses, damages and harms on surveyed protected assets (interests), expressed in money for example.

Partial risks are: health risk, risk of damage / destruction of given property, risk of damage or destruction of the environment, risk of damage or destruction of infrastructure or technologies, and risk connected with welfare violations caused by conflicts in the society or by a lack of vital needs and services (e.g. water and electricity).

Security risk of supply chain includes risks connected with supply chain system safety without regard to supply chain system vicinity safety, i.e. all partial risks and moreover risks connected with interconnections among the supply chain system assets [1, 4, 9].

6. IMPACT SCORING CATEGORIES USED IN ENGINEERING PRACTICE

Impact is a harmful action of disaster, i.e. harmful phenomenon on protected assets. Engineering practice works with 3 impact categories namely acceptable (tolerated), conditionally acceptable and unacceptable. Acceptable (tolerated) impact does not cause significant problems to an entity and does not cause a security and development violation to the entity. The entity deals with it by means of insurance (insurance companies, banks, UN economists usually use a level of acceptability determined by two per mile of annual budget). Conditionally acceptable impact causes average damages and losses, short-term retardation of economic growth and of security. Entity deals with it by prepared measures and activities which ensure that the violation of security and development do not lead to long-term losses and damages. Unacceptable impact is an impact which may cause an entity destabilization and termination. To avert it entity must have continuity plans and crisis plans.

7. CONCLUSION

The above paragraphs show new concept of supply chain purpose. Its mission is to arrange safe supply chain and safe supply chain vicinity. It is different from usually used concepts in literature [10-14]. With use of engineering approach we decided to solve real problems of supply chains, i.e. we search for problems and their solution with use of strategies of risk engineering disciplines under real conditions in a site. We started to collect real data corresponding to the described concept of supply chain for answer the following questions:

- Which phenomena that threaten supply chains are critical for them?
- Which suggestions of measures and activities in terms of legal, technical and educational fields will lead to improving supply chain safety?
- To which phenomena it is necessary to establish preventive, mitigating, reactive and restoring measures and activities in priority so that benefit of public interest and of supply chains´ operators may be reached?
- What legislative measures support the benefit for public interest and for supply chains´ operators?

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APPLICATION OF MOVING WINDOW MEDIAN FILTER FOR UAV CONTROL

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Abstract: *Digital processing of measuring signals is a very effective tool in the data processing. Noise that is superposed to the desired signal often decreases the quality and precision of measured quantity and that is the reason why the knowledge of noise characteristics of every sensor is very important. As for measurement of flight parameters of unmanned aerial vehicles (UAVs) MEMS sensors with ineligible noise characteristics are usually used, it is necessary to perform a proper digital filtration of measured data. Moving window median filter is very suitable for suppressing of chirp noise that is often present in output signals of MEMS magnetometers and accelerometers. The article deals with application of moving window median filter and moving window average filter and their combinations in the MEMS sensors data pre-processing and processing.*

Keywords: *noise, filtration, moving window average, moving window median*

1. INTRODUCTION

For the position determination and navigation of UAVs and also conventional (traditional) aircrafts several sensors are used. Nowadays and especially on UAVs, due to the power consumption, low weight and small dimensions, MEMS sensors are widely spread. In general, the main disadvantage of MEMS sensors is a higher internal noise, which decreases the quality of sensed values and complicates precise measurements. For the position angles determination inertial measurement unit IMU 9 DOF with ADXL 345 accelerometer, ITG 3200 gyroscope and HMC 5843 magnetometer was used. Tested magnetometer and especially accelerometer have a remarkable chirp noise (Figure 1) that considerably affects position angles or computed velocity and trajectory. There are several digital filtration methods: average, median, high pass and low pass filters, Kalman and Extended Kalman filters. Due to needed dynamics of output filtered data (important for position determination and stabilisation of UAV or camera system) fast and simple methods for data preprocessing with small computational demands have to be used.

Real measured data have several peaks from to –80 g up to +45 g. For better representation, on the bottom graph on Figure 1 zoomed data are shown.

2. FILTRATION

We decided to use moving window median (MWM) filter for the chirp noise reduction and moving window average (MWA) filter for smoothing. Filters with the window width of only few samples (max. 9) were tested, which results only into a short time delay, so the signal dynamics were influenced minimally.

2.1 Moving window median filter

The median is the numerical value separating the higher half of a sampled data from the lower half. The median of a finite list of numbers (*n*) can be found by arranging all the samples from the lowest value to the highest and picking the middle one [1]. The basic reason why we used median filter is that median is not influenced by signal spikes. For comparison moving window median filter with window size of $n = 3$, 5 samples was tested. The main disadvantage of median is, that median is a less representative, because it is only an estimation of average [1].

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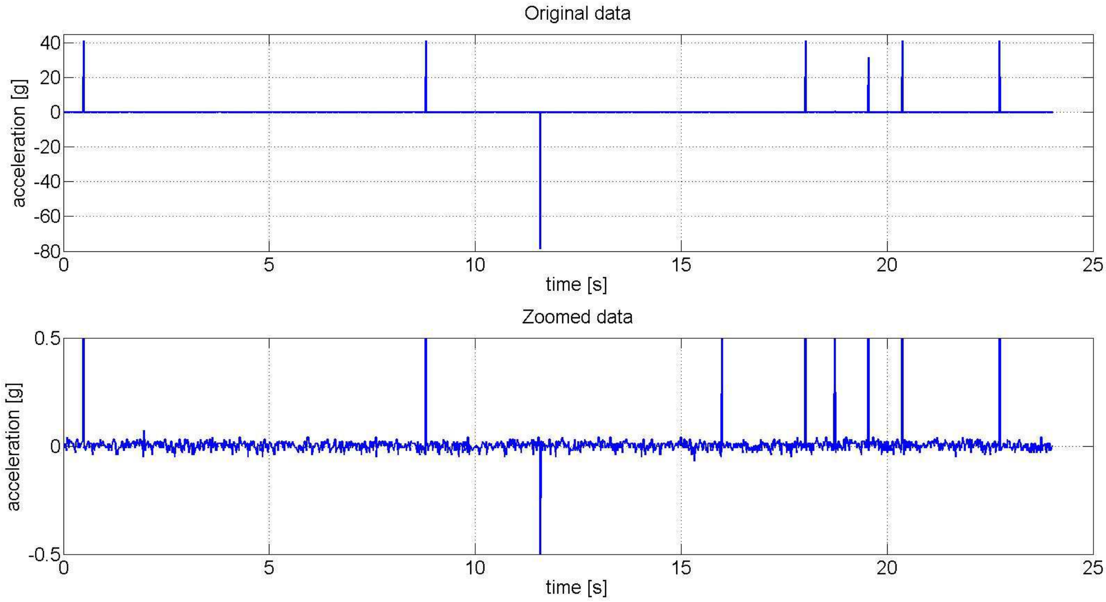

Figure 1 Chirp noise of ADXL 345 accelerometer in x axis

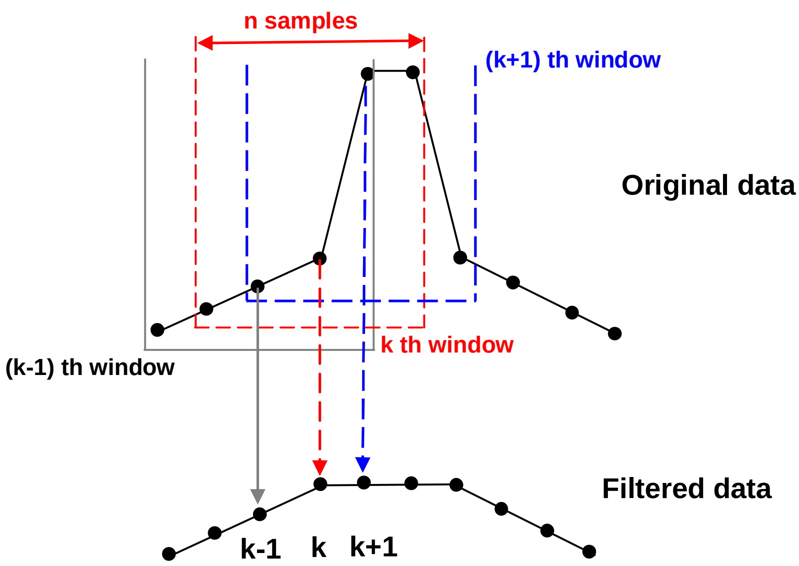

Figure 2 Principle of moving median filter

Figure 2 illustrates how two consecutive peaks (chirp noise) can be reduced with the MWM filter with the window size of 5 samples. Filtered data are not influenced by these two peaks – the peaks are replaced by an actual median value of a current window [2].

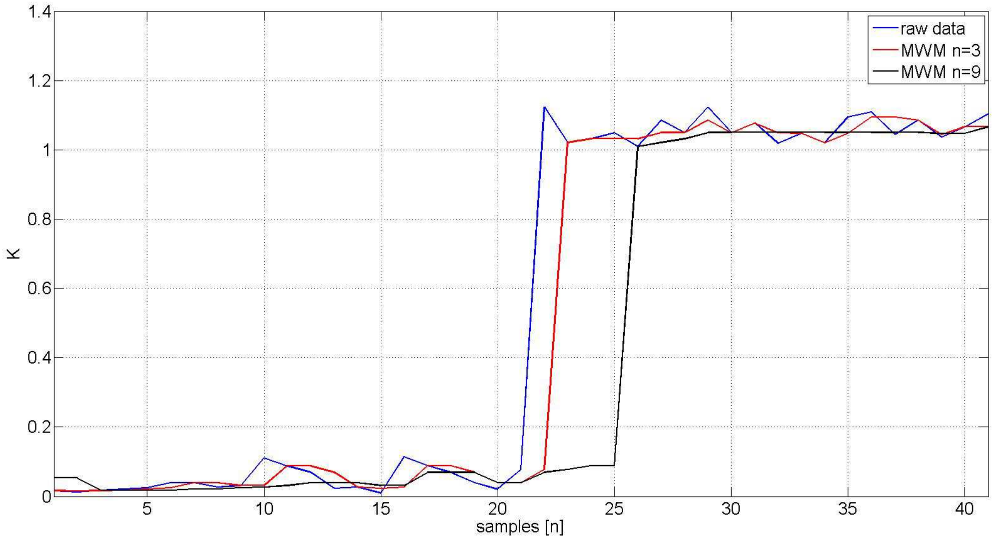

Figure 3 Transient characteristics of moving window median filter

While using moving median filter, we have to consider the delay in time domain. Moving median filter with window size of odd samples number causes delay of (n–1)/2 samples (Figure 3).

2.2 Moving window average filter

A moving window average filter is a type of a finite impulse response filter commonly used for improving the signal-to-noise ratio of the time dependent data. The smoothing action of the moving average filter decreases the random noise amplitude, but also reduces the sharpness of signal edges (Figure 4). Of all the possible linear filters that could be used, the moving average produces the lowest noise for a given edge sharpness. The amount of the noise reduction is equal to the square-root of the number of points in the average. For example, the 4 samples wide moving window average filter reduces the noise by a factor of 2. The lowest noise is obtained when all the input samples are treated equally – the moving average filter [3].

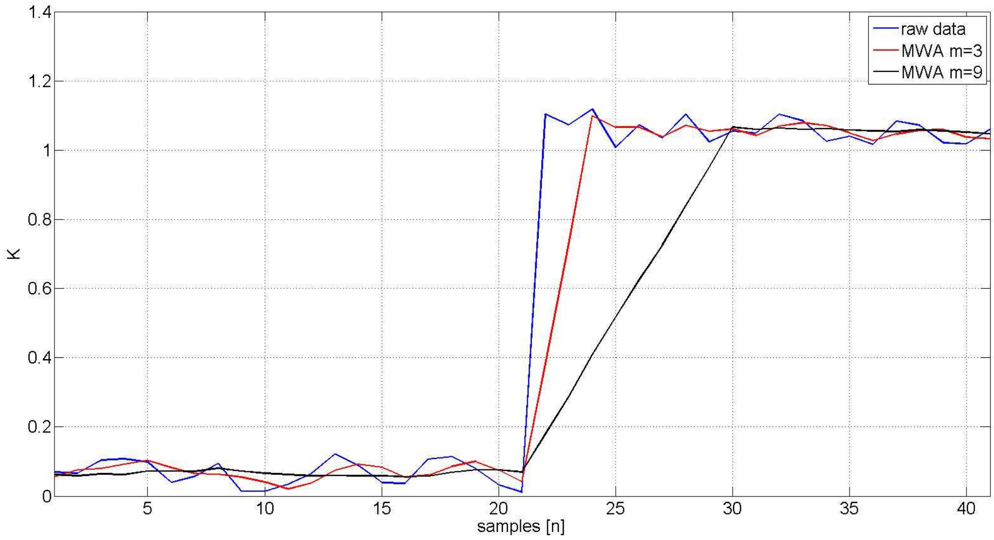

Figure 4 Transition characteristics of moving average filter

While using a moving average filter, we have to consider with the time delay, too. The moving average filter with a window size of m samples causes delay of (m–1) samples.

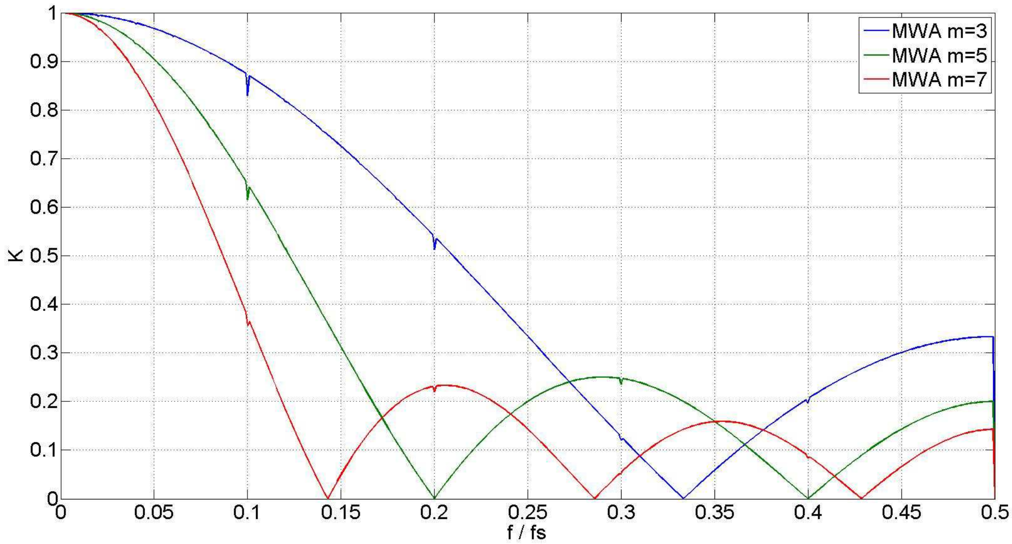

Figure 5 Frequency response of MWA filter

On the Figure 5 frequency response of the MWA filter is illustrated. It can be asserted that the roll-off is very slow and the stop band attenuation is not good. The moving average filter cannot separate one band of frequencies from another. As the window size increases, the attenuation is greater and the number of bins increases. Therefore it has a poor frequency response.

2.3 Combination of MWM and MWA filters

When we combine median and averaging filter, we can decrease the chirp noise with median filter and consequently the median filter output can be used as the input for the averaging filter and so we get smoothed data.

We tested several combinations of moving average filter applied on the data after moving median filter utilization. We know that the shocks in the acceleration data usually take 1 sample (rarely 2 samples) so the window size of the MWM filter of 3 or 5 samples is sufficient. Due to the dynamics the MWA filter window size can be 3, 4 or maximum 5 samples.

3. RESULTS

For verification of mentioned filters we tested them on the noisy signal with several peaks (Figure 1).

During test measurements, the IMU 9 DOF was connected to the ATMega microcontroller in Arduino Duemilanove board through the I2C interface. Sampling frequency (*fs*) used during measurements was 100 Hz. This signal represents real measured data from mentioned IMU. For the noise reduction comparison, on some graphs zoomed data are shown.

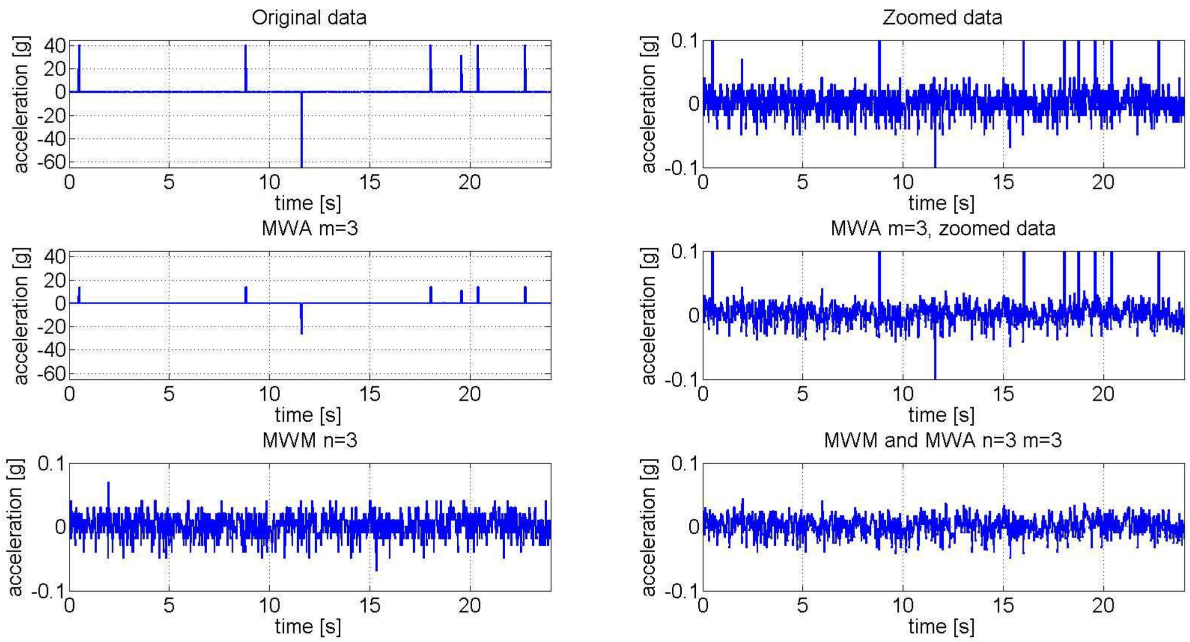

Figure 6 Real data and filter application

As expected, the median filter successfully removed the spikes from the data. Both filters were successful in reducing baseline noise represented by the standard deviation (STDEV- σ) of the signal. There was a significant difference in the STDEV between filtered and unfiltered data. STDEV of unfiltered data with noise and peaks was 2.5487. For the comparison STDEVs after filtration are shown in Table 1 and Table 2.

$$\sigma = \sqrt{\frac{1}{k}\sum_{i=1}^{n}(x_i - \bar{x})} \quad (1)$$

where k - number of samples,
x_i - actual value,
$\bar{x}$ - true value of signal

As the sampling frequency was 100 Hz and time duration of signal is 24 seconds, k was 2401 samples.

Table 1 MWM and MWA filters comparison

Window size	σ of MWM [g]	σ of MWA [g]
3	0.0182	1.47
5	0.0133	1.1417
7	0.0130	0.9653

As there were several spikes in the original dataset, STDEV of MWM filter was smaller than STDEV of MWA filtered data. There is no significant difference between the MWM filter with the window size of 5 and 7 samples, so there is no reason to use a wider window than 5 samples.

Table 2 Combination of MWM and MWA filters

MWM window size *n*	MWA window size *m*	σ [g]
3	3	0.0141
3	5	0.0116
5	3	0.0119
5	5	0.0109

In comparison with a single MWA or MWM filter, the combination of the MWM and MWA filter provided even better results. Combination of the MWM filter using the window of 3 samples and the MWA filter with the window of 5 samples has a time delay of 5 samples. The combined filter with MWM filter window of 5 samples and MWA filter window of 3 samples has a time delay of 4 samples. If we consider 100 Hz sampling frequency, it causes time delay 0.05 s or 0.04 s, respectively, which is acceptable for example for the stabilised camera system mounted on a UAV

4. CONCLUSION

Measurement results confirmed that digital signal pre-processing is a very effective tool in the data filtration process. The simplest digital pre-processing filter is the averaging one. During the measurements the real sensor data using moving window average, moving median and their combination were processed. Though the MWA filter is not able to solve the problem of chirp noise, it has a better performance than the MWM filter for the data smoothing. Moving window median filter was successful in spikes removing from the noisy data. The attenuation caused by the filtration directly depends on the width of the used window. Because low time delay was required filters with only 3 – 9 samples in one window were tested. After the pre-processing of the accelerometer real data with spikes STDEV decreases with the MWA filter 10 times and using the MWM filter 100 times. This fact makes consequent complementary or Kalman filtration more efficient. Even better results were achieved using the combination of MWM and MWA filters. These pre-processing filters are used for accelerometers and magnetometers from IMU.

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IMPLEMENTATION OF SELECTED FLIGHT REGIMES OF ERGATIC AVIONIC SYSTEM INTO HEURISTIC MODELS

Tobiaš LAZAR[1] - Pavol KURDEL[2] - Ján LABUN[3]

Abstract: *Methods of the estimation of stability and controllability of recent ergatic avionic systems (LES) are based on numeric and graphic outputs of flight information recorders. To estimate dynamic stability a time recording of the position of controls in impulse amplitude or width-modulated shape isused separately. A method of the implementation of amplitude modulated signals of suggested heuristic LES model is described in the paper.*

Keywords: *stability, controllability, control pilot operator (OP), flight parameter, semi-natural modeling, local estimation*

1. INTRODUCTION

Effective controllability of recent LES is determined by:

- level of energy consumption spent on its control,
- information flexibility of control system, which accepts OP energy consumption and its influence on effective handle-bars stability (rudders, flaps, wing flaps, air brakes, etc.) at metasystem program fulfillment,
- characteristics of assistance systems and stability automatons,
- amplitude – phase characteristics of control systems including OP.

Effective energy (force) level needed for LES control is secured by performance realization systems (hydraulic, electric, etc.), through which OP deflects rudders as well as other aerodynamic control elements. Control systems, which realise the change of flight regime in two-factor way (i.e. rudder deflection and OP force) are used as well. Modern, mainly supersonic jets have rudders hinge moments controlled by rudder drives, which react sensitively not only to the change of controllers position but also speed of their movement. OP spent force (energy) in LES control is artificially realised with the help of load mechanisms, the characteristics of which secures pilot´s comfort. Quite demanding requirements are imposed on frequency and amplitude characteristics of LES control system, which must comply with not only rudders but also assistance systems.[2] Complex flight conditions require the change of characteristics, the range and preciseness of which is set by the system with cognitive control architecture.[3] The meaning of such arrangement of LES control is to enable OP to perform the change of one regime into another one in a simple way and also compensate for the influence of outer environment.

2. COGNITIVE REACTIONS

LES cognitive reactions to altered flight conditions are performed by:

- the change of engines working regime,
- the change of LES configuration,
- the change of control into alternate ergatic process in case of the failure of LES main control system,
- safeguarding and control of reliable work of decisive LES architectonic units,
- fast compensation of the influence of outer conditions on the change of LES properties.

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Composition (integral) of drive properties into characteristic LES controllability and stability manifestations requires mainly:

- adjustment of the change of LES aerodynamic gravity center considering the position of engines (engine) including accepting their input and output characteristics,
- accepting gyroscopic engines (engine) moments mainly at maneuver flights,
- comfort in LES control of the operator – pilot is based on cognitive estimation of static controllability of assistance systems, the function of which is reflected in his self-realisation and mental load.

The following quantitative indicators of static controllability are realised in mathematical models devoted to the research of asymptomatic learning and OP skills:

1. Out of small and slow deflections of the controller by OP from the original value, this equals LES equilibrium. In the analysed case, LES configuration, weight, centering does not change and the flight is not performed behind performances limits.
2. During the flight behind flight envelope when OP moves controllers at unvaried LES configuration and centering. Aircraft drives and balancing systems stay in the position of travel flight regime.
3. At fast change of LES configuration, weight, centring and drive performance regimes. In such experiments, flight speed and reference acceleration stay the same which is secured by OP´s stabilization of controller positioning.

The indicator of controllability has different estimation principle in each of listed manifestations. After performing the first experiment, the indicator is estimated according to generally valid principle [3]:

$$\text{CONTROLLABILITY INDICATOR ESTIMATION} = \frac{\left(\text{PARAMETERS CHARACTERISING OP´S ACTIVITY}\right)}{\left(\text{PARAMETERS CHARACTERISING OP´S REACTIONS (RESPONSES)}\right)}$$

Figure 1 Summary of parameters influencing LES controllability

At the analysis of horizontal static controllability of recent aircrafts two kind of controlled movements are analyzed:

- abrupt change of trajectory decline angle at constant LES speed,
- LES acceleration and deceleration at straightforward flight.

At the analysis of horizontal and side stability the controllability is judged according to the following LES movements:

- by set side deflection at straightforward flight trajectory and constant speed,
- by the rotation of LES around its horizontal and vertical axes at unaltered speed.

A skill, which is analysed at the changes of spend energy (force) on the controllers and balancing characteristics, which is obtained by measuring the positioning of the controller is the output of OP parameters estimation.

3. CONTROLLABILITY IN THE PROFILE OF CONTROL SKILL BY OPERATOR - PILOT

As the scheme of mutuality and influence in LES control (Figure 1) illustrates, the movement of the controller, which transforms pilot´s professional giveness is the only OP output. Professional giveness is concentrated into unique human (biological) functions in connection with ergonomically shaped environment is the initial assumption of the interpretation of personality skill, which is appraised by LES controllability.

Controllers (controller) movement and energy (force) (Figure 2) spent at it show the method of research by which the applied cybernetics is reduced into control theory method. Presented simplified view enables to integrate given control manifestation into control circuit as the circuit element. It is necessary to balance the need of LES physical controllability harmonization and its effective OP control into their mutuality. It follow from the presented object (LES) and subject (OP) descriptions that the mutuality determines cognitivity and capability (adaptability) derived from this, it means LES controllability and OP skill. Transformation of both of these properties is realised in the feeling of necessary doses of OP´s spent energy in the deflection of the controller, which evokes expected reaction (response) of LES. When OP cannot feel the change of force in his influence on the controllers, then he loses an important part of the information about the change of LES flight regime. Mistakes in control are the result, in some cases also the loss of control circuit stability. As the results of the research in given field have shown [4], the loss of control circuit stability occurs not only at the loss of force measure but also too small values of control factors which is describes by a graph (Figure 2).

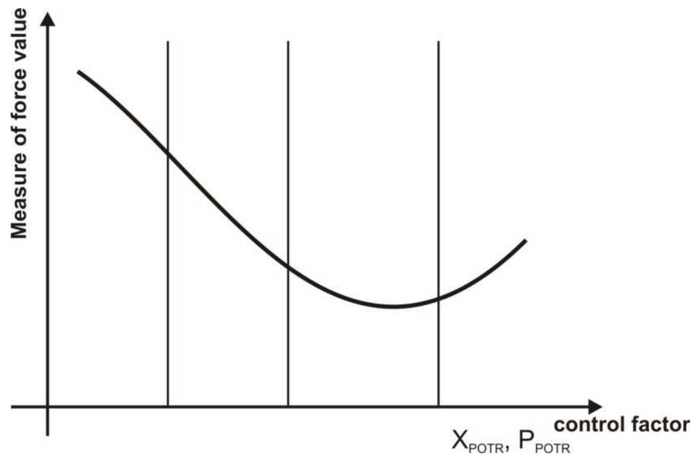

Figure 2 Graphic representation of the measure of LES controller movement and spent force X_{POTR}, necessary controller deflection, P_{POTR} – necessary OPś force value

Graphic representation of the measure of control factors change LES movement parameters (see Figure 3) in space in different ways. Time changes can be expressed by the number of points $\boldsymbol{Z_i(t)=\alpha(t), M(t), V_{iz}(t), H(t), \ldots, \omega_x(t), \omega_y(t), \omega_z(t)}$, in $\boldsymbol{n}$ – dimensional Euclidian space $\boldsymbol{E}$, which can be divided into a range of characteristic zones. Characteristic zones create the environment of possible parameters $\boldsymbol{Z_i}$ of aircraft movement together.

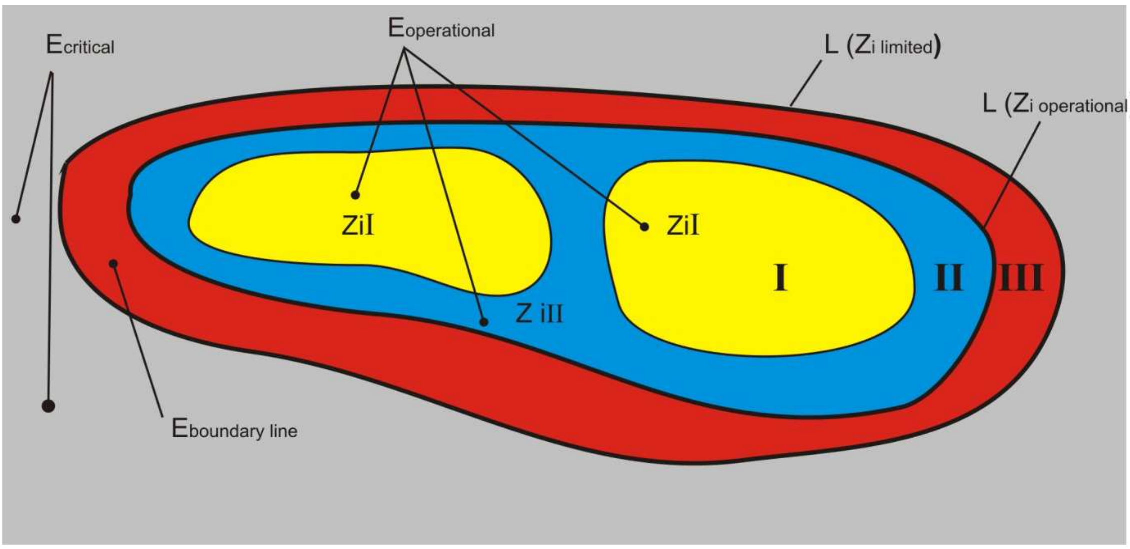

Figure 3 Profile of distribution of possible flight parameters Z_i, LES at OP control factors influence.
Legend: I – main zone, II – operational zone, III – limit zone separated from operational one by the limit range of permitted values.

Zone $E_{operational}$ – operational values of those parameters, for which the following is valid

$$\left|Z_i\left(t\right)\right| \le \left|Z_{i\ \mathrm{permitted}}\right|$$

Zone $E_{limited}$ – values of limit parameters determined by the following equation

$$\left|Z_{i\ \mathrm{permitted}}\right| < \left|Z_i\left(t\right)\right| \le \left|Z_{i\ \mathrm{limited}}\right|$$

Zone $E_{critical}$ – parameters values which are dangerous for LES flight regime if the following is crossed

$$\left|Z_i\left(t\right)\right| > \left|Z_{i\ \mathrm{limited}}\right|$$

As Figure 3 shows, outer limits of profile $L(Z_{\ limited})$ show potential occurrence of critical flight regimes, $L(Z_{i\ permitted})$ – is realisation area of normal operational parameters. Internal part of profile E^{Pr}, which is closed by boundary line $(Z_{i\ permitted})$ contains all possible values reachable in normal flight operation for which the following is valid: $|Z_i(t)|\le|Z_{i\ permitted}|$ which lies in the zones ***E(I)*** and ***E(II)***. In concord with valid classification the following parameters belong here: ***V*** – speed, ***H*** – flight height, $n_{x,y,z,}$ – multiples of acceleration, haunch angle, which are inevitable conditions of flight task fulfillment. The second zone contains parameters permitted in LES limit operation.
The area, which fills the internal and external area contain only those LES parameters, which correspond with limit flight regime ***E(III)***. These are limit speed values, haunch angle, flight height, crossing of which evokes acute danger.
Outer closed space belongs into the area of controllability ***left of the line*** $L(Z_{i\ limited})$ and presents a profile of dangerous critical dynamic states. It is necessary to accept the characteristics of the area (Figures 2 and 3) so that they would comply with the requirements of the operation, LES weight and requirements of specifically defined tasks fulfillment in searching the solutions of controllability increase.

4. HEURISTIC MODEL OF COGNITIVE LES

Standards of aircraft capacity define the levels of stability and controllability so that areas of successful control (OUR) in each flight period, i.e. since the take off until landing, were obtained. Showing complexity of mutuality working in the relation *man* – machine shows the need to implement cognitive principles, the implementation of which into aviation practice requires the knowledge of design and simulation of models.
Structures of system behavior are determined by heuristic modeling on the base of conclusions obtained by the method of induction and observation [5].
The process of heuristic modeling contains:

- Investigation of functional laws of modeled system,
- creation of algorithms from elementary information processes from which functional laws are created,
- correction of model according to the results of observation up to obtaining suitable results.

Analysed heuristic models of cognitive LES accept the profile of zones E^{Pr}, E^{m}, E^{Krit} of Euclidian space ***E*** (Figure 4). Changes of dynamics and aerodynamic LES changes, which have the greatest influence of OP´s skill, present the basic elements of created models.
These are:

- changes of Mach number M, flight altitude, period of horizontal and side oscillation, time of damping of occurred non-steady state evoked by the malfunction of acceleration multiplications amplitude time,
- manifestations of the influence of haunch angles on static stability (specifically side static stability),
- essential changes of horizontal stability at speeds close to sonic speed,
- essential changes in trajectory static stability at speeds close to sonic speed,
- drop of effectiveness of controllers at supersonic speeds,
- growth of rudder hinge moments at reverberant and supersonic speeds.

Listed elements (but also others, which are not presented considering wide range of research) bring specifics into LES control which enable to skillful OP to increase his professional art.

Analytic – synthetic method of the determination of stability and controllability of LES heuristic model in the environment of mathematical lab (MATLAB) is the example. A circuit, into which model OP enters, has been simulated within the research performed at the Department of avionics at TUKE in Kosice.

Dynamics of ergatic complex is determined by vector equations (Figure 4).

$$dx/dt = Ax + Bu + Bp.w$$
$$y = Cx + G.u \tag{1}$$

Vectors of states:

x = [change of flight speed (DV), change of haunch angle, derivation of angle Θ change of angle Θ].

Scalar parameter is selected by operator - pilot: ***W***

Compensator described by vector equations presents the system of stabilization:

$$u = K1x + K2z + K3w$$
$$dz/dt = K4z + K5y + K6w \tag{2}$$

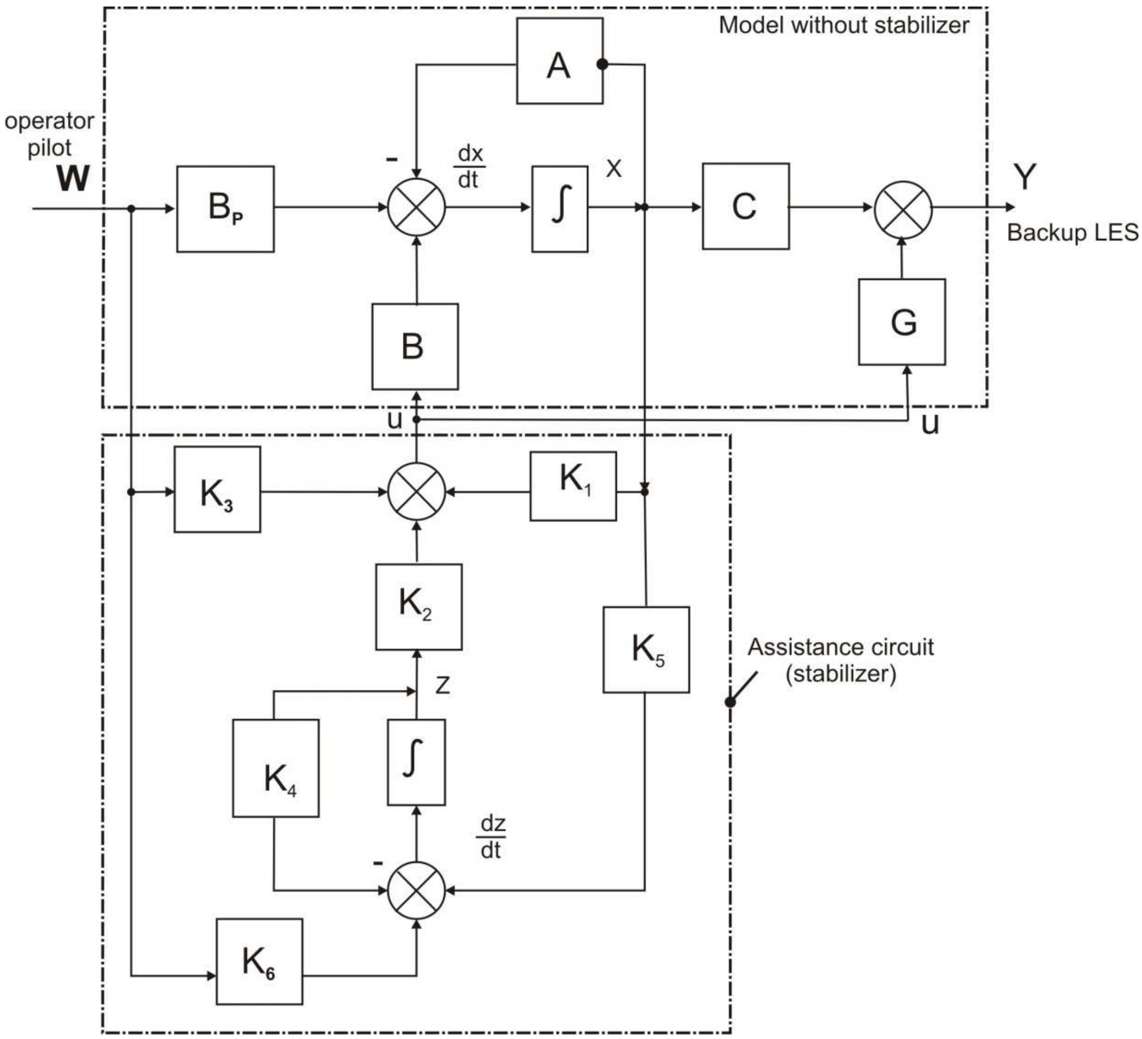

Figure 4 Heuristic model of LES stabilization

Model parameters:

- stabilised flight regime of agile LES,
- flight level 7000m, (23 000 ft),
- Mach number 0,8.,
- flight airspeed V0 = 250km/h. (135knot)

Numeric forms of equations (1), (2) are available at the Department of Avionics, Faculty of Aeronautics of Technical University of Košice.

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The aim of modeling was to illustrate the mutuality of relationships between OP and aircraft (LES unit). The need of object and subject adaptabilities were considerably shown by simulation. Compensator, the design of which was performed by the method of geometric position of roots (Evans method), is secured by LES adaptability to the change of flight conditions. Compensator For suggested LES enforcement, the compensator stabilised sufficiently and shaped suitable conditions for control in observed range, which has shown in the smooth shape of transfer characteristics. The compensator has been designed so that it could accept relevant permitted changes.

5. CONCLUSION

The compensator stabilizes the model in a narrow range of stability in its designed enforcement. Such property of the stabilizer can be used in ergatic system for the training and education of the operators - pilots. When observing flight security, the compensator (stabilizer) requires setting the range of permitted changes and their instrumental securing (Figure 3).Suggested model can be used as a model in suggested intelligent identification system, where it will also be a part of supervision program of OP skills observation.

This work was funded by the European Regional Development Fund under the Research & Development Operational Programme project entitled "Construction of a research & development laboratory for airborne antenna equipment, ITMS: 26220220130."

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SAFETY AND RESCUE SYSTEM FOR SMALL UNMANNED AERIAL VEHICLE

Pavol LIPOVSKÝ[1] - Ján BAJÚS[2] - Jozef HUDÁK[3]

Abstract: *Civil applications of unmanned aerial vehicles (UAV) are encountering a significant growth all around the world. Considering this fact, there also exist many subjective and objective causes that induce emergency or crash situations of a UAV. The key task is to recognize a critical state, when there is needed a decision, whether to activate the rescue sequence of the system or not. For this purpose, it is necessary to continuously monitor a large amount of parameters on-board the UAV. There are three types of sensorics used for monitoring: UAV control and navigation sensorics, sensorics of application equipment and specific sensorics of the rescue system. The article introduces the electronic equipment as it is being developed at our department and presents initial results obtained during experiments with a realized parachute rescue system for a small UAV.*

Keywords: *UAV, safety and rescue system*

1. INTRODUCTION

Accidents are representing an inevitable critical part of aviation. There are many sources of critical situations, but the human factor and hardware failures are the most significant.

With current development in the area of legislation for UAVs and their incorporation into the controlled airspace, safety issues have arisen. It is expected, that all UAVs will have to have implemented some kind of a safety system. The most simple of these systems is a parachute module that can not only prevent damage of the UAV, but can also prevent from crash damage of other property [1].

2. ELECTRONIC EQUIPMENT OF A UAV

Based on current trends in the area of UAVs, there are two main types of sensoric equipment from the topological view. First and the most used is the centralized system. It is widely used in small, low cost UAVs. The center of the system is often a powerful microprocessor, which controls/computes almost everything based on the data obtained from sensors directly connected to the microprocessor pins. The second type is a decentralized system with electronics forming modules that are connected to one shared system bus. Each module has its microprocessor, so the workload of computation is shared. From the view of purpose, there can be basically specified three types of sensorics used on the UAVs: control and navigation sensorics, sensorics of application equipment and specific sensorics of the rescue system. Figure 1 shows the simple block diagram of on-board electronics as it is being developed at our department.

From the block diagram it is clear, that the electronics being developed is a complex modular system, so other devices such as backup modules for navigation and control could be attached. There are two independent, but identical system buses in the developed system, to avoid fatal error when one of the buses fails. In normal state, they are used for different purposes. One system bus is for communication among the modules, the other is used by the safety and rescue module to permanently check the states of individual modules. If a bus failure occurs, these functions are merged for the functioning bus.

The safety and rescue module, which is a part of the safety system, includes microcontroller for processing the data from system bus and emergency receiver/transmitter, and also from the flight envelope sensors, a secondary IMU (inertial measurement unit). This secondary IMU can be used also for emergency navigation.

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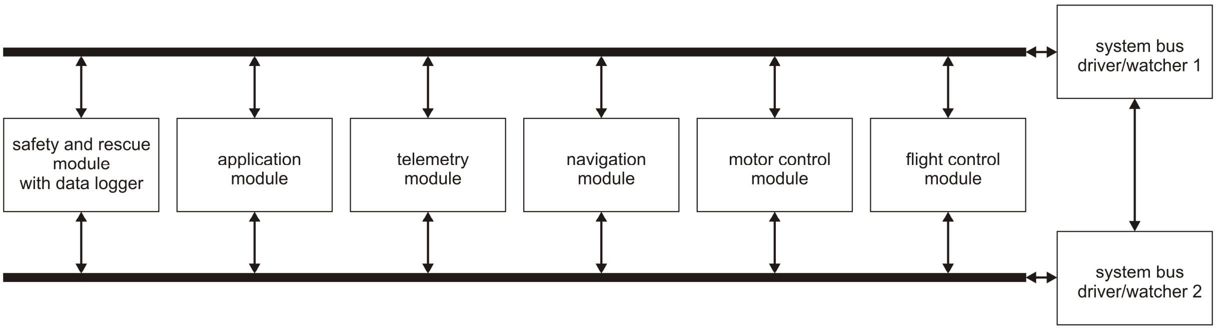

Figure 1 Block diagram of the electronics for UAV under development

For example, if there is a failure in a flight control module, the microcontroller starts the "return to home" sequence. If the navigation module fails, it also launches the "return to home" sequence (based on the IMU data in a safety and rescue module) or it starts the emergency landing procedure. If a motor control module fails, it launches the parachute. The flight envelope is exceeded when a fatal failure occurs, so the result is also a parachute launch. After the launch a beepeng sound is generated and the emergency signal receiver/transmitter begins to transmit the signal through its non-directional antenna for a faster location of the UAV.

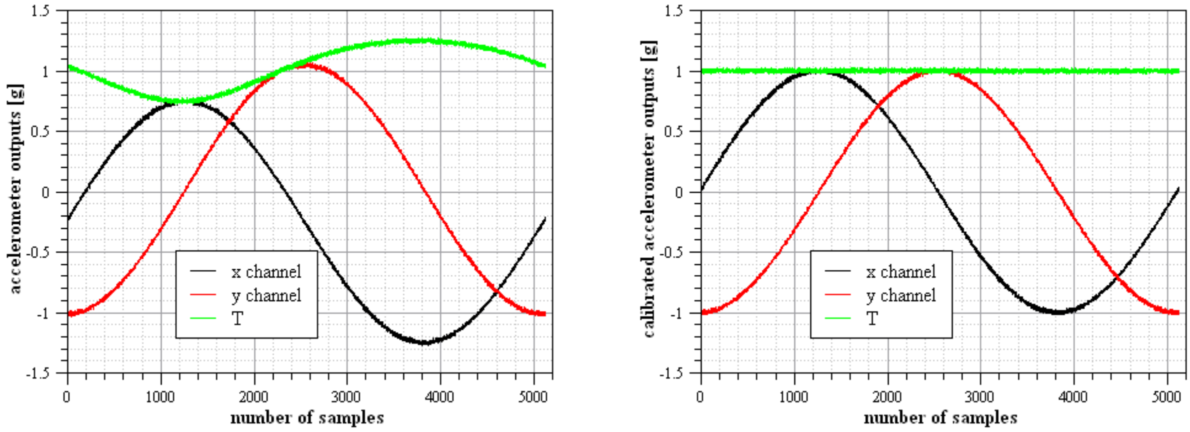

Figure 2 Comparison of uncalibrated and calibrated outputs of accelerometers

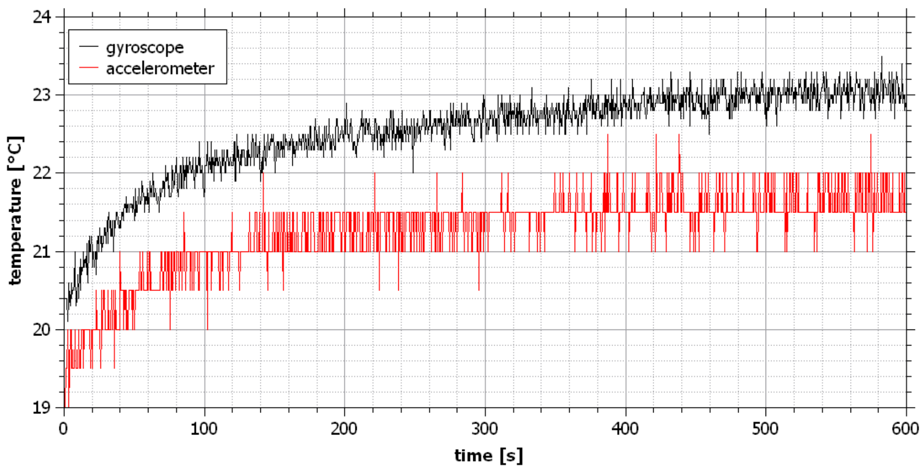

Figure 3 Electronics temperature development after power-on

To properly detect critical situations, the sensors used have to be calibrated and compensated for temperature dependencies. The calibration of sensors is a very important factor that improves overall safety. In Figure 2 and Figure 3 are shown examples of uncalibrated and calibrated accelerometers [2] outputs and temperature development after start-up of the electronics. So the calibration, as a process, is itself a part of the safety system of a UAV.

3. PARACHUTE MODULE DESIGN AND ITS TESTING

When designing a parachute, we have to maintain the physical principles. Descending of an object with a parachute is dependent on the resistive force created by dynamic pressure that is created by the movement of a parachute in the air, on the diameter of a parachute and its drag coefficient C_D. Dynamic pressure is a function of velocity and air density, it is dependent on altitude and temperature. C_D also depends on the size and the shape of the parachute. For calculation it is sufficient to use the gravitational force and the drag force:

$$\begin{gathered} F_D = F_G \\ \frac{1}{2} C_D S \rho v^2 = mg \\ v = \sqrt{\frac{2mg}{SC_D \rho}} \end{gathered} \tag{1}$$

Where: F_D is the drag force,
F_G is gravitational force,
m is mass of the object including parachute,
S is effective surface of parachute,
ρ is air density,
g is gravitational acceleration.

But this simplification, when C_D is used as a measure of parachute effectiveness, can be misleading, due to the fact, that when descending, also horizontal and not only vertical components of velocity can occur. Also, by higher velocities, it is possible that the shape of the parachute will be deformed and thus the effective surface will be decreased [3].

The UAVs used at our department are almost all in the weight of maximum 1.5 kg. We have chosen 6 m/s as the critical value of descending velocity. This value is a compromise between the descending velocity and the weight of the parachute. This velocity is sufficient for preventing larger damages caused by the falling object. For comparison, when descending with parachute, the impact energy is 27 J, compared to the energy of free fall from the height of 5 m, which is approximately 1875 J.

Figure 4 Photography of parachute

Calculated diameter of the parachute for chosen velocity is 103 cm, but there has to be added the weight of the parachute module, so the final diameter of the parachute is 125 cm. Parachute alone weights 200 g and the launcher device weights 100 g, so, after recalculation, estimated descending velocity is 5.45 m/s. The photography of the realized parachute is in Figure 4.
For testing purposes and later utilization as a logging device was created an electronic module that records values of barometric pressure and accelerations. This device consists from small IMU unit, microcontroller and EEPROM (Figure 5). The data can be extracted by PC via the USB port.
Activation of the parachute is realized automatically, by signal from the on-board electronics or manually with transmitter at 433.92 MHz frequency with 600 mW transmitting power. Transmitted data are carried with amplitude modulation with modulation index 1, so called OOK (on/off keying) modulation. The protection from the unwanted parachute launch is realized with 128 bit digital code. In the beginning of the transmission is sent the preamble, next is synchronizing word and then the 128 bit code for parachute launch [4]. The launch of parachute is realized with electro-mechanical device.

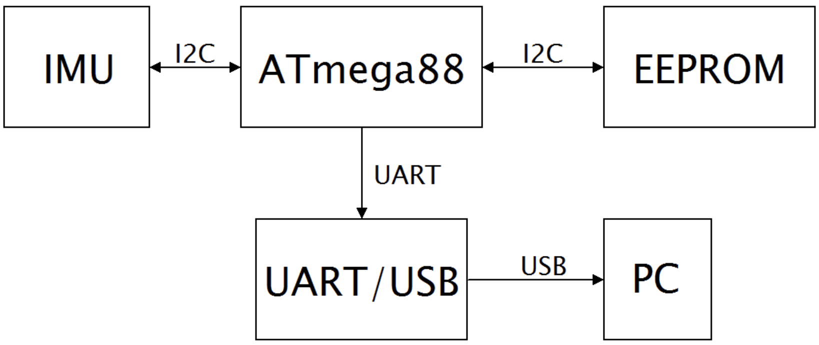

Figure 5 Block diagram of test data recording module

The recording of acceleration during the test of the parachute is shown in Figure 6. The parachute is completely opened in time 1.28 second after the launch. During the launching and opening process, maximal measured acceleration was 9.5 g. This value is relatively high, but causes no significant damage to the object, but to prevent damage of sensitive mission dependent equipment, a damper will be implemented in the nearest future. In the time from 2.68 to 3.4 second is visible small oscillation of the parachute. The impact acceleration was quite high, but the object was not significantly damaged. Based on the data, minimum height of the UAV for safe parachute landing is 10 m.

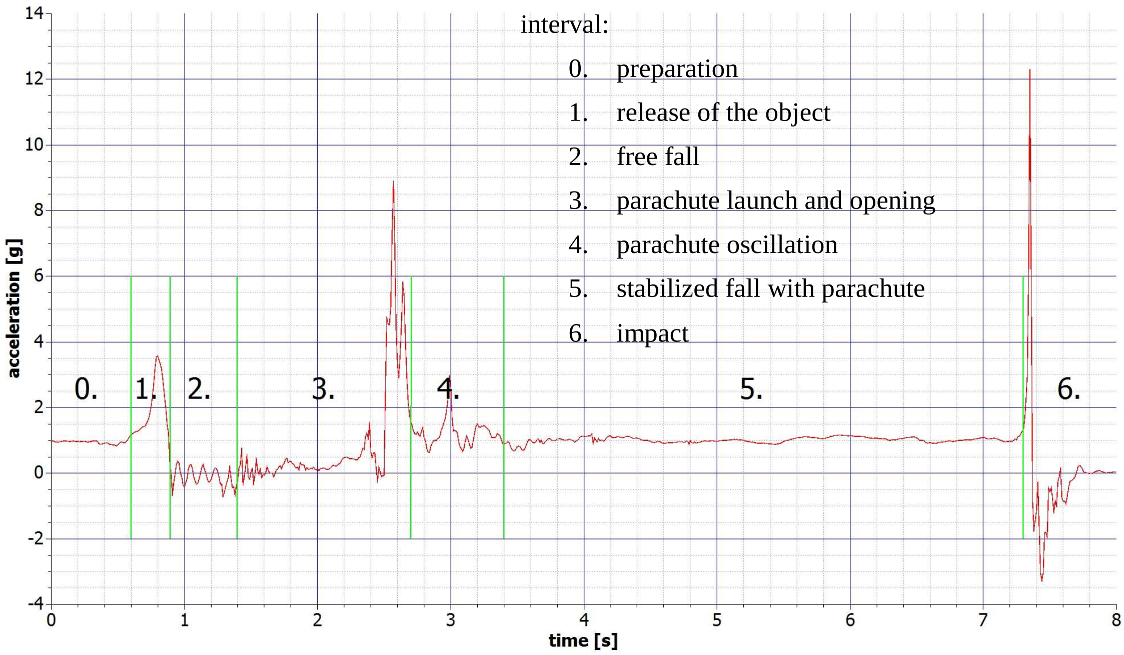

Figure 6 Recording of acceleration during the test of the parachute

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4. CONCLUSION

In the ongoing development at our department, safety issues have a high priority. It is necessary to avoid damages caused by tested UAVs and thus implement a safety and rescue system. This safety system could be viewed as not only the hardware, that is on board of a UAV, but also includes processes such as proper calibration of used sensors, technical base in the form of calibration workstations created across our faculty and also the training of the personnel. These all are forming a safety system of a UAV.

First results of parachute module testing have proved a proper function of this module. Based on the data, further improvements have to be made. The first one is installation of a damper to the parachute to suppress stress created during the launch and opening sequence of the parachute. The second one is to change the material used for the parachute to lighter one and so to realize larger parachute, but with the same weight. This will result into a better protection of often expensive and sensitive mission dependent electronics equipment.

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THE E-LEARNING AND VIRTUAL REALITY TECHNIQUES APPLICABLE TO TRAININGS PROVIDED TO AVIATION ENGINEERING STAFF

Przemyslaw MADRZYCKI[1] **- Marek SZCZEKALA**[2]

Abstract: *For years now the Air Force Institute of Technology and the Polish Air Force University have been carrying out research studies and implementation efforts in the area of new training techniques and systems. The outcome of these common efforts is the e-Learning System designed to give instructions and provide training to the maintenance staff of the Polish Air Force. At present, they proceed with a new design of a diagnostic simulator that makes use of virtual-reality (VR) techniques. The both techniques are intended to set up a modern training centre capable of modern and effective training of the aviation engineering staff. This paper is intended to present the potential for applying the most recent instructional/training techniques to aviation. It also outlines a concept of a comprehensive training system that benefits from the e-Learning and simulation-based techniques with the aim to develop skills that are necessary for the engineering staff of the Polish Air Force with*

Keywords: *E-learning, virtual reality diagnostic simulator, ground engineering crew, training*

1. INTRODUCTION

Well-scheduled end efficient training is one the key factors that are decisive for safe operation of aircrafts. Over the passing decades the design solutions of aircrafts and their on-board equipment have subjected to massive changes. Aircraft structures have achieved enormous level of saturation with electronic equipment, computer systems and automatic solutions. Consequently, operation and maintenance principles of aircrafts and rules for inspection of the equipment by the maintenance personnel have also amended. All these factors enforced alterations in the approach to trainings of both on-board staff and ground-based engineers and technicians. In line with continuous progress in design of aircrafts and their on-board equipment it is necessary to keep pace with modern training and teaching methods that offer much better educational opportunities and final achievements as compared to conventional techniques. This paper outlines the most advanced training techniques that have been applied to training syllabuses for Polish Air Forces. The Air Force Institute of Technology in Warsaw and the Polish Air Force University in Dęblin are jointly the co-authors of the training systems that have already been implemented to current practice and are efficiently used for trainings of Polish engineering and maintenance personnel.

2. „SOWA" - THE E-LEARNING SYSTEM FOR TRAINING OF MAINTENANCE STAFF

Conventional approach to training of aircraft maintenance staff assumes use of real aircrafts. The trainees, upon completion of a cycle of lectures, keep perfecting the acquired skills with use of a tangible aircraft or a helicopter. It is an expensive and troublesome method that leads to premature wear and fatigue of aircrafts. Due to safety reasons the conventional training techniques are also unsuitable to demonstrate all possible and already discussed defects as well as all hazardous circumstances (fire, fuel or oil leaks, etc.). All these drawbacks can be eliminated when new training methods that benefit from e-learning techniques are applied. Training aids are developed as multimedia presentations that benefit from the most modern solutions, such as animations, interactive presentations, 3D models, etc. The aids can be either individually used by each trainee who can reproduce them whenever he/she wants or the form of a multimedia lecture can be applied (blended learning).

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Beside the new form of knowledge presentation the e-learning technique offers totally new opportunities that better suits current needs.

- Possibility to provide trainings via the Internet,
- Interactive use of multimedia training aids,
- Remote access to training aids, virtually from any location (workplaces, home computers, etc.),
- Ability of self-practice at whichever time of day,
- Development of individual training schedules and syllabuses to match specific needs of trainees,
- Possibility to develop individual 'training paths' dedicated to selected trainees,
- Permanent on-line contact with lecturers and tutors via communication means (e-mails, discussion groups, etc.),
- Permanent monitoring of the training process and stimulation of the progress by asking questions, tests, etc.

The system has been implemented at Polish Air Force University in Dęblin and has been efficiently used for 5 years to train engineering and maintenance staff of air forces. The system structure is shown on the diagram below:

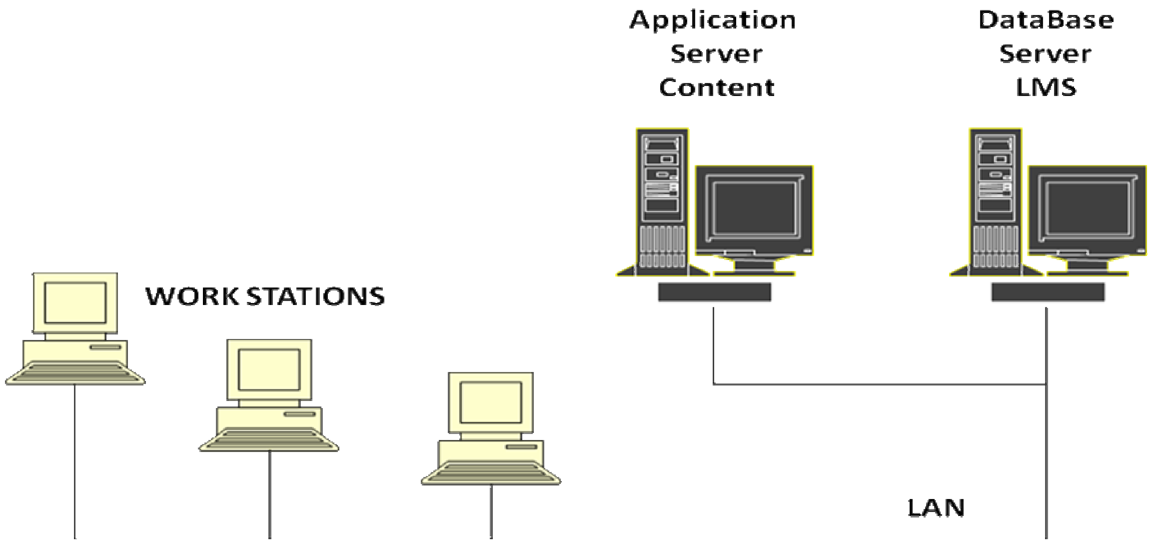

Figure 1 The functional structure of SOWA system

Data Base Server – the server where the Learning Management System (LMS) is loaded. The server stores all system information related to trainees, logging data, training paths, test results, reports, etc.,
The Learning Management System (LMS) – the IT system that enables management of students and training aids that are assigned to each trainee. LMS enables execution of all administration actions (enrolling a new student, removing a student from the database, transferring students between groups, etc.), training operations (assigning selected lessons to each student, setting up a syllabus for training courses, development of individual training paths) as well as supervising operations (monitoring over execution of trainings, progress of students, test results).
Application Server – the server where training aids are stored,
Content – training aids that are developed in the SCORM format and that comprise lessons, topic-related blocks or entire courses.
Workstations – computer stations that are connected to servers via a network. For the assumed configuration only a local network (LAN) is used, but logging into the system via the Internet is also possible. The system enables consecutive operation of as many as 100 workstations. The workstations enable reproduction of the lessons and other training aids independently by each trainee and acquisition of the teaching content of the training individually by students at the own pace. Trainees have their own login names and passwords that enable to get rid of assignment to individual workstations and access the system from any computer within the network.

The SOWA system has been implemented in the form of a ‘multimedia classroom’ furnished with audio and video equipment. Such a solution enables the trainees to remotely attend conventional lectures with use of multimedia training aids (‘blended learning’). Currently the system comprises training aid related to the M-28 aircraft and the W3- SOKÓŁ helicopter. In 2013 development of training aids for the PZL-Orlik aircraft is scheduled and these aids shall be also incorporated into the system. An example of training aids as well as the multimedia classroom is shown in the following illustrations.

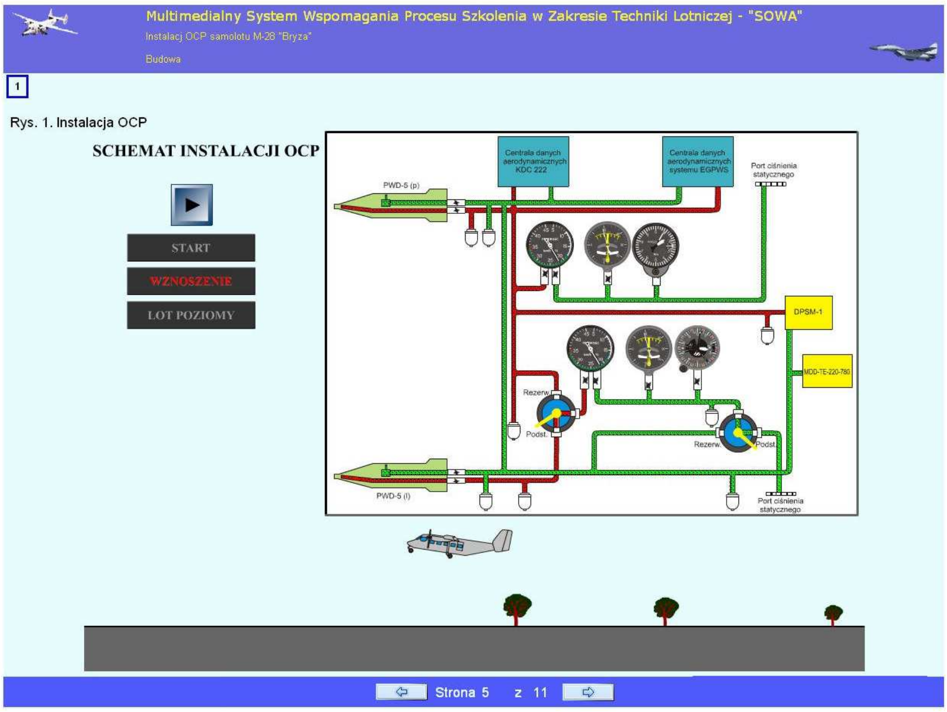

Figure 2 An example of the training course content

Figure 3 The e-Learning classroom

Over the time when the training system was in use the separate studies were carried out to asses applicability of the new teaching tool to trainings. The survey was performed in the form of anonymous questionnaires.
The major objective of the survey was to assess the usefulness of the new training method, the way of presenting the training content and to evaluate how efficient the trainings are with this new technique applied.

The system and the method have been highly appreciated by the trainees. The most essential advantages of this new approach, strongly emphasized by the surveyed participants, include easy access to the training aids (content), ability to learn at their own pace, and easiness of going through the syllabus again. Below (Figures 4 ÷ 7) presented are some selected survey results related to evaluation of the e-learning system.

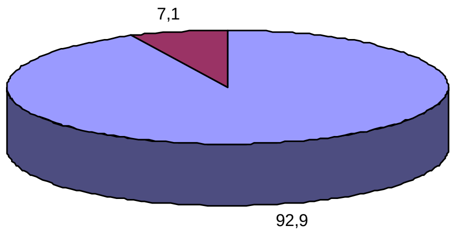

Figure 4 Answers to the question "Is the multimedia (computer-based) training a good form of acquiring knowledge from the training content?" "Yes" – 92.9 %, "I don't know" – 7.1 %

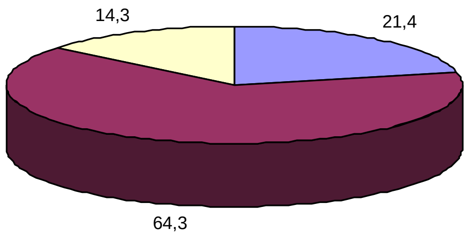

Figure 5 Answers to the question 'Do you mandatory need any consultation with your tutors(s) after having completed the e-learning supported training course?' 'No' - 64.3 %, 'Yes' – 21.4 %, 'I don't know' – 14.3 %

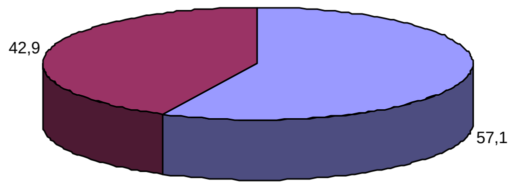

Figure 6 Answers to the question 'Do you believe that the training supported with e-learning technique is more efficient that the one that employs only conventional tools?' 'No' – 42. %, 'Yes'- 57.1 %

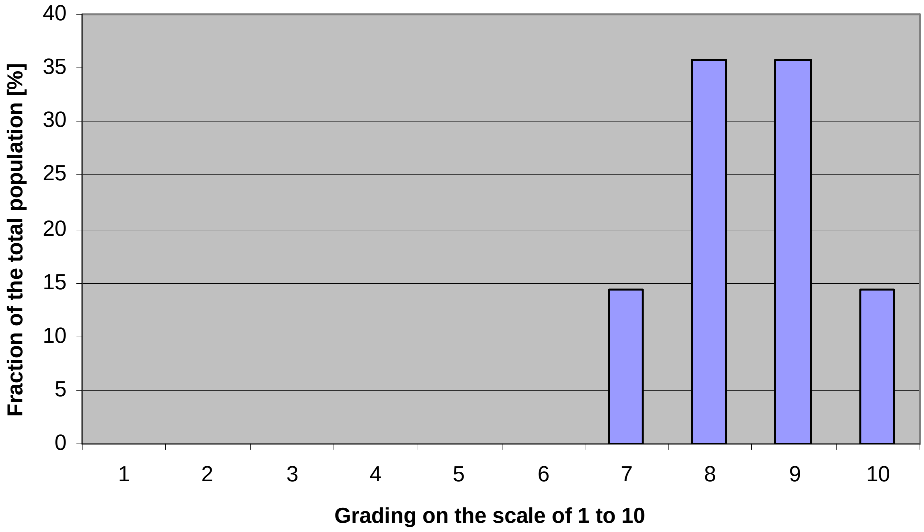

Figure 7 Evaluation (on a scale of 1 to 10) how useful the training are with use of e-learning techniques

The achieved results have proved high efficiency of the training with e-Learning techniques applied. The outcome also indicated inherent opportunities to enhance the system when new simulation techniques based on virtual reality (VR) are incorporated thereto.

3. APPLICATION OF VIRTUAL REALITY (VR) TECHNOLOGIES FOR TRAINING OF MAINTENANCE STAFF

The world of Virtual Reality (VR) offers nearly unlimited training opportunities. A well developed 3D model of any object with suitable software enables reproduction of the object shape, forms of individual object components, physical properties of them as well as mutual physical and functional relationships between them in virtual reality. Also operation principles, all possible deficiencies and defects and remedy methods (troubleshooting) for them can be modelled. All these benefits make the virtual reality tools more and more frequently considered as a training environment. A very important factor is also the possibility to make trainees familiar with components or situations that are very difficult or even infeasible for demonstration with the use of real aircrafts.

In 2009 the consortium made up of Air Force Institute of Technology and the Polish Air Force University embarked on studies with the aim to develop a diagnostic simulator of an aircraft with use of virtual reality techniques. This year the simulator has been completed and shall be commissioned for operation at the Air Force University in Deblin. The simulator is meant for training of maintenance personnel to tech them how to carry out pre-flight inspections of aircrafts in a proper manner as well as to detect and remedy typical defects and deficiencies that may be revealed during inspections.

The simulator comprises the following components:

- Virtual cockpit;
- Virtual fuselage;
- Instructor workplace;
- Control application;
- Package of training aids related to the M-28 aircraft;
- IT system.

3.1 Virtual cockpit

Virtual cockpit – has been engineered on the basis of touch screen displays installed on a mounting frame. The displays provided really realistic visualization of all components that are normally installed in a cockpit (indicators, switches, aircraft controls, knobs, etc.). All components are interactive and react when touched by a trainee. All interactions are kept up between components of the virtual cockpit and the virtual fuselage of the aircraft, e.g. opening of the fuselage door entails appropriate indication on the cockpit instruments, movements of the aircraft controls leads to appropriate dislocation of the tail unit components or ailerons of the fuselage. The cockpit is designed as a modular structure that enables its transportation and installation at various locations. The view of the virtual cockpit is shown on the snapshot below.

Figure 8 The Virtual Cockpit

3.2 Virtual aircraft fuselage

Virtual aircraft fuselage – the virtual fuselage workbench was developed as visualization on a large-size display. The reproduced aircraft fuselage is fully interactive. Handling operations (zoom in, zoom out, opening of hatch compartments, disassembling of power packs, etc.) is carried out with use of a computer mouse. Strict interactions are provided between the virtual fuselage and the virtual cockpit, exactly the same as in case of a real object. For instance, when airfield sources of power voltage are connected to the virtual aircraft it triggers illumination of corresponding indicating lamps in the cockpit and appropriate indications of voltmeters.

3.3 Instructor workplace

Instructor workplace – is designed as an independent computer workstation. The simulator is controlled by means of a software application that is able to supervise and govern all computers within the IT system as well as monitor status of computers and the simulator network on the current basis. Instructors are in power to create and manage individual accounts of trainees. Each student has its own 'history' that comprises a list of completed training courses with achieved results. The instructor makes the decision which training form out of four available options is selected as well as which deficiency is to be simulated.

The snapshot below shows the simulator that was on display during the 21st International Defence Industry Exhibition MSPO in Kielce, Poland. On the foreground one can see the Instructor Workplace with the virtual fuselage display standing in the background at the left-hand side.

Figure 9 The simulator put on display during the 21st International Defence Industry Exhibition MSPO in Kielce, Poland.

3.4 Control application

Control application – is developed and installed on the computer of the Instructor Workstation. It enables execution of both administrative functions (enrolling a new student, removing a student from the database, keeping records on the training history, debriefing, etc.) and as well as operations strictly related to trainings. The application enables the instructor to select one of four available training modes:

- Demonstration;
- Practicing;
- Reproduction;
- Evaluation (grading)

In the mode of demonstration the specific exercise is shown together with the soundtrack. All activities associated with execution of a specific check are carried out with no participation of the trainee. Switches, toggle switches, indictors, etc. that should be normally operated by the trainee are indicated with a marker. Simultaneously all operations to be executed are explained by a voice of a virtual instructor to focus the trainee's attention on specific parts of the virtual cockpit or fuselage.

Practicing mode – consists in execution of the required check by the trainee himself. The trainee unaidedly switches necessary sources of power supply and carries out a specific sequence of switching and checks. This training mode assumes that the instructor is also allowed to simulate specific irregularities that should be detected by the trainee. The student should identify these irregularities and undertake the necessary virtual remedy actions.

Reproduction – consists in reproduction of already recorded activities of the trainee. The system keeps record of all switching operations that had been carried out in the cockpit and these actions of the trainee are automatically visualized in the virtual cockpit. It is the training mode that is then used to evaluate and review the competed exercise during the debriefing discussion.

Evaluation (grading) – consists in making comparison between the operations carried out by the trainee and the check list (technological sheet) for the assigned check operation. Technological sheets are purposefully developed as check lists since the control software is able to supervise and to verify whether the switching operations and checks had been carried out by the trainee correctly and in the proper sequence. It is the operation mode that enables unbiased automatic assessment of the trainee behaviour and grading for successes and mistakes.

3.5 Training package

Training package – was developed with use of the Vizard virtual environment. The package creates a 3D model for the cockpit and fuselage of the M-28 aircraft according to the logic concept and functionalities of the real object. The model comprises 21 logic paths of checks that are to be carried out in the aircraft cockpit during the pre-flight maintenance. For the training in execution of the external checks for the aircraft as many as 29 logic paths of inspection were developed and implemented to enable performing of the checks on a 'virtual fuselage'. These activities were additionally supplemented by implementation of additional information that present important training content in a well-perceivable form, i.e. animations, messages and warnings.
The pictures below present visualization of selected virtual checks.

Figure 10 Checking of on-board rechargeable batteries and electrolyte level

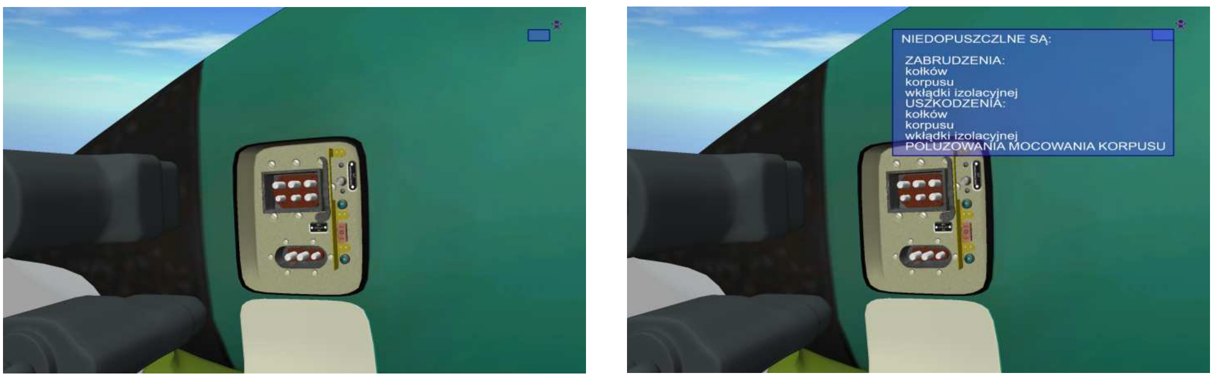

Figure 11 Checking of the connector for airfield power supply source with instructions for a trainee

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Figure 12 Checking of modules in the technical compartment hatch

Figure 13 View to the central part of the control and instrumentation panel

Figure 14 View to the top part of the control and instrumentation panel

3.6 IT system

IT system – comprises computers, the visualization system on touch screen displays and components of the local network (LAN). For engineering of the simulator only typical, commercially available PC computers were used, which substantially contributed to reduction of the project expenses.

4. EFFICIENCY ASSESSMENT FOR APPLICATION OF VIRTUAL REALITY TECHNIQUES TO TRAININGS

To check the efficiency of the new training method the tests were conducted on 2 groups of technicians who were trained in maintenance of the M-28 aircraft on-board equipment as well as electrical and radio-electronic devices. Those technicians were aviation mechanics, with skills in maintenance of other aircraft types but with no experience with maintenance of M-28 aircraft. One group was trained in the conventional way – with extensive theoretical lecturing and limited practical training on real aircrafts. On the contrary, some theoretical background was provided to the other group at first with further extensive training on the simulator and later some training on the real aircraft.

Upon completion of the training members of the both groups were asked to perform the specified checks on the real aircraft according to prescribed diagnostic procedures. All actions were observed and evaluated by the instructor. To provide the maximum possible unbiased approach the correctly performed actions were graded as '1' and incorrect ones as '0'. Each inspection procedure out comprised a set of 5 up 10 actions – type and amount of actions depended on the inspection type. For instance, to correctly perform check of the flight parameter recorder the trainee should:

- check how individual parts of the flight parameter recorder are arranged inside the cockpit
- key in the correct pilot's index
- automatically turn the recorder on
- manually turn the recorder on
- check the correctness of the recorder operation

Each of the foregoing actions was evaluated separately.
To evaluate the gain in the trainee's knowledge the following formula was used:

$$\text{factor increase knowledge} = \frac{\text{training the after trainee by achieved results}}{\text{achieve to result possible maximum}} \times 100\% \qquad (1)$$

Results of conducted tests are presented in the Fig. 15 and 16.

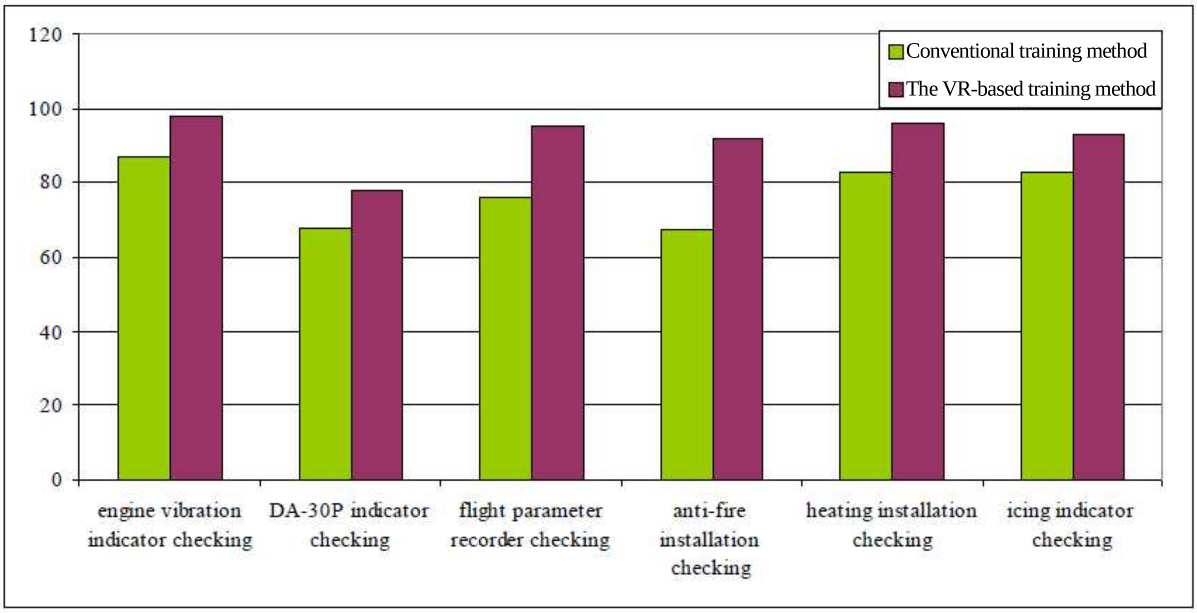

Figure 15 Comparison between factors of the knowledge gain for trainees who received conventional training and the ones after VR-based training with regard to maintenance of on-board equipment and electric devices.

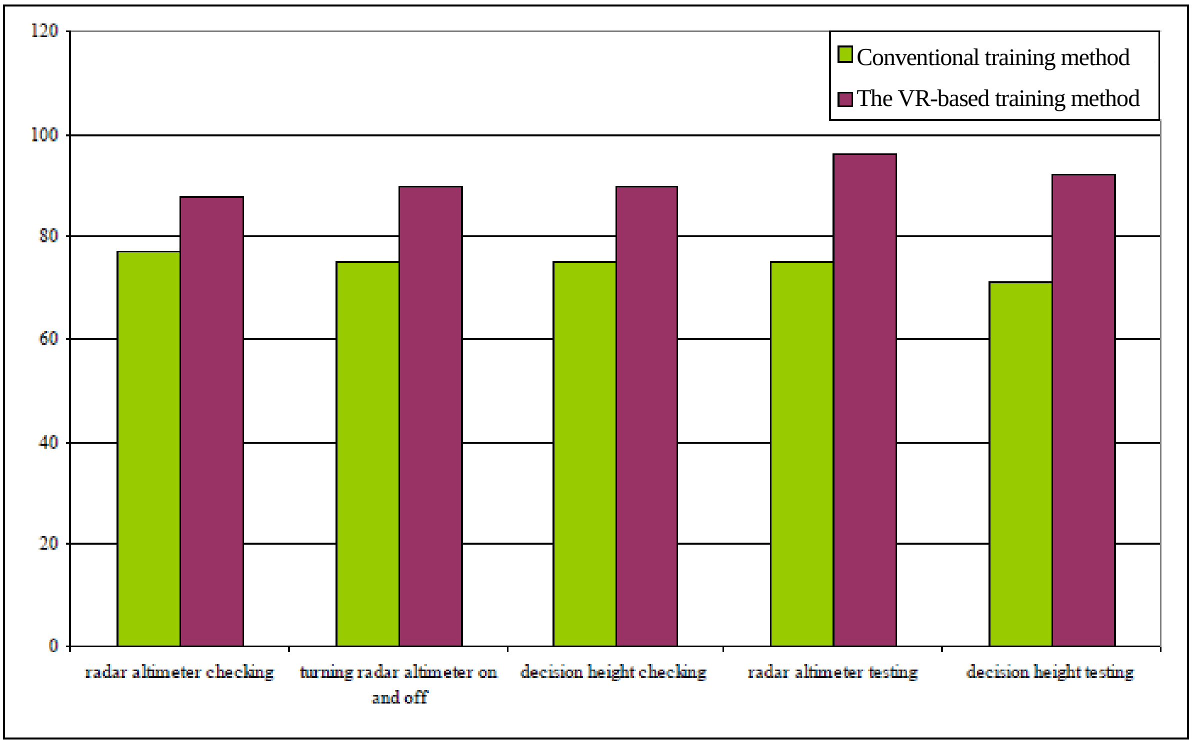

Figure 16 Comparison between factors of the average knowledge gain for trainees who received conventional training and the ones after VR-based training with regard to maintenance of on-board radio-electric equipment.

As one can see, for all diagnostic procedures the new training method that assumed application of the diagnostic simulator proved to be more efficient than the method that had been used beforehand.

CONCLUSIONS

- Complexity of modern aircrafts enforces application of still more and more sophisticated and efficient training methods and tools.
- The experience from development, implementation and studies on efficiency of modern training systems unambiguously confirm that e-learning and virtual reality perform well as training techniques for maintenance and engineering personnel.
- Both techniques offer new opportunities that are unavailable for conventional training and teaching methods.
- The methods for dissemination of knowledge through multimedia presentations and virtual 3D models are better accepted by the generation of young users as compared to conventional methods.
- Both e-learning and virtual reality have already found their application to training systems. The next technique that is now entering the area of training activities is Augmented Reality (AR).

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ACTIVE AND PASSIVE SAFETY FOR THE APPROVAL OF ROAD VEHICLE

Ľubomír MORAVČÍK[1]

Abstract: *The road safety is affected by several factors quality of infrastructure, behaviour of drivers, including their proper training and also safe cars. For the safety of vehicles in the approving process a number of regulations (regulatory acts) apply, regulating the technical requirements in the active and passive vehicle safety, but also in the environment. In the area of technical requirements for vehicles and their parts significant changes occur constantly, mainly due the progressive technological developments. A large number of regulatory acts are often changed due to a tightening. These regulatory acts relates directly to manufacturers, because their manufactured vehicles have to meet these requirements. That these regulatory instruments are evolving in the right direction proved the fact that due to the better road safety the number of fatal accidents in the last two decades shrunk, although the volume of traffic has tripled. A significant progress has been achieved only through the improved vehicle safety and only in a small measure thanks to the improvement and upgrading of the infrastructure.*

Keywords: *technical requirements, safety of vehicle, construction of vehicle, regulatory acts, approval of vehicle*

1. INTRODUCTION

Every vehicle operated on the road has to be approved. Evidence of approval of a vehicle is the vehicle registration document (Vehicle license / registration certificate). Approved vehicle must not be a source of threat to road safety, human health and life or the environment, and there shall not be any pollution or deterioration of the road. In order for the vehicle to be authorized to operate on the road it must meet number of technical requirements also called „regulatory acts".

The field of technical requirements for vehicles and their parts is experiencing constant changes mainly due to progressive technological developments. The proof that these regulatory acts are progressing in the right direction is the fact that due to increased road safety, the number of fatal accidents in the last two decades has decreased, while the volume of traffic tripled. This significant progress has been achieved due to improved vehicle safety and, not least, through upgrading and improving infrastructure. The noise level has reduced by about 90% since the 1970, and if we stay in this period, emissions (NO_x and other toxic substances) produced by one vehicle at that time equals to emissions of hundred vehicles produced today.

Vehicle safety is also an element of competitiveness and therefore the vehicles manufacturers dedicate increased attention to this issue.

2. ROAD SAFETY

The road safety or the prevention of an accident is affected by many interrelated factors:

1. Transport infrastructure
   - Construction of roads (motorways, expressways)
   - Technical condition of the roads
   - The quality of the road surface
   - Traffic signs (condition and level, new features, variable signing)
2. Vehicle
   - Technical requirements for vehicle
   - Active and passive vehicle safety
   - Level of information technology used in the vehicle and outside the vehicle (early warning system)

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3. Driver
   - Quality of driver‘s training
   - Level of driver’s theoretical and practical skills
   - The impact of preventive and educational habits (traineds unconditional reflexes)
   - The level of driver’s health and mental abilities
   - New drivers tests
   - Aggressive behavior
   - Violation of traffic rules
4. Organization of transport
   - Redirect traffic during rush hour
   - Intelligent Transport Systems
   - Flyover junctions layout
   - Introducing elements of combined and intermodal transport
5. Safety and road traffic smoothness control
   - Providing the service
   - Ensuring the flow of traffic during rush hour
   - Repression
   - Objective liability
   - Financial penalties
6. Legal and technical environment
   - The quality of laws and technical standards

As seen from the above, vehicle safety is only one of many factors affecting road safety.

3. VEHICLE SAFETY

When developing new vehicles it is emphasized that the vehicle meets the safety requirements. These requirements are set by valid regulatory acts, but also by customers needs. In addition, vehicle manufacturers themselves are developing a variety of safety features that are intended to increase the safety of the vehicle. The main purpose of vehicle safety is life and health of the vehicle crew, but also other road users (pedestrians, cyclists, other vehicles, etc.). In general, the goal is to minimize the likelihood of an accident and if this occurs, to ensure protection of health and life. To achieve this goal it is possible to apply different features that can be called safety of the vehicle.
The term safety of the vehicle means two basic categories of safety: active and passive safety.

3.1 Active safety of vehicles

Active safety prevents the accident and is a result of harmonic chassis design, which takes into account the wheels guidance, suspension, steering feedback and breaks stability. It is manifested by optimal dynamic behavior of the vehicle also when avoiding obstacles. Steering control is not intended only as a precise transfer of movement of the steering wheel to the wheels, but should inform the driver about a power required to operate according to the state of the road surface (for example, the slippery surface). Breaks stability ensures not only keeping one foot braking on straight road, but also around the curves. Active safety components are:

1. travel safety,
2. conditional safety,
3. perceptual safety,
4. operator safety.

Travel safety is the result of a harmonious approach to conducting wheel chassis, suspension, steering and brakes. It is visible in optimal dynamic behavior of the vehicle.

Conditional safety – is affected by psychological state (of the driver), which depends on the comfort, visibility, vibration, noise and climate impacts.
Visibility - the better driver sees surrounding traffic conditions, the lower is the risk of unexpected situations.
Vibration - affects the driver and result as disturbance (into frequency range of 1-25 Hz stuttering, tremors etc. falls also vibrations).

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Noise – is manifested as audible disturbance when driving the vehicle. It can comes from within (engine, gearbox, shafts, axles) or outside (tires, road and wind noise).
Vibration and noise impact resistance and concentration of the driver. Good sound insulation and well-balanced suspension cab reduces the noise levels, therefore can reduce the risk of road accidents.
Climatic conditions are the air temperature, humidity, air flow and air pressure.
Pleasant climate in the car keeps the driver in good condition and ready, even during long journeys. Good heating, ventilation and air conditioning are important for supporting high standards of vehicle safety.

Perceptual safety - the level of safety, which increases the perceptual security, focuses on lighting equipment, audio warning devices, direct and indirect view of a vehicle.

Operator safety – relaxed driver (driving without stress), as well a high level of driving safety, requires an optimal design for the driver's surroundings with respect to its comfort.
Safety and comfort are interlinked in many aspects. Driver who sits comfortably, has a good posture and easy to read, easy to understand and reach ergonomic devices and controls, can better manage and better concentrate on the surrounding traffic conditions. The driveline has also an important role. A vehicle that provides good management capacity in terms of electronic engine management, or even automatic transmission, puts less stress on the driver.

Overview of active safety:

- ABS (Anti-lock Braking System) – anti-lock brakes, prevents the wheels from locking while braking and allows the driver to maintain control of the vehicle,
- ADM (Automatic Dimming Mirror) – auto darkening mirror; prevents glare in the rearview mirror caused by the lights from the moving vehicle behind,
- ALC (Adaptive light control) – allows to adjust the orientation of the beam according to driver’s needs, for example in urban areas may be more useful if the light beam’s orientation is wider, while on the highway longer. The orientation of the reflectors is managed by bending and the slope of the road,
- BAS (Brake Assistance System) – braking assistant, in critical situations and when the ABS regulates brake pressure, brake pedal may begin to vibrate, which can cause the driver to release the pedal to prevent these vibrations, which however reduces the effectiveness of braking,
- ASR (Anti-Slip Regulation) – prevents wheelspin and changing direction on acceleration,
- RDC – tyre pressure control system,
- EBD (Electronic Brake-force Distribution) – distribution of the electronic brake power optimally between front and rear axles,
- ESP (Electronic stability program) – is improving the driving control and automatically stabilizes the vehicle in all situations,
- Intelligent suspension – automatically adjusts ride height according to speed and road conditions,
- Power Steering – reduces the power required to operate the vehicle, therefore making the control of vehicle easier,
- HUD (Heads-Up Display) – visualization of data relevant to the driver in the driver's vision angle,
- Night Vision – uses an infrared camera and the image is projected on the HUD display, hence allows better management at night and in bad weather conditions,
- Signaling of incorrectly closed door,
- TCS (Traction control System) – a system that prevents wheel overspin and allows the driver to maintain control of the vehicle, it controls engine power and sometimes braking system,
- VARILIS (Variable Intelligent Lighting System) – a flexible intelligent lighting system that uses fiber optics and is able to change the characteristics of the light beam immediately,
- Xenon headlight – bulb that generates light due to the electric arc, its power is larger than the one of conventional halogen lamps,
- RFT (Run Flat tyre) – type of tyre, which allows to drive to safety with a puncture; different tyre manufacturers use their own names for this technology,
- etc.

3.2 Passive safety of vehicles

Passive safety includes all the features and measures in the vehicle that minimize the consequences of an accident or prevent it. Passive safety is especially important when the driver cannot actively intervene in the affairs of the road anymore.
Passive safety can be divided into external (exterior security) and internal (interior security).

External safety - the term passive safety includes all actions associated with the vehicle, which are useful in minimizing injuries in road traffic collisions and outside the vehicle (pedestrians, cyclists). Factors that determine the external safety are the behavior of the car body during deformation, and the external shape of the car body.

Internal security - is the protection of the vehicle by those kind of measures that are minimizing the acceleration and initial internal forces on the passengers in the event of an accident, and also provide enough space for survival and ensure the operability of the critical components of the vehicle to rescue passengers from the vehicle.

Important for passenger safety are:

- the behavior of the car body during deformation,
- strength of the passenger compartment and a large living space during accidents,
- restraints,
- deceleration systems,
- bump in the interior,
- control systems,
- deliverance of passengers,
- fire protection,
- etc.

Passive safety features overview:

- Airbags (front, window, side, knee, front to rear passengers) - prevent the collision of the body, respectively individual body parts of the steering wheel, instrument panel and other interior parts of the vehicle absorb shock and reduce the risk of injury,
- Active head restraints - in case of an accident they are moving forward and upwards thus reducing the risk of neck injuries,
- Anti-slip passenger system - prevents slipping of the pelvic area from the seat in the event of a frontal collision,
- Safety belts - prevent sudden movement of the body in the accident,
- Safety features of the vehicle structure – are increasing the firmness of the car body in the event of collision by creating zones with progressive deformation and absorption capacity (Fig. 1),
- Collapsible steering column – in case of an accident it reduces the driver’s risk of hitting the steering wheel,
- Child lock - prevents opening the car door from inside,
- Electric lock with automatic locking,
- Parking Assist – Audio signaling when reversing towards obstacles,
- FPS (Fire Protection System Safety) – a system which blocks the supply of electricity and fuel in case of an accident, to avoid the risk of fire,
- System for avoiding of wedging of a small car – is used in trucks to reduce the risk of wedging of a small passenger car in a frontal collision,
- Announcement of a traffic accident (eCall),
- etc.

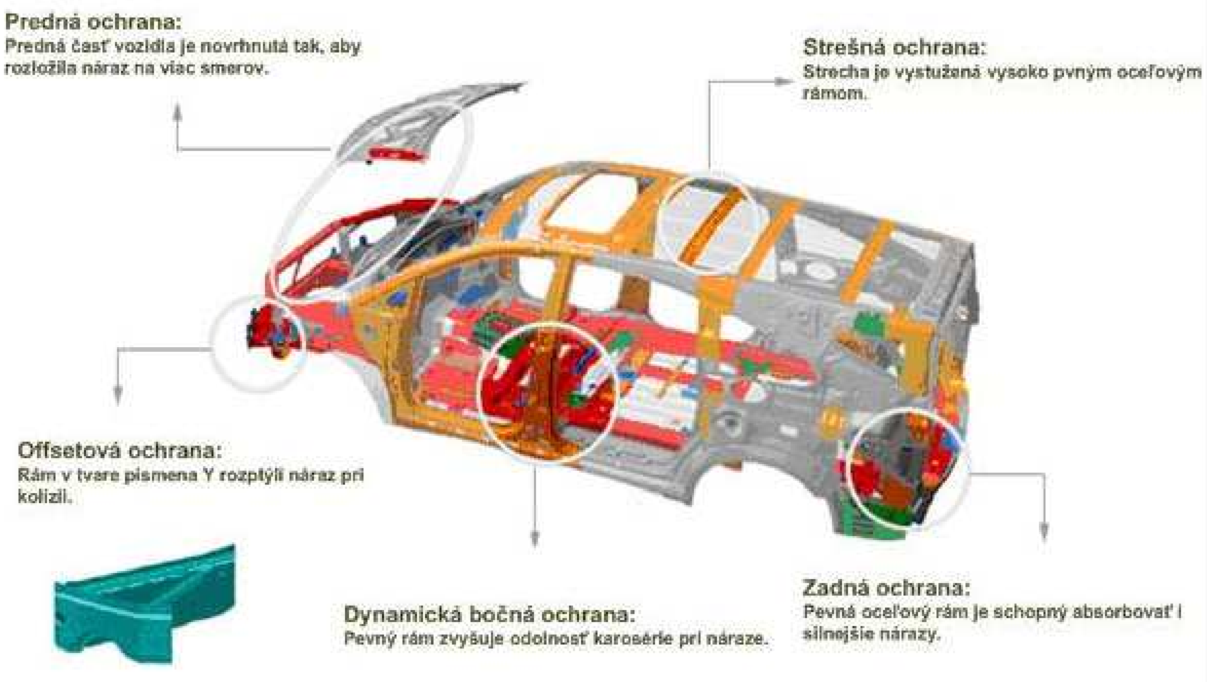

Figure 1 The safety features of the vehicle structure

4. APPROVAL OF VEHICLES

There are the two main parallel systems of regulatory acts in the field of vehicle approval and a new system of global technical regulations.

The first group consists of the Geneva regulations issued under the 1958 Agreement (Agreement concerning the adoption of uniform conditions of approval (verification of identity) and reciprocal recognition of approval for equipment and components for motor vehicles concluded March 20, 1958 in Geneva. The Decree of the Minister of Foreign Affairs no 176/1960 ECR). The agreement provides only the framework conditions. Specific regulatory acts are solved by individual UNECE, which formally annexed to the Agreement. The former Czechoslovakia signed the agreement in 1960 as the eighth state. The agreement does not bind the parties to the mandatory application of all or specific regulations of the UNECE. The use of every regulation of the UNECE shall the member states first notify. The Member state of the agreement, that notified the regulation, is obliged by the agreement to recognize approvals under this Regulation granted by other states and should not subject such laws or create obstacles for the adoption and introduction into service of approved vehicles or their parts. A member state of the agreement, that has notified the use of certain rules therefore does not have to, but may apply these regulations within its territory or some of them as required. This is a national matter for each state. This system allows only partial approval pursuant to various regulations - regulatory acts.

The second group are the EU rules accepted in the form of EC/EEC directives, and now also in the form of EU/EC/EEC regulations. These regulatory instruments are binding for all Member States. In some cases, they are parallel to the UNECE regulations, in some cases they are separate regulatory acts. This system allows approval of the entire vehicle by meeting all regulatory acts.

The third group consists of global technical regulations (GTR) issued under the 1998 Agreement (Agreement concerning the establishing of global technical regulations for wheeled vehicles, equipment and parts which can be fitted or used on wheeled vehicles. Notification of the Ministry of Foreign Affairs of the Slovak Republic no 415/2003). Like the UNECE regulations, the global technical regulations are also mandatory for member states as lond as the individual states are transforming them into their national legislation. In the European Union these rules have to be transformed by the EU regulatory acts (second group) in the form of EC/EEC directives or regulations of the EU/EC/EEC.

Prior entering the EU, the Slovak Republic was following only the regulatory acts only the first group. As for the third group, the Slovak Republic was a member of the agreement, but did not apply any of the global technical regulation. After joining the EU, the regulatory acts of the other groups became mandatory for the Slovak Republic. Currently, in accordance with the recommendations of the CARS 21 report some partial regulatory acts of the EU (separate directives) will be replaced by the UNECE regulations. Vehicle manufacturers will be able to reduce their administrative burden.
In the next section, I will discuss only the second group - the technical requirements under the EU regulatory acts.

5. TECHNICAL REQUIREMENTS FOR VEHICLES

The relevant regulatory acts are setting the technical requirements for vehicles. When approving the vehicle for operation on the road, each vehicle must meet all the technical requirements established by regulatory acts. The approval of vehicles is regulated by the regulations of the European Union concerning the construction of vehicles, which can be divided into three groups:

1. motor vehicles and their trailers (category M, N and O),
2. motorcycles, trikes and quads (category L),
3. wheeled agricultural and forestry tractors (category T).

Fig. 2 is a schematic division approval of vehicles between three basic framework directives.

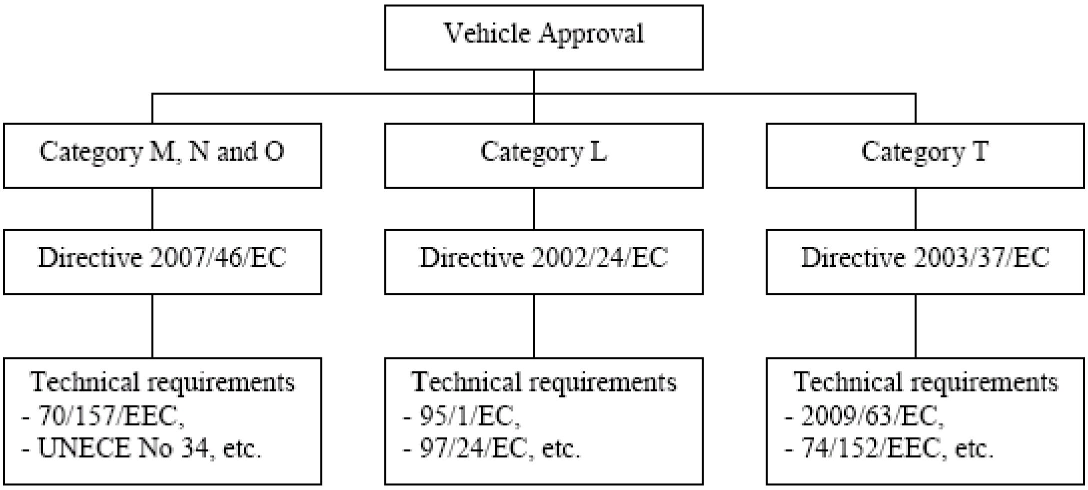

Figure 2 Schematic of vehicle approval

Technical requirements for vehicles can be classified as:

1. technical requirements of active safety, which include braking, steering effort, an audio alarm, tire assembly, front view, defrosting and demisting of the windscreen, devices for indirect vision (mirrors), speedometer and reverse gear, wiper and windscreen washer, connecting devices etc.,
2. technical requirements for passive safety, which include frontal collisions, side collision, anchor tabs seat belts, ISOFIX anchorages systems, safety belts and restraint systems, seats and their anchorages, head restraints, vehicle interior equipment, access to vehicles, vehicle maneuverability, locks doors, external projections, pedestrian protection, wheel covers, rear protective equipment, fuel tanks, protection of the driver against the steering mechanism, safety glazing, handles for passengers etc.,
3. technical requirements of the environment, which include emissions (EURO 5 and EURO 6 or EURO V and EURO VI), noise, recyclability, electromagnetic compatibility, air conditioning systems, etc.,
4. other technical requirements, which include the installation of lighting and light-signaling devices, place for the rear registration plate, weights and dimensions, location and identification of controls, tell-tales and indicators, towing devices, protection against unauthorized use, heating systems, engine performance data plate and VIN, hydrogen system, general safety, gear shift indicators, alarms, electrical safety, LPG, CNG, etc.

Fig. 3 is a graphical presentation of the technical requirements for vehicles of category M1.

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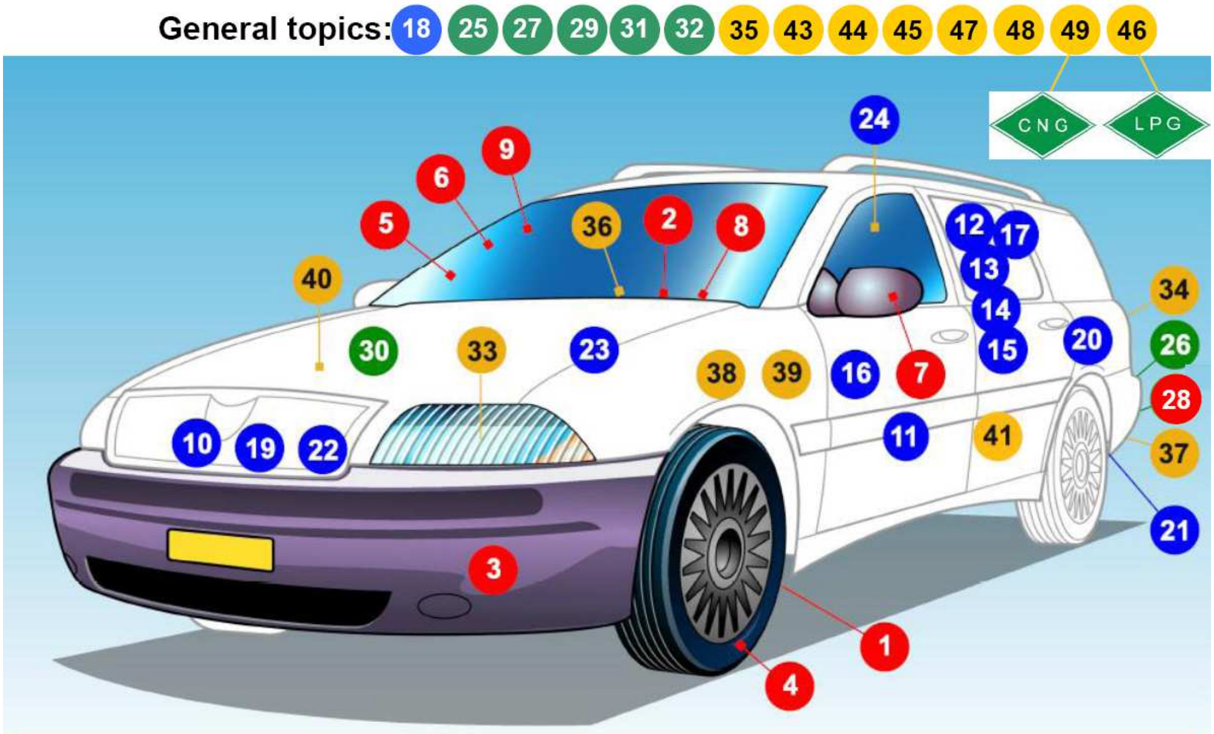

Aktive safety		
1	Braking	(ES) 661/2009 - EHK OSN 13H-00
		(ES) 661/2009 - EHK OSN 13-11
2	Steering equipment	(ES) 661/2009 - EHK OSN 79-01
3	Audible warning devices and signals	(ES) 661/2009 - EHK OSN 28-00
4	Tyres and installation of tyres	(ES) 661/2009 - (ES) 458/2011
		(ES) 661/2009 - EHK OSN 30-02
		(ES) 661/2009 - EHK OSN 117-01
		(ES) 661/2009 - EHK OSN 64-01
5	Forward field of vision	(ES) 661/2009 - EHK OSN 125-00
6	Windscreen defrosting and demisting systems	(ES) 661/2009 - (EÚ) 672/2010
7	Devices for indirect vision and their installation	(ES) 661/2009 - EHK OSN 46-02
8	Speedometer equipment including its installation and Vehicle access and manoeuvrability	(ES) 661/2009 - (EÚ) 130/2012
		(ES) 661/2009 - EHK OSN 39-00
9	Windscreen wiper and washer systems	(ES) 661/2009 - (EÚ) 1008/2010
28	Mechanical coupling components of combinations of vehicles	(ES) 661/2009 - EHK OSN 55-01
Passive safety		
10	Frontal impact	(ES) 661/2009 - EHK OSN 94-01
11	Side impact	(ES) 661/2009 - EHK 95-02
12	Safety-belt anchorages, Isofix anchorages systems and Isofix top tether anchorages	(ES) 661/2009 - EHK OSN 14-06
13	Safety-belts, restraint systems, child restraint systems and Isofix child restraint systems	(ES) 661/2009 - EHK OSN 16-04
14	Seats, their anchorages and any head restraints	(ES) 661/2009 - EHK OSN 17-08
15	Interior fittings	(ES) 661/2009 - EHK OSN 21-01
16	Vehicle access and manoeuvrability	(ES) 661/2009 - (EÚ) 130/2012
	Door latches and door retention components	(ES) 661/2009 - EHK OSN 11-03
17	Head restraints (headrests)	(ES) 661/2009 - EHK OSN 25-04
18	External projections	(ES) 661/2009 - EHK OSN 26-03
19	Pedestrian protection	(ES) 78/2009
20	Wheel guards	(ES) 661/2009 - (EÚ) 1009/2010
21	Rear underrun protective devices	(ES) 661/2009 - EHK OSN 58-02
22	Fuel tanks/	(ES) 661/2009 - EHK OSN 34-02
23	Protection of the driver against the steering mechanism in the event of impact	(ES) 661/2009 - EHK OSN 12-03
24	Safety glazing materials and their installation on vehicles	(ES) 661/2009 - EHK OSN 43-00

Environment		
25	Emissions Euro 5 a 6	(ES) 715/2007
26	Permissible sound level	70/157/EHS
27	Recyclability	2005/64/ES
29	Electromagnetic compatibility	(ES) 661/2009 - EHK OSN 10-03
30	Air-conditioning systems	2006/40/ES
31	Emissions (Euro IV and V) heavy duty vehicles	2005/55/ES
32	Emissions (Euro VI) heavy duty vehicles/	(ES) 595/2009
Other		
33	Installation of lighting and light-signalling devices on vehicles	(ES) 661/2009 - EHK OSN 48-04
34	Space for mounting and fixing rear registration plates	(ES) 661/2009 - (EÚ) 1003/2010
35	Masses and dimensions	(ES) 661/2009 - (EÚ) 1230/2012
36	Location and identification of hand controls, tell-tales and indicators	(ES) 661/2009 - EHK OSN 121-00
37	Towing device	(ES) 661/2009 - (EÚ) 1005/2010
38	Protection of motor vehicles against unauthorised use	(ES) 661/2009 - EHK OSN 18-03
		(ES) 661/2009 - EHK OSN 116-00
39	Heating systems	(ES) 661/2009 - EHK OSN 122-00
40	Engine power	80/1269/EHS
41	Manufacturer's statutory plate and VIN	(ES) 661/2009 - (EÚ) 19/2011
43	Hydrogen system	(ES) 79/2009
44	General Safety	(ES) 661/2009
45	Gear shift indicators	(ES) 661/2009 - (EÚ) 65/2012
46	LPG	(ES) 661/2009 - EHK OSN 67-01
47	Vehicle alarm systems	(ES) 661/2009 - EHK OSN 97-01
48	Electric safety	(ES) 661/2009 - EHK OSN 100-01
49	CNG	(ES) 661/2009 - EHK OSN 110-00

Figure 3 Graphical representations of the technical requirements for vehicles of category M_1

6. CONCLUSION

Several industry more vehicle manufacturers are investing considerable funds in developing new safety systems, which aim to prevent the accident as a negative phenomenon of the road, or in case of an accident to eliminate the consequences of an accident. Currently new technologies are available that can dramatically improve vehicle safety (such as electronic stability control) or reduce CO_2 emissions (such as tyres with low rolling resistance). Conventional vehicles are not equipped with all known safety features that are available on the market because of their higher price. Vehicle manufacturers typically fit the latest safety features into the highest classes of vehicles manufactured, but over time these elements are becoming almost routine feature of lower vehicles classes too.

Research has indicated that the introduction of such technologies as standard on new vehicles would bring significant benefits for the road safety. These new security technologies are already invented. Features such as Electronic Stability Control Systems are already appearing within some markets on an increasing number of vehicles. The electronic stability control systems would be even more beneficial on vehicles such as heavy trucks and tourist coaches than by passenger cars. Often there is no incentive on the market which would make the manufacturers voluntary install the electronic stability control systems, since buyers usually are not the ones who benefit from it.

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DETERMINATION OF CHANGE IN RETROREFLECTION OF MICROPRISMATIC SHEETING DEPENDING ON CLEANLINESS

Lenka MORAVČÍKOVÁ[1] - Ján GERGIŠÁK[2]

Abstract: *Retroreflective sheeting and its characteristic to reflecting light back to the source of light (retroreflection) provide for traffic sign visibility and legibility during night. Retroreflection of sheeting is mostly dependant on both cleanness of traffic sign and car headlamps and size of illumination β and entrance angle α. Generally, retroreflection is nonlinearly decreasing with increasing of angle α and β.*

Retroreflection at observation angle α from + 0.1° to + 2.0° and illumination angle β from+5° to + 40° was measured on both clean and soiled microprismatic sheeting. By means of applying dirt particles with different diameter from 250 μm to 10 μm were achieved various stages of soiled sheeting. Rapid decrease of retroreflection was observed in all angles α. Dependence curves of retroreflection on observation and illumination angles and cleanliness were designed.

Keywords: *goniophotometric laboratory, retroreflection, cleanliness*

1. INTRODUCTION

The night-time visibility of traffic sign depends primarily on the sign being adequately retroreflective under all possible road geometry situations. Retroreflectivity refers to the ability of specially engineered surface to preferentially reflect incident light back to its source. One of the most common applications of retroreflective material is to use it as base material of sign face of traffic sign to improve nigh-time visibility and legibility of sign. Retroreflective sign cannot return more light than they receive. In road situations, sign reflects only a fraction of the incident light coming from the vehicle headlamps toward the vehicle/driver. The sheeting has no selective control on the location of the driver. It distributes light in the general opposite direction of the incident light [1].

Retroreflection of microprismatic retroreflective materials decreasing non – linearly with increasing of observation angle α and illumination angle β. It is mostly dependent on both these angles, on cleanliness of sign face of traffic sign and headlamps. Illuminating angle is continuously changing. It increases with the movement of vehicles towards the traffic sign. The observation angle is determined by vertical distance between the headlights of the vehicle and the height of the driver's eyes [2, 3]. Some of the new microprismatic sheeting could by special composition of prisms reflect more light under higher observation and illuminating angles. This is intended for drivers of larger vehicles. By optimizing both the retroreflective efficiency and the distribution pattern (based on optical sheeting design) of the retroreflected light the return pattern of light can be improved [1].

The amount of mud on roads has increased in recent years due to the increased traffic density, usage of salt for de-icing with consequent increase in the amount of dirt collected on the sign face of traffic signs and on the headlamps. The dirt deposits on headlamps tend to cause the light output to decrease below horizontal (the light used for visibility) and increase near and above horizontal. The largest changes in light output from headlamps occur after winter drive with decreases and increases in a large part of the headlamps beam. The dirt effects tend to reduce the light output. In Slovakia drivers shall use headlights during daylight to indicate their presence that causes dirt to stick to the glass of headlight because they are hot. The dirt on headlamps has effect on the light distribution. The dirt absorbs and scatters the emitted light therefore affecting the intended light distribution. The total effect can be both reduced light for the driver and increased glare for the incoming driver [4, 5].

The problem of direct effect of dirt on retroreflection of microprismatic retroreflective sheeting was studied. At first, the sizes of dirt particles on the road were determined by using test sieves of metal

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wire cloth. By means of applying dirt particles with different diameter from 250 μm to 10 μm were achieved various stages of soiled sheeting. Amount of both light absorbed or scattered by dirt from light source on the sheeting and how the retroreflection of sheeting is influenced was studied. Retroreflection at observation angle α from + 0.1° to + 2.0° (in 0.1°steps) and illumination angle β from +5° to + 40° (in +5° steps) was measured on both clean and soiled microprismatic sheeting. The changes in retroreflection of microprismatic sheeting were expressed using dependence curves of coefficient of retroreflection of clean and dirty sheeting on different illuminating and observation angles.

2. METHOD

2.1 Test dirt

For this experiment was used dirt from road after winter maintenance. About 2 kg of dirt from shoulder of size approx 3 m long and 0.4 m wide was collected. Dirt was left air dried over 24 h and subsequently fractions of dirt particle sizes were determined according to ISO 2591-1 by using test sieves of metal wire cloth with nominal sizes of opening of 1000 μm, 250 μm, 100 μm, 75 μm and 60 μm. The dirt was sieved for 5 min. The sizes distribution of dirt particles was as follows more than 1000 μm (42%), 1000 μm to 250 μm (35%), 250 μm to 100 μm (16%), 100 μm to 75 μm (2%), 75 μm to 60 μm (3%) and less than 60 μm (3%).

2.2 Test samples

Samples of new white microprismatic retroreflective sheeting from one manufacturer of sheeting with different Batch No. were selected. Sheeting was applied by genuine procedure by manufacturer of traffic sign on aluminium base plate. Size of measured samples was approx 150 cm^2. The white sheeting is the basic material and most often used in producing sign face of traffic sign. This type of sheeting is mostly used for portal traffic sign on highway roads and first class roads. All samples were measured in new state three times. Microprismatic retroreflective sheeting can be applied on the base plate with different rotations. The rotation angles for used microprismatic retroreflective sheeting are 0° and 90°. The favourable application of this sheeting on traffic sign is in rotation 0°. There was measured coefficient of retroreflection in both rotation angles. The percentage changes were calculated as ratio between measured coefficients of retroreflection in rotation angles 0° and 90°.

2.3 Test conditions

All samples of sheeting were conditioned 24 h laboratory temperature and relative humidity before measuring. On each sample was applied dirt with particle size of 250 μm to 100 μm, 100 μm to 75 μm, 75 μm to 60 μm and less than 60 μm. The sample was moist under approx. 45° to the horizontal with laboratory temperature water. The water was allowed to drain for a second and on wetted samples was evenly applied dirt. The excess dirt was removed by tapping the sample. On the samples was applied less than 0.01 g of dirt. Sheeting´s surface lost majority of gloss after dirt was applied. Samples were left air dried for hour and afterward coefficient of retroreflection was measured. This procedure was repeated on all samples for three times. After measurement the dirt was cleared away by flow of laboratory temperature water and by wet soft cloth of fabric (water did not clear surface of samples properly). The dirt was re-applied after cleaning of samples.

2.4 Test equipment and procedure

Coefficient of retroreflection was determined according to CIE 54.2 using standard Illuminant A. Samples were measured in goniophotometric laboratory by using goniophotometer from LMT Company GO-H-800 and device for measuring retroreflection RETRO 2000.

Prior to photometry, the samples were placed in holder attached to the goniometer platform. Samples were placed perpendicularly (retroreflection axis) and in the centre of the circle to the source of light. All samples were measured in observation angles α from 0.1° to 2.0° (in steps 0.1°) and illumination angles β_1 from +5° to +40° (in steps +5°) and β_2 0°. Chosen observation and illumination angles are according to standard EN 12899 Part 1 Fixed, vertical road traffic signs. Part 1: Fixed signs. The distance from sample to the measuring device was 15 m.

The stable laboratory conditions were established by using two air conditioning units in goniophotometric laboratory. Units were turn off during measurement. Results of coefficient of retroreflection for both clean and dirty samples were expressed in cd/lx/m^2. Exact measured area used for calculation of coefficient of retroreflection was determined by sliding calliper. The results of measured coefficient of retroreflection of samples were averaged. The percentage changes were calculated as ratio between measured coefficients of retroreflection on clean and dirty samples.

3. RESULTS AND DISCUSSION

3.1 Changes in the coefficient of retroreflection

Coefficient of retroreflection of clean samples in rotation 0° and 90° decreased in almost all combinations of observation and illumination angles. Chosen examples of percentage changes in combinations of observation and illumination angles are shown in Tab. 1. Reduction 50 % and more was noted in illumination angles from +20° to + 40° and observation angles from 0.1° to 2.0°. Growth from 10% to 20 % was noted in illuminating angle +5° and observation angles 0.3°, 1.5°, 1.6°, 1.7°, 1.8° and 2.0°.

Table 1 Percentage change of coefficient of retroreflection, rotation angles 0°/90°.

β / α	Change [%]				
	+5°	**+15°**	**+20°**	**+30°**	**+40°**
0.3°	14	-42	-53	-63	-53
1°	-17	-59	-64	-61	-51
2°	17	-50	-58	-52	-60

Different curve of decrease in coefficient of retroreflection in higher observation and illumination angles was noted between rotation 0° and 90°. The curve in rotation 0° had lover slope than in rotation 90°. Small increase in retroreflection was noted in rotation 0° around illumination angles +30° and all measured observation angles see Figure 1.

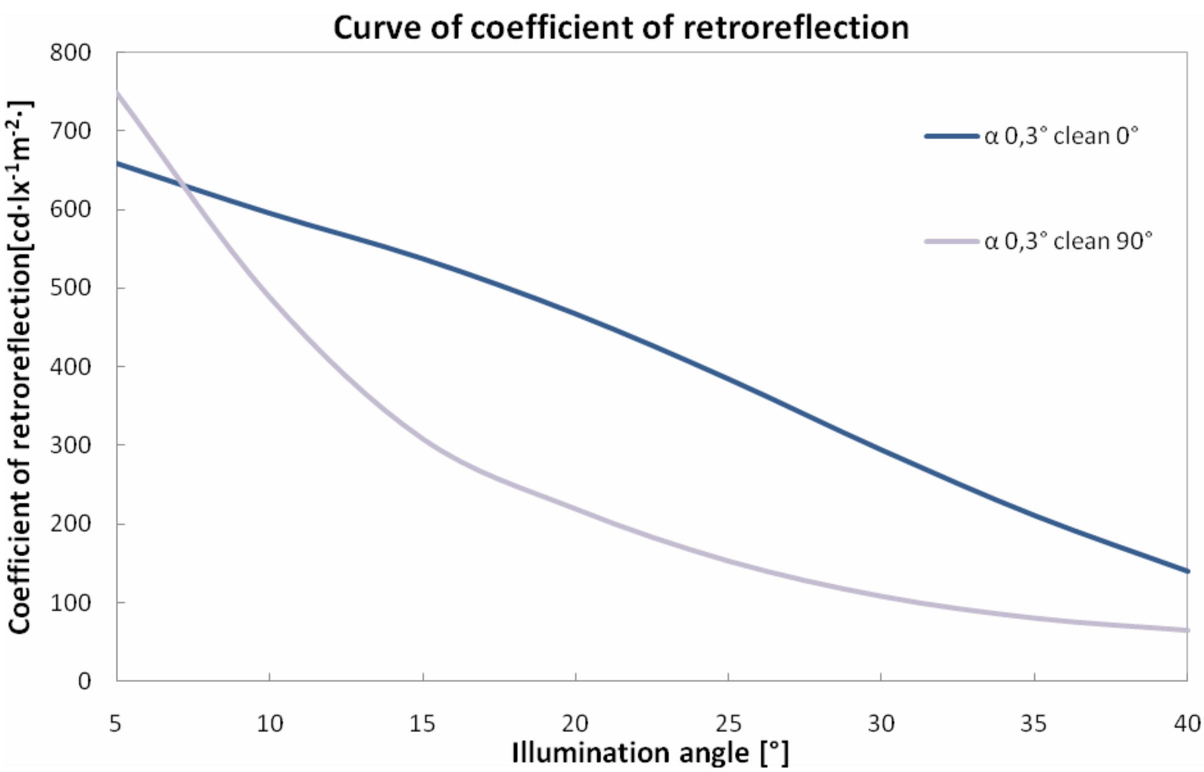

Figure 1 Curves of coefficient of retroreflection in observation angle 0.3° for clean sheeting in rotation 0° and 90°

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3.2 Changes in the coefficient of retroreflection between clean and dirty sheeting

The changes in retroreflection were expressed by using dependence curves of coefficient of retroreflection. Dependence curves of clear and dirty samples for rotation 0° and observation angle α 0.3°, 1.0°and 2.0°are shown in Fig 2, respectively Fig 3 and Fig. 4.

In observation angles α 0.3° and 1.0° were noted the highest decrease by using dirt particles with the smallest sizes of 75 μm to 60 μm (more than 45% reduction in retroreflection) and less than 60 μm (more than 50 % reduction in retroreflection). In observation angle 2.0° was noted lower decrease in both dirt particles sizes of 75 μm to 60 μm (from 23 % to 48 % reduction in retroreflection) and less than 60 μm (from 25% to 57 % reduction in retroreflection). In case of observation angle α 2.0°was noted growth in coefficient of retroreflection in clear and dirty samples around illumination angle +35°.

When all size dirt particles were used significant loss of gloss were observed.

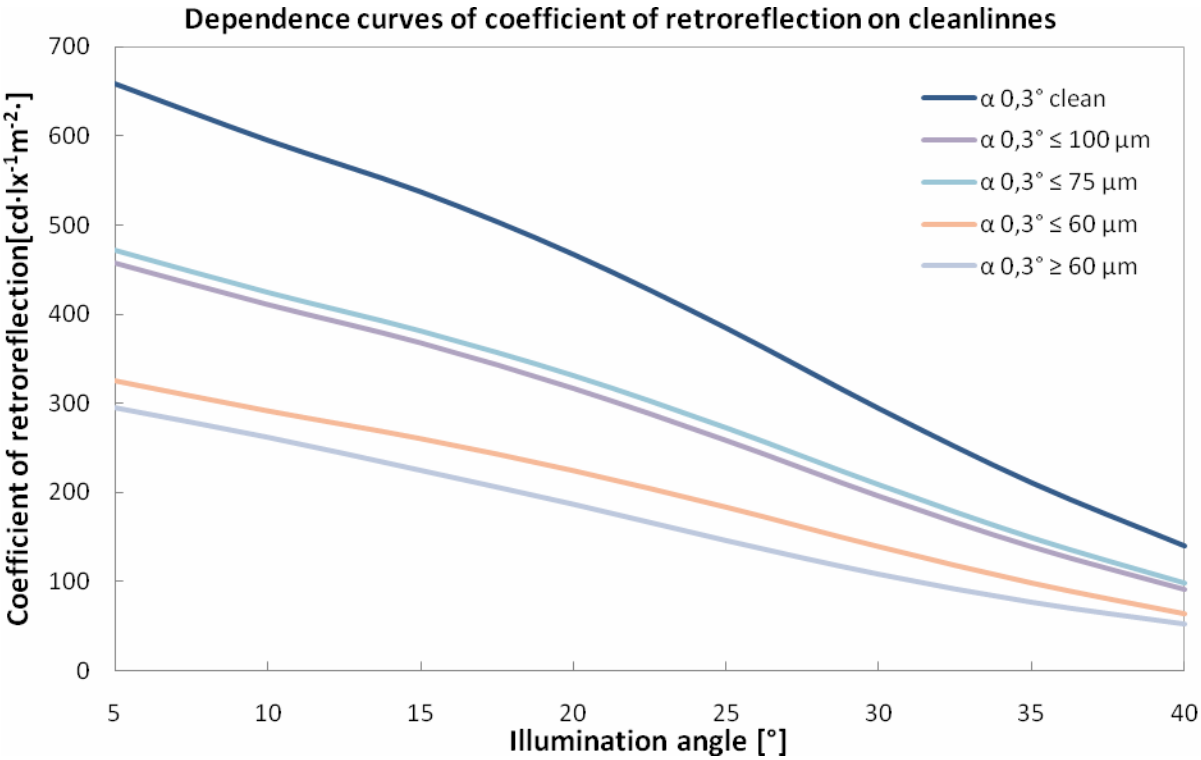

Figure 2 Dependence curves of coefficient of retroreflection for observation angle 0.3° for clean and dirty samples

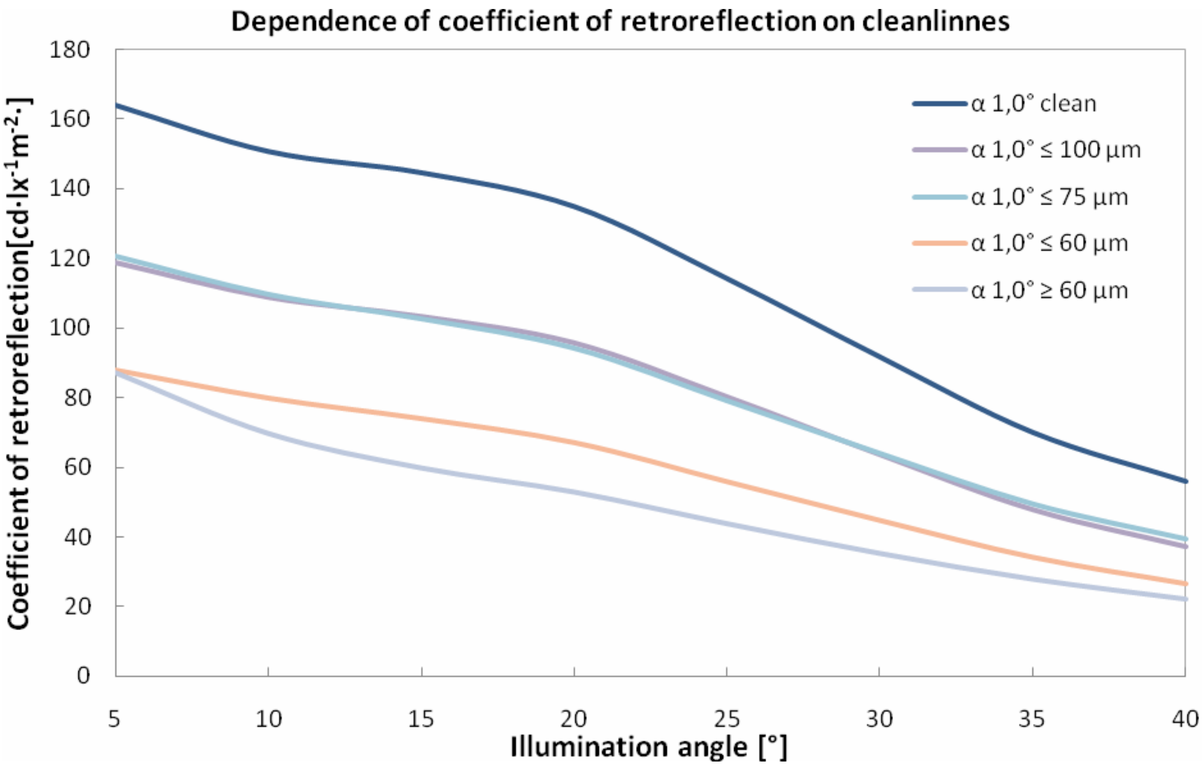

Figure 3 Dependence curves of coefficient of retroreflection for observation angle 1.0° for clean and dirty samples

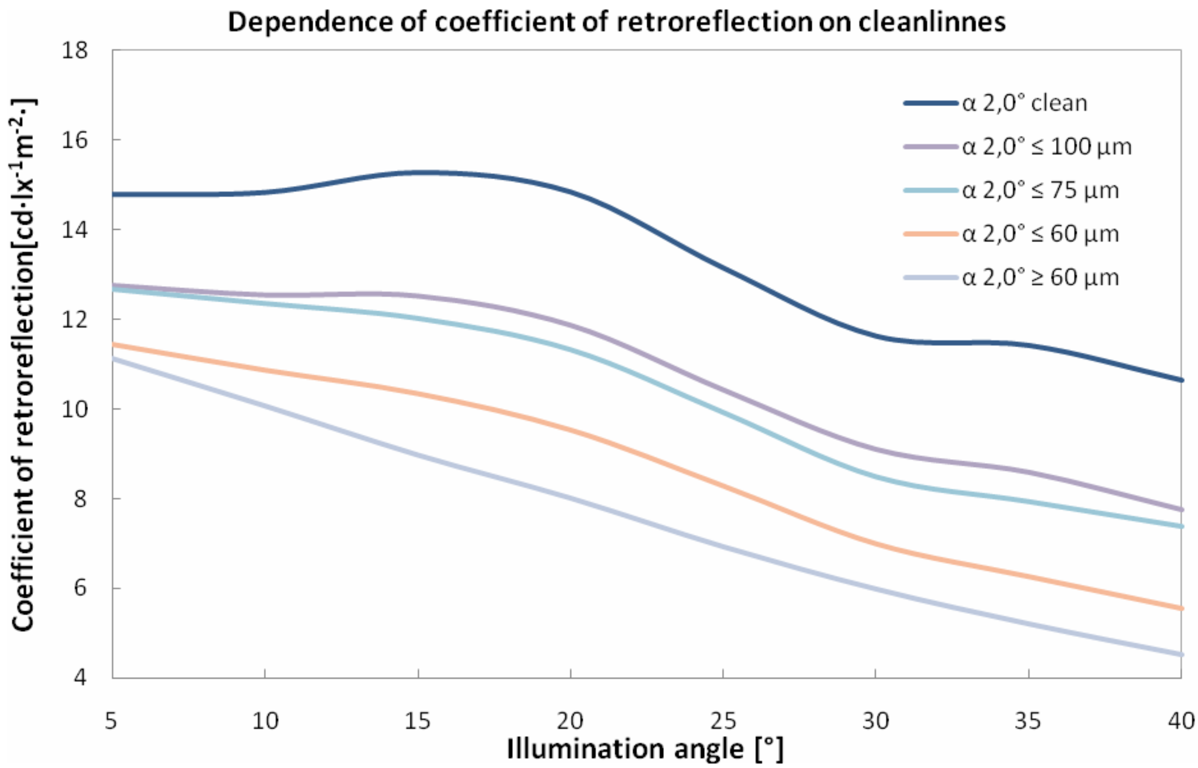

Figure 4 Dependence curves of coefficient of retroreflection for observation angle 2.0° for clean and dirty samples

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4. CONCLUSION

This study evaluated changes in coefficient of retroreflection of clean and dirty microprismatic retroreflective sheeting. Samples of sheeting were soiled three times by dirt particles of sizes from 250 μm to 100 μm, 100 μm to 75 μm, 75 μm to 60 μm and less than 60 μm. Values of measured coefficient of retroreflection in various combinations of observation α and illumination angles β were obtained by using goniometer and unit for retroreflection measurement and dependence curves were drawn. Changes in retroreflection in clean and dirty sheeting were calculated.

The results indicate that rotation of sheeting is one of important aspects for sustainable retroreflection for drivers. There was observable decrease in retroreflection when measured in rotation 90°. Applied dirt particles tended to reduction in coefficient of retroreflection in all combinations of observation α and illumination angles β. The highest decrease was noted when dirt particles with the smallest sizes of 75 μm to 60 μm and less than 60 μm were used.

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CURRENT TRENDS IN THE AREA OF UNMANNED AERIAL SYSTEMS PERSONNEL EDUCATION

Václav MOUCHA[1] - Katarína DRAGANOVÁ[2] - František KMEC[3]

Abstract: *Unmanned Aerial Systems (UAS) represent an aviation sector, in which broad possibilities of innovative applications have been opened. We suppose that in next few years their development will have arisen exponentially. Currently are UAS considered as a key future technology with a huge potential and commercial utilization. However professional UAS operation will be dependent on the corresponding education of the specialized personnel not only in the area of precision, safe and secure control, but also in the area of construction, sensoric and electronic equipment, data processing and also in the area of legislation and operation. The article deals with the preparation process of the academic student education in the area of UAS construction, electronic equipment, testing and operation at the Faculty of Aeronautics of the Technical University of Košice.*

Keywords: *unmanned aerial system (UAS), sensoric systems, avionic systems, aircraft construction*

1. CURRENT STATE

In the international aviation community there is a wide consensus that unmanned aerial vehicles (UAVs) have a perspective future. And also laic public begins to understand and respect the idea that the UAV development is not only a fashionable excess and these vehicles represent the next step in the aviation progress. The vision about the future UAV application possibilities discovered at first in the USA and Israel and afterwards in Europe. Nowadays every modern armed force is equipped with unmanned aerial vehicles as indispensable devices for a successful combat action leading and organisation. Potential commercial UAS utilization in the civil sector will be huge, mainly after finishing of the legislation process of the UAS integration into the civil airspace.
Scientific research and application development in the area of unmanned aerial vehicles and systems got a high priority not only in the USA but also in the EU that confirms its integration into the list of the EU strategic goals. Consecutive implementation of unmanned aerial systems in the army or in the civil sector brings an increased social demand for the specialized trained technical personnel. It is assumed that the first users of unmanned aerial vehicles in the civilian market will be governmental organizations.
In the present situation the driving force of the UAS research and development are several US and some of the European universities that solve the problem of unmanned aerial systems in the way of projects, courses and university societies in the first place. Bachelor education at these universities is focused on the piloting skills, technical and operational knowledge about the UAS utilization in different types of environment [1,2]. Due to the quick removal of UAVs from the army into the civilian sector it is intended that currently existing demand for the bachelor and engineering study graduates will be enormous in the near future [3].
In Slovakia UAS application development is already a subject of several companies and universities. It concerns mainly development for applications as Earth's surface and objects monitoring or mapping. On the other side the systematic education and specialized preparation in this area hasn't been a subject of any Slovak high school or university. Nevertheless at the Department of the Aviation Technical Studies of the TUKE Faculty of Aeronautics in Košice a working team was created which started its initial work on the preparation of the education in this perspective aviation segment [4]. In 2013 the KEGA grant for a conception preparation, educational documentation and material conditions for the preparation of the integrated study program "Unmanned aerial systems" for the first level of study of the academic education was acquired.

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2. PROJECT OF STUDENTS EDUCATION IN THE UAS AREA

The basis of UAS construction nowadays represent modern "rapid prototyping" technologies and their broad applicability is based on the implementation of the latest dynamically developing information-communication technologies called "Internet of Things". Preparation of students from the Faculty of Aeronautics is focused on the technical knowledge and skills and also practical proficiency development. The emphasis is laid on the theoretical and practical knowledge integration into the one educational process with the priority setting on the practical utilization of modern technologies in the construction [5,6] and in the specific applications of the unmanned aerial systems.

By the study program preparation professional integration of aviation specializations is expected which results into the practical skills of each graduate in the first place, mainly from the construction design and development, electronic systems and construction parts manufacturing, together with the command and control abilities in regard to the unmanned aerial vehicle operation.

Faculty of Aeronautics members have thanks to their pedagogical and scientific activities, long-term experience with the military pilots, air traffic controllers and other aviation personnel training and construction and avionic equipment experience a sufficient pedagogical and scientific potential for the superior study program in the area of unmanned aerial systems preparation.

The conception of the "Unmanned Aerial Vehicles" study program is based on the integration of the existing accredited study programs. The study program core will be created by two programs which directly concerns about the mechanical construction and electronic equipment of unmanned vehicles, i. e. 5.2.13 and 5.2.4. branches. The remaining part of the study program will be complemented with selected subject of the other aviation specializations that have a connection with the unmanned aerial vehicle system control and operation and with general academic subjects.

Concerning that in Slovakia there have been created neither legislative nor material conditions for the medium and large size UAVs, the student preparation will be focused on small UAVs. Although UASs usually represent radio controlled vehicles with a small weight, it is necessary to analyze and solve possible risks, reliability and operational security and safety analogous to the manned aircrafts.

Foreign universities that offer education in the area of UAS proceed in the similar way. Usually all the three levels of the university study are concerned, whereby the technological programs dealing with UAS involve the areas of electrotechnics, engineering, operation and legislation [7,8].

The first bachelor level is focused mainly on:

- Programming and robotics fundamentals;
- Remotely piloted aircraft command and control;
- Electronic and technological UAV systems;
- Technical and operational UAS legislation;
- Current and future technologies;
- Analysis of the actual demands in the industry.

The practical education is based mainly on the simulator trainings followed by the substantial UAV control.

2.1 Project phases

The solved project of the education in the area of unmanned aerial systems at the Faculty of Aeronautics of the Technical University of Košice is divided into the three planned realization phases.

Project first phase planned results:

- Design of the web page dealing with unmanned aerial systems is assigned on the actual project results presentation.
- System for testing includes preparation and realization of the UAV testing hall technical equipment and putting into the service the system for the small multirotor unmanned aerial vehicle pilotage testing.
- Preparation of the documentation for the "Unmanned aerial vehicles" study program based on the experience of other universities and the latest scientific knowledge of the UAV area.
- Writing of the contributions on the level of the international scientific conferences dealing with the problems solved in the project (Fig. 1).

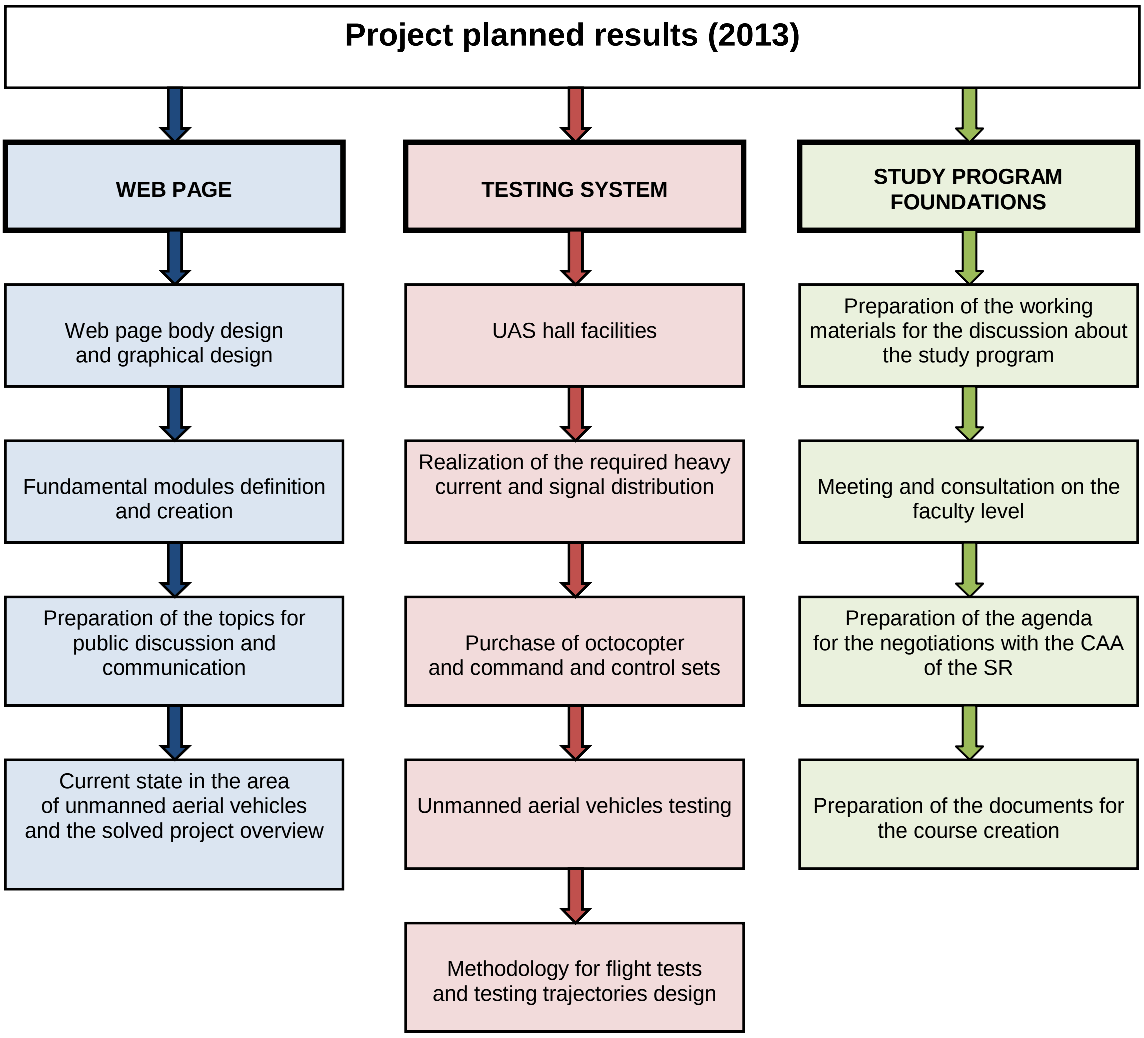

Figure 1 Project first phase planned results

Project second phase planned results:

- Design and realization of the required technical equipment and instrumentation of the laboratories for the sensor testing and calibration and for the UAV assembly.
- Comprehensive documentation for the "Unmanned aerial vehicles" study program elaboration.
- Preparation of the e-documents for the modules dealing with air navigation and the actual UAV legislation.
- Writing of the contributions on the level of the international scientific conferences focused on the UAS area (Fig. 2).

Project third phase planned results:

- Building and workstation facilities preparation and putting into the operation of the technical devices for the rapid prototyping implementation into the teaching process in the area of mechanical parts construction and electrical parts realization.
- Completion of the rooms building and technical equipment of the measurement workstations for the navigation component testing.
- Elaboration of the foundations for the schoolbook for the "Unmanned aerial vehicles" study program dealing with UAV sensorics.
- Writing of the contributions on the level of the international scientific conferences dealing with the problems solved in the project (Fig. 3).

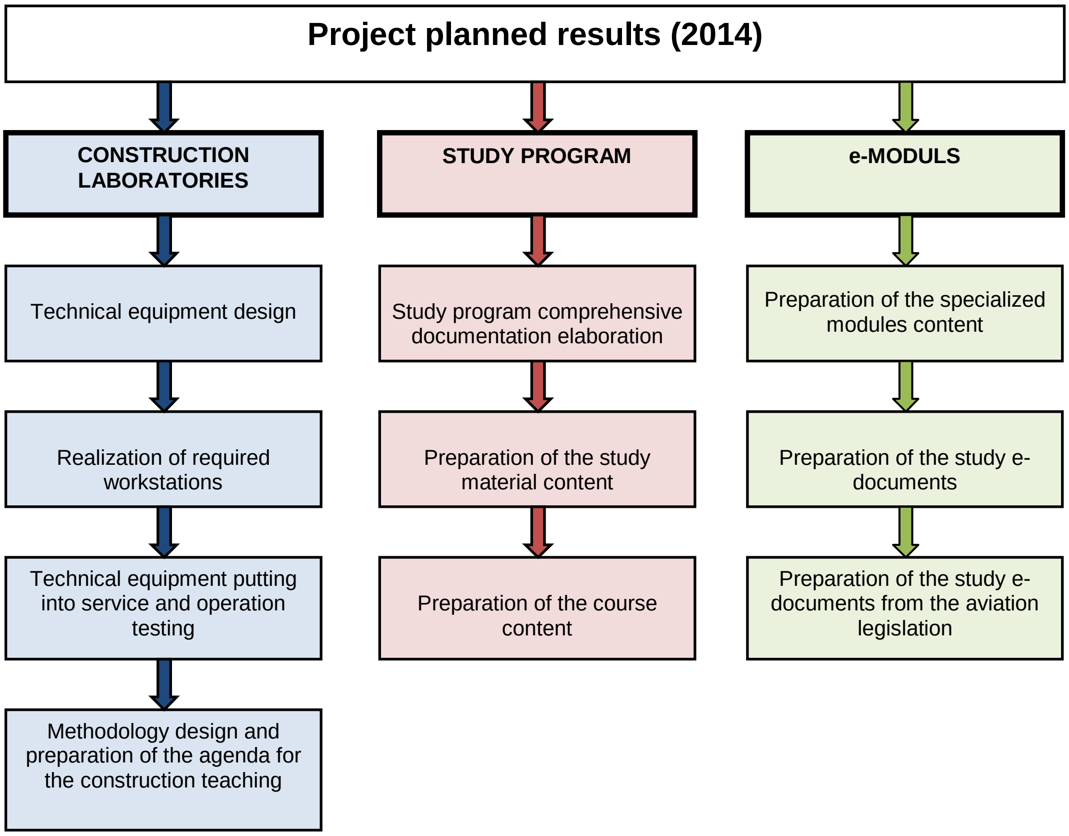

Figure 2 Project second phase planned results

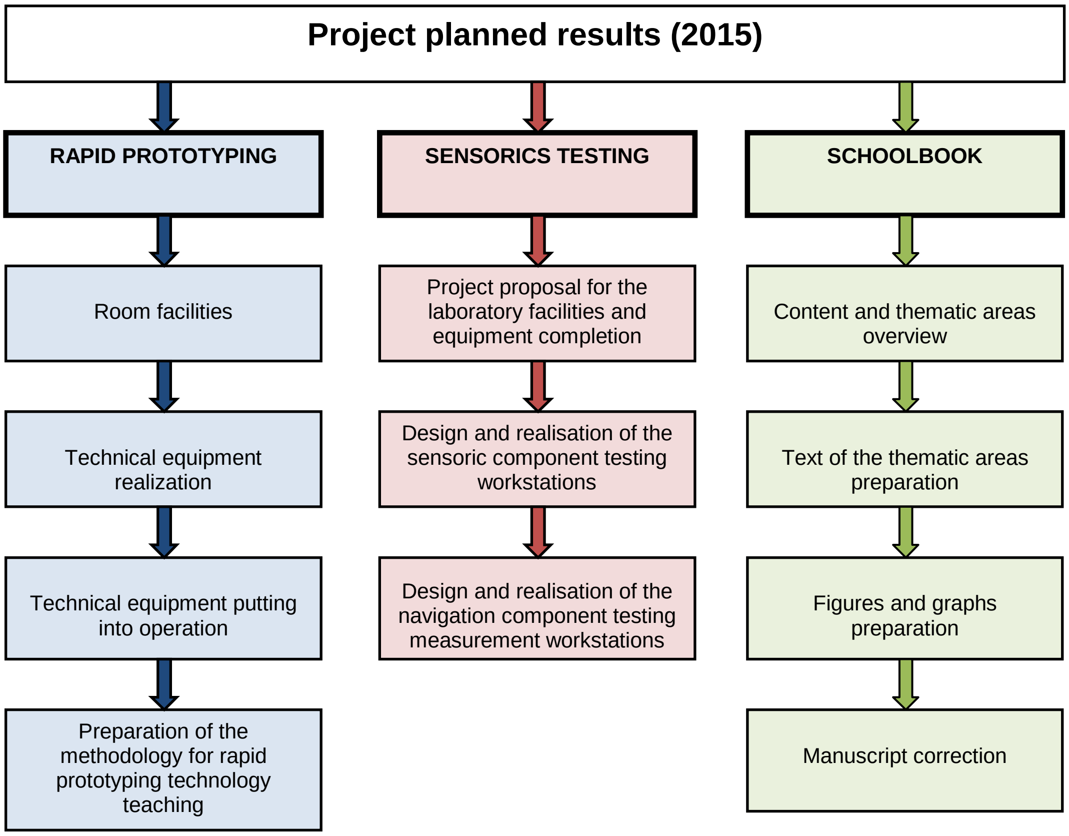

Figure 3 Project third phase planned results

Project contributions in the social, economic and business practise we can consider:

- Improvement of the conditions for the practical skills and experience development in the area of aircraft electronic equipment and mechanical construction of the bachelor study students.
- Scientific research performed at the Faculty of Aeronautics of the Technical University of Košice extension, namely in the area of aviation electronics, construction, operation and control.
- Training of the specialists and their incorporation into the international collaboration in the UAV area.
- Graduate profile also in compliance with the international requirements.

3. CONCLUSION

Number of applications using small UAS begins to increase also in the civil sector gradually. This fact can be observed also in Slovakia. Considering that in Slovakia there is practically no existing aircraft industry, at the Faculty of Aeronautics of the Technical University of Košice we have an ambition to intercept the present world-wide development in the new perspective aviation segment - in the unmanned aerial systems and so to take up again to the previous long-term successes of the Slovak aviation training, education and research. It is obvious that UAS utilization in many different applications will cause an increase in the requirements for the UAS operation license and continuous licence compliance. The main reason of this requirement is motivated by the need of the corresponding specialized knowledge and technical abilities acquisition for the safe and economical UAS flights in the airspace performance. Analogous to the training and education, there are also in the research and scientific area wide possibilities mainly in the technological process investigation, in the material engineering, aerodynamics, reliability, safety, stability, in the area of communication and data transmission security, in the sensor and sensoric network development, in the application development etc.

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MEASURING AND TESTING GNSS WITH VERTICAL GUIDANCE

Andrej NOVÁK[1]

Abstract: *This paper describes the consistent preview of the measuring and testing GNSS with vertical guidance. This paper describes comprehensive information about current and future possibilities of maintenance and improvement of instrument flight procedures at airports with seasonal or occasional air traffic under instrument flight rules (IFR). A Global Navigation Satellite System (GNSS), as a source of position information available worldwide is considered as a key enabler to this purpose.*

Keywords: *GNSS, IFR, Flight Validation*

1. INTRODUCTION

The Global Navigation Satellite Systems (GNSS) have changed the face of navigation dramatically in recent years, in that they can give an accurate and instant readout of position almost anywhere in the world. The Measuring and testing GNSS requires three essential components:

- the aircraft with the flight crews,
- the procedure or navigation aid requiring validation,
- and the flight inspection system (FIS).

The particular set of issues comes with each component. Flight crews must be trained and current in the airframe. The airborne platform must be certificated, maintained, and operated. The flight inspection system consists of complex avionics equipment and software. Before a procedure can be flight inspected, flight inspection criteria must be developed and implemented. The main focus in this paper will be on the airborne platform, the flight inspection system and incorporating developing technologies. [2]

When I first started flying at 2005, there were two types of instrument approaches. The first kind was the non-precision approach, which offers only lateral guidance. Those pilots flying a non-precision approach learn the “dive-and-drive” drill, which calls for a quick descent from final approach fix (FAF) to minimum descent altitude (MDA). The MDA must be strictly maintained unless and until the runway is in sight and the aircraft is in position for a normal descent and landing. The second was the precision approach, which is so named because it incorporates vertical guidance too. It sounds straightforward and during training flights in good weather condition, it usually is. The situation changed with the advent of challenges to requirements for non-precision approach in actual instrument conditions. Even for the pilots with a lot of experience can be challenging the combination of low altitude, low airspeed and looking outside on the runway during a non-precision approach. Controlled Flight into Terrain (CFIT) accidents have resulted when pilots were not up to those challenges. The good news is there is now a third type of instrument approach: “approach with vertical guidance” (APV). The traditional precision and non-precision approaches rely on ground-based navigation aids, such as the localizer and glide-slope antennas, which are expensive to install and maintain. However, the APV is based on signals from the global positioning satellite (GPS) constellation and the European Geostationary Navigation Overlay Service (EGNOS) that EASA certified in 2006. The first trial LPV approach based on EGNOS was at the airport Valencia (Spain). EGNOS has improved on GPS to the point where EGNOS approaches can provide minimums equivalent to Category I Instrument Landing System (ILS) minimums, i.e., as low as 200 feet above ground level (AGL). Together, GPS and EGNOS eliminate the need for airport-specific navigation aids, which means that more airports in more places can benefit from having one or more APV approaches.

Since APV approaches include vertical guidance and can, in some cases, provide approach minimums equivalent to Category I ILS, you may wonder why EASA doesn’t simply classify them as precision approaches. Here’s the answer. Officially, the APV is different because it does not meet the

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International Civil Aviation organization (ICAO) and EASA precision approach definition. That definition applies mostly to localizer and glide-slope transmitters. In addition, EASA and ICAO definitions for a “precision approach” carry a great deal of documentation, definition, and associated costs. Rather than try to change these standards and the associated international agreements, both ICAO and EASA adopted the term APV. [1, 3]

2. PROCEDURES FOR MEASURING AND TESTING GNSS

2.1 Definition

Flight validation is a flight assessment of a new or revised instrument flight procedure to confirm that the procedure is operationally acceptable for safety, flyability and design accuracy, including obstacle assessment and database verification, with all supporting documentation. Includes flights performed with Simulators (except desktop software simulators).

Flight evaluation is a validation flight of an instrument flight procedure with an aircraft.

Flight inspection is an operation of a suitable equipped aircraft for the purpose of calibrating ground based NAVAIDS or monitoring/evaluating the performance of Global Navigation Satellite System (GNSS).

ARINC 424 is a standard by which a navigation database is created to interface with an airborne navigation computer (i.e., FMS, GPS receiver, etc.). he navigation database will provide paths and termination points for the navigation computer to follow. [4]

2.2 Aircraft Requirements

The aircraft avionics configuration must be appropriate to support the procedure to be flight measuring. Flight Inspection of RNAV Standard Instrument Departure (SID), airways, and Standard Terminal Arrival Route (STAR) may be accomplished with any flight inspection aircraft capable of the procedure’s ARINC 424 path and terminators. RNAV approach charts provide separate minima for Lateral Navigation (LNAV), Lateral and Vertical Navigation (LNAV/ VNAV), LP, LPV, and RNP. Inspection of an RNAV procedure with vertical guidance requires an appropriately equipped flight inspection aircraft. Flight inspection of a LNAV approach procedure (without vertical navigation) may be accomplished with any flight inspection aircraft capable of the procedure’s ARINC 424 path and terminators. [4]

2.3 Pre flight preparation

Prior to departure for a flight check the flight inspector is responsible for the flight inspection system serviceability, calibration and that the calibration will remain current for the expected duration of the check. All relevant data must be obtained to enable the execution of the flight check. This data may include:

- Facility information and status;
- Type of check required;
- Survey data.

The Ground reference station is to be deployed in accordance with the Flight Inspection System Manual published in University of Žilina. A detailed ATC briefing shall be conducted in accordance with the University of Žilina ATC briefing pack. [5]

2.4 The flight inspection system warm up time

During normal operation of the Flight Inspection System (FIS), all parameters except Received Signal Level (RSL) will be within operating tolerances immediately after the system is powered on. RSL parameters will be within operating tolerances after 45 minutes. The flight inspector is to ensure RSL parameters are not used prior to 45 minutes of the Flight Inspection System being powered on. The flight inspector is to check correct operation of the system fans prior to conducting the flight check. An audible check is satisfactory.

Figure 1 The Ground reference station at the Zilina airport. [5]

2.5 The flight inspection system temperature/RSL

All parameters measured by the Flight Inspection System will be within operating tolerances over an ambient temperature range of 10°C to 30°C. All parameters except RSL will be within tolerances over an ambient temperature range of 10°C to 45°C. The flight inspector is to check the aircraft cabin temperature to ensure operation within the specified temperature range. The cabin temperature is to be recorded on the relevant run sheet and also recorded on the final flight check report. The flight inspection system is calibrated at -70dBm. At signal levels above -50dBm the flight inspector should be aware that errors may be present and thus limit use of the FIS at RSL above -50dBm. [5]

2.6 The flight check

During the flight check the flight inspector will organise a run list that will enable the aircraft and crew to measure and record the required parameters. The number and type of runs will depend on the type of check being conducted and will be selected from the flight check procedure. The flight check procedure document provides guidance and instructions:

- The flight profile to be executed.
- Parameters to be measured.
- Tolerances to be applied.
- Data to be recorded.
- Reference to the flight check recording.

The procedure can also be used as a run sheet for the flight inspector to record facility specific information, measured parameters and cross reference to the flight check recording. The flight inspector is responsible for:

- Checking of correct fan operation.
- Filtering is set to automatic.
- Ensuring that all profiles, tests and recordings are completed with consideration to the type of check being undertaken i.e. Commissioning, Annual, Routine.
- Site data width is to be adjusted to actual value measured at the beginning of each check.
- Glide slope back set is to be calculated using the coordinate calculator.
- Calculation and application of tolerances.
- Any localiser modulation above 60% is to be investigated. Data shall be extracted and a normalised plot produced.

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- Position quality 3 is required for all Instrument landing system (ILS) recordings except coverage and clearance recordings. Position quality 1 or 2 is satisfactory for all other recordings.
- Mean width recordings should be made at the discretion of the flight inspector. This will be required when poor course structure causes poor correlation with mean width recordings.
- Reporting all required data.
- Production of the flight check report.

Additional flight inspector duties that facilitate efficient flight check include:

- Effective liaison with the airport operator and technical staff.
- Monitor flight technical error to ensure that the average track accuracy is within an average of 15Microamps.
- Efficient air/ground communications.
- Explanation of reports.

Figure 2 Airborne and ground equipment AT-940 with spectral analyser and selective millivolt meter.

2.7 Post flight

On completion of the flight check mission the flight inspector is responsible for:

- Reporting any flight inspection system faults.
- Updating FIS log if required.
- Updating the central data base for any new or updated site data.
- Archiving the flight check report both electronically and in hard copy.
- Production of the flight check report in a timely manner and ensure that the site data file relevant on the day of check is appended to the report.
- Obtaining a review of the flight check report.
- Issuing the report to the facilities operator.

2.8 Flight Check report

On completion of the flight check mission the flight inspector shall produce the flight check report to the standard prescribed in this manual including the following considerations: all recordings shall be printed and included as part of the report. Recordings shall not include raw course deviation indicator (CDI) or Aircraft position traces. The report shall include the actual site data record pertaining to the facility being inspected. The flight check report is to be checked by another qualified and current flight inspector prior to release.

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3. MEASURING PARAMETERS FOR GNSS

Recording of GNSS parameters during the flight test is not required for NPA. However, the parameters in Tables 1 and 2 can support analysis of GNSS signal anomalies or interference encountered.

Table 1 GNSS parameters

Parameter	Definition	Purpose
Cross track distance	The across track distance computed by the GNSS receiver or FMS with GNSS sensor.	Provides a continuous record of the total system error component perpendicular to the desired track segments.
Active way-point	The active way-point identifier.	Gives a continuous indication of the active way-point.
Distance to active way-point	Distance to the active way-point in nautical miles.	Provides a continuous record of the GNSS receiver computed distance to the active way-point.
Bearing to active way-point	Bearing to the active way-point.	Provides a continuous record of the GNSS receiver computed true bearing to the active way-point.
No. of satellites visible	The number of space vehicles visible to the GNSS sensor.	Continuous indication of the satellites in view.
No. of satellites tracked	The number of space vehicles being tracked by the GNSS sensor.	Continuous indication of those satellites for which a range solution is being tracked.
Carrier-to-noise density ratio	The carrier-to-noise density for each satellite visible to the GNSS sensor.	Continuous indication of received C/N0 from each satellite. Useful for investigating interference problems.
HDOP	Horizontal dilution of precision.	Continuous indication of the geometric dilution of the GNSS position accuracy in the horizontal plane.
RAIM alarm	Indicator of lost GNSS signal integrity as computed by the GNSS receiver/sensor RAIM algorithm.	Continuous indication of RAIM alarm status. Can be used to investigate loss of RAIM occurrences along with other inputs such as HDOP, HFOM, aircraft attitude (roll, pitch and heading) and satellite carrier-to-noise.
Date and time	GNSS UTC date and time.	Provides an accurate time for each GNSS position solution to be compared to a reference system.
GNSS position	Present position latitude and longitude.	Provides a continuous indication of the GNSS position.

Table 2 Flight test system parameters

Parameter	Definition	Purpose
XTKER	The across track error. Derived by calculating the position difference between the GNSS and the positioning system, and then extracting the vector component that is 90 degrees from the track heading.	Provides a continuous record of the NSE (Navigation System Error) component perpendicular to the desired track.

ATKER	The along track error. Derived by calculating the position difference between the GNSS and the positioning system, and then extracting the vector that is in the direction of the track heading.	Provides a continuous record of the NSE component in the direction of the desired track.
WPDE	Way-point displacement error is the vector sum of the XTKER + ATKER.	Can be calculated for the point at which the position reference system indicates the aircraft is abeam the way-point being checked. Includes known errors inherent in the measurement system used.
Positioning system position data	Precise position of the GNSS antenna relative to the position system reference frame.	Provides a continuous record of the GNSS antenna position.
Positioning system status	Operational status of the positioning system.	Provides continuous indication of the operational status of the position reference system.

4. CONCLUSION

In summary, a significant portion of this paper was devoted to discussion of the legal rules of EU laws, standards, and guidance material for aircraft certification and operation. An in-depth knowledge of each of the documents is required to provide engineering support for a modern flight inspection fleet in the EU. Maintaining, operating, meeting mission requirements, and complying with applicable standards are very complex tasks.

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PASSENGER TERMINAL FLOW ADJUSTMENT ACCORDING TO ACCESSION OF CROATIA TO EU – A CASE STUDY OF SPLIT AIRPORT

Stanislav PAVLIN[1] - Matija BRAČIĆ[2] - Mate MELVAN[3]

Abstract: *An airport passenger terminal represents an intersection of different passenger and baggage flows between airside and landside. The paper will deal with the passenger and baggage flows in the passenger terminal at the Split Airport in the context of the Croatian accession to the European Union. In the first phase the Republic of Croatia will not be a Schengen Agreement signatory. The paper will analyze the current passenger terminal, domestic and international passenger and baggage flows, and the flows of passengers and baggage after joining the EU within the existing terminal.*

Keywords: *airport passenger terminal, passenger and baggage flows, passenger terminal planning*

1. INTRODUCTION

The passenger terminal of an airport represents the place where air travel starts and ends. If the airport is planned for international and domestic traffic, the flows are separated as well as for arrivals and departures [1]. These four basic passenger and baggage flows are also called the terminal passenger flows [2].

Some airports i.e. some air carriers have also transit flights, and the passengers may stay during ramp handling onboard aircraft or be transported to the passenger terminal. In practice these passengers do not change the flight number.

There is also the category of transfer passengers, passengers who change flight, that is: from domestic arrival to domestic or international departure or from international arrival into international or domestic departure.

The paper deals with the passengers and baggage flows at the Split Airport in the context of Croatian accession to the European Union. The current passenger and baggage flows in domestic and international traffic have been analyzed as well as the potential flows of passengers and baggage after the Republic of Croatia enters the EU, which in the first phase will not be a member of the Schengen Agreement. The analysis encompassed the arrival, departure and transfer flows of passengers and baggage.

2. SPLIT AIRPORT

The Split Airport is an international airport open to public air transport. With 1.4 million passengers in 2012 it represents the third airport in the Republic of Croatia regarding the number of passengers. A specific characteristic of the Split Airport is its extreme seasonality, i.e. during the summer tourist season the traffic volume is extremely high, at a monthly level some ten times higher than during winter months. According to traffic on a peak day the Split Airport with about 25 thousand passengers on Saturday in peak season (about 2% of annual traffic) represents the first airport in the Republic of Croatia. At peak loads the quality of passenger handling falls below the usual standards.

For comparison, in 2012 the Zagreb Airport realized 2.3 million passengers, and the peak day was about 10,000 passengers or about 40% of traffic of the peak day at the Split Airport.

Very high peak loads impose the need for additional capacities which are not economically cost-efficient since these occur only on Saturdays during the peak tourist season, for about four months, i.e. only some twenty days in a year.

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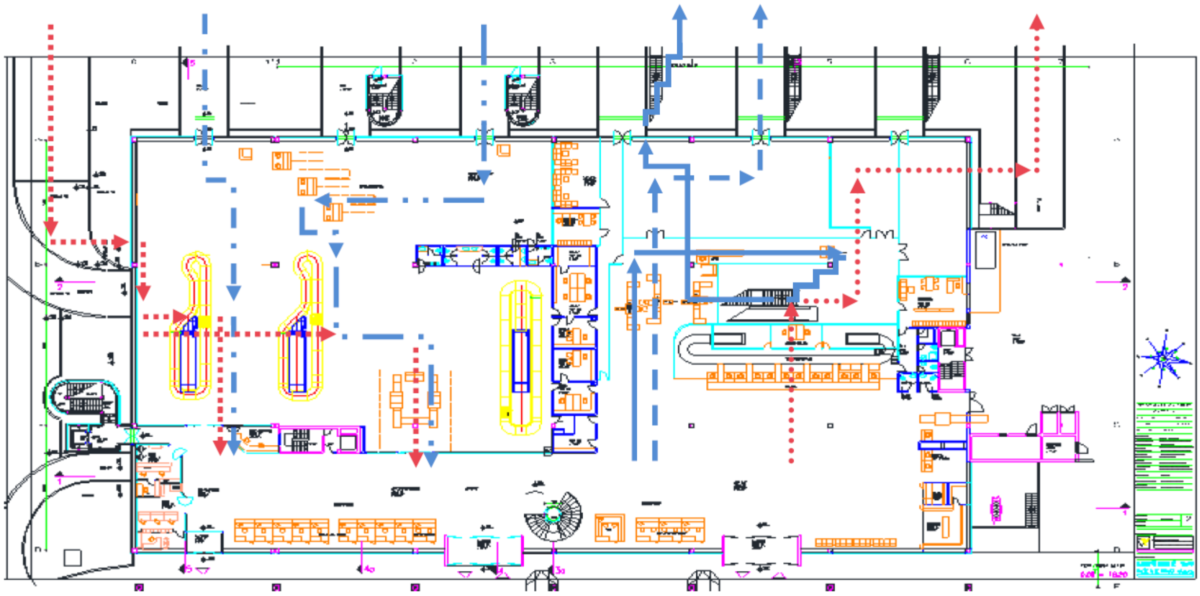
The Split Airport terminal building belongs to the category of centralized passenger terminals since all primary facilities of the same group are located at one place [3], and considered from the aspect of horizontal distribution of passenger and baggage flows it belongs to the category of simple passenger buildings (Figure 1).



domestic departure - passengers
intern. departure – passengers
domestic arrival - passengers
international arrival - passengers
domestic/intern. departure - baggage
domestic/intern. arrival - baggage

Figure 1 Passenger and baggage flows at Split Airport

From the aspect of vertical distribution of passenger and baggage flows the terminal building has been designed as a one-floor building. The ground floor of the terminal building accommodates all the facilities except the common international outgoing waiting room which is located on the first floor.

3. ANALYSIS OF PASSENGER AND BAGGAGE FLOWS

3.1 Analysis of departure flows

The departure passenger and baggage flow is partly common for the domestic and international traffic (Figure 2). The passenger can check in for a flight via the Internet, self-service devices or by registering at the counters at the airport, where separated baggage is checked in. After the check-in an international passenger can proceed with the customs procedure. After having screened all the passengers, the passenger on departure flight for destinations within the Croatian territory goes to the waiting room on the ground floor of the passenger building, whereas the international passenger goes to the waiting room for international departures which in on the first floor of the passenger building [4], passing first custom and passport control.

After X-ray screening the baggage is lowered by means of a conveyor belt to the sorting area in the basement where it is sorted onto appropriate trolleys and taken to the aircraft. During boarding of passengers the baggage and the passengers are paired by means of the *Baggage Reconciliation System* developed for this purpose at the Split Airport.

The departing passenger and baggage flows within the territory of the Republic of Croatia are identical before and after Croatian accession to the European Union. With the accession of the Republic of Croatia into the European Union, the international outgoing flows of passengers may differ regarding the customs. The outgoing flights towards the countries of the European Union do not require customs control, whereas the flights towards other countries have to undergo customs control.

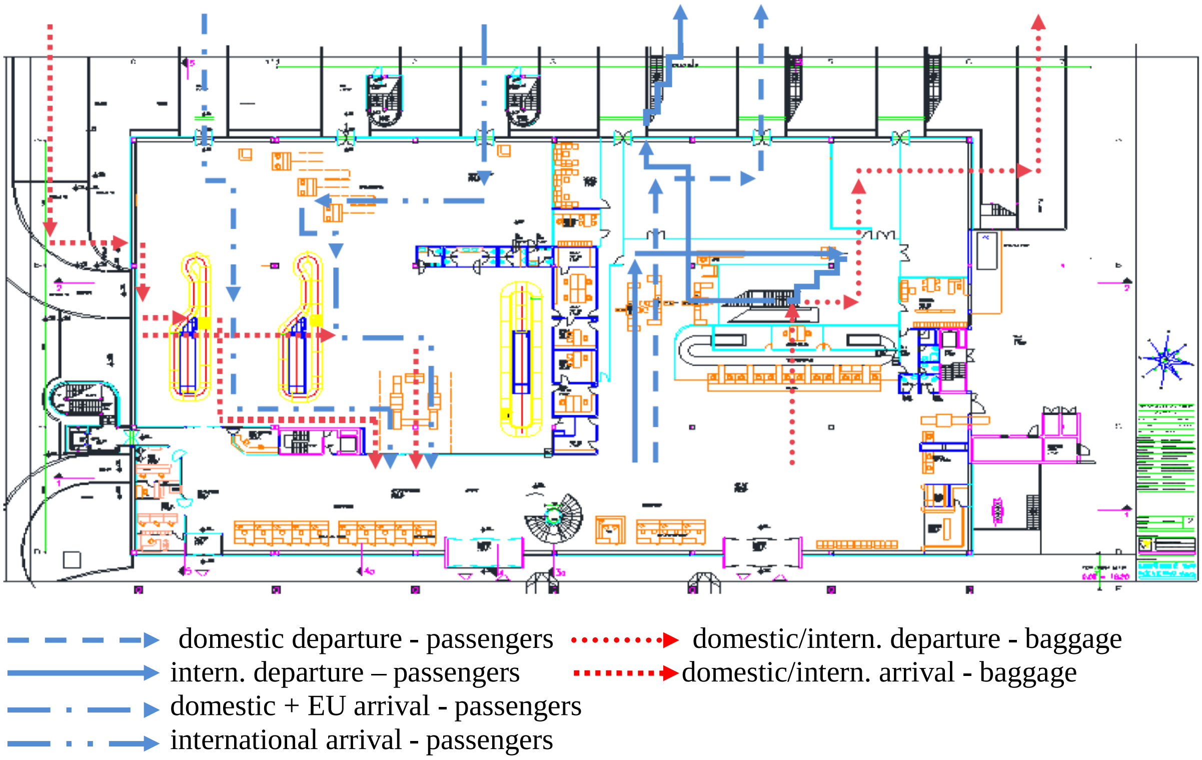


Figure 2 Passenger and baggage flows at Split Airport after Croatian accession to EU

3.2 Analysis of arrival flows

The arrival passenger flows are divided into international and domestic ones. After the accession of the Republic of Croatia to the EU the flows of international passengers will remain unchanged, with the introduction of a new line for passengers from the European Union countries who need no customs control (Figure 2). The new line is used by the passengers from the European Union whose baggage tag has been marked by green designations attached at all origin airports in the European Union countries. In the segment of domestic passengers the flow will be adjusted with the international ones because of the need for customs control of the checked baggage of those passengers who are coming from the countries outside the European Union on combined lines. This change will encompass about 80% of incoming international passengers [5]. International passengers arriving from the countries which are not members of the European Union are subject to customs control and supervision through the existing lines.

The incoming baggage is unloaded from the aircraft and transported to the sorting area where it is placed on the conveyor belt which delivers the baggage to the passengers.

3.3 Analysis of transfer flows

The analysis of transfer flows at the Split Airport shows that currently there are no clearly defined flows of transfer passengers, i.e. the passengers who are in transfer pass the mentioned procedures on arrival (domestic, international arrival) exit to the landside and then proceed to the mentioned procedures for terminal departure passengers (domestic, international).

With the accession of the Republic of Croatia into the European Union regarding the transfer passenger and baggage flows there will be substantial changes. In order to be able to establish the transfer passenger flows certain changes need to be undertaken within the passenger building. It is necessary to build a corridor, i.e. a passage leading the passengers directly from the domestic/international arrival towards domestic/international departure.

Transfer passengers arriving by a domestic flight and continuing their trip towards international destinations within EU, after the accession of Croatia to the European Union will realize their transfer via direct transfer area. An example of such transfer is presented in Figure 3 in case of a passenger arriving from the Zagreb Airport (EU member, Schengen non-signatory) via Split Airport (EU

member, Schengen non-signatory) towards Munich Airport (EU member, Schengen signatory). Such a passenger arrives to domestic arrival, receives at the transfer counter a transfer ticket and proceeds directly to passport control [6]. Here, the transfer flow joins the outgoing international passenger flow. After passport control the passenger proceeds to the upper level of the passenger building to the waiting rooms for international departure.
In case the passenger is in transfer from a domestic flight to an international flight towards countries that are not European Union members a customs control needs to be passed before the passport control.
The baggage transfer flow includes unloading of baggage from the aircraft, transport to the sorting area, where it is sorted for the next flight, and transported to the transfer aircraft (Figure 3).

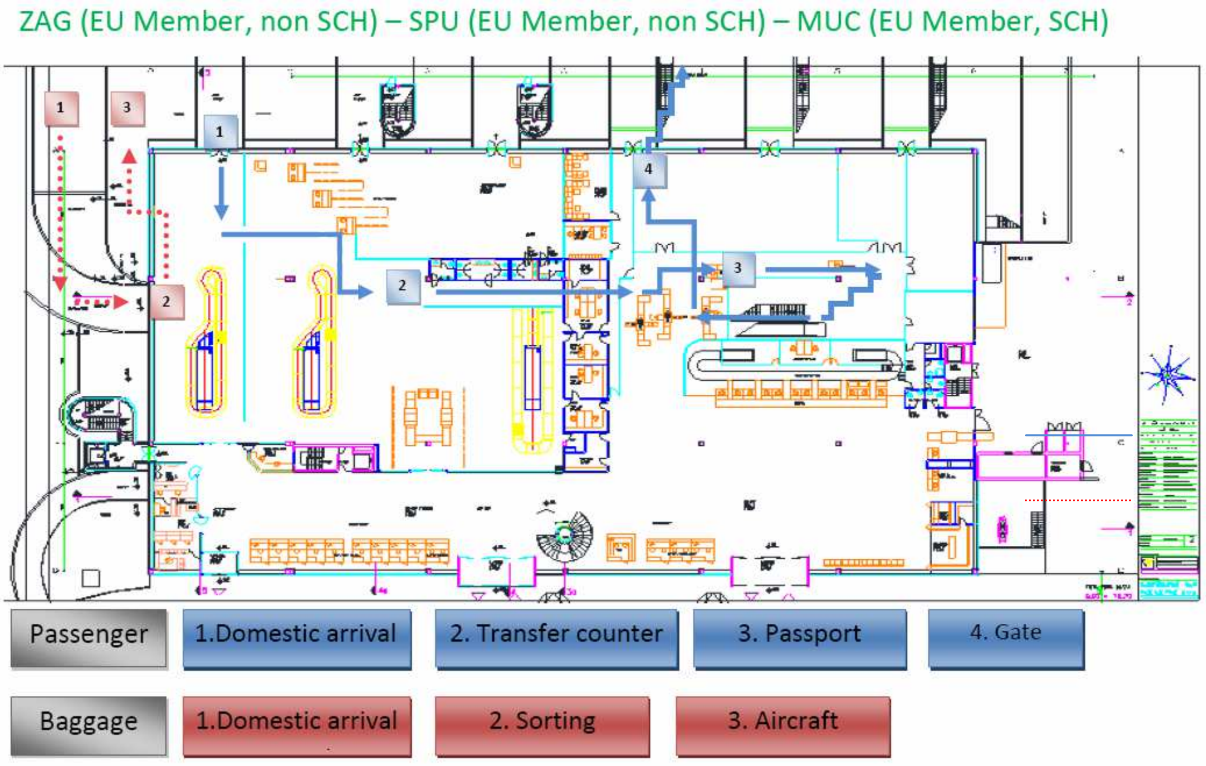


Figure 3 Transfer passenger and baggage flow between domestic and international destination

In case of transfer from the international arrival to domestic departure flight, the passenger performs transfer via direct transfer area. An example of such transfer is the passenger arriving from the Paris Airport (EU member, Schengen signatory) and via Split Airport (EU member, Schengen non-signatory) continues to the Zagreb Airport (EU member, Schengen non-signatory). This is presented in Figure 4.
Upon entering the international arrival the passenger passes through border control, receives at the transfer counter a transfer ticket and proceeds through direct transfer area to the outgoing waiting rooms in domestic departure.
The passengers arriving from international flights from the countries that are not members of the European Union, due to security control and customs control, have to exit on the landside and pass through the departing procedures.
The transfer flow of baggage passes through the sorting area. If the baggage arrives from an international flight from the countries that are not members of the European Union, an additional security screening of the checked baggage is necessary.
The transfer between two international destinations via Split Airport will be performed by direct transfer area. The international transfer can include countries that are not members of the European Union and the European Union member countries. Furthermore, international transfer can proceed towards countries that are not signatories of the Schengen Agreement and towards countries that are signatories of the Schengen Agreement.

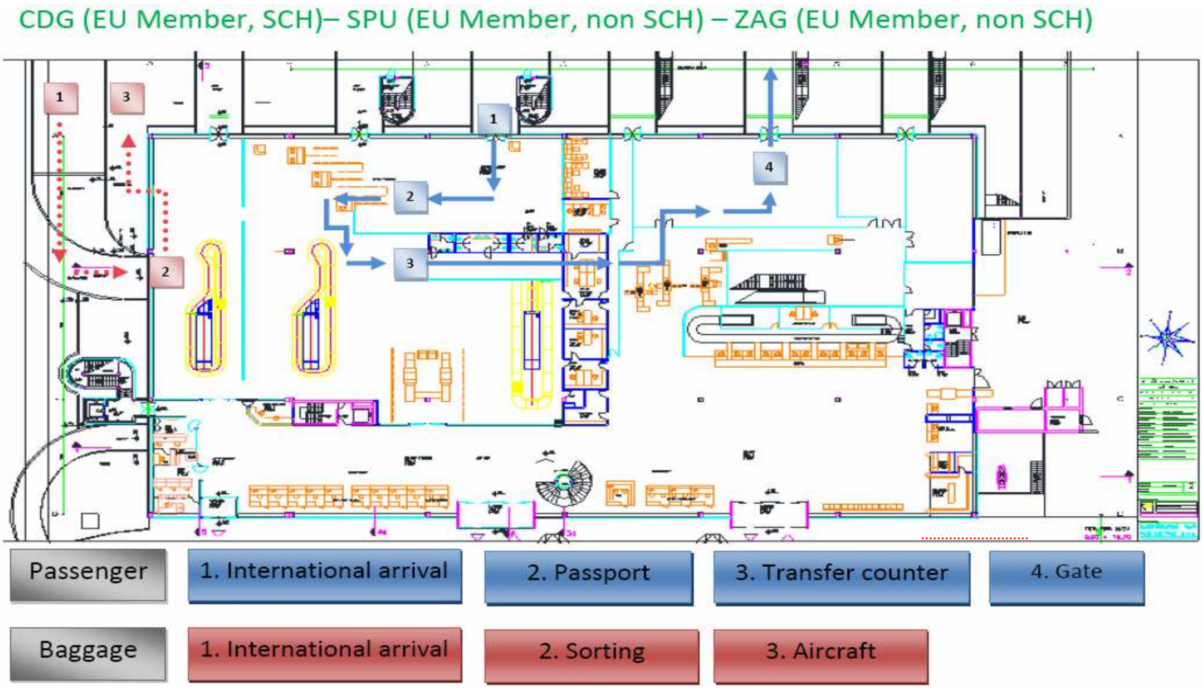


Figure 4 Transfer passenger and baggage flow between international and domestic destination

The most frequent transfer at the airport between two international destinations is the arrival of passengers from a country that is a European Union member and Schengen Agreement signatory via Split Airport towards a European Union member country and Schengen Agreement signatory. Such international transfer flow of passengers includes only border control and issuing of a transfer ticket to the passenger (Figure 5).

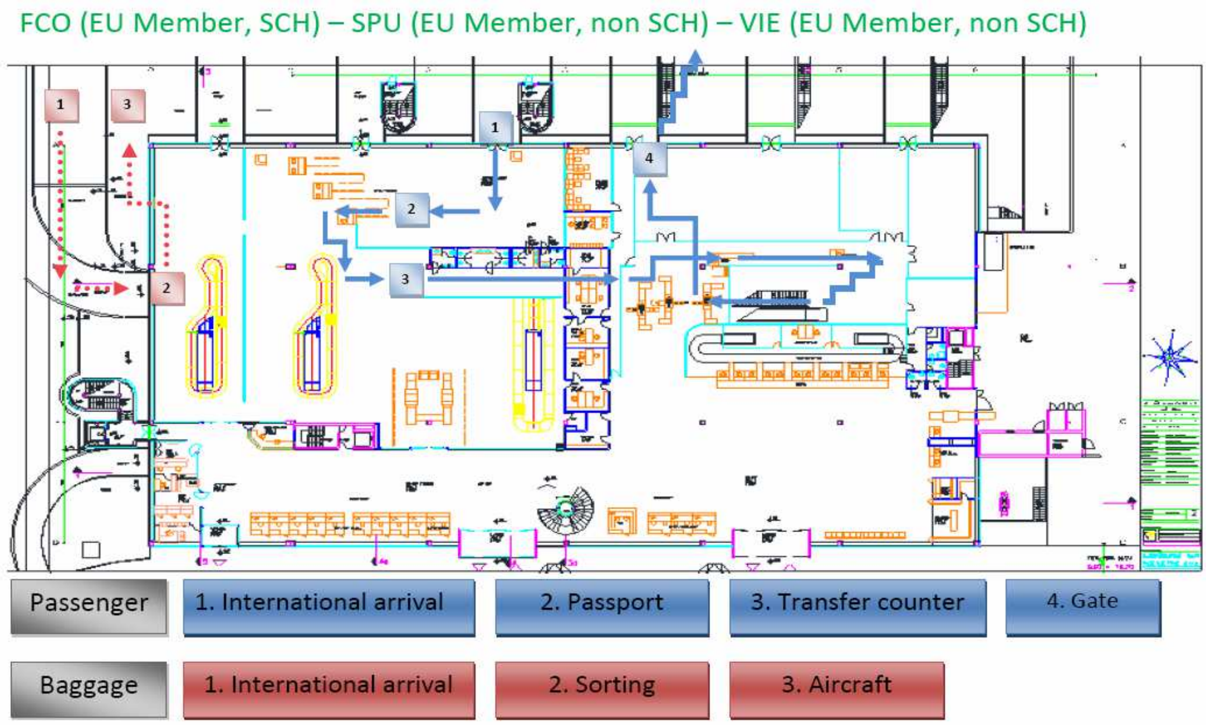


Figure 5 Transfer passenger and baggage flow between two international destinations

The baggage transfer is done at the sorting area, by sorting the baggage for the next flight.

4. CONCLUSION

The paper has analyzed the passenger and baggage flows at the Split Airport terminal building regarding the flows that will result from the accession of the Republic of Croatia into the European Union, taking into consideration the space of the passenger building and the required technical and technological facilities.

With the accession of the Republic of Croatia into the European Union the incoming and outgoing passenger and baggage flows will be slightly changed, only for the flights between those destinations, i.e. countries that are members of the European Union. The difference is reflected primarily in the customs control segment due to the fact that with the accession into the European Union the Republic of Croatia is entering the unique customs clearing system and unique security screening.

Major changes in the passenger and baggage flows occur in the segment of transfer flows. Apart from the defined transfer flows of passengers and baggage after the accession of the Republic of Croatia into the European Union (not the Schengen system), in the Split Airport passenger building certain reconstructions will have to be done in space such as the construction of passages for transfer passengers, thus facilitating substantially the procedures for the transfer passengers and improving the quality of service in this traffic category, while the overall quality of service will be below the usual standards at peak loads.

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MODEL FOR SUPPLY CHAINS´ SAFETY MANAGEMENT

Dana PROCHÁZKOVÁ[1]

Abstract: *The safe community is now at time of globalisation very dependent on a safety level of supply chains ensuring the territory serviceability by basic commodities necessary for humans´ lives. Series of negative consequences from recent years connected with supply chains show their high importance in the period when the JUST IN TIME principle in firms´ process management is a normal practice. E.g. the recent oil supply interruption to Central and Western Europe as a consequence of discrepancies between the Ukraine and the Russian Federation revealed the high vulnerability of afflicted countries on the given commodity and it let to opening the new problem that the EU is forced to solve for its security and development. The supply chains represent multistage interdependent systems, at which among individual levels the material, finance, information and decision flows circulate in both directions. Therefore, they belong among big complex systems, the type of which is a systems system. The paper presents the model for supply chains´ safety management based on this reality.*

Key words: *supply chain; provision of territory services; security; safety; model for safety management.*

1. INTRODUCTION

For ensuring the human security and development, there is necessary to govern the safety with the goal to make up the safe human system [1-3]. To ensure the safe human system it is not easy, because the human system is a system of systems [4], i.e. system of several mutually interconnected systems. Consequences of interconnections (interfaces) are mutual dependences, the character of which is physical, cyber, territorial and organisational [4-6]. Mentioned interdependences are the sources of further vulnerabilities of human system that magnify integral risk of a given system by increase of cross-section risks of system of systems [4-6]. As a consequence of growing globalisation the new sources of disasters take on force, i.e. critical infrastructure failure and supply chains´ failures. The present paper deals with problems of supply chains in the broadest concept, i.e. not only from the viewpoint of supply chain itself, i.e. from the viewpoint of its structure and co-operation of its individual parts***, but also*** from the viewpoint of its impacts and profits for a given locality in which they are under operation, i.e. for locality public assets and territory. By this feature the paper concept differs from most of current works and it is reality that its concept includes the public protection.

From the reasons of fulfilment of targets of humans that may be realised only if human communities are in safe territory, the object of present paper is the supply chains safety that ensures safe supply chains that do not threaten its vicinity, i.e. other systems with which they are mutually interconnected or which they influence. The result of study, by help of methodology processed in the frame of project FOCUS [7-9], is the creation of model of supply chains safety management.

2. SUPPLY CHAIN

The supply chains are composed of suppliers, producers, distributors, sellers and customers. They represent multistage systems at which among individual stages in both directions they run flows of materials, finances, information and decisions. Material flows include the flows of raw materials, semi- finished products and complete products in direction from supplier to customers. Reversely oriented there are the flows of products designated for repair, recycling or liquidation. Finance flows include different sorts of payments, credits, flows following from proprietary relations etc. Information flows interconnect the system by information on purchase orders, supplies, plans etc. Decision flows are sequences of decisions of participants influencing the all-inclusive productivity of

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supply chain. Supply supplier and all its sub suppliers who participate on assembly and fulfilment of supply according to a contract between the final supplier and the supply booker, must co-operate. The supply chain may contain more co-operation stages and it is always related to fulfilment of one supply. The mutual relations among individual co-operation stages are based on contractual ground fulfilment [10]. From the methodological viewpoint each supply chain is a system of systems [4, 5].

In engineering disciplines directed to risk at present we use two disciplines [5], which for supply chains divide to a set of disciplines the target of which is: supply chain security, i.e. security of supply chain without regard to supply chain vicinity (security management); and supply chain safety, i.e. security and development of both, the supply chain and its vicinity.

Many professional works deal with ensuring the first target, which has been pursued in engineering disciplines since the beginning 80s [5]. The other target is more ambitious on understanding and on methods of engineering disciplines. It has been pursued since a half of 80s but from reasons of big demands on: data (there are necessary data on: system, system vicinity, linkages and flows between system and its vicinity); comprehension of problems and their connections in a case of open system of systems; methods of problem structuring, analysis and solving the problems, is only enforced in domain of nuclear technologies and astronautics [5], namely in spite of it solves interconnection of targets of humans in domains social, environmental and technological [3].

3. SAFE SUPPLY CHAIN

Regarding to present way of problem solving given above, we use two concepts for ensuring the safe entity [4, 5]; i.e. security management and safety management. From the analysis of professional literature dealing with measures and activities connected with supply chains it follows that the first mentioned concept being simpler is more often used in practice [10-13]; i.e. the target is the supply chain security and impacts of supply chain on its vicinity is out of interest. At use of advanced one we also cope with risk connected with use of goods transferred by a supply chain as a weapon [10].

With regard to general knowledge, summarized in works [3-10], the main problem of many publications on supply chain security management and of practical instructions lies in reality that attention is mostly concentrated to social disasters and the impacts of natural and technological disasters and organising accidents are neglected. E.g. according to work [11] the supply chain security management covers all processes, technologies and resources exploited in a systematic way to fight against end-to-end supply chain crime. The primary goal of each single supply chain security management measure is either to prevent a crime, to detect a crime, or to recover from a crime incident in the fastest possible time. The single supply chain security management measures fall typically into one of the following five categories: cargo, facility, human resources theft, smuggling, counterfeiting, sabotage, blackmailing for financial gain, terrorism for destruction, and any type of fraud and corruption (the detailed crime definitions subject to national and international regulations). It means that supply chain security management applies processes, technologies and resources in a systematic way to fight against crime. The definition does not address that the application of these processes, technologies and resources must done in compliance with an array of formal and informal supply chain security rules. Crime prevention tactics and strategies must be designed in accordance with explicitly proclaimed laws, regulations and conventions and implicit values, believes, norms and conventions. Supply chain security management is a systematic and continuous process to enhance prevention, protection, preparedness, monitoring, detection, mitigation, response, and recovery from disruptive criminal and terrorist activities and incidents in the supply chain. For human security and development we need not only supply chain security but also supply chain vicinity security [8-10]; i.e. we should apply supply chain safety management [10].

4. SUPPLY CHAIN RISKS

The safety and risk are not complementary quantities even though they together relate by a certain way. In each system both quantities depend on processes, acts and phenomena being under way in a given system and in its vicinity. In advanced concept the concentration to safety has higher targets than concentration to risk because it follows system security, system development, system existence, system vicinity existence and co-existence of different systems [4].

In work [10] the phenomena representing the high risks for supply chains were identified:
- traditional disasters that damages property – fires, natural disasters, electric energy outages and outages of important equipment,
- social disasters as thefts, robberies, violence and terrorism,
- failures of human society management (organising accidents) as political instability, fluctuations of currency rates, failures in energy supply, resources supply as a consequence of political problems in a country of supplier,
- fraudulent transactions and consequences of errors in centric planning in a economic domain,
- outages of cyber nets,
- demands of very ambitious consumers (they demand precise and fast supplies) in respect to short life cycle of some products,
- demands for ensuring the comprehensive correspondence at products according to legal rules of individual countries,
- outages in communication among responsible actors in basic sectors of supply chain,
- possibility to use some goods as weapon.

5. USED TERMS AND THEIR DEFINITIONS

With regards to works [3-5,9, 10] the definitions of terms connected with security and safety are the following:

1. The supply chain is a multistage system in which among individual stages in both directions they run material, finance, information and decision flows. The supply chains are composed of suppliers, producers, distributors, sellers and customers. The activities are realised on the basis of contract between final supplier and supply booker.
2. The disasters for supply chains are the phenomena that caused damages and losses to supply chains. They include phenomena belonging to the category „all hazards approach" [14] and specific phenomena connected with humans and their behaviour that do harm the both, i.e. the supply chain participants prosperity and the fulfilment of tasks for which they were established (insufficient co-ordination of activities, failure of outsourcing activities, intent attacks etc.).
3. The supply chain vulnerability is a predisposition of supply chain (its protected assets) to harm / damage origination. It is an inherent property of supply chain, i.e. not a static variable. In the scale of time and space (egging the projection into area), certain aspects dominate at different points in time and at a different locations.
4. The supply chain resilience is a supply chain capability to overcome impacts of a given disaster.
5. The supply chain risk is a probable size of losses, harms and detriment caused by a disaster with size of normative hazard (mostly design disaster) on supply chain and public assets or subsystems rescheduled on selected time unit (e.g. 1 year), site unit (e.g. 1 km^2) and on basic supply chain participants groups, i.e. it is always site specific.
6. The supply chain security is a situation / condition at which the probability of supply chain assets´ harms, damages and losses is acceptable (it is almost sure that harms, damages and losses cannot origin).
7. The supply chain safety is a set of measures and activities for ensuring the security and sustainable development of supply chain, its assets and public assets.
8. The supply chain security management is planning, organisation, allocation of resources, humans and tasks with aim to reach demanded security level of a supply chain.
9. The supply chain safety management is planning, organisation, allocation of resources, humans and tasks with aim to reach demanded safety level of supply chain and its vicinity.
10. The supply chain safety engineering is a set of engineering measures and activities by which the supply chain safety is ensured in real conditions of a given site.

6. DEMARCATION OF SUPPLY CHAINS UNDER ACCOUNT

With regard to results from analyses of critical infrastructure safety given in the professional literature [1,5,9] and in sources quoted in given works and from historical experiences it is necessary to follow supply chains that ensure: resources; materials and products serving the energy production; electric energy supply in a sufficient amount and quality; oil supply in a sufficient amount and quality; earth gas supply in a sufficient amount and quality; drinking water supply in a sufficient amount and quality; medicament supply in a sufficient amount and quality; food supply in a sufficient amount and quality; resources supply for strategic industry supply in a sufficient amount and quality; protected means supply in a sufficient amount and quality; resources supply for basic industry producing daily articles need in a sufficient amount and quality; supply of reliable information important for human safety management; removing the wastes preventing the harms and losses in human system.

7. METHODS OF SUPPLY CHAIN SAFETY MANAGEMENT MODEL BUILDING

With regard to the present knowledge it is necessary to give that for supply chain safety management fundament is the analysis and assessment of risks connected with mutual interconnections in supply chain sectors and in whole supply chain (i.e. in agreement with [4] it is necessary to consider interdependences in system of systems; i.e. at risk identification it is necessary also to use cross-sectional criterions). The assessment of criticality of individual systems (sectors) of supply chains and the whole supply chain is not trivial matter because under different conditions the sectors and the whole have a different role active, reactive, critical or damping (not additive). E.g. the existence of several variants of electricity supply to one site decreases the energy infrastructure criticality but it increases expenses etc.

The purpose of model for supply chain safety management is to show basic steps by which it is possible to ensure supply chain security and supply chain vicinity security. The model building method goes out from system concept of supply chains; it considers them as system of systems (several overlapping systems) [4], which means that their complex behaviour, function and development depend on both, the number and properties of partial systems and the diversities of their interconnections, i.e. their linkages and flows among them and also across them. The linkages and flows going across the partial systems are the originators of internal dependences (interdependences). The presented model is created by method of analogy to existing safety management models [3-5].

8. MODEL FOR SUPPLY CHAIN SAFETY MANAGEMENT

With regard to data and knowledge in [3-5, 9, 10, 13-16], method described in works [5, 7] and assumption that each supply chain is open system (i.e. risk sources are internal and external disasters and human factor [3-5, 14]) it is created a model for safety management having ten processes, i.e.:

1. ***Process 1*** that ensures the risk management of disasters, the sources of which are inside and outside of supply chain plus human factor; i.e. it follows supply chain and parameters of vicinity in which supply chain operates. It is composed of: assessment of expected disaster size; determination of occurrence probability of important disasters; judgement of supply chain vulnerabilities at important disasters; determination of impacts of important disasters on supply chain. It creates a base for ensuring the safe supply chain.
2. ***Process 2*** that ensures designing and planning the measures and activities for ensuring the supply chain security at considering all important disasters [3,14]; i.e.: supply chain layout (chain structure, chain origination, transport routes, location of storages); performing the measures and activities for ensuring the supply chain security; plan of renovation of supply chain after disaster; plan of training the personnel performing the supply chain; supply chain activities´ monitoring; and correcting measures and activities for a case of important deviations in supply chain operation.
3. ***Process 3*** that ensures designing and planning the measures and activities for ensuring the supply chain vicinity security at considering all important disasters [3,14]; i.e.: supply chain layout by a way that it may not threaten vicinity, i.e. all public assets; performing the measures and activities for ensuring the supply chain vicinity security; plan of renovation of supply chain vicinity after disaster; plan of training the personnel performing the supply chain; supply chain activities´ monitoring; and correcting measures and activities for a case of important deviations in supply chain operation.
4. ***Process 4*** that ensures the harmony among the main activities connected with supply chain commodities, i.e.: subject of supply (its manufacture, transport and distribution); following the deviations in a process of commodity management; and operating loops. It goes on ensuring the stabilities of processes, the minimisation of delays, the quality and the other critical aspects connected with the operation.

5. ***Process 5*** that ensures the safe assets of supply chain, i.e. problems connected with: facilities, equipment or services; vehicles; shipping; products; and data systems. It goes on averting of insiders activities.
6. ***Process 6*** that ensures the safe human sources, i.e. problems connected with: acceptation of employee; understanding the employee behaviour features important for supply chain operation; employee training; employee self-control; implementation of procedures that ensure correct employee behaviour; and employee stimulation.
7. ***Process 7*** that ensures good business partners, i.e. problems connected with: screening the possible partners; authentication of possible partners; producing the ways of negotiation with partners regarding to their behaviour; monitoring the partners behaviours; and audits of partners.
8. ***Process 8*** that generates the capabilities for overcoming the impacts of extreme disasters that affect supply chain, i.e. problems connected with: business continuity; specific response training; investigation of causes of extreme impacts; assembling the evidences; reparation of harms; and court settlement.
9. ***Process 9*** that ensures the dislocation of criminal and illegal supply chains, i.e. problems connected with: formation of base for disruption (ensuring the sources, determination of means, logistics, transport of means, distribution of means); and with support of governments and customers.
10. ***Process 10*** that ensures integral safety of supply chain, i.e. the coordination of all pillars, i.e. processes directing to supply chain safety (PSM – process safety management).

The supply chain safety management model is shown in Figure 1. The base constitutes the concept at which there are determined processes that are important for whole chain safety.

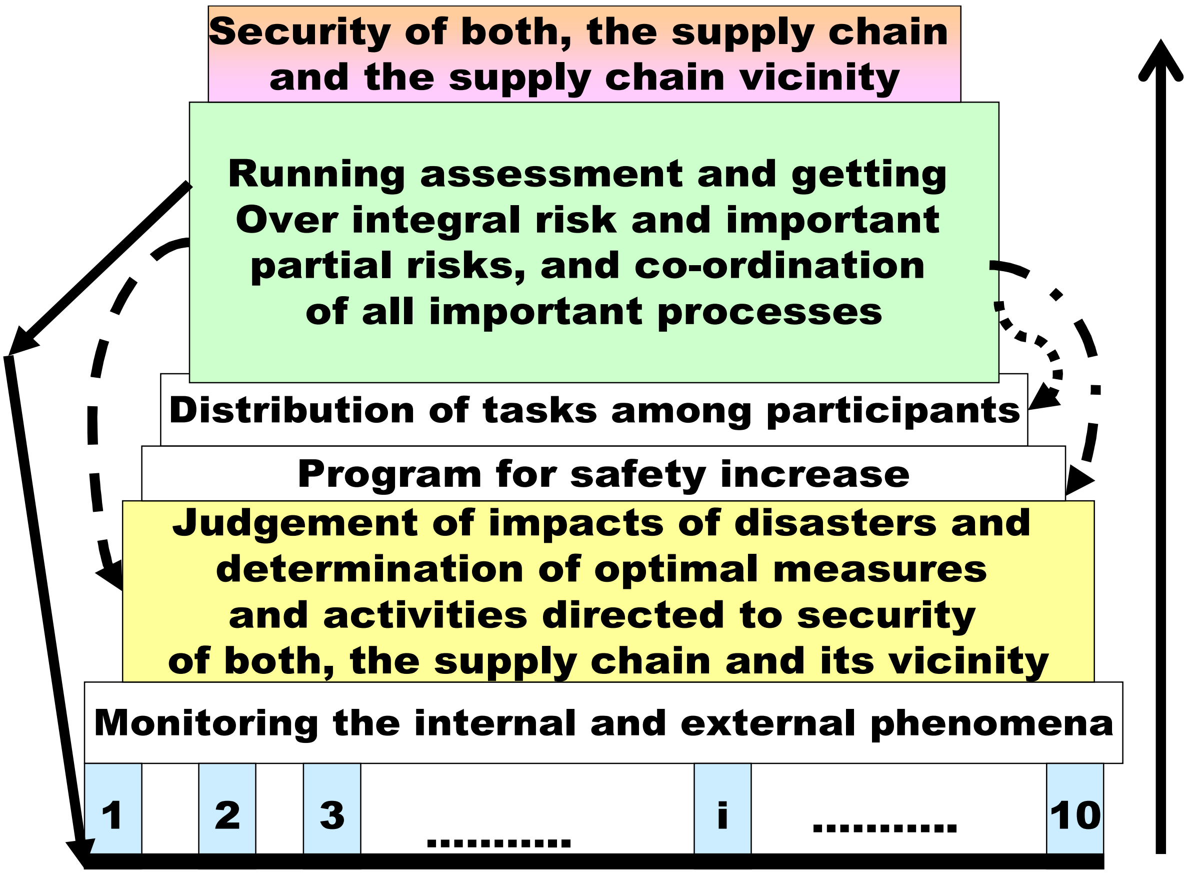

Figure 1 Model of management of supply chain safety; black block – concept for specification of important processes of supply chain; dotted line – feedback 1; broken line – feedback 2; dashed line – feedback 3; full line – feedback 4.

On Figure 1 it is evident the principal role of concept on the basis of which the important internal and external processes and phenomena are determined. It is followed by: processes´ monitoring; judgement of impacts of all disasters (i.e. internal and external processes and phenomena) on supply chain; and determination of optimal measures and activities directed to security of both, the supply chain and its vicinity. Demands on determination of optimal solution for all processes and phenomena are fundamental – see principals for safety management [3, 4] and frequent conflicts the most suitable measures for some processes [17]. Because the implementation of measures and activities needs sources, forces and means and time for realisation, it is necessary in harmony with [3]: to process program for increase of safety of supply chain; to determine measures for judgement of safety level in the sense of effectiveness of measures and activities for ensuring the supply chain safety (indicators); and to fill program by projects that are interconnected and contain processes realising the individual measures and activities.

The safety management system (SMS) includes organisation structure, responsibilities, practices, rules, procedures and sources for determination and invoking the prevention for disasters that are results of processes inside and outside of supply chain or at least mitigation of their unacceptable impacts. As a rule it is connected with many aspects, apart from the organisation of employees, identification and assessment of hazard size, risk size, organising system, management of changes, emergency and crisis planning, safety monitoring, audits and scrutiny processes.
With regard to data in work [3] the program for increase of supply chain safety has the following steps:

1. Determination of tasks (partial targets) and strategic goals for supply chain with regard to safety directed to security of both, the supply chain and the supply chain vicinity.
2. For each process that is connected with supply chain to determine suitable target and running indicators for safety level judgement.
3. To process dictionary for needs connected with integral safety management.
4. To harmonize standards, good practice methods and local procedures.
5. To determine set of target indicators.
6. To determine set of running indicators.
7. To determine way of assessment of target indicators specific for a given supply chain.
8. To determine way of assessment of running indicators specific for a given supply chain.
9. To determine way of assessment of all indicators together and marginal limits for a given supply chain.

In practice it means that for each sector of selected authority the target and running indicators are determined and they have form of limits and checklists [3]. To them there are assigned criteria for assessment and scales by which it is determined if target is reached or is not reached. For creation effective safety management system the basic principle is that all participants play certain roles and at safety realization they must fulfil these roles (see stage „distribution of tasks among participants“ in Figure 1).
Because the world dynamically changes it is necessary to follow continuously safety level, i.e. size of integral risk that includes also cross-sectional risks connected with interdependences and important partial risks of supply chain. In case that limits and conditions are not kept, it is necessary to perform changes as show feedbacks in Figure 1. Because changes requires sources, forces and needs, firstly it is realised feedback 1 and only if it does not ensure expected result the feedback 2 is realised etc. Only in case of occurrence of extreme phenomena with catastrophic impacts the feedback 4 is immediately realised.

Safety management system for supply chain is lean on concept of disaster prevention or at least of mitigation of severe disaster impacts that includes obligation to introduce and keep safety management system [3 in which the following problems are taking into account:

- roles and responsibilities of persons participating in important hazards management on all organising levels and in ensuring the training,
- plans for systematic identification of important hazards and risks connected with them that are connected with normal, abnormal and critical conditions, and for assessment of their occurrence probability and severity,

- plans and procedures for ensuring the safety of all components and functions, namely including the object and facilities maintenance,
- plans for implementation of changes in territory, objects and facilities,
- plans for identification of foreseeable emergency situations by systematic analysis including preparation, tests and judgement of emergency plans for response to such emergency situations,
- plans for continuous evaluation of harmony with targets given in safety concept and in the SMS, and mechanisms for examination and performance of corrective activities in case of failure with aim to reach determined targets,
- plans for periodic systematic assessment of safety concept, effectiveness and convenience of the SMS and of criterions for judgement of safety level by top workers group.

9. CONCLUSION

Model for safety management of supply chains compiled on the basis of present knowledge is the process model in which they are represented the both, the individual important elements of process of safety management and the feedbacks by which it is possible to correct cases in which demands of safety are not fulfilled.

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POSSIBLE SCENARIOS OF HUMAN SYSTEM DEVELOPMENT AND OF EU RESEARCH

Dana PROCHÁZKOVÁ[1]

Abstract: *Security situation in the world and in each territory continuously changes with time, and therefore, it is necessary to form new safety culture for ensuring the human security and sustainable development in the EU. After experiencing many crises in the last few years, it is clear that the security and sustainable development concept of the EU should be changed. It should not cover only the inner market but also other areas supporting the real economy and mainly, it has to contain the systematic support of the European inhabitants. One of the targets is to build a safe community with a sufficient sustainability. The paper gives six scenarios of the human system sustainable development. Because the qualified research is very important for strategic management ensuring the conditions for security and sustainable development the six possible scenarios of disaster research and their management in the EU is created and tested.*

Key words: *security; safety; sustainability; human system; strategic management scenarios; research scenarios*

1. INTRODUCTION

Security situation in the EU, world and in each territory continuously changes with time, and therefore, it is necessary to form new safety culture taking into account actual knowledge and experiences with interdependences among the public assets leading to extreme social crises (in history e.g. great famines). With regard to the historical development there are: a lot of preventive and mitigation measures that have been applied into practice by legal rules, technical standards and norms and public instructions; response systems; and renovation ways. However, it is true that their effectiveness decreases with time because new risks emerge and territory and human vulnerabilities increase in all domains. With regard to this reality the research would originate the optimal strategy for further development. Evaluating the present knowledge, experiences and conditions in the EU, the paper proposes six possible human system development scenarios and six possible research scenarios and results of their assessments from the viewpoint of optimal security and development of the EU up to 2035.

2. WHAT WE KNOW ON THE EU SECURITY AND SUSTAINABLE DEVELOPMENT

Present goal of humans is to live at safe space, and therefore, the UN formulated the aim of a “safe human system” in 1994 [1] and the EU “safe community” in 2004 [2]. In agreement with the EU and UN proclamations and the professional knowledge there is necessary for conservation and sustainable development of the human society to create the safe territory. With regard to present knowledge we should consider that we want to build safe open dynamically variable system that is a complex system the model of which is the system of systems (SoS), i.e. several overlapping systems [3]. The concept of the EU security is described in detail in [4].

The human system security and development are disturbed by disasters, i.e. internal or external phenomena that lead or from a certain size can lead to damages, harms and losses on system assets. It means that human system safety is affected by both, the processes, actions and phenomena that are under way in human society, environment, planet system, galaxy and other higher systems, and the human management acts. Therefore, for safety reasons we must negotiate with risks of different origin and kind. The research performed under the FOCUS project [5] deals with principles of negotiation with risk at stages of its mitigating and managing in selected sections of human system management and it gives tools for public administration for public affairs governance because it is responsible for territory governance and conditions. Especially, it concentrates to the EU governance.

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There are used results of sets of national and international projects realised in the EU, Member States and elsewhere in the world; e.g. the USA (especially FEMA), Russian Federation, Japan, China, India, Brazil etc., which are documented by professional literature.

3. METHOD OF SCENARIO COMPILATION

Generally, the scenario is a set of isolated and interconnected processes or phenomena in time and space, which takes place at different spatial and temporal scales. Scenarios are used for different purposes. It is de facto succession, a chain of events in time, area, space or space-time. This string can be deterministically given or stochastically random and the degree of randomness can in some cases be evaluated by statistical methods, by methods based on fuzzy sets and by experts. In terms of present knowledge, we know that there are sets of events that seemingly have no visible internal connection, but the result of which is some specific state of the system. In these cases we talk about so-called deterministic chaos. In systems engineering, there exist methods to describe and understand it.

Scenario-as a tool of proactive management is historical-system model which describes the development of process in its different forms (variants) depending on the conditions or decisions taken. It mimics the mechanisms and processes that take place in the system. Its aim is primarily to identify critical phenomena or points, which affect further development, i.e. which provide alternative choices between different final states. For the purposes of emergency planning and crisis management in practice, we put together the following types of scenarios: scenario of impact of any disaster, scenario of response to the occurrence of disasters; scenario management.

The FOCUS project aim is foresight, i.e. not prediction or prognosis, and therefore, the method of scenario compilation is rather liberal.

In spite of this we respect at scenarios compilation the following steps:

- identification of key assumptions or factors that affect the form of scenarios,
- focusing on factors that have a high potential impact on the shape, size, scope, etc.,
- identification of factors with an uncertain nature and try alternative solution of the scenario.

A prerequisite, however, is a relatively small number of factors that could be incorporated into the possible variants.

Development of scenarios consists of:

- gathering of prognostic information about the system and its surroundings,
- identification of targets of studied system,
- identification of internal factors, or. barriers to development of the system,
- identification of external factors, or. barriers to development of the system,
- identification of alternative management strategies for the system (it is necessary to take into account existing management mechanism and its variants, which can be realized in future periods, simultaneously it is necessary to formulate a strategy for development of the system - which direction is desirable),
- compilation of scenario,
- interpretation of scenario.

In all the steps above given it is necessary to consider:

- assessment of current state and current decisions in terms of future development,
- qualitative factors and strategies of various participants,
- the fact that the future is uncertain and multidimensional,
- the fact that each system must be examined globally and systemically,
- the fact that the information and strategies are not neutral, but biased,
- multiple approaches that are complementary,
- the fact that there are biases in strategies of people and prevent them.

Management scenarios can have different forms, depending on the use intended. Development of scenarios from the perspective of strategic management has the strict procedure [6] but the FOCUS project scenarios are only foresight, and therefore, they cannot respect the strict procedure as in engineering domain.

4. SCENARIOS

After experiencing many crises in the last few years, it is clear that the security and sustainable development concept of the EU should be changed. It should not cover only the inner market but also other areas supporting the real economy and mainly, it has to contain the systematic support of the European inhabitants. One of the targets is to build a safe community with a sufficient sustainability. This means to correctly manage the observed area and to ensure the daily needs of the EU citizens, to render help after disasters, transform the way of financing of emergency situations based on insurance etc.

With regard to current knowledge, it is necessary to use a systematic approach and to seek consensus among the three basic systems that is the system of the environment, social system and technological system. The above-given systems create the human system representing every area at dealing with problems connected with sustainability and security.

4.1. Background for sustainability

On the basis of current knowledge, the fulfilment of physiological needs only is not sufficient for a human life anymore. H. Maslow [7] showed that there are other needs such as security and safety, self-realization and social asserting. The basic orientation of research and public administration to security, safety and sustainability, and on their management started after the big terrorist attacks in the USA 11/09/2001, 11/03/2004 in Madrid, 03/09/2004 in Beslan, 07/07/2005 in London etc. after which humans finally realized what security means for them and their development and what really has the biggest value for human.

Current knowledge and experience [3] show that in order to reach the demanded state of a system, including the human system and its development, it is important to set targets and procedures for their achieving that are dependent on sources, forces and means, which are always a lack. Therefore, it is necessary to focus on priorities and manage sources, forces and means in space and time to a gradual target fulfilment.

Orientation to the human system allows on one side to use the apparatus of systematic analysis and systematic engineering [3], on the other side to understand security and sustainability in a wider sense than it is usual; military-political orientation has prevailed until now – e.g. in documents of Pan-European Conference in Haag, in 2004. Systematic concept also allows understanding of the inner interconnections that are caused by the flows of capital, information, things, energies, arms, drugs and human mobility. Apart from this, it is necessary to know the area and its protected assets, possible disasters threatening it, ways of threatening, accessible sources, sources of energy and food [3].

Research scenarios come out of the EU security concept [4]. Concept is a common feature or characteristic. Concepts are necessary for the development of scientific knowledge and as an abstract expression they serve as key factors in development and testing of theories. In order to create a conception of no-matter-what system development, we must use data, leave the pseudo-philosophizing and lean on two pillars: that are knowledge and engineering approach at handling a risk, since the engineering approach unlike empty specifying must always find a site specific solution. First, we are going to give the EU concept of sustainable development as a scheme, in which there are both elements and data taken into account for the sustainable development of the EU. It contains both the vision about the sustainable development of the EU, and the vision of its ensuring. On the basis of assessment of data and knowledge from professional publications, the list of which is in [3], the concept is made with help of a complex approach [4], targets and principles given in the conception of the UN "The safety of human system" [1] and in the conception of the EU "Safe community" [2]. The basis of conception is to control with qualification all the phases of disaster management of all kinds [8], i.e. to pointedly, with qualification and interconnection ensure the management focused on security and sustainable development, emergency management and crisis management [3].

4.2. Scenarios of the human system sustainable development

Scenario is generally a complex of both isolated and interconnected processes and phenomena in time and space that run in various spatial and time scales. Scenarios are used for various reasons. It is de facto about succession, chain of events in time, area, space or space-time that can be deterministically given or stochastically random, while in some cases it is possible to assess the rate of randomness by statistical methods, methods based on fuzzy sets or with help of experts [9].

Current level of knowledge requires supplying a theoretical concept of sustainable development by accessible political and normative measures. Applying of the precautionary principle is in accord with the very weakly sustainable development. For the assessment of the development plans of big area complexes, it is necessary to generate specific indicators of sustainable development that will allow us to assess the homeostasis on a regional level. Paradigm of the current assessment of region development and development concepts heads for the pseudo-sustainable development with various level of profit [10]. Therefore, the optimal result requires applying of more variants of solutions, i.e. set of various scenarios and applying the formalized multi-criteria analysis [9].

Catalogue of the methodical scenarios for the strategic assessment of impacts of development intentions on the environment under the big area complexes (regions) and the requirement of sustainable development according to work [11] contain 6 scenarios of sustainable development. Variants were created by the methodical elaboration of works of Turner from 1995, who applied the Solow´s theory, holder of the Nobel prize for economy from 1987 for the "neoclassical model of growth" [12]. The comparison or the variants with principles and requirements for the strategic safety management targeted to security and sustainable development of protected assets [3] show that the variants correspond to the current knowledge and experience. On the basis of knowledge on human system, its assets (lives and health of humans; property; public welfare; environment, critical infrastructures and technologies) and priorities (safe human system in a dynamically variable world), variants of sustainable development scenarios were created, by the method of analogy, Table 1.

Table 1 Scenarios of the human system sustainable development

A	*Name:* ***Zero variant of the human system development*** *Target:* Preserving of the current trend *Characteristics:* a variant without elaborating the strategic plan of the community development, i.e. interest area including human society; development of interest community on the basis of a current state prolongation; preserving the current trends of community development and that both the negative and positive ones.
B	*Name:* ***Variant of the very highly sustainable development of the environment*** *Target:* Absolute preference of the environment protection. Stationary phenomenon of economy. *Characteristics*: industry reduction; all mining areas closure; minimization of using the non-renewable sources in energetic; no more new land acquisition; reduction of the quantitative development of transport infrastructure; no more new sources of air pollution; request for the construction of sewage and sewage water treatment plants in all villages; extending the number and area of all types of protected areas and the areas of ecological stability; decentralized and extensive agriculture with putting the stress on landscape maintenance; forests with original wood composition return; renovation of wetlands of small brooks and ponds; untouchables of outside-forest green and of small landscape elements; strict protection of cultural heritage; only dispersed recreational activities.
C	*Name:* ***Variant of the weekly sustainable development of the human system*** *Target:* Preference of the environment protection and significantly limited economic development. *Characteristics:* Considerate exploiting of non-renewable sources; using the renewable sources under their regeneration capacity; strict selection of localities for new economic activities, the place change principle; the condition of applying the best accessible technologies for these activities; preference of the reconstruction of old industrial structures before a new land acquisition; support of the railway, at road transport only the quantitative changes, support of gas in villages, sewage water treatment plant construction; limitation of mass recreational activity; extending the area of protected places of all types; Areas with ecological stability system development; strict protection of water and wetlands ecosystems and outside-forest green; both economic and microeconomic compensation of residual impacts.

D	*Name:* ***Variant of the medium sustainable development of the human system*** *Target:* Stress on the critical natural capital protection. Economic development with partial limitations. Debasement of the environment can be replaced by the artificial capital (apart from the critical natural capital). *Characteristics:* Development of the system of small area and big area protected territories; global limitation of the Areas with ecological stability system; protection of the environment focused only on the protected areas; on all the other areas the development of economic activities is preferred; acceptable wide acquisitions of land for transport infrastructure and industrial zones; new energetic infrastructure construction support; new water works, stream regulations, hydro-melioration; intensive agricultural mass production; concentration of housing and recreation functions; natural sources and the environment decrease is replace by help of economic or technical compensations.
E	*Name:* ***Variant of the highly sustainable development of the human system*** *Target:* Preference of an economic development. Compensation of damages on the environment. *Characteristics:* Development of economic activities similar to the previous case – D; protected areas limited both in extension and degree of protection; development of economic activities also in protected areas (natural resources mining, agricultural production etc.); placement of recreational and sport activities into the naturally most valuable areas; economic compensation of ecological loss for both the individuals and society; technical compensations (precious ecosystem transfer, artificial creation of the environment, recultivation).
F	*Name:* ***Variant of the maximum economic development*** *Target*: Economic development at the expense of the environment, without limitations or compensations. *Characteristics:* Maximization of economic profit; unlimited exploiting of all the natural sources; placement of new infrastructure and economic activities with no regard to the natural conditions and impacts on the environment; qualitative limitation in favour of economic aims is acceptable also for the housing and recreational function ; for the development of technical, energetic and water infrastructure, economic targets are preferred instead of the social, hygienic and environmental ones; preference of the new saving and economical technologies only at the basis of the CBA analysis results; economic value of the environment and natural resources is seen as zero, therefore, no compensations of the caused impacts are considered.

Analysis of Table 1 shows that from viewpoint of human needs [3] and from the perspective of development:

- variants B, F, A are unacceptable,
- variant E is unreal, since the prove from viewpoint of precaution that there are no hidden risks is missing,
- with intended targeted effort, it is necessary to realize variant C or D. At variant D, which allows bigger interventions into the environment than variant C, it is necessary to apply strictly the precautionary principle and at the negotiation with risks to also focus on the possible impact of decisions for the future.

Continuing dynamic development in the controlled treatment of human system allow us to see deep facts that not possible to ignore. On one side, it is about the gradual elaboration of supportive work tools in favour of sustainable development, mainly the indicators of sustainable development, development of legal norms and following methodology in area of impact on human system assessment, including the growing number of home strategic development concepts. On the other side, the fatal collapse is evident of the theoretical concept of sustainable development on global scale. As a replacement for the scientific concept failure, passing of political and normative measures is demanded. In contrary, for the socially-economic and technically-area development the strict application of precautionary principle is demanded currently. The phenomenon of increasing risk orders a need to admit the coexistence of the environmental, technological (economic) and social system and to seek consensus for their common development.

Recent results of the project FOCUS [5] show that the main problems of the EU, i.e. the EU vulnerabilities that are obstacles to sustainable development are the following: all hazard approach [8] is not systematically applied; some disasters are underestimated; systematic, strategic and proactive management is not implemented in practice; there are gaps in the management of risks, engineering of risk and in negotiating (trade-off) with risks; research do not appoints priority orientations, its targets are influenced by politicians or lobbyists; methods of application and orientation of strategies are not regularly controlled; reasonable strategy for disaster management is missing; disaster management often does no respect the cycle of disaster occurrence; stress on the problem solution is missing, there are only many discussions about it; there is a lack of sources for the implementation of human needs; there is a lack of tools for the EU financial stability ensuring; there is a lack of management tools that support the protection of inhabitants and sustainable development.

4.3. Scenarios of research

Concept respecting the given knowledge and approaches is the basis on which the FOCUS project builds on [5]. It executes both the revision of the current inner frame of the EU and proposes areas that are important for the EU sustainability enforcement. According to principles of a good practice, only the systematic, persistent and well managed complex of measures and activities guarantees achieving the EU sustainability now and in the future.

Supervisory measure of scenario opportune ness at processing the model framework for logical model of EU research to 2035:

1. Description of the process - the EU decision-making and management will be based on present findings and experiences
2. The EU security concept that is described above [4] will be step by step realized.
3. The critical points of the process will be step by step removed - the EU vulnerabilities are the following: all hazard approach is not systemically applied; some disasters are underestimated; systemic, strategic and proactive management is not implemented into practice; gaps in risk management, risk engineering and in trade-off with risks; research does not determine priority orientations, its targets are influenced by politicians or lobbies; application procedures and orientation of strategies are not regularly verified; reasonable strategy for disaster management is missing; the disaster management does not often respect disaster life cycle; accent to problem solving is missing, still only a lot of discussions on problems; lack of resources; lack of instrument for ensuring the EU finance stability; lack of management supporting the public protection and sustainable development.

On the basis of the targeted method of scenario creation (see chapter Methods) and aims and facts described above, the scenarios of research are created, Table 2.

Table 2 Possible scenarios of disaster research and their management in the EU

A	*Name:* ***Zero variant of research*** *Target:* Preserving the current trend. *Characteristics:* Variant without any elaboration of the strategic plan of disaster research and their management in the EU, i.e. projects of research will be assigned oriented to disaster research and management in the same way as today and no attention will be paid to interconnection of outcomes and to obtaining realizable solutions in favour of the compact concept of safe community with sustainable development progress.
B	*Name:* ***Variant underestimating research – market will deal with no matter what*** *Target:* Absolute underestimation of research. *Characteristics:* Research will be conducted ad hoc since there is a faith that market is best for the safe community and its development ensuring (preference of market and faith in the omnipotence of economy). Every citizen must arrange for his own safety, i.e. he must procure knowledge, information and relevant tools to himself.
C	*Name:* ***Variant of research oriented only to applied research*** *Target:* Preference of a research only in parts, where there are problems, currently. *Characteristics:* Only those parts are investigated in research that the administration needs for the current deciding, no systematic knowledge for dealing with future problems are gathered.

D	*Name:* ***Variant of research oriented to basic and applied research*** *Target:* Stress at the choice of projects is put on the medium sustainable development of the EU communities. *Characteristics:*. Development of a research is concentrated both on basic tasks and on the applied research that deals with both current urgent tasks and prepares the basis for dealing with the future tasks that outcome from the concept of a safe community with sustainable development. Meaningful projects are set, the results of which it is possible to interconnect and they outcome from verified data and right methods for their elaboration.
E	*Name:* ***Variant of research oriented to strategic division of support of basic and applied research with emphasis on the results succession*** *Target:* Stress is put on such a choice of projects that will provide the preference of a safe community with sustainable development today and in the following 20 years along with a prospect to another 50 years. *Characteristics:* Development of a research is defined by the strategic plan that is elaborated on the basis of a safe community with sustainable development concept based on the systematic and proactive approach reacting to the dynamic development of a community, having clear priorities that are always supported by the EU. Meaningful projects are set in basic and applied research, the results of which are possible to mutually interconnect and they outcome of verified data and right methods for their elaboration.
F	*Name:* ***Variant of a maximum support to basic research*** *Target:* Mainly, it is necessary to support basic research. *Characteristics:* Maximization of demands for basic research, transforming the results into practice is underestimated. It based on the idea that research brings knowledge but it is not able to deal with current problems since the implementation of results lasts too long.

Expert assessment of data in Table 2 (5 experts – university education, more than 30 years practice in research and in research management, more than 10 years with responsibility on research results) shows that from viewpoint of human needs [3] and from the perspective of human system development:

- variants A, B, C are unacceptable,
- variant F is unreal, since the research loses capability to support security needs in human live practice,
- with intended targeted effort, it is necessary to realize variant D or E. The variant E has higher priority for realisation with regard to targets given in the EU security concept [2].

From the viewpoint of management the following facts regarding to the type of research characterisation, hold:

1. The worse research scenario $\Rightarrow$ the EU disaster management is ad-hoc $\Rightarrow$ the EU is not capable systematically to solve critical problems $\Rightarrow$ the EU decline.
2. The bad research scenario $\Rightarrow$ the EU disaster management is only oriented to crises $\Rightarrow$ the EU will only solve crises but with many difficulties $\Rightarrow$ slow declination of the EU present trend of development.
3. The mean research scenario $\Rightarrow$ the EU disaster management is progressive, i.e. it creates fundament for problem solving $\Rightarrow$ the EU will be capable to solve problems based on knowledge management principles $\Rightarrow$ conservation of present trend.
4. The good research scenario $\Rightarrow$ the EU disaster management is strategically created $\Rightarrow$ the EU creates strategic plan of development based on present knowledge and experiences $\Rightarrow$ the EU will belong to global security actor because it will have strong fundament for problem solving.

For Europeans there is necessary minimally to realise variant three.

5. CRITICAL REVIEW OF PRESENT SITUATION IN THE EU

The critical assessments performed in the FOCUS project by the CVUT team [5] revealed the critical items that might be considered in the EU development strategy, research and legislation. These critical points must be getting over in order that the way to reaching the EU aim "EU is global actor" might be open.

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The research, which is described in Annexes to [5]:

- deals with the EU governance level from the viewpoint of natural disaster management. It identifies deficits at natural disaster management from the viewpoint of safe community concept that has been promoted by the EU since 2004. For its realisation there is necessary sophistically managing the disasters that damaged the security of community and its assets, i.e. to apply measures and activities of prevention, preparedness, response and renovation. For practical purposes there are necessary good technical solutions based on recent findings and experiences and correctly aimed governance of public affairs supported by legislative with sufficient legal force, finances, qualified human personnel and material base,
- concentrates to disasters that are connected with processes by which environment and planet itself react to human activities and it judges the level of governance of public affairs in the EU from viewpoint of strategic management of these disasters that is aimed to constitution of safe community,
- concentrates to social domain in which there are a lot of phenomena that threaten security of humans, public assets and whole communities. Considering the number of victims of extremist Breivik at July 22, 2011, civil disturbances, traffic with children, socially segregated localities etc., so we see that there is necessary also to manage disasters that are represented by prejudicial phenomena at social domain that damaged the security of community and its protected assets,
- concentrates not only to basic system elements (assets), but also to links among assets (physical - matter-of-fact, territorial, cyber, logical) and flows which create more or less important couplings that in some case quite fundamentally determine the behaviour of human system. The disasters damage critical infrastructure and the supply chains. Therefore, the disaster management have been gained the upper significance with grow of human demands on life quality and with human vulnerability increase and with drop of natural sources,
- concentrates to problems in public administration (governance of public affairs) management, because the social crisis can origin always when it fails.

If the human system is understood as human's live space, it is open system that is in interaction with its vicinity. On human activities there are reacted both, the planet system and the environment. The European Union has promoted the safe community concept since 2004. For concept realisation there is necessary sophistically to manage disasters that disturb security of community and their assets, i.e. to apply measures of prevention, preparedness, response and renovation. For practical realisation there are necessary good technical solutions based on recent findings and experiences and correctly aimed good governance (public affair management) that is supported by legislative of sufficient legal force, finances, qualified human personnel and material base.

6. CONCLUSION

Because it is well known that each concept enables to solve only problems that it can differentiate, we choose for research the complex EU security concept based on system insight. The concept is based on all advanced get-at-able knowledge that is accessible in public sources and on experts´ experiences from problems´ solutions in strategic management, emergency management and crisis management on the different international, governmental and sector levels.

Research of both disasters and the ways of their management is important for ensuring the safe community with sustainable development. There are many problems necessary to solve in the monitored segment and they are on different levels, i.e. technical, operative, tactical, strategic and political.

The basic requirement is so that:

1. The research was targeted, i.e. the already-known was not researched without a good reason.
2. The research sought and solved open problems, namely correctly with regard to current knowledge and experiences on ensuring the safe community and its sustainable development.
3. The research demanded objective results under given conditions, i.e. to systematically present the results in front of a relevant expert community and to make them be a subject to a public opponent control. With this, plagiarism can be avoided, the real protection of intellectual property will be ensured and the development of creative abilities of individuals that has a creative potential and that are willing to give it in favour of the EU and its inhabitants' development will be supported.

4. The research would not distort the results – the style "the fundamental is what an authority says" holds development back. Therefore, it is necessary not to dissimulate conflicts among outcomes of projects since their existence is normal. Under the effort of finding the right solution, it is necessary to make it a subject of a thorough investigation with aim to find the causes of problems and to define an optimal solution of them in a given conditions and within the given possibilities.

The main task of the future EU security research is to create systems for knowledge-based decisions and effective utilisation of land and nature. Therefore, the EU must remove prejudice in favour of lobbying groups the interest of which is different from public interest.
In the previous chapters, the base is given summarizing the current knowledge, on the basis of which the knowledge level research was conducted in the area of disasters and their management in the EU with regard to building the EU as a safe community with sustainable development. On the basis of verified data files made by qualified methods, many real gaps of higher or lower importance were discovered. The basic system's gaps were marked in chapter "What is necessary to improve". According to the level of their handling, six possible scenarios of the EU research were compiled, from which it clearly follows that the research is important and that it must be clearly targeted according to a strategic plan put together with regard to current professional concept of the EU as a safe community with sustainable development and to the fact that the EU, as every other community, has only limited possibilities; therefore the solution of problems must be divided into suitable time intervals, must be flexible and all the participants, according to their possibilities, must take part in the problem solution.

Results given above and in detail described in [5] show the need of qualified research based on system concept of the world (including the EU) performed without pre-arranged parti pris that is sometimes is source of preferential treatment of some groups, i.e. corruption that is always brake of long-term development.. With regard to above given results it is clear that we build world (including the EU) for the humans, and therefore, it is necessary to do both, the support of new technologies and new infrastructures enabling the human sustainable development and the reduction or at least mitigation of their impacts on human health and security by strategic risk management, the caution against lobbying in research is very necessary.

The lobbying at decision-making in the EU is much extended; it is observed also in the research. Because no strict boundary between lobbying and corruption, which brake development, it is necessary to apply management that will support good to public interests.

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NEW TRENDS IN TECHNOLOGIES FOR AERONAUTICAL COMMUNICATION SERVICES

Stanislav RYDLO[1]

Abstract: *The article describes new trends in aeronautical communication services, presents new technologies for these especially for ground - air voice communication in air traffic services. It focuses on the principles, technological solutions and their operational capabilities.*

Keywords: *aeronautical communication services, B-VHF, 8.33 kHz spacing*

1. INTRODUCTION

The main communication channel for air to ground and air to air is the VHF radio band. In the short time the VHF air band in Europe is expected to saturation, and it currently is a lack of available frequencies or overcrowding. The main reason of this is the traditional concept of air traffic management, based on tactical aircraft control. This creates an increased demand for voice communication channels linearly with increasing density of traffic. International aviation organizations are dealing these kinds of problems. Investigating the possibility of more efficient use of radio spectrum, seeking new ways of the aeronautical communication and propose changes in the organization of the air traffic. One solution is a research project B-VHF, which was co-financed by the European Commission within the Sixth Framework Programme and its aim is to explore the possibility of the using of the frequency spectrum, thus overcoming the problem of lack of channels in the VHF air band. Focus B-VHF project is to analyse the feasibility of broadband VHF aeronautical communication system based on OFDM (Orthogonal Frequency Division Multiplexing), MC-CDMA (Multi-Carrier Code-Division Multiple-Access) technology. It includes both voice and data services and is being developed by a consortium of companies together as National Air Traffic Services Limited of England or Lufthansa German Airlines and a few others. [1]

2. B-VHF BASIC PRICIPLE

The system was designed as a terrestrial mobile broadband system using time-division duplex (TDD). This method is a duplex connection using a half-duplex communication, based on a time-division channel. The transmission at the physical layer utilizes orthogonal frequency division multiplexing (OFDM), it divides the distribution signal to a few tens to hundreds parts, which are transmitted to the frequency-shifted sub-carrier by a small stream of each of them. Compared with existing systems is the utilization of each channel frequency much greater as shown Fig. 1

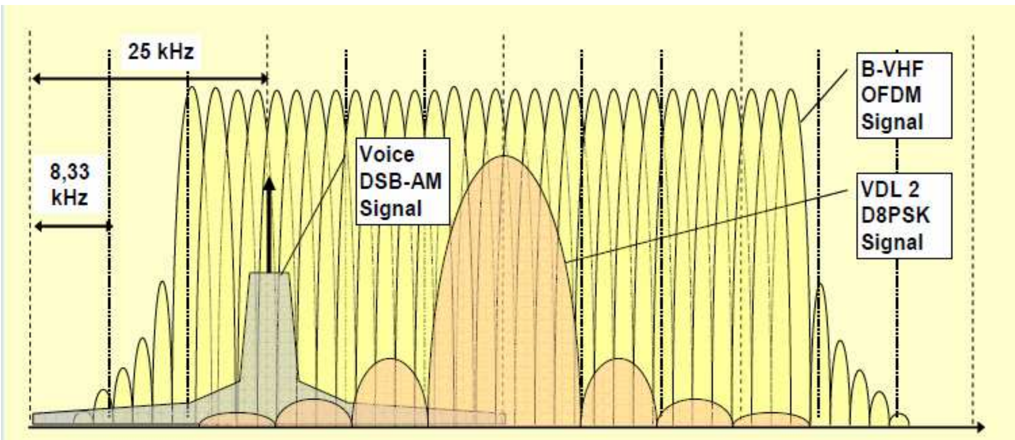

Figure 1 The spectrograms of the radio signals [5]

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The sub-carriers are orthogonal to one another, and therefore do not cause interference between each other. Sample orthogonal signal is shown in Fig. 2. TDD and OFDM combination provides sufficient capacity communication channel robustness combined with flexibility. These are the requirements for the ATM communication system. [2]

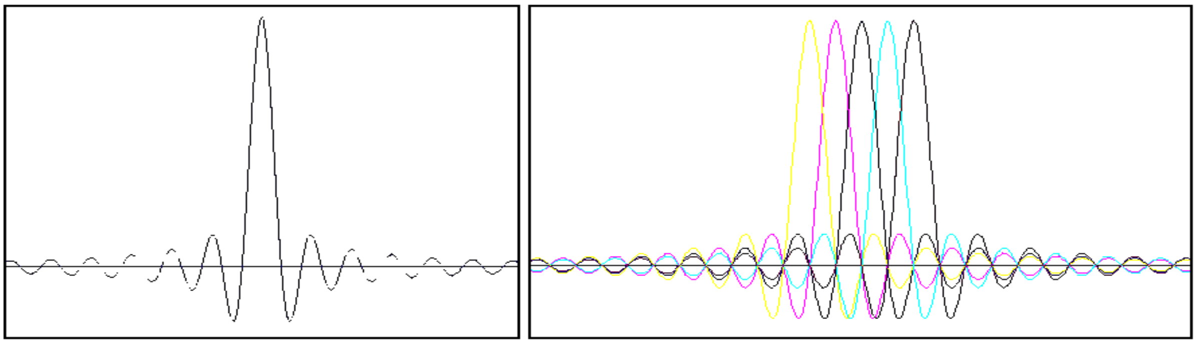

Figure 2 The spectrograms of carrier and orthogonal sub carriers [5]

3. THE USING OF THE RADIO SPECTRUM

B-VHF system is based on needs, making best use of radio band. Fig. 3 shows the theoretical situation of indeterminate use of bandwidth each type of connection.

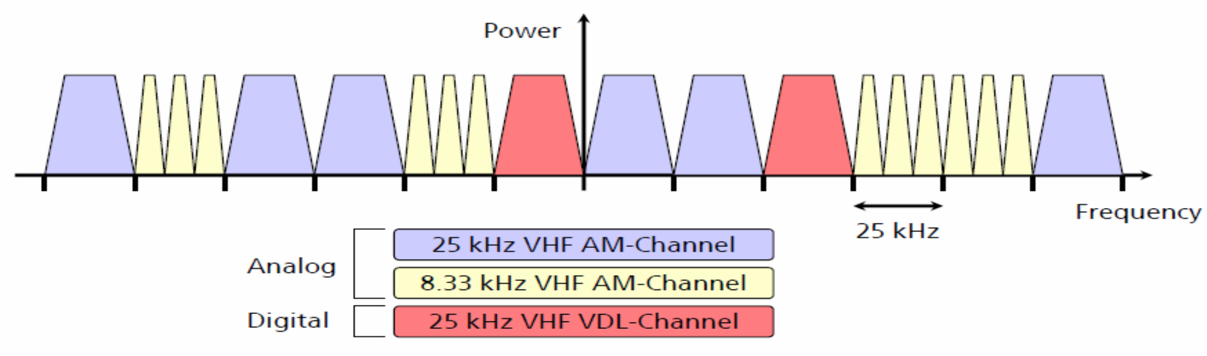

Figure 3 The theoretical situation of the VHF band using [5]

The band here is divided into a 25 kHz spacing channels and it is used for both the digital and analog connections. Analog channels are at some frequencies divided into three channels with 8,33 kHz spacing. The most important feature shown here is their number of use (power). The theoretical model is constant across all channels of communication and are constantly occupied and used. The situation is completely different in practice. As shown in Figure each channel is used differently. The number of using depends on the time of day, the current density of traffic in the area or even the type of information that are transmitted.

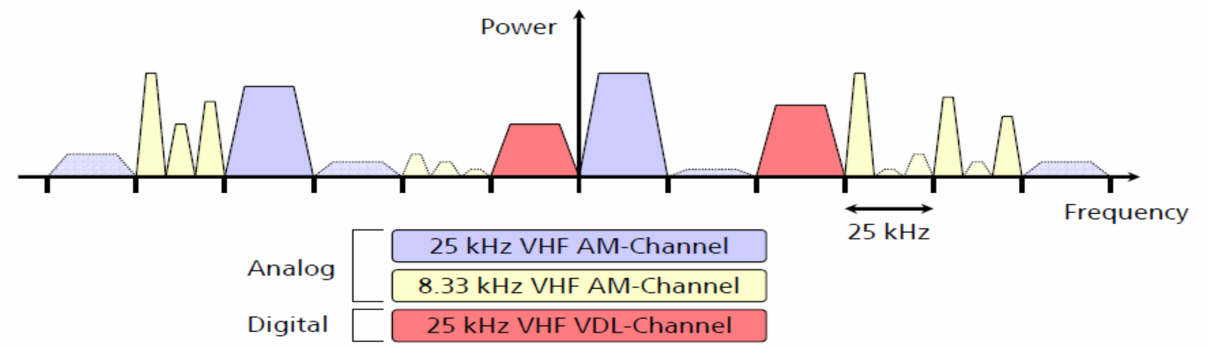

Figure 4 The practical situation in VHF band using [5]

Certain sub-carriers in the MC-CDMA spectrum (eg, it may be bands in narrowband systems) may be unoccupied. This opens up the possibilities of parallel use of existing 8.33 kHz systems and MC-CDMA. MC-CDMA can fill the gaps in the use of narrowband systems, without interferences.

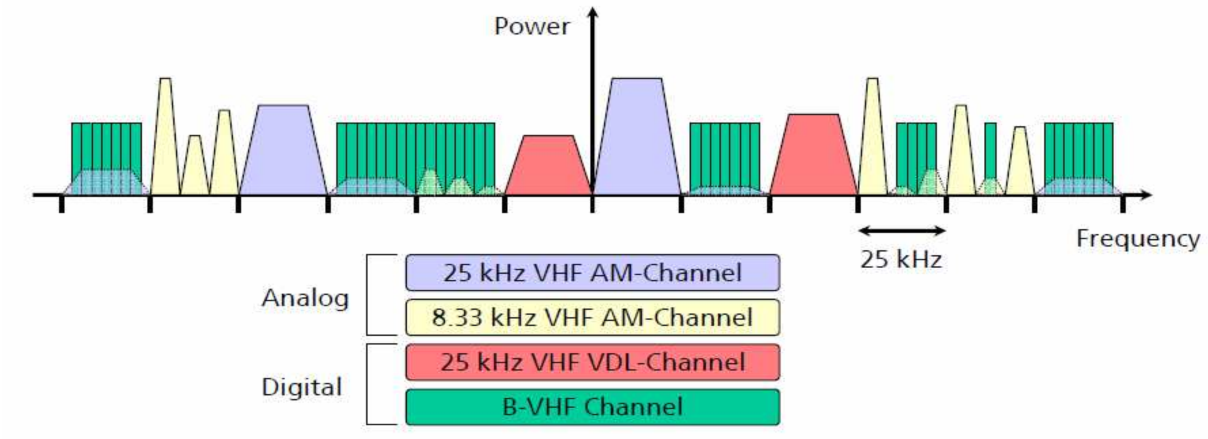

Figure 5 The transition to B-VHF [5]

B-VHF system has been designed as a modern, fully digital broadband system capable of meeting the tasks asked of future communication systems described in strategic documents ATM. Firstly, it should be installed and used in parallel with other systems VHF band. During the transitional period, would gradually replace the existing narrowband systems, and eventually remained as the one communication system operating in the VHF band. [4]

The system has undergone extensive testing from the physical layer to the entire complex system tests. The results showed that B-VHF is able to work under different conditions with as many users as corresponding to the expected density of future air traffic. [4]

4. B-VHF SYSTEM

B-VHF is a terrestrial broadband VHF system integrating voice and data links using cell architecture using multi-carriers (CDMA).

The concept of the system is based on a network of ground stations, working as a network control station determines the configuration, time synchronization, connecting and checking the network and access to voice and data connections.

One possible extension of the system is functioning without its ground stations, where one aircraft would be taken over its function. This would allow the system to operate in areas without infrastructure of ground stations. (B-VHF avionics would probably still include working with radio AM-DSB for just such areas).

B-VHF system uses multiple broadband channels to provide its services. The exact width of the channel has not yet been clearly defined, while the test widths are 1 MHz and 500 kHz frequency band.

Preferred range for which the system is built is 118 to 137 MHz, system properties allow to work in other bands that are used in aviation, up to frequencies that use DME (Distance Measuring Equipment).

B-VHF integrated system was designed to provide simultaneous support for almost all used types of services related to the safety of the flight, including all types of air traffic services, general services and air traffic voice and data messages for the operational airlines management.

B-VHF system is full-duplex based on TDD (Time-Division Duplex) method and supports point-to-point (PP) voice and data air-ground, ie directly between the ground station and the specific aircraft, using implicit / explicit discrete aircraft address. The system is also capable of voice and data broadcast, multicast, and thus all the services associated with this type of transmission.

All ground transmission stations are always a point-to-point and are referred to as reverse connection (Reverse Link - RL). The aircraft can transmit only to the ground station, which checks the user. In the event that an aircraft uses conjunction with other aircraft, ground stations working as switchboard and forwards RL reports from sending aircraft through the forward link (Forward Link - FL), ie, the

ground station to the aircraft or aircraft that are within the cell serviced by the ground station. Connecting through a ground station is used to replace a typical AM-DSB connection between aircraft, other aircraft when they hear what is transmitted, but also the establishment of direct links between specific stations.
Air traffic services are currently provided to 25 nm (43.3 km). Air Control Centre services area covers a distance of 60 nm (111.12 km), while the provision of en-route services may exceed 175 nm (324.1 km). B-VHF is a cellular system aimed at new operational concepts such as dynamic use of airspace. The system should cover the same area and perform the same functions as do current systems.
Each cell is placed in a designated area for its unique frequency and is able to provide multiple aircraft voice and data connection, which previously required several narrowband VHF channels.
One cell should be able to provide voice circuit for several sectors of the air traffic control and simultaneously make voice and data links between aircraft. In most cases it should be possible to use existing ground equipment only is a remake of the stations of the B-VHF.
Coverage of large areas in the provision of en-route services is the solution "cloning" of ground stations. This way, several work stations as one large. If aircraft is between two cloned cells it must take place so-called handover, because divergent zone that is used by cells.
Unlike the transition from one cell to provide a service to another with a different kind of service, which remains under the control of the operator on board the aircraft, the handover between cells of the same service provided to a large area of concern ground stations and requires no action by the crew. [3]

5. CONCLUSION

B-VHF system comes with a completely new approach to spectrum use. Compared to the current narrowband systems the operational channel is around 1 MHz wide, but can use the spectrum more effectively than existing systems. Firstly, B-VHF uses the sub-carrier with a smaller stream with much narrower spectrum than that of narrowband systems to transfer. And the second reason is that sub-carrier frequency of a channel may not be placed all together, but may be divided into a larger bandwidth, than is 1 MHz. This would be a great advantage in the first stage of transition, where the system B-VHF occupied mainly unused channels.

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LABORATORY MEASUREMENT OF FUEL CONSUMPTION OF PASSENGER VEHICLES

Branislav ŠARKAN[1] - Ivana ŠIMKOVÁ[2]

Abstract: *The fuel consumption can be considered as one of the most important operating characteristics of road vehicles. In the article there are resolve the possibilities measurement of fuel consumption under laboratory conditions of the Department of road and urban transport. In vehicle driving simulations on roller test of performance for the purpose of quantifying the volume of fuel consumption has been mounted the volume flowmeter installed into the fuel system of the vehicle. By proposing the methodology of measuring fuel consumption is an effort to move closer to the real conditions of operation of the vehicle in an urban or extra-urban cycle.*

Keywords: *Fuel consumption, fuel flow meter, factors affecting fuel consumption*

1. INTRODUCTION

The fuel consumption is one of the main criteria in assessment economy of propulsion mechanisms of road vehicles. Assessment of propulsion mechanisms is carried out by the measurement of fuel consumption. Those measurements can be performed using agreed standards and regulations by exactly defined way. The regulations also determine the measurement conditions, which must be observed that the results of the measurements reflect the actual fuel consumption as accurately as possible. An important finding is that the actual fuel consumption does not have a sufficient explanatory power. Therefore, it is necessary to take into account the achieved performance of the engine, the course of the engine torque and fuel type when we compare two types of propulsion mechanisms (engines) in terms of fuel consumption. By the place of measurement of fuel consumption we considering about of the laboratory measurements of fuel consumption and the measurement of fuel consumption by driving test (in urban or outside of urban traffic).

2. GENERALLY KNOWN METHODS FOR FUEL CONSUMPTION MEASUREMENTS OF PASSENGER CARS

We can measure the fuel consumption according to several ways and methods and also we can divide the methods according to several aspects. The basic division is shown in the following paragraph.

According to the method of measurement:

- volume and weight methods
- on the basis of the calculation of exhaust emissions the quantity which were produced
- electronically (e.g. information from engine control unit)

According to the used methodology:

- national norms (e.g. STN 30 0510)
- international directives and regulations (EHK OSN no. 101, 80/1268/EHS)

We could have continued in division, e.g. according to the place of fuel consumption (in laboratory, during the driving test), but in other approaches to measuring fuel consumption there is just a modification or combination of methodologies that were already mentioned.

2.1 Volume and weight methods

It is necessary to underline that those methods are used and defined mainly for measuring the fuel consumption of the engine itself. The use of the weight method in an operation of the motor vehicle is practically impossible. But the method is usable in certain kinds of measurements in laboratory

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conditions. Volume method is quite widespread even for measure of fuel consumption of vehicles in operation. For this purpose are used flow meters in different technical versions [1].

2.2 The method of a calculation from the quantity of exhaust emissions produced

This way of measure of fuel consumption is regulated by UNECE regulation no. 101-Uniform provisions concerning the approval of passenger vehicles powered by an internal combustion engine only, or powered by a hybrid electric power train with regard to the measurement of the emission of carbon dioxide and fuel consumption. The regulation applies to measurement of carbon dioxide and fuel consumption or measurement of electric energy consumption and range of vehicle of category M1, vehicles powered by an internal combustion engine only, or powered by a hybrid electric power train and the measurement of electric energy consumption and electric range of categories M1 and N1 vehicles powered by an electric power train only. In the annex no. 6 of this regulation is described methodology of measurement of the carbon dioxide emission and fuel consumption of vehicles powered by an internal combustion engine only.

Example of calculation of fuel consumption for vehicles with a positive ignition engine powered with petrol:

$$FC = \left(\frac{0{,}1154}{D}\right) \cdot \left[\left(0{,}866 \cdot HC\right) + \left(0{,}429 \cdot CO\right) + \left(0{,}273 \cdot CO_2\right) \right] \quad (1)$$

Where: FC - fuel consumption [1/100km],
HC - excessive hydrocarbon emissions [g/km],
CO - excessive emissions of carbon monoxide [g/km],
CO_2 - excessive carbon dioxide emissions [g/km],
D - density of the test fuel.

The operating cycle is composed of the 1 part (urban cycle) and of the 2 part (outside urban cycle). The cycle is shown in Figure 1. Elementary urban cycle is repeated four times during the cycle and then the part 2 – outside cycle follows. The help of this cycle (NEDC) is obtained an emission value by which the value of fuel consumption is calculated according to equation (1) [2].

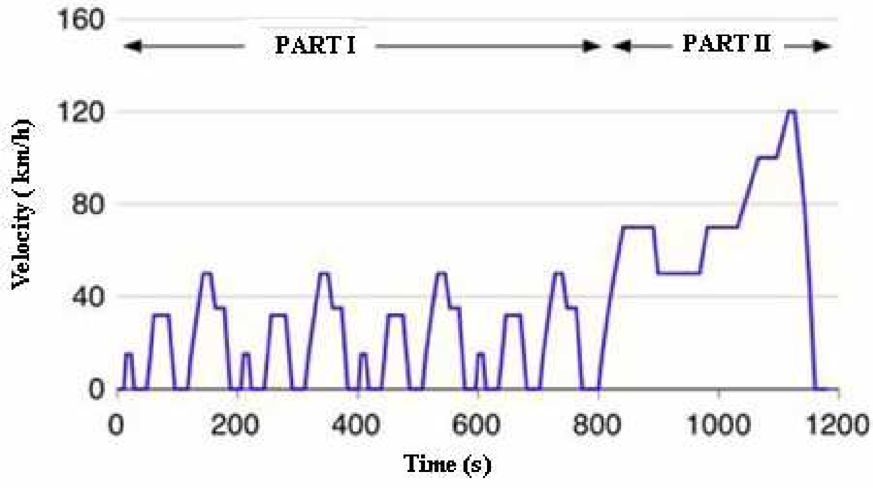

Figure 1 The operating cycle NEDC

3. THE WORKPLACE OF MEASURING FUEL CONSUMPTION

Laboratories of Department of Road and Urban Transport (DRUT) are laboratories are equipped with technique to measure fuel consumption with the simulation of different operating conditions of the vehicle. The following chapter describes the technical elements that are involved in the mention types of tests.

1. Roller dynamometer MAHA LPS 2000
It allows measuring fuel consumption at different constant speeds, where the wheels rotate on the rollers and at the display we can observe current speed in km/ h. Roller dynamometer also allows you to simulate power loss due to air resistance and rolling resistance of the rolls.

2. Flow meter Flowtronic 205
The flow meter allows to measure the total fuel consumption in litres, specific fuel consumption in l/100 km and hourly fuel consumption in l / h. The device at the end of measurement records the total fuel consumption in cm^3. If you want to know the total fuel consumption in l/100 km is necessary to enter a distance travelled (km) to the calculator of the device.

3. The device recording data (speed and distance travelled) from the engine control unit (TouchScan, HiScan, Atal AT 520M).

4. Other techniques

- ventilator allows sufficient cooling of engine and radiator of vehicle, because when measuring the consumption of the roller dynamometer, the engine or radiator is not cooled enough by impact of air
- extraction equipment exhaust by reason closed of the laboratory and production of air pollutants directly in the laboratory
- lashing straps with which the vehicle is securely fastened, to avoid the possible movements of the vehicle to the sides or from the cylinders
- meteorological station which measures the ambient temperature and humidity in the laboratory before and after measurements

4. ACTUAL MEASUREMENT OF FUEL CONSUMPTION

The measurement of fuel consumption at the roller dynamometer MAHA LPS 2000 is without any problems in conditions of constant speeds. Dynamometer is without a flywheel in the laboratory of department of road and urban transport that would allow simulate the ride of a vehicle with variable speed. In the absence of a flywheel we cannot simulate the inertia during acceleration and deceleration of the vehicle (that means acceleration and deceleration of the vehicle). In laboratories DRUT can be realized only measurement of fuel consumption at any constant speed of the vehicle, or when idling. The purpose of the following described measurement results it was found, what is the usefulness of the workplace for detecting fuel in laboratory conditions.

4.1 The measured vehicle

The measurements were performed on a passenger car brand Kia Ceed 1,6 CVVT with parameters in the Table 1.

Table 1 Parameters of vehicle

Swept volume	1 591 cm^3
Maximum engine power	90.00 kW / 6 200 RPM
Type of fuel	BA 95
Gear unit / number of degrees	4 s., automatic
Operating weight	1 191 kg
Maximum design speed of the vehicle	187 km/h
Combined fuel consumption	7,0 l/100 km

4.2 Comparison of mass and volume methods

From the vehicle was removed fuel pump with a pressure regulator (Fig. 2). Fuel pump was placed outside of the vehicle in fuel tank and with a supply of fuel was through the fuel hose to the fuel system of the vehicle. The tank with fuel and fuel pump was placed on laboratory scales Kern KB 10000 with valid calibration. Since the tank with fuel pump and fuel was constantly exposed to the open surroundings, it was necessary to determine the amount of fuel, which is distilled for 1 minute during the circulations of the fuel pressure regulator from a part of the pressure regulator back to the tank with fuel. Therefore, there is in Table 1 the mass of weights obtained from Kern KB 10,000, adjusted by the amount of 0.4 grams per minute, as a loss, which is caused by the distillation of fuel in the tank and in the specific laboratory conditions. Values were recorded at the same time from the measuring instrument as well as from the flow meter every minute. In Table 1 are recorded the value of fuel consumption during idling of vehicles. The values of laboratory scales are calculated using the measured fuel density 0.7464 kg.dm^{-3} per volume consumption, which is then comparable with the values of the measuring device Flowtronic 205. The results show that after 10 minutes the consumption was recorded by a laboratory balances 77.7398 cm^3 and flow meter 77.024 cm^3 idling vehicles and there is a difference of 0.7158 cm^3. The measuring equipment Flowtronic 205 differs from laboratory balances by only 0.92 % in the steady state mode of the vehicle.

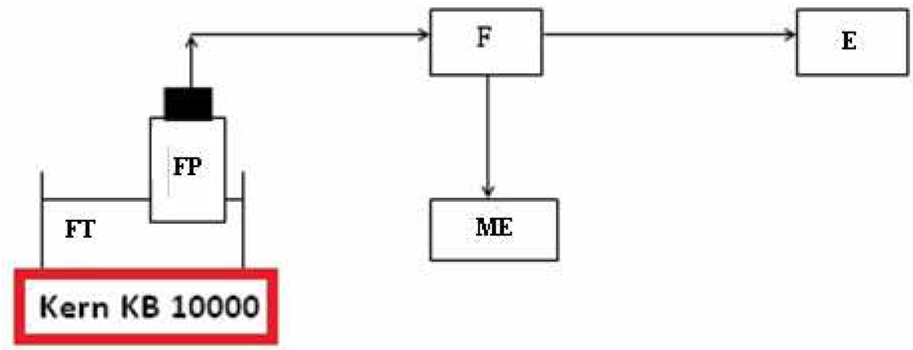

Figure 2 Involvement of the flowmeter to the fuel system
(FT- fuel tank, FP- Fuel pump, F- Flowtronic 205, ME- member evaluation, E- engine)

Table 2 Comparison of fuel consumption

	Kern KB 10 000			Flowtronic (cm^3)
	Weight (g)	Modified (g)	Recalculated (cm^3)	
1	4,8	4,4	5,9553	6,64
2	11,8	11,4	15,2465	15,936
3	18,7	18,3	24,5378	25,232
4	25,3	24,9	33,3199	34,528
5	32,2	31,8	42,6112	43,16
6	38,2	37,8	50,6297	51,128
7	43,5	43,1	57,7572	58,432
8	49,2	48,8	65,3939	65,072
9	54,0	53,6	71,7578	71,712
10	58,4	58,0	77,7398	77,024

It is necessary to noted that the measurement by mass method of measuring fuel consumption of road vehicles is time-consuming and technically demanding. Both methods require intervention to the fuel system of the vehicle, but the volume method seems to be preferable in laboratory tests. In many laboratories is the possibility of linking the volumetric the flowmeter and the roller dynamometer, then we have a results of comprehensive fuel consumptions from one device.

4.3 Measurement of fuel consumption in simulations of fault in ignition

Fault in ignition means when fuel mixture is incorrect ignited in one or more cylinders of the engine that also influences on the fuel consumption of the vehicle. For this type of simulation was mounted spark plug with limited function in the third cylinder engine. Of course, the error increases notably the amount of unburned hydrocarbons in the exhaust emissions and while reduces the value of λ - lambda that makes the mixture more rich. The OBD system (On Board Diagnostic) informs about the fault by the indicator (MIL-mall indicator lamp) on the dashboard. In Table 3 and 4 are shown the results of fuel consumption during the simulated speed 90 km / h on a roller dynamometer MAHA LPS 2000. There were simulated two states (without fault and with fault in ignition). Each measurement was repeated three times because of greater explanatory power and it took 1 minute. The results reflect the assumption that during a fault in the ignition leads to a massive increase in fuel consumption which the value exceeds 50%.

Table 3 Measurement of fuel consumption at 90 km/ h without fault

t = 60 [s]	Flowtronic	Volume	OBD distance	Specific consumption
No. of measurement	[cm^3/min]	[l/min]	travelled [m]	[l/100km]
1	94,952	0,094952	1 500	6,330
2	90,304	0,090304	1 500	6,020
3	93,624	0,093624	1 500	6,242

Table 4 Measurement of fuel consumption at 90 km/ h with fault

t = 60 [s]	Flowtronic	Volume	OBD distance	Specific consumption
No. of measurement	[cm^3/min]	[l/min]	travelled [m]	[l/100km]
1	134,792	0,134792	1 500	8,986
2	138,784	0,138784	1 500	9,252
3	136,784	0,136784	1 500	9,119

5. CONCLUSION

The fuel consumption of motor vehicles is one of the most important operating characteristics, which directly defines the cost ratio of their operation. In practice we often meet with the requirement of laboratory tests of measuring fuel consumption. Their use is mainly in those researches (impact of settings the engine control unit, impact of the driver, impact of the type of fuel, impact of vehicle technical condition, etc.)

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RISKS IN RAILWAY TRANSPORT

Karel SELLNER[1]

Abstract: *The paper describes risk issues in transport especially in railway transport. First section is dedicated to risk factors, risk types and risk management in railway transport. An analysis of different risk types is oriented to following areas: impact of economical development, competition, legislative and commercial condition changes, management systems, technical equipment and to risks coming from natural disasters, technical failures and accidents. Solutions and ways for risk reductions are proposed. Second section is oriented to comparison and evaluation of railway transport risk rate in relation with different risk factors. Based on their evaluation effect size and probability of risk establishment scheme is developed. This scheme shows dependence between magnitude and probability of risk formation. Third section describes briefly situation in railway transport, former development and main conditions necessary for next growth.*

Ke words: *railway transport, risk factors, risk management, scheme of risk measure, conditions and trends of growth.*

1. RISK MANAGEMENT AND RISK FACTORS OF RAILWAY TRANSPORT GROWTH

There are many risk factors in every human activity both in private and business life and it is desirable to know, manage and solve them. It is interesting, that for the very first time in business area an urgent need to manage risks appeared in transport. An elimination of transport risks was necessary already in very beginning of river transport and mainly during development of railway transport in the middle of 18th century. This concerned mostly safety of transport and how to prevent accidents on transport road – in case of railway transport mainly single-track. There were created and continuously developed much technical and organizational measurement for solving these situations. With time there were recognized other risk factors in railway transport with different importance and it was necessary to find ways how to manage them in order to keep the safety and to satisfy market demands as well.

In area of railway transport we can split risk factors having influence to results and electivity into following main groups:

1. Development of the economy on a global scale, as well as the territorial
2. Competition of other forwarders
3. Legislative and commercial conditions in the national and international levels
4. Management systems and technical equipment
5. Natural disasters
6. Technical defects, failures and accidents

Influence of particular factors, its importance and ways of risk management is different for particular factors. It is suitable to analyze these factors from the point of view of their content and the impact on the results of railway transport and the level of risk of the individual factors in terms of frequency and severity.

1.1 Development of the economy on a global scale, as well as the territorial

All transport processes, mainly in freight transport directly depend on global and territorial development of economy. From statistical data published by The Czech capital information agency [5] comes that transport and logistics business is one of most risky business and risk of bankruptcy in Czech Republic is more than twice higher than average. In railway transport – because of transport companies size – is frequency of bankruptcy low but regarding other risks is the situation similar like in other transports, in some cases are the impacts more serious. Amount of risk depends on the focus of the economy of individual Territories, especially on the fact if it is open economy with high ratio of international trade and on structure and orientation of national economy branches.

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It is clear that global impacts are more serious for open economies. In a similar way higher importance exists for economies oriented to goods production than for economies oriented to agriculture or tourism.
The consequences of economic crises in railway transport of goods are at least directly proportional to size and duration of the crisis, but from statistical results is clear that decrease is higher and that usually its consequences appear earlier and last longer. Risk of significant decrease of transports is announced by economical results decrease and it is deepened by saving measurements and ending with delay after economical recovery. Rate of growth is usually lower because of rationalization measures in other sectors of the national economy.
A rate of the seriousness of the risk is high in railway transport, frequency is low but the whole impact is considerable. Defense against this risk is very difficult, consists mainly in the early reduction of costs, rationalization of activities and – if possible – reduction of capacity. In railway transport is reduction of capacity difficult due to the significant volume of fixed costs independent of the volume of performances. A better way is to increase the reliability of the goods transport, to guarantee transport times and to offer wider services with better quality and flexible applications competitive prices and services.

1.2 Competition of other forwarders

The risks arising from competition of other forwarders is permanent and it is necessary to consider him in establishing the concept of the railway transport development, as well as in its operational managing. This risk is up to date as for the transport of persons, as well as for the transport of goods. It is possible to split it into two main groups – forwarders representing other transport types and other railway forwarders.
The basic risks in the first group lie in the areas of reliability and safety of railway transport, in economic difficulty and the quality of transport for the end customer. With all these factors relate to and their optimization on the technical possibilities and economy of railway transport.
Risks arising from the reliability and safety of railway transport cannot be for objective and subjective reasons completely excluded and will be described in more details in chapters 1.5 a 1.6. Objective reasons are mainly in extreme weather conditions, subjective are due to a failure of technical equipment or human factors. Long-term analysis shows that the level of risk is lower than in road and water transport.
Risks resulting from the economic cost to the end customer, i.e. price of transport (both personal and freight transport), lie primarily in the transport price changes for other types of transport in the individual segments and commodities. The basic measure is a continuous monitoring of the development of transport prices and tariffs and the flexibility to respond to their development by tariff measures and a system of discounts. The second important area is the improvement of services offer. This is related to the risk in the area of competitiveness, in terms of the transport speed. Even more important than speed in this respect is the issue of the total travel time, in particular for the transport of goods, the time between loading of the goods and delivery to its destination. In addition to monitoring the evolution of transport time is necessary to do measures both in technical area (increasing of permitted speed on the tracks and railway vehicles) and in the area of high-quality staffing and security and traffic management and transport-related operations.
The risk of competition, paradoxically, is possible to reduce by thoughtful cooperation with other types of transport and forwarders using their strengths. This concerns in particular the development of combined transport with the aim of minimizing the total transport time at maximum use of advantages and share of transportation of railway containers, or contrailers and transport bodies.
Competition from other railway forwarders is especially in a period of lower demand for transport of goods economically significant factor. It refers to a lesser degree, domestic carriers, who are usually focused on the transport of bulk substrates, to a greater extent major international transport and forwarding companies. Developments in the company, management and institutional arrangements are lately very dynamic. It consists mainly in the creation and strengthening of multinational organizations with a comprehensive ensuring of transport, forwarding and commercial activities. This gives prerequisites for reducing overhead costs, better utilization and optimal mix of transport means and, in effect, to profitable offer for customers regarding time and costs. Defense is once again watching the technological progress, the implementation of new organizational and technological procedures,

appropriate marketing strategy, quality and flexible tariff policy. It is also a good idea considering cooperation with other domestic and foreign companies. For both of the core group, the severity of these risks is not only in their size but more in their frequency. Then here it is more about the permanent monitoring and defend against competitive, mostly, evolutionary development.

1.3 Legislative and commercial conditions in the national and international levels

Changes in national and international legislation may be a significant risk factor with an impact on operating performance and financial results of railway transport. Basically there are two categories of legislation. The first is national or international legislation having a bearing on railway transport, the second is a transport (railway) legislation set by the national or international regulations and standards. Risks arising from general legislation come primarily from changes in the area of environmental protection, safety and liability of carriers. Any modification in the environment affects both investment costs and usually operating costs. In the economic area it can lead to the necessity of the costs joined with infrastructure and vehicles modifications. It concerns mainly the issues of noise, air pollution, as well as the design and maintenance of railway equipment. Changes in the area of the safety of railway operations are also in the field of general legislation and are generally reflected in modifications to the railway rules and standards and there leads to the corresponding impacts. Legislation changes in the area of responsibility can lead to economic impacts, especially in the area of higher investment and operating costs. Similarly, it may appeal the consequences of tax adjustments.

Risks coming from the transport and railway legislation are, in addition to the already mentioned, especially in the construction changes requirements for additional equipment and, in some cases, in the prohibition of the use of certain units or even entire vehicles generally or for certain types of transported substrates. The second effect is measures in the area of typification and the unification of the railway equipment. In both cases, the size of the risk factors reduces in general transition period that allows preparation for strict introduction, however, usually it leads to extra costs in the beginning.

Commercial conditions in railway transport have certain specifics resulting in passenger transport primarily from the obligation of the State to ensure that basic transport, mainly regional, accessibility. This implies the need for subsidies for all carriers which provide this basic service. The risk then is to change the rules for the financing of regional transport from the State or Districts. In freight transport, which operates on market principles this risk doesn´t exist. The problem is in terms of freight tariffs in competition with other carriers, particularly foreign ones. The solution in both cases is the improvement of the offered services and reducing of operating costs; for freight transport in addition it is permanent cooperation with the carriers, especially important ones, and the setting of optimal tariffs.

1.4 Management systems and technical equipment

The organizational structure and management systems of railway companies have significant impact on the financial results and position on the transport market. Organizational arrangements resulting from the legislative framework must create conditions for the effective operation of the company in the minimum administrative overhead. Management systems based on these conditions are then tasked in the various areas and levels to ensure the optimization of economic and qualitative requirements for railway transport in accordance with the requirements of carriers, i.e. customers of the railway company. The risks lie mainly in a few flexible organizational structure and management systems that do not use modern information technology and management methods. A significant role related to organizational structure has also a composition and qualifications of employees at the particular positions. For the chosen profession, it is necessary the periodic training, testing and control of knowledge and abilities.

Technical equipment is very important for the proper function of the railway. Usually railway infrastructure is owned by the State and railway forwarders use it under fixed equal conditions. The improvement of its level cannot be influenced by particular forwarders, but it is their interest and the interest of the State, that the infrastructure is in good quality, because the number of passengers and cargo, especially in international and transit transport has an impact on the economy of the State and the gross domestic product. The risk lies in the lack of financial resources for the modernization of the railway infrastructure.

The technical equipment of railway forwarders itself has also an importance for their economy and their underestimation mean a significant risk factor. This includes mainly railway vehicles which good technical condition and appropriate construction and conceptual solution is a prerequisite for success. In this area is important also energy demand, quality and ensuring of an effective maintenance. An important role here is played by the cost of the lifetime of the device (LCC methodology) and application of trouble-free maintenance methods with sophisticated system of preventive controls and maintenance actions [1]. Other technical devices have a similar importance. Risk elimination consists in correctly built the conception of the company generally in this area, as well as on sufficient financial resources for its implementation.

The frequency of these risks is quite large and depends on the development of management and technology of technical equipment manufacturers and also on new solutions and procedures. Important is also the monitoring of equipment and organizational, technical and business methods and principles of other transport enterprises. The level of management and technical equipment is directly linked to the competitiveness of the company and its position in the market. It is, of course, influenced by the development of technology and the national and international economy.

1.5 Natural disasters

Objective reasons for endangering the safety and operability of the railway transport are based primarily in the extreme natural and climatic conditions. Natural disasters are in our geographic area, fortunately, not very frequent, but still a risk factor of all infrastructure including transport infrastructure and technology. Railway infrastructure is threatened less than water and road infrastructure. This is due to the fact that rail lines were built in the past, so that the rise of large water flows does not affect them. This is verified also by large floods in the last decade, when in many cases the good condition of the railway infrastructure caused that railway transport could overtake transport from other modes of transport. However, the risk of natural disaster remains and extreme natural events, whether it's a violent thunderstorm with local floods or windstorms, can affect also railway infrastructure. This can result to problems with securing of an alternate transport and economic losses associated with removing of defects and with unrealized transport.

It is generally recommended for similar risks to have an insurance against the consequences of natural disasters [2]. For railway infrastructure, this solution is difficult. An appropriate solution to these risks is the readiness for fast and high-quality removing the consequences of natural disasters, such as the removal of foreign objects on the tracks — trees, rocks and landslides. Even more important is consistent and regular maintenance, which can prevent many potential events disrupting railway traffic. Regarding extensive devastation of the railway infrastructure – on local lines – it is appropriate to consider the effectiveness of its recovery.

1.6 Technical defects, failures and accidents

While natural disasters and their consequences can be influenced only partly, this group is influenced with aim to minimize them. The risks are caused mainly by technical defects both on the route and its security system, and on the vehicle fleet. The second major reason is the failure of human factor, together with the level of control mechanisms. As a result of these faults may be a limitation of railway operations and at worst case even railway accidents. Risks arising from objective reasons exist with relatively small frequency and their importance is not high and is locally limited.

Risks coming from technical defects and failure of human factor require after their identification to implement necessary in order to reduce these risks. It is necessary to implement and control measures how to minimize them. Regarding technical defects it is especially early and consistent maintenance of equipment and the objective control of the technical condition. Regarding failure of human factor the basic measure is to set up necessary professional requirements, perfect initial and periodic training of personnel with testing of their knowledge and skills and functioning system of controls and penalties. In case of repeated or serious defects, it is necessary to draw conclusions in the education system, and, if necessary, to modify the construction or system maintenance.

2. COMPARISON OF RISK RATE IN RAILWAY TRANSPORT

As in the previous text, but also knowledge of the complexity of the railway transport is clear that determination of the impact and the objective quantification of individual risks is difficult and in some cases even impossible.

The development in the global economy as well as the territorial scale allows a certain extent making a prognosis of impacts on the volume of shipments and prepare measures to minimize losses in case of a decrease and grow making measures in its recovery.
Risks arising from competition from other carriers cannot be quantified. Continuous monitoring of competitors and of demographic and economic trends and thoughtful progressive strategy and ability to implement it is to enhance the impact and the share of railway transport and individual forwarders on the market.
For described legislative and commercial conditions in the national and international levels, the risks are difficult to quantify. Their severity may be high, but if they are not from the perspective of different modes of transport, as well as individual carriers non-discriminatory, they can be successfully eliminated. In-time and continuous monitoring of the preparation and development of these processes as well as preparation and implementation of the necessary measures is very important.
Management systems and technical equipment of railway companies and their good level are necessary for their effective functioning. The risks are on one hand in the concept and strategy of the company, if it is not analyzed and updated on an ongoing basis and, on the other hand, in the lack of financial resources to its implementation. In particular cases it is possible to quantify successfully the risks.
The risks connected with disasters both in terms of frequency, as well as in terms of the severity of the individual cases are difficult to predict, and thus to quantify them. Their influence and impacts is possible to reduce by preventive measures resulting from the evaluation of past events, by the creation of contingency plans and by the monitoring of the situation together with system of fast information transfer.
Regarding risks arising from technical failures, the threat of traffic and accidents, the situation is similar with the fact that the frequency and scope of these risks can be largely affected by high-quality maintenance of infrastructure and other technical equipment and by strict training and testing of employees. The size of the consequences is possible to reduce by the optimal number, equipment, and relocation of technical and accidental devices.
In spite of the difficulty, and so far little attention paid to the analysis of risks and their consequences in railway transport it is possible to draw some general conclusions and schematically represent the dependency of the frequency and severity of individual risk factors. This schema is shown in Figure No 1. It indicates that the highest severity has the risk associated with the development of the economy. Implications for the volumes and economic results of freight transports are usually higher than the economic decline in the national economy and the recovery time is longer.
This is due to the intense efforts of carriers to increase company efficiency, among other things also by minimizing the requirements for transports and by reducing raw material consumption. In contrast, the risk of competition from other carriers has a large frequency, because it is an on-going activity.
For well-run company with a flexible response to the development of the transport market the impact on economy is not too serious. In general it can be concluded that like in other sectors of the national economy it is necessary also in transport to consider the risks and to know their impact and the paths to their elimination.

3. CONDITIONS AND TRENDS OF FUTURE DEVELOPMENT

Since 1995 until start of the economic and financial crisis performance in railway transport grew. However, the freight transport already in 2008 proved in most countries, a slight decrease in performance, which further deepened the in 2009. In 2008 took place on a European scale to a decline in transport performance by up to 15%, in the following year, the situation was worse and the decline amounted to 40%. The largest decline was according to the UIC [3] for railways in the Balkan countries. In the Czech Republic amounted to around 25%.
It was due to the global financial and economic crisis and reduced transport requirements. A positive feature is that in the third and fourth quarter of 2009 in comparison with the first half at home and in neighboring countries the decrease reduced or stopped and in 2010 and 2011 it was achieved slight growth.

A further decline mainly in the field of industry and construction in 2012, continued also this year, in the Czech Republic again led to a decline in transport performance in the freight transport and the reactivation is possible at the break of this and next year.
The reduction of the dynamics appeared also in other countries. Nevertheless it is possible to expect on a global and European scale in the long term the further development of performance in both passenger and freight railway transport. This is true even in the Central European region, including the Czech Republic and its neighboring countries.
Loss of dynamics came also to passenger transport in times of economic and financial, but the difference is less than in freight transport. Further development depends on the time and the speed of economic recovery and development of the economy.

As a condition of growth and economic results in railway transport is mainly:

- global economic recovery in the global and European scale
- development of the economy and economic indicators of the national economy and the development of international trade
- harmonization of the different modes of transports in the internalization of external costs and efficient co-operation of transport systems
- continuous improvement of the infrastructure, as well as technical and technological equipment of railways
- optimally segmented organizational structure of the railways, the use of computer technology and modern management methods
- the optimal professional structure and number of quality employees to ensure the labor productivity growth.

It can be assumed that the positive developments in railway transport will be retained. It is confirmed by the volume of the world's investment into railway transport, which is currently 123,5 trillion Euro per year, of which 59% is intended for the purchase of new vehicles, 30% for infrastructure and 11% on technology [4]. By 2015, according to the same source, should investment growth at a rate of about 4.5% per year to 157 trillion Euro.

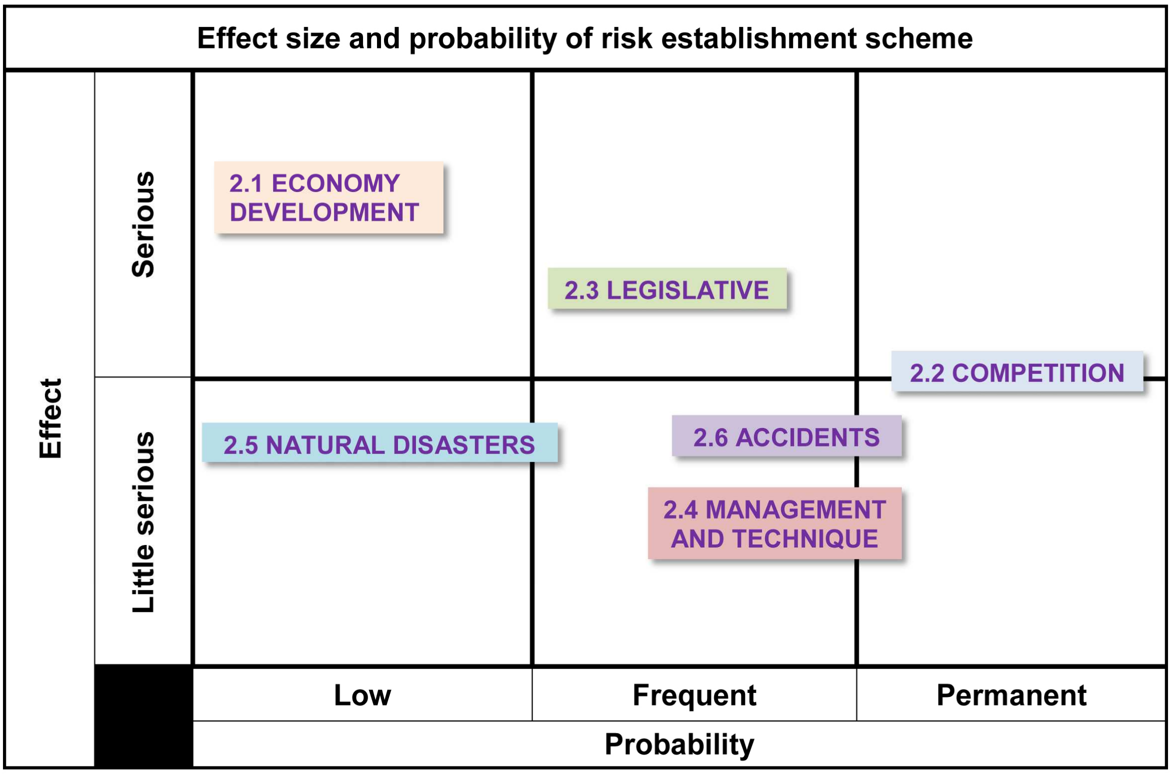

Figure 1 Effect size and probability of risk establishment scheme

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ROAD SAFETY ASSESSEMENT IN A-LEVEL ROAD SECTION

Tibor SIPOS[1] - Katalin TANCZOS[2]

Abstract: *Nowadays, the forgiving road and self-explaining road design is very important in the view of road safety point, hence the authors analysed a network element of the A-level road network. Road Nr. 82.was analysed in order to determine the difference between the characteristic of the existing road network and referred parameters of the road design regulations. It was proved trough accidental statistics and geoinformatics analyses that there was coherence between self-explaining, forgiving road properties and the number and the severity of the accidents on the road Nr. 82.*

Keywords: *road safety, statistical analysis, self-explaining road*

1. INTRODUCTION

Prevention of accidents, reduction of their quantity is the aim of national transport policy, because social-economic costs of accidents are about 1-2% of the gross national product in Europe. In order to reduce the likelihood of accidents, features of installed static road infrastructure (e.g. convex rounding, site plan arch, longitudinal gradient, etc.) and the regulation of its traffic (e.g. speed limit, caution of dangerous curves) should be designed in the future so as to satisfy the requirements of the road transport system, by forming a coherent unity. In the research we attempt to build up a model of connection between specific infrastructural parameters and the evolved accidents.

2. SURVEY

To manage the pilot-measurement, a suitable vehicle to measure the locality, an accurately working GPS navigation system, an image capture system with excellent quality and a frame rate were required, as well as a geographical information system, to synchronize the captured images and the GPS signs.

The survey was recorded in a geo-database. The data model is an object-oriented data model. Its aim was to define intelligent individuals and create new connections (relations) with the other individuals. The geo-database approximated the physical and logical data model.

Eight pre-defined system parameters (lane, width, shoulder sealing, median barrier, shoulder barrier, lane widening before curve, slope, rumble strip, roadside hazard) and the related weighting factors (Elvik R., 2005.) were necessary to evaluate the level of safety.

To evaluate the level of safety, the processing unit, which is capable of recording the above mentioned determinative system parameters is shown in the Figure 1.

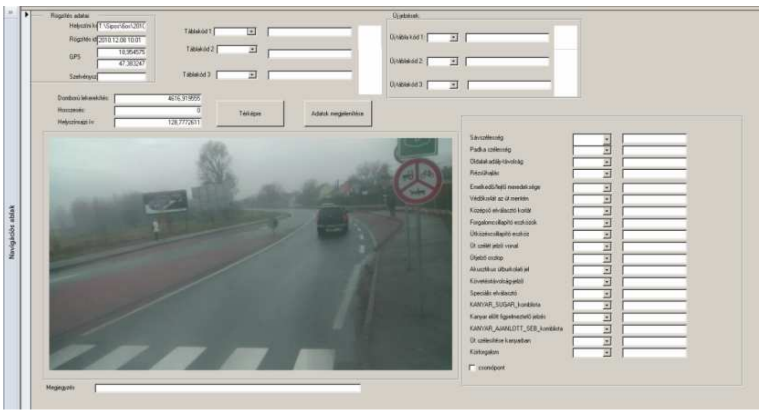

Figure 1 Applied processing software

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During the recording of parameters, the nature changing cross-sectional segments were marked. Then the examined parameters were recorded after moving 50 meters away. This was necessary during the spatial analysis so that the beginning of changes could be identified, furthermore, the specific parameters of the phase could also be assigned.

3. EVALUATION

The accident data belonging to the particular road sections was assigned to the geo-database (2005-2007) to distinguish fatal, serious, and slight injury accidents. Then the safety value formed by the weighting of the parameters was assigned to the sample, providing the pilot phases.

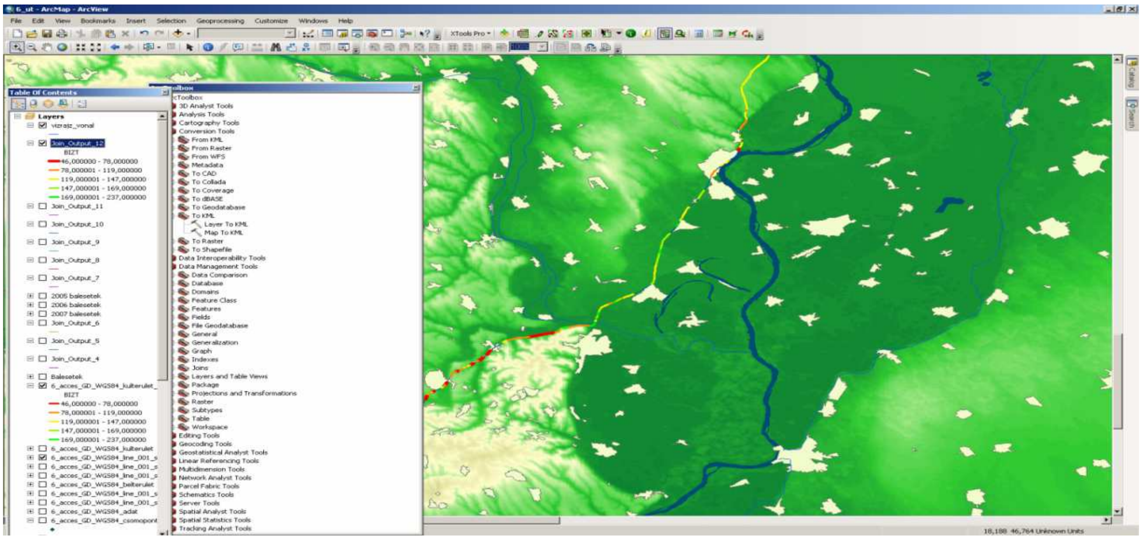

Figure 2 Assignment of accident data to phases

Safety values were ranked to safety categories for statistical analysis. By examining the frequency values of these categories, it can be stated, that the distribution of the pilot phases follows a normal pattern (Figure 3).

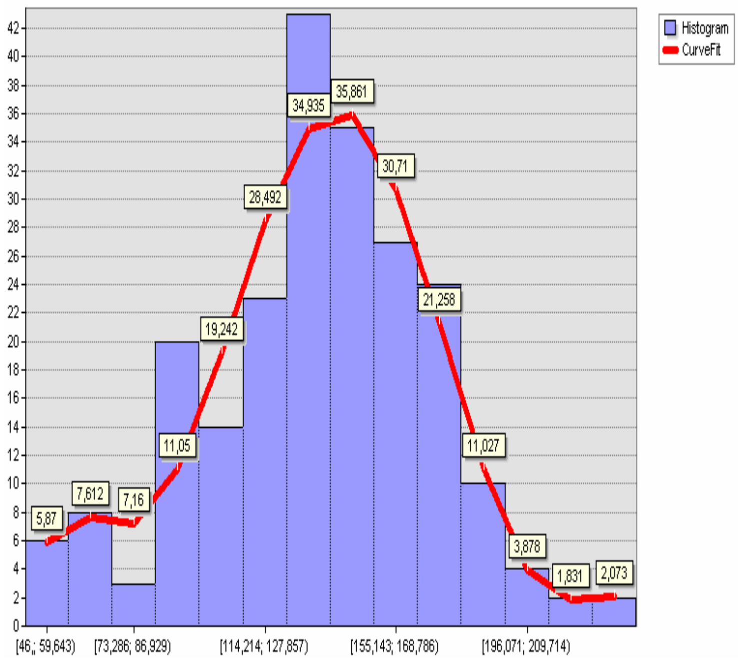

Figure 3 The relative distribution diagram of the pilot and the evaluation's theoretical function

The number of assessed phases during the pilot was 221. The cumulative hazard's average value assigned to the sample was 137.61, while its dispersion was 36.1.
Based on the examination, it can be stated, that the high safety category is not specific for the significant part of the pilot. The specific safety categories of the pilot phases are exemplified on Figure 3.

4. VALIDATION

It is worth examining whether there is any connection between the particular safety categories and the accident data. To determine it, a test of independence was made. The population sample is a consistency of the accident data with different outcomes, belonging to the particular safety categories.
The null hypothesis was that the characteristics of each criterion are independent from each other, thus the particular safety categories and the accidents are independent events.
Of course, the alternative hypothesis is its opponent. To decide whether our assumption was correct or not, the sample was tested by a trial function.
In an optimal situation, it is a one-sampled, non-parametric Khi trial function, which the independence-test can be made with.

$$\sum_{i=1}^{n}\sum_{j=1}^{n}\frac{(f_{ij}-f_{ij}^{\bullet})^2}{f_{ij}^{\bullet}} \quad (1)$$

where: f_{ij} indicates the elements of the matrix made of the real accident data,

$f_{ij}^{\bullet}$ indicates the derived elements which are independent from each other.

There are 5 distinguished groups of safety level, so based on this fact the following initial table can be set up (Table 1).

Table 1 Outcomes of accidents, and their frequency by group-classifying

	Number of accidents								
	2007			2006			2005		
Group of nature	Fatal	Serious	Slight	Fatal	Serious	Slight	Fatal	Serious	Slight
5	1	4	4	6	7	6	7	6	15
4	1	12	12	7	15	20	1	14	13
3	6	12	12	6	18	20	7	14	18
2	4	6	6	4	10	17	2	14	13
1	5	27	27	11	36	79	8	42	67

The accident data for the 3 years can be regarded, resulting in the contingency table above.

5. HYPOTHESIS EXAMINATION

Firstly, we have to define the verge frequency's fitting multiplication per component, and the independent factors which are derived from the number of element's ratio of the whole pattern. Then the [1,1] cell's empirical frequency (f11) has to be deducted from the cell frequency (f*11) of the theoretical independent distribution [1,1].
The disparity's value has to be squared, then this number is to be divided by the cell frequency (f*11) of the theoretical independent dispersion [1,1]. This has to be carried out in every cell's case and then these numbers have to be summed.

6. RESULTS

The Khi trial function's statistical value is χ^2 = 21.48. Since the independence rate of the function was 8, and the assumption referred to the independence was determined by 5% significance, the Khi trial function's critical value is 15.507.
The 21.48 value defined by the trial function, is higher, than the critical value of 15.507, thus we reject the null hypothesis, and establish that the distribution by outcome of safety categories and the accidents are not independent from each other.

7. FURTHER RESEARCH AREAS

The hypothesis examination shows that safety categories and accidents are not independent from each other by outcome. To confirm the relationship, the definition of Cramer or Csuprov coefficient is necessary. The value of Cramer-coefficient can be calculated in the following way:

$$C = \sqrt{\frac{\chi^2}{N_{\min}\left((s-1)(o-1)\right)}} \quad (2)$$

where: s indicates the number of lines,
o indicates the number of columns,
N frequency,
χ Khi test function empirical value.

The coefficient shows, that there is a weak connection between the criterions. Thus, the definition of exponent variables, which show low correlation, and the expansion of the examined variables are objects of further research.

8. CONCLUSION

During the research, an assumption was made to examine the correlation between the specific infrastructural parameters and the evolved accidents. The 8 pre-defined system parameters were recorded in a geo-database after a pilot measurement, then, based on a statistical examination, it has been established, that there is a connection between the created safety categories, and the outcome of accidents. The aim of further research is to expand the probative variables in order to better approximate the model to reality.

The work reported in the paper has been developed in the framework of the project „Talent are and cultivation in the scientific workshops of BME" project. This project is supported by the grant TÁMOP-4.2.2.B-10/1-2010-0009.

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UAV COMPOSITE CONSTRUCTIONS FATIGUE MONITORING BY INTEGRATED MAGNETIC MICROWIRES

Miroslav ŠMELKO[1] - Dušan PRASLIČKA[2] - Pavol LIPOVSKÝ[3]

Abstract: *Using of Unmanned Aerial Vehicles (UAV) became the every day reality. Even though they do not carry passengers, they are frequently used closely to the human residences as conventional planes. Large amount of composite materials is used for UAVs constructions, due to the construction weight decreasing. Fatigue of composite materials is the object of many scientific researches and has a considerable impact on the UAVs operational safety. The tabled article deals with possibilities of using of integrated magnetic microwires for composite materials fatigue monitoring. Magnetic microwires have miniature dimensions and besides fatigue monitoring can be also used as a multi sensor for magnetic compass navigation, in-situ tensile stress measurements, temperature measurement or as a short range distance sensor.*

Keywords: *UAV, composite materials, magnetic microwires*

1. MAGNETIC MICROWIRES

Magnetic microwires are composite materials which were first prepared by Taylor in 1924 [1]. They consist of a metallic core covered by glass coating. Magnetic properties of such composite materials are mainly determined be chemical composition of a metallic core, mechanical dimensions of a microwire, ratio between the core diameter and glass coating thickness and post-processing.

For fatigue monitoring Ferrum based mono-domain microwires with bistable magnetic behaviour are used. These microwires are highly sensitive to the applied tensile stress. By embedding of such a microwire into the construction material, material fatigue can be monitored, represented by changing of tensile stress inducted in construction during production. Carrier of information about microwire status is a parameter called switching field H_{SW}. Amorphous microwires with high positive magnetostriction are characterized by a rectangular hysteresis loop.

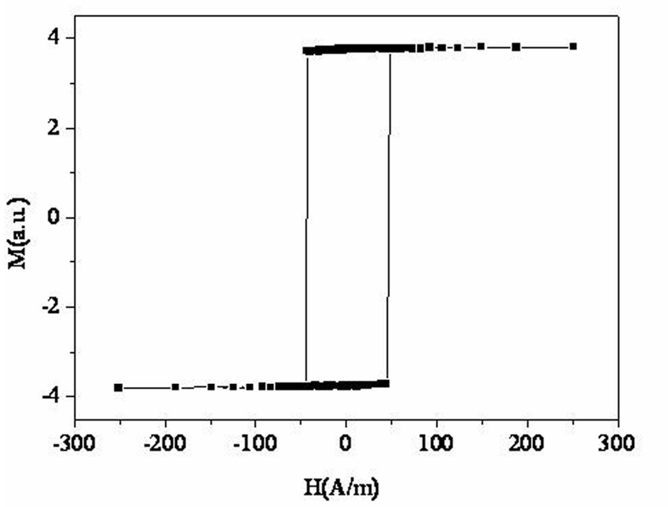

Figure 1 Bistable magnetic behaviour

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The domain structure of such a microwire consists of one axial domain in the centre of a wire, covered by radial domains. Such domain structure shown bistable behaviour, see Fig.1. Magnetization of a microwire has only two states, positive and negative saturation (M_{S+} and M_{S-}). Changing between these two states runs through the single Barkhausen jump, when the external magnetic field reaches the value of a microwire switching field H_{SW}. The magnetic properties of microwires are determined by the megnetoelastic interaction of magnetic moment with the mechanical stresses, thus the switching field is very sensitive to the applied mechanical stress [2]. Due to the different thermal expansion coefficients of the metal core and glass coating, additional stresses are applied on a metal core, hence the switching field is sensible to temperature, too.

2. OPERATION PRINCIPLE

As it was expressed before, switching field of magnetic microwires is a carrier of information about several physical quantities such as external magnetic field, tensile stress, temperature and so on. It can be measured by a simple induction method based on precise measuring of time [3]. The fundamental principle is presented on next Fig. 2.

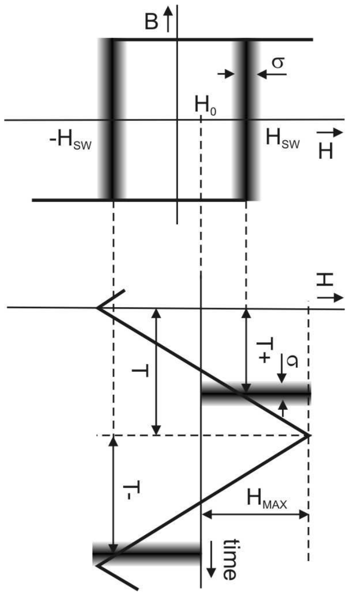

Figure 2 Fundamental principle of induction method

Tested microwire is placed in excitation field of triangular shape with H_{MAX} amplitude. Changes of the microwire magnetic state are indicated by inducted voltage peaks in a sensing coil. The primary carrier of information about switching field and related qualities are the times T_+ and T_-, as is evident from the Fig. 1. One can derive the following Eqs. (1) and (2) which create two series of samples X_+ and X_-, as a result of the excitation field slope.

$$x_i^+ = \frac{2T_i^+}{T}\overline{H}_{MAX} = (H_{SW})_i + (H_{MAX})_i - (H_0)_i; \quad (1)$$

$$x_i^- = \frac{2T^-}{T}\overline{H}_{MAX} = (H_{SW})_i + (H_{MAX})_i + (H_0)_i; \quad (2)$$

The mean values of ambient magnetic field and microwire switching field could be simultaneously derived by subtraction and summation of Eqs. (1) and (2).

$$\overline{H}_0 = -\frac{1}{2N}\sum_{i=1}^{N}(x_i^+ - x_i^-); \quad (3)$$

$$\overline{H}_{SW} = \frac{1}{2N}\sum_{i=1}^{N}\left(x_i^+ + x_i^-\right) - \overline{H}_{MAX}; \quad (4)$$

From this brief explanation one can easily realize how easy it is to get values of H_{SW} and H_0 in a direct digital form and construct micro sensors of various physical quantities. Noise of H_{SW} is then a limiting factor in reliability [4]. So it is still a challenge for producers of microwires to produce it defect free, in optimal chemical composition and reproducible.

3. EXPERIMENTS AND RESULTS

As the UAVs are mainly constructed from composite materials, glass-fibre composite samples was chosen for experiments. In all experiments, excitation field frequency of 500 Hz was used and H_M was set to 600 A/m. The measured sample (Fig.3.) was a composite fibre-glass strip with the embedded N38 microwire ($Fe_{38.5}Ni_{39}Si_{7.5}B_{15}$). The sample consisted of two layers of a glass fibre fabric, a cloth waved in a symmetric proportion between warp and weft. Used resin was certified LH160 from the Havel company and samples were produced in cooperation with the TULI s.r.o. company. The microwire is positioned between the layers in the warp fibres direction. The sample has physical dimensions of 0.54 x 14 x 250 mm and is cut from a sheet of a composite material. The sheet was prepared with 13 microwires embedded and will be divided into 13 independent samples.

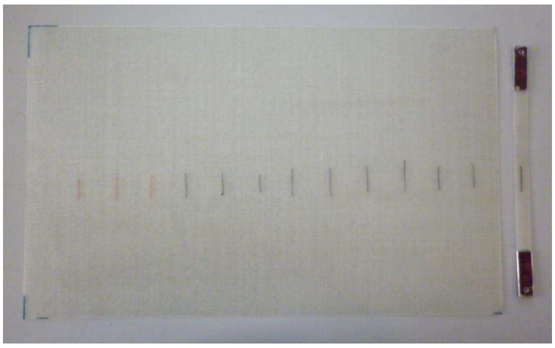

Figure 3 Sheet of glass-fibre composite with one sample prepared from it

One kind of measurement was performed on prepared sample. Sample was clamp in a force gauge stand and tensile stress was produced by gradual increasing and decreasing steps of the sample length with 0,05 mm change. Produced forces were in the range from 0 to 200 N which responds to the tensile stress in the range from 0 to approx. 27 MPa. Measured tensile stress and microwire response is presented below, see Fig. 4.

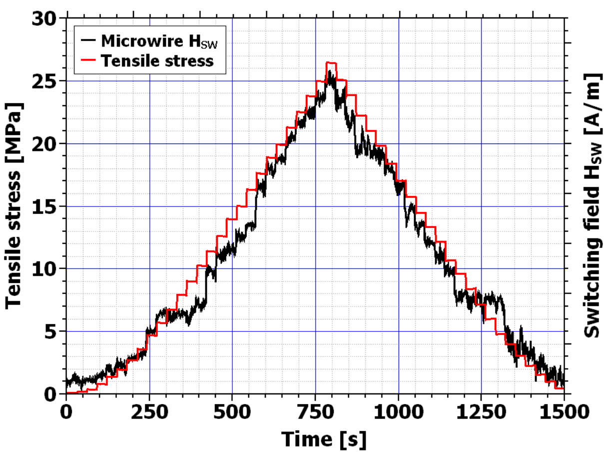

Figure 4 Tensile stress measuring with embedded microwire

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The embedded microwire reflects the tensile stress applied to the sample. Reaction to the applied stress is with no delay. It can be seen that the reaction does not clearly correspond to the applied stress. We suppose that this behaviour is caused by non-ideal adhesion between the microwire and sample. Noise of measured response is caused by chemical and mechanical properties of the chosen microwire. These properties and noise parameters are a point of our recent [4] and present research. No structural analysis was performed for this samples and it will be the point of the following research. Hardware modernisation is also in progress.

4. CONCLUSION

Presented measurement method can be used as an advanced method for laboratory testing and production quality control in a wide range of potential applications, especially in aviation. Almost every current plane has some parts of fuselage produced from composite materials. Content of composite materials can be in range from 40 % of airplane weight for big passenger planes to 100 % for ULs and UAVs. Based on presented experimental results it is clearly visible that this method is useable for detecting of the processes under the material surface. Small dimensions of microwires allow to embed them into the construction material and provide information's about the material status. The miniature cheap contactless sensor can be created and placed into different locations of the construction.

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MODEL OF HUMAN FACTORS RISKS IN THE AIR TRAFFIC CONTROL

Richard STECHA[1] - Ivan NAGY[2] - Vera VOSTOVA[3]

Abstract: *Air Traffic Controllers (ATCOs) play a crucial role in the Air Traffic Control which is considered as the most visible and flexible part of the Air Traffic Management (ATM) system. Despite all automated process and tools for ATCOs decision-making support the control of the airspace and air traffic and problem solving will remain in hands of the controllers. No system is 100% reliable and accurate and any human-provided actions can be fully supplied by machines. All decisions made by a controller are influenced by huge number of factors. Their impact varies on each person individually and it is impossible to distinguish which factor has the most significant influence on flight safety and which the less. The first part of this paper is focused on impact of objective and subjective aspects on human factors in the air traffic control. The special interest is concentrated on influence of day-time and season, air traffic type, aircraft movement phase, meteorological conditions, flight-release conditions, air traffic intensity in particular airspace. The second part concentrates of combinations of risk factors and a construction of their model. Data presented in this article contains 981 air traffic control involved occurrences records covering 2000 – 2012 years in the Czech Republic, Great Britain, Canada and United States of America.*

Keywords: *Human factors, air traffic controller, workload, risks, model*

1. INTRODUCTION

Human Factors have been defined briefly as “fitting the task to the man“ (Grandjean 1981), and “designing for human use (Sanders and McCormick, 1992), and more lengthily as “aiming to design appliances, technical systems, and tasks in such a way as to improve human safety, health, comfort and performance” (Dul and Weerdmaster, 1993). An implicit fourth and operationally interesting, definition (that with which controllers might concur) is “give us the tools and we will finish the job” (Oborne, 1992). Clearly Human Factors is about the giving the human operator an efficient working environment and tools which take account of human strengths and limitations, but it is also about selecting the most suitable operators and giving them the required skills. In this way Human Factors seek to optimize Human Performance and thus system performance, but not to the detriment of the health (physical and psychological) of the humans in the system. Human Factors can therefore be said to be “work-focused”, though they are also demands of “healthy” work.

Human Factors have its roots in applied psychology, but with substantial inputs over the years from fields as diverse medicine (e.g. to understand psychological effects on human of work systems), physics (e.g. to understand perception), engineering and design. In fact people who are working in Human Factors themselves come from a range of backgrounds such as psychology and engineering, and it is considered a hybrid discipline.

In contrast to the embracing of automation by a range of other industries, Air Traffic Management (ATM) in practice at the time remained very human focused with relatively little automation support. Nevertheless, with the evolution of computer-based systems the Human Machine Interface (HMI) became an item of central interest to the ATM community, as it was seen as desirable to replace older radar screens with systems that could super-impose more information for the controller, to enable more efficient performance. Legibility and contrast, font size and design, were subsequently the subject of research for quite a long time time. In parallel, the controllers’ workload evolved as a central issue for successful system design, arguing that appropriate design of the human-machine interface could help to reduce operators’ workload, thus contributing to overall safety and efficiency.

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The aim was to increase "capacity" (volume of traffic) in response to more public demand and accessibility to flight-based travel. It became obvious to many that Human Factors could be a key enabler to increase capacity and hence growth of the industry as a whole. The human element in the ATM systems, still the key element, should therefore receive support in order to improve performance. The Air Traffic Controllers play crucial role in the Air Traffic Control, which is considered as the most visible and flexible part of Air Traffic Management (ATM) system. The ATM comprises airborne and ground-based functions (air traffic services, airspace management and air traffic flow management) to ensure the safe and efficient movement of aircraft during all phases of flight operations. Despite the all automated processes and tools for controllers' decision-making support of the airspace and air traffic control, together with problem solving will remain in hands of controllers. No system is 100% reliable and accurate and no one can replace all human-provided actions. All decisions made by controller are influenced by considerable number of factors. Their impact on each person varies individually and usually it is impossible to distinguish, which factor had the most significant impact on flight safety and which was less important. On the other hand, the research of the Human Factors and Human Performance is very complex and takes a lot of time in the future because the issue is not closed one. Despite advances in technology, ATM is still critically dependent on the day-to-day performance of highly skilled front-line personnel, such as controllers, engineers, supervisors and other operational staff. Operational personnel safely and efficiently handle millions of flights, and effective human performance at the front line makes this to be done. [1]

2. METHOD

The study is based on wide retrospective analysis of the air traffic occurrences where controllers were involved (ATC Involved Occurrences). For the unity of data interpretation and classification the author of this paper asked for the assistance in this matter the majority of European and overseas investigation institutions and Air Navigation Services Providers (ANSPs). Several organizations had not been interested in and some denied providing the data because of their sensitivity. Thanks to positive approach of five asked bodies it was possible to summarize and analyze 981 accidents and incidents between 2000 – 2012 in the Czech Republic (Air Navigation Services of the Czech Republic, Armed Forces of the Czech Republic), Great Britain (Civil Aviation Authority), Canada (Royal Canadian Air Force) and United States of America (National Transportation Safety Board). The data are extracted from the national databases in individual format and content. The Czech ANSP (civil) data were collected directly from their internal database. The records are mostly complex and contain all time-location information, occurrence description, controller's workload, weather information and occurrence category. Other data (especially from the USA and Canada) were received as written reports containing almost the same details without incident category. This classification was assessed based on its description (distances between the aircraft, their heading, consequences) according to EAM2/GUI3 Mapping Between the EUROCONTROL Severity Classification Scheme & the ICAO Airprox Severity Scheme. Some databases contain information concerning time on duty, time after break and controllers age.

Initial normality data test was successfully checked (data have normal distribution). For statistics constructions was used IBM SPSS Statistics Base, ver. 21 software. Tested data was linearly correlated, summarized and analyzed. The risks model philosophy is based on measuring of non-symmetric difference between two probability distributions x_i and y, in other words the similarity of data is measured by the Kullback-Leibler divergence. Matlab 2007b software was used for the construction of the model.

3. ATC INVOLVED OCCURRENCES

3.1 Scope of the research

The research was focused on the Air Traffic Control (ATC) involved occurrences led to the accidents or incidents in the Air Traffic. The level of ATC involvement was considered as the main contribution (cause) of controllers or secondary role (factor) in the occurrence. The occurrences were divided into nine categories; each category was "qualitatively" described as a severity risk according to ESSAR2 – Reporting and Assessment of Safety Occurrences in ATM. The study covers Accidents, Serious, Major and Significant Incidents (Category A, B, C).

Incidents without impact on flight safety (Category E) were included only in part and the Not determined (Category D) incidents were omitted. [2]. This number covered the whole spectrum of flights, i.e. commercial (scheduled and non-scheduled), general aviation, military, instructional and special flight (e.g. aero-medical, sightseeing, positioning etc.). Analyzed factors were day-time and season, air traffic type, aircraft movement phase, meteorological conditions, Moon-phases, flight-release conditions, air traffic intensity in particular airspace. Occurrences by types and numbers are presented in the Figure 1.

Table 1 Occurrences Types and Categories

Occurrence Type	**Frequency**	**Percent**
Separation Minima Infringement	629	64,1
Controlled Flight Into Terrain	43	4,4
Mid-Air Collision	27	2,8
Ground Collision	30	3,1
Airspace Infringement	101	10,3
Another Aircraft Interference	21	2,1
Runway Incursion	100	10,2
Aircraft Mis-Identification	23	2,3
Mis-Communication	1	0,7
Total	**981**	**100,0**

The accident ratio (Controlled Flight Into Terrain (CFIT), Mid-Air Collision (MAC) and Ground Collision (GCOL) is 10.3 %. All of them occurred in the USA; 75 people died, 6 people were seriously and 3 people easily injured.

4. THE ROLE OF INDIVIDUAL FACTORS

4.1 Season, day and day-time

The density of air traffic does not remain constant during year and varies with seasons. The typical year distribution of air traffic can be characterized as continuous increase in first seven months (January – July) and continuous decrease in the next period of the year. The peak of the air traffic sets in summer and is connected with holidays and travelling of significant number of population. The highest number of accidents and incidents does not fall on summer months, when the density of air traffic is highest, but coincides with spring months. In other words: The higher number of aircraft in the airspace automatically does not imply higher number of accidents nor incidents. The number of aircraft is not the single and isolated factor. It relates with their clustering, i.e. with the density of air traffic in individual parts of the airspace – the sectors. This factor has more representative value concerning the workload of air traffic controllers.

Other important factor was a distribution of air traffic during the week. The amount of air traffic on Mondays, on Tuesdays and on Wednesdays is almost the same and reaches slightly to 14 % of all-week amount. Sharp rise of air traffic is typical for Thursdays (nearly 15 %) and this trend is followed by other increase above 15 % on Fridays. Saturdays are characterized by descend of air traffic and Sundays (13.5 %) on the contrary by increase above first three week-days. [3]. The occurrences week distribution was in line to the air traffic amount. The peak of all incident categories was observed on Thursdays, when the air traffic increase is typical; the lowest numbers were documented during weekends. On the other hand accidents during Thursdays are rare.

Furthermore there was analysed the impact of various hours of a day on the appearance of incidents and accidents. Of course, the amount of the air traffic during a day is variable and its typical distribution is characterized by the peak between 08:00 – 12:00 local time [3]. This is followed by the highest number of incidents in all severity categories with the exception of accidents. Significant amount of worst occurrences, such as accidents, falls on the period 04:00 - 07:59 hours. At this time there is not the air traffic peak but its sharp increase after minimal traffic between midnight and 03:59 leads to big number of accidents as well as the highest number of serious incidents (Category A) in comparison with the rest of periods of a day.

4.2 Weather and flight rules

Weather plays in the aviation very important role in the aviation. Adverse meteorological conditions can influence not only planned aircrafts route (vertical and horizontal) but their unexpected changes can lead to dangerous situation in flight. The basic weather characteristics are visibility, clouds ceiling, sky coverage by the clouds, wind direction and speed, temperature and significant weather phenomena (storm, rain, snow...). The accidents/incidents reports were very often reluctant to specify all weather details. When the weather contributed to an occurrence, it should be mentioned in the report but sometimes the information concerning weather conditions is absent. Therefore, the meteorological significant information was interpreted in three main groups (1 – weather was ideal, i.e. visibility more than 7 km, ceiling above 5 km, clouds coverage to 2/8, no significant wind), 2 – weather had not any impact on the occurrence but was not ideal, i.e. visibility 4 – 7 km, ceiling 3 – 5 km, clouds coverage 3/8 – 5/8, no significant wind, 3 – weather had significant impact on the occurrence and was observed at least on dangerous meteorological condition (strong wind, low visibility or ceiling etc.). Correlation between the weather and occurrence categories was significant at 0.01-level.

Absolute maximum of occurrences was documented in meteorological conditions described as “normal weather”. Absolute minimum of all occurrences was reported during adverse weather. On the contrary, the highest number of accidents was observed when the weather was ideal, i.e. without dangerous meteorological phenomena. These data are interesting because it is probable that controllers in ideal weather are reluctant to admit the possibility of safety problems. On the other hand, during adverse meteorological conditions they (and air-crews as well) are more able to take into account the severity of the situation and the number of incidents is significantly decreasing. Flight rules (visual or instrumental) had not any significant impact on the occurrence arising nor their category. It turned out, that types of flight were also analyzed and none special type proof significance for occurrences rising as well.

4.3 Controllers workload

Workload is an important focus because errors can be induced if mental task demands exceed the capabilities of the human operators. In this way, the consequences of these errors might be critical and detrimental to safety. Workload might simply be defined as the demand required from the human operator. This definition, however, is overly limiting because it only includes the requirements generated by external sources (e.g. task difficulty).

In order to address workload completely, it is also necessary to consider demands generated internally that compete for an operator’s resources. Therefore, an appropriate human factors definition of workload is: Workload is the demand placed on an operator’s mental resources used for attention, perception, reasonable decision-making and action. [4].

The controller’s workload is subjective sensation (impression) and has not any accurate measures. According to occurrences reports was controllers workload level assessed as the level of the air traffic controlled by them (1 – low workload, 4 – the highest workload). Task demands are not a single factor that can affect the effort required by a task. The time on task for a given task demand will also affect the performance as well as the workload of the operator. The workload increases as a function of time, even if the task load is stable. After a variable threshold of time, resources are exhausted and an increase in workload and breakdown in performance are likely to occur. The operator gives up or “sheds” the least significant parts of the task in order to make workload more manageable. [4].

There are two extremes, very light traffic (low workload) and very intensive traffic (high workload). These extremes are connected with very low number of occurrences; number of accidents is practically zero. Logically, serious incidents are the most frequent occurrences during high workload of the controllers. The alarming information is frequency of accidents and incidents of all categories in positive conditions – workload/traffic felt as normal closer to low. The reason is in unintended lowering of controllers’ awareness and their feeling that “anything could not happen” in these good conditions.

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4.4 Phase of flight

Airports are locations with higher frequency of occurrences in comparison with en-routes. It is reflected in the phase of flights involved in accidents or incidents. Most occurrences are connected with aircraft approach and descent for landing. Those phases of the flight are from controllers' perspective the most challenging due to the number of aircraft, their different headings, altitudes, vortex-categories and speeds. The right aircraft sequencing for this maneuver is crucial and the probability of controllers' or pilots' error rises. The safest phase of aircraft movement is taxiing. Despite this assumption occurrences connected with mentioned phase of flight (especially ground collisions and runway/taxiway incursions) are more frequent, than en-route contingencies, yet their consequences being not severe.

5. THE RISKS MODEL

The risks model is based on computing the Kullback-Leibler divergence between data measured in different occurrence situations. Occurrences in the air traffic control are modeled in dependence on other measured variables observed in particular occurrence. The aim is to identify variables with significant impact on the occurrences and which values imply occurring of critical situations in the air traffic control. According to descriptive statistics results (see above) there were four most significant variables entering the modeling, i.e. time ($x_{1;t}$), weather ($x_{2;t}$), phase of flight ($x_{3;t}$) and traffic ($x_{4;t}$), controllers' workload respectively. Categorization of time (6 blocks per 4 hours), weather (3 degrees), phase of flight (4 degrees) and traffic (4 degrees) is the same as described in part 4. Modeled output y_t is classification of occurrence. For purposes of the modeling are occurrences categorized into 3 output groups – group 1 represents accidents and serious incidents, group 2 represents major and significant incidents and group 3 represents no safety effect incidents.

At the beginning there is data set of 981 records. Training group of secondary inputs is divided into x^i clusters (1, 2 or 3 in-line with output). We observed differences among of inputs in each particular cluster.

For discrete probability distributions y and x, the Kullback-Leibler divergence is defined to be

$$KL = \sum f_i \ln \frac{f_i}{g_i} \tag{1}$$

where ***f*** and ***g*** are distributions of data for different occurrences.

All inputs are discrete therefore their distributions will be characterized by normed histograms (see Figure 1).

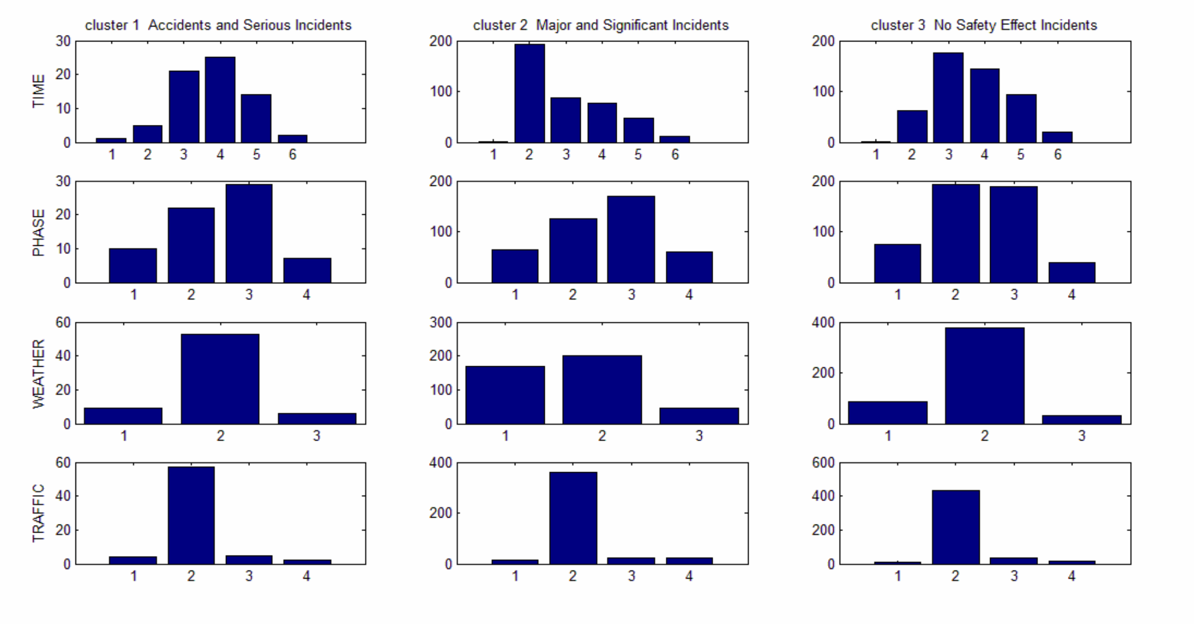

Figure 1 Histograms of modelled output

Table 2 Kullback-Liebler Divergencies

x_1 = time		
0	0,3840	0,0444
0,5671	0	0,3409
0,0387	0,2633	0
x_2 = phase of flight		
0	0,0074	0,0110
0,0080	0	0,0302
0,0111	0,0279	0
x_3 = weather		
0	0,2048	0,0098
0,2495	0	0,1772
0,0102	0,1587	0
x_4 = traffic		
0	0,0209	0,0187
0,0204	0	0,0088
0,0142	0,0082	0

KL Divergences among the clusters from the variable x are small (1-2, 1-3 and 2-3), therefore traffic has not any significant impact on occurring of one special class of accidents and incidents. Model interpretation of the other histograms leads to these results: The biggest values of divergence were observed between clusters x1 and x3 for values 1 and 2, and values 2 and 3, which means that the most significant impact of weather prevails within Major and Significant incidents. The phase of flight x2 has no importance within the safety effect incidents.

6. CONCLUSION

The air traffic density on particular days of the week and particular periods of time (peaks and saddles) affects the frequency of occurrences. The majority of occurrences were observed at airports and in their vicinity during final approach and landing. This phase of flight is the most critical for controllers as for pilots. Airports' traffic contributes to the occurring of accidents and incidents. The period of year had no impact on incidents' occurring. Higher workload did not implicate higher amount of incidents. The most of them appeared during normal operational workload. Proper arousal (i.e. no under- or overload) is vital to fulfil all controllers tasks at requested quality. Flight releases had no significant impact on accidents or incidents occurrence; the distribution was identical for visual and instrumental flight rules. Mathematical risks model considers as the most critical factors day-time and meteorological conditions for Major and Significant incidents. Significant impact of the other analysed variables was not discovered.

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THE POLICY OF ALLOCATING TRAIN PATH IN THE LIBERALIZED CONDITIONS OF RAIL MARKET

Ondřej ŠTĚPÁN[1] - Tatiana MOLKOVÁ[2]

Abstract: *The article deals with problems in system of capacity allocation and train paths in liberalised condition of rail market mainly in process of preparation the annual timetable. Here are identified current problems from point of the Czech Infrastructure Manager (Railway Infrastructure Administration, state organization) which can lead to decreasing of the quality of the railway transport system. In the article are further analysed the similar processes in different European railway infrastructure managers. Possible solution of problem is given at the end. This solution should lead to stabilization of system and defining the exact rules leading to increase of quality standards in railway transport system.*

Keywords: *train path, liberalized rail market, path allocation, transport policy*

1. INTRODUCTION

In liberalized railway market is especially, around the large agglomerations and major transport routes, overloading to infrastructure. Connection of these agglomerations makes strong transportation demand and carriers in segment of public long-distance transport on railway line connecting these agglomerations between themselves compete for getting the largest share of the transport market. If several carriers operate in long-distance railway line, the capacity of the infrastructure in immediate vicinity of agglomerations and quality of other segments of railway transport (suburban and cargo) are reduced.

With progressive opening access to the railway transport market, which happens within meaning of traffic regulation 2007/58/ES, it is necessary regulate approach from carriers. The aim of regulation should be establish such rules of capacity allocation of railway line for carriers to railway transport remained attractive as a whole and not just in a lucrative segment, especially in segment of long-distance transport.

2. ANALYSIS OF ALLOCATION OF PATHS IN PROBLEMATIC PARTS OF THE INFRASTRUCTURE IN THE CZECH REPUBLIC

The first line, in which trains are operated on commercial risk of carrier, is line Praha – Pardubice – Olomouc – Ostrava (see Fig.1). Problems with capacity of railway and decrease of quality of suburban and cargo traffic around Praha and Ostrava go hand in hand with open of market. Alluded segment of infrastructure is situated on tracks of European transit corridors. In view of technical equipment of infrastructure are those tracks in high technical standard (electronic safety interlocking system, speed to 160 km/h).

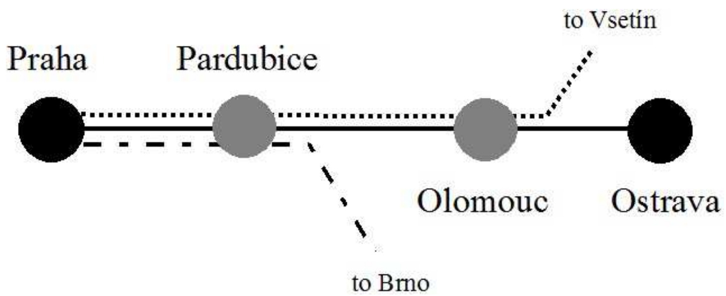

Figure 1 Scheme of railway line Praha - Ostrava. (Source: Author)

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Around Praha are in this track using up another long-distance lines from South-East and lines of suburban traffic. Only on line Praha – Ostrava in timetable 2013 are 3 carriers, which have almost identical policy of stopping on stations. Everyone practice their trains in 2 hours periodic timetable (in top time in 1 hour tact). It follows that peak time in this line is offered 3 trains per hour. At some parts of line it is possible to extend this offer of trains operating on lines Praha – Olomouc and Praha – Pardubice – Brno. Thanks to these other trains are on part between Prague and Pardubice in the peak time offer to 6 long-distance trains per hour. Example of this situation is shown in the Table 1.

Table 1 Departures of trains of long-distance line from Praha hl. n. in direction Pardubice between 16:00 and 17:00.

Line	Departure from Praha hl. n.
Praha – Pardubice – Olomouc – Ostrava	16:09, 16:12, 16:16, 16:29
Praha – Pardubice – Olomouc (– Vsetín)	16:47
Praha – Pardubice (– Brno)	16:39

Source: Author, [1]

If is added suburban traffic around Prague to this trains, capacity of infrastructure is up to the limit. Total number of trains in most workload part between stations Praha-Běchovice and Úvaly is on Figure 2. Surveyed part has 3 track lines, where track No. 0 is using for changing of stronger direction in long-distance traffic.

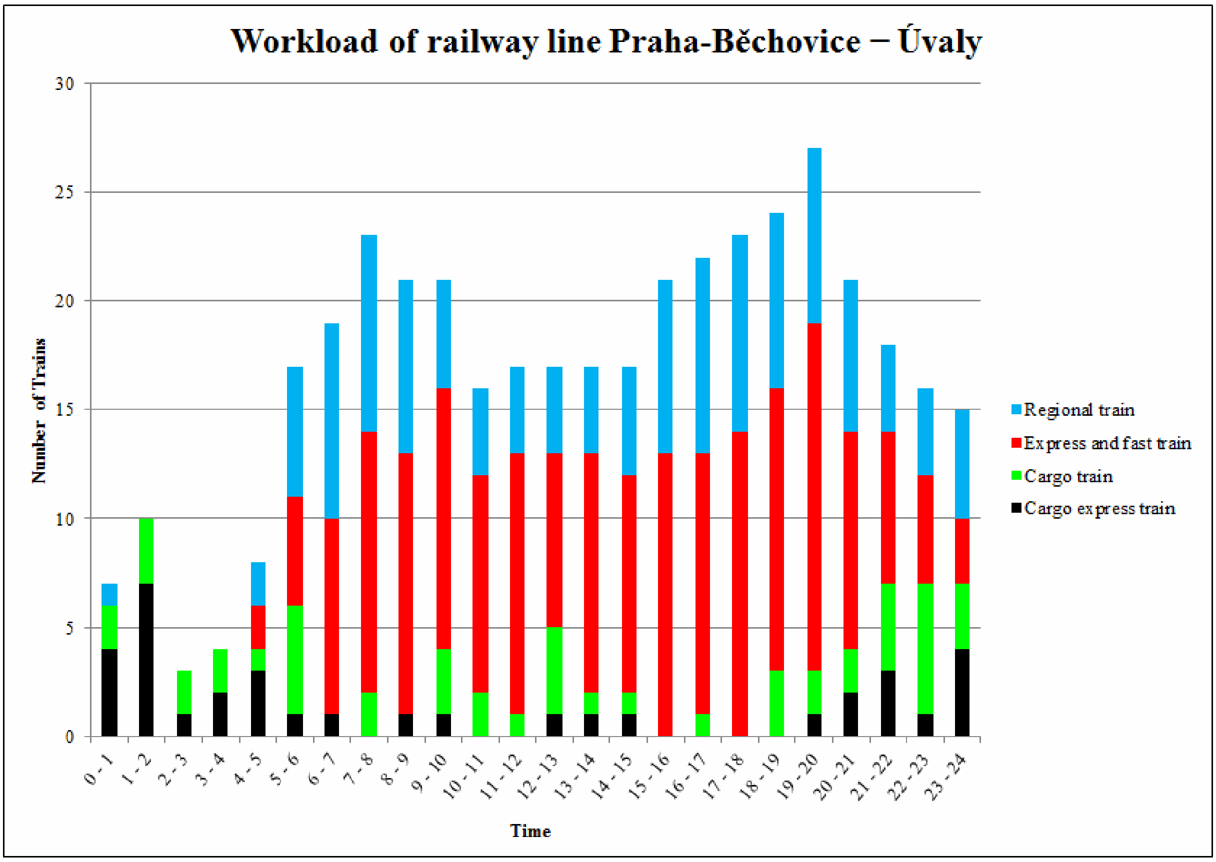

Figure 2 Workload on part of track line Praha-Běchovice – Úvaly. Source: Author, [1]

On the Figure 2 it can be seen that cargo transport is marginal share. In consequence of strong long-distance traffic and suburban traffic is impossible allocate paths for cargo carriers. For cargo carriers, which have trains with point of departure or terminal station in junction Praha, are allocated paths only at night. Carriers of transit cargo trains have to use bypass paths out of the junction Praha.

These paths aren't so high technical standard like corridor tracks and carriers can't make full use of the technical possibilities of their vehicles. From workload of this hurt part it can be seen that timetable is in view of stability of traffic unstable. In the case of a train delay, this delay is transferred to other trains and thereby (thanks to the traffic density) reduces quality of traffic.
In area of Ostrava agglomeration is reduced regional traffic because of strong long-distance traffic on Praha – Ostrava line. In part Prosenice – Ostrava on the railway line except Praha – Ostrava line are operated long-distance trains Brno – Ostrava (1 hour periodic timetable in whole day). At morning peak time in the regional traffic occurs to long stays in stations due to passing trains for long-distance traffic. In the Table 2 is shown comparison of 2 trains, where first one is in traffic peak time (train No. 3306) and second one is on traffic saddle time (train No. 3301). From comparison of section speed it is evident that in traffic peak time section speed decreases up to 20 % compared to trains in the traffic saddle. This situation reduced quality and attractiveness of regional traffic for passengers.

Table 2 Comparison of section speed of regional trains on railway line Ostrava-Svinov – Prosenice.

Train	Route	Total stays [min]	Section speed [km/h]
3306	Ostrava-Svinov (6:33) – Prosenice (7:47)	23,5	57
3301	Prosenice (4:31) – Ostrava-Svinov (5:29)	7	73

Source: Author, [1]

To put railway transport remained on overloaded parts of the infrastructure attractive for all segments of transport and there was no major qualitative differences between individual segments, it's necessary to set rules for allocations of paths at composing of timetable. These rules should lead to uniform load of infrastructure and to harmonized development of all segments of railway transport on liberalized market.

3. APPROACHES TO THE TRAINS PATHS ALLOCATION OF CONGESTED SECTIONS OF THE RAILWAY INFRASTRUCTURE

The following section is an overview of procedures infrastructure manager in the annual timetable in respect of requests for each conflicting paths and procedures at overloaded sections of the railway infrastructure.

3.1 Czech Republic

Infrastructure manager in the Czech Republic is Správa železniční dopravní cesty, s. o. (hereinafter "SŽDC"). If request, which are in conflict between themselves or which are situated on overloaded parts of the infrastructure, are submit, SŽDC suggests another path for carriers.

The primary key to determining the order of priority in the coordination of train paths is the following order:

1. public railway transport to ensure transport needs of the state,
2. public railway passenger transport to ensure transport service within the territory of the region,
3. combined transport,
4. rail transport in the extent of the framework agreement
5. regular international passenger transport,
6. regular international freight transport.

In case that after coordination of paths isn't possible suit requests of carriers for allocations paths SŽDC declares auction of these paths and one of carriers can get it.

Source: [2]

3.2 Slovakia

In Slovakia infrastructure manager is Železnice Slovenskej republiky. Requests of allocation of path, which are in mutual contradiction, are solving by so-called coordination consultation. In this part is the crucial moment date of submission of request.
In case that request is in overloaded part of the infrastructure is using following order:

1. public passenger transport on the railway infrastructure in order to provide for the transport needs of state or basic transport services of the regional country district,
2. international transit transport on the railway infrastructure,
3. combined transport.

Source: [3]

3.3 Poland

Infrastructure manager is Polskie Linie Kolejowe S. A. (hereinafter "PLK"). When requests of allocation of path are in mutual contradiction, PLK get talks over to hurt carriers. Generally in composition of timetable is following hierarchy of paths for processing requests:

1. passenger qualified trains and international,
2. passenger inter-regional and regional trains providing morning commuter service i.e. trains with arrival to indicated station between 5:30 and 8:30 a.m.,
3. other passenger inter-regional,
4. passenger regional trains providing evening commuter service i.e. trains with departure from indicated station between 2:30 and 4:30 p.m.,
5. other regional passenger trains,
6. freight priority trains for which priority over other freight trains during train path allocation and traffic regulation was requested by the applicant in train path application,
7. freight trains,
8. empty passenger trains and light locos.

If requests of path are in overloaded part of infrastructure, PLK can declaim auction for this path. Along the way of coordination of paths is possible on overloaded part of infrastructure allocated path for carrier in different time, train category or restrain stopping of train in problematic part.

Source: [4]

3.4 Germany

Infrastructure manager is DB Netz AG (hereinafter "DB"). In solving conflicts of competitive paths DB tries to move required path in public transport in interval ± 3 min and in cargo transport ± 15 min. In case that with this way isn't found possible solution, DB gets talks over to hurt carriers. If in this step isn't found solution of conflict of paths too, DB coordinates paths in following order, what is same with coordination requests of path in overloaded parts of the infrastructure:

1. regular-interval or integrated network services,
2. cross-border train paths,
3. train paths for freight traffic.

Source: [5]

3.5 Austria

Infrastructure manager is ÖBB Infrastruktur AG (hereinafter "ÖBB"). In allocation of paths ÖBB proceeds just as in Slovakia so important is date of request of path. When the date in different requests is same, ÖBB gets talks over to hurt carriers. If isn't found compromise ÖBB use following order:

1. path based on a framework agreement, where this path is necessary to fulfill the commercial conditions laid out in the framework agreement,
2. paths for fixed-cycle traffic and paths crossing a national border in accordance,
3. other paths.

In certain parts of the infrastructure (mainly overloaded parts) in process of coordination of requests of paths ÖBB can look at total range of transportation of each carrier or at total length of path. In this case it is prefer path for length mileage.

Source: [6]

3.6 Switzerland

Schweizerische Bundesbahnen (hereinafter "SBB") is infrastructure manager in this country. Requests, which are in conflict, are solving in conference of hurt carriers, which arrange SBB. In coordination of requests and paths of trains it has to preserve unified network periodic timetable in public transport. Then it is possible prefer paths, which are during validity of timetable several times. Trains of cargo transport for which is impossible find alternation path (of technical reasons) are preferred before other cargo trains. SBB can in overloaded parts of the infrastructure allocate each path based on public tender.

Source: [7]

3.7 France

Infrastructure manager in France is Reseau ferré de France (hereinafter "RFF"). In coordination of requests of paths RFF get conference between hurt carriers, when theirs requests are in mutual conflict. For coordination of requests of paths and their processing in annual timetable are applied following rules:

1. national and international paths leaded completely or partially in nationwide network designed for these paths,
2. international cargo transport,
3. paths for satisfying of needs in public commitment.

In case of overloaded infrastructure RFF prefers requests of paths in systemic timetable (as for public trains as cargo trains) and further carriers which have requests of paths for more than 200 days and discharge following criterions:

- have entering into general agreement with RFF
- for paths is demanded systematic timetable.

Source: [8], [9]

3.8 Netherland

Infrastructure manager is ProRail BV (hereinafter "PR"). In solving of mutual conflicts of requests of paths PR challenge hurt carriers to give him suggestion for solving this conflict. In requests of international paths are regarding times of departure/arrival on border station as fixed point and with this cannot be moving.

Source: [10]

4. ADJUSTMENT OF PRINCIPLES OF ALLOCATIONS PATHS IN OVERLOADED PARTS OF THE INFRASTRUCTURE IN THE CZECH REPUBLIC

Accesses of each of infrastructure managers in European countries are very similar. Analysis of information from individual network statements in chapter 2, shows that access to coordination of requests of paths in the Czech Republic is set good. Problems, which exist on the network and which are described in chapter 1 of this article, are brought on by no respecting regulations, which are adduced in these network statements. For improvement of utilization of permeable capacity of railway lines and for improvement of quality of various segments of railway transport should be suitable to accept some of next provisions.

4.1 Penalty of different path

In every part of railway line is choose representative path, which is define as standardized path. This standardized path has been rise from family of trains, which are the most frequent in hurt railway line. Into this family it is possibly include trains with similar characteristics, especially with comparable section speed. These trains are very similar in view of permeable capacity and timetable, which is composite from these trains, is very near of parallel timetable. Utilization of infrastructure is also uniform. In case of insertion of paths, which are very different with their characteristics from standardized path, comes in not only to negative effect in permeable capacity in hurt part of railway line, but also to decreasing of quality of transport segments, which has majority on the railway line. These paths, which are illustrated on the Figure 2, can be charge with penalty.

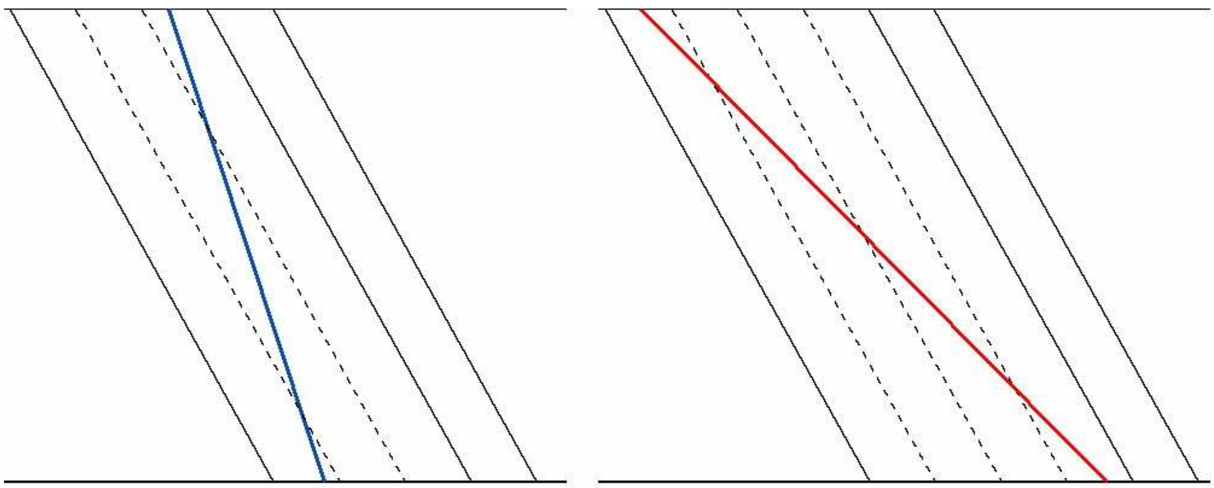

Figure 3 Example of different paths (fast train and slow one).

Source: Author

Charging of penalty is possible by 2 ways. The first one is charging into price of transport route. The second one is reduction of priority of train in composition of timetable. This second approach can be use especially at paths, which have their characteristics under level of standardized path.

4.2 Consistent utilization of auction of paths

In case when carriers have wholly identical demands on requests of allocations of infrastructure capacity, especially in time position of path, it is necessary consistently observe regulation of network statement. Carriers at bottom are requesting for one train path. In case, when in mutual negotiations between infrastructure manager and carriers is not possible to find acceptable solutions, infrastructure manager declares auction of this path. The path is allocated to carrier with the highest offered price.
Pitfall of adherence to auction of paths is possibility of disadvantages of carriers with small capital. It could be targeted price increases by the carrier, which has an important market share to the point, where other carriers haven't offer the possibility of overcoming. From this reason is necessary this process about allocating of conflict paths system partially regulate.
Current access of infrastructure manager, when in case of more requests of the same path on one railway line are requested paths moved in a matter of a few minutes, influence negative whole system. These trains are going in short sequence consecutively (see Table 1) and their influence is very negative especially to the quality of the others segments of transport, which are operating in the same railway line.

4.3 Legislative measures

In view of maintenance and rising of existing share of railway transport in total transport volumes it is possible legislative prioritize certain segments of railway transport at the expense of others in the process of allocation of railway infrastructure capacity. Segment, which has large potential and it isn't support by legislation, is higher speed cargo transport. The vast majority of passenger trains, both long-distance, regional or suburban, is operated in order to ensure that the transport needs of the area. In section of cargo transport isn't any advantage like this in the Czech Republic.
The large influence to development and improvement of transport volumes in cargo transport has transport of units of intermodal transport, especially containers and semi-trailers. Their technical characteristics of trains are similar to passenger regional trains. If trains of intermodal transport have been included on the level of trains to ensure transport needs of the area, it's possible accelerate their transit mainly in overloaded parts of the infrastructure. These trains should be preferred even before the trains kept on commercial risk carrier.

5. CONCLUSION

In order to maintain a competitive railway transport position on the transport market, it needs access to all segments of the railway evenly. Control quality without discrimination of segments of railway transport and so keep their attractiveness for end costumers can set an appropriate policy of allocating train paths to carriers.

In terms of open railway market it's necessary to provide clear rules to carriers by which the path will be allocated in conflict situations and overloaded parts of the infrastructure. On railway lines with homogeneous or heterogeneous (train paths are parallel) traffic it's advisable to choose a method of penalty of different path. In cases, when carriers request allocation of one path and is impossible achieve a satisfactory outcome agreement, auction of path is a suitable method. Changes to legislation should be in the process of allocating train paths hit mainly if it is necessary for the sustainability of the transport market to favor certain segments of the railway in front of others to be attractive and competitive with other types of transport (cargo transport).

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CZECH APPROACH TO SMART PUBLIC TRANSPORT

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Abstract: *Public transport in the Czech Republic is used by the 34 % of the passengers which is the highest number in the EU. This success began with the development of integrated transportation systems at the beginning of 90ties of the 20th century. Nowadays the individual systems formally administrated by counties (municipalities) are integrated at different levels. The main goal for the near future is to keep existing users on board. Public transport in the Czech Republic teeters on the edge - a new urban passenger is gained with difficulties and existing users can easily leave. That is why the public service needs to offer new benefits for its users, right and in-time information and integration of single transport providers in information and payment services.*

Keywords: *public transport, real time information, multimodal journey, data.*

1. INTRODUCTION

The paper is to present a concept of pan European multimodal journey planner and the proof of the concept coming from the national and European research and pilot operation in the Czech Republic coming from project JSDV "unified data system in the public passenger transport in the Czech Republic" (2011-2013). The project aim is a conceptually built telematics system with a standardized interface that allows integration of data in real-time information to the systems of a carrier / integrated transport system or operator / road administrator systems. In the frame of the project the design of the central system is being made with the possibility to integrate existing systems (based on non-standard solutions) and simultaneously support official implementation of a national standard to set out conditions for unified solution and obligations to share specific data with the central system (the system is to share real time data only that are to be paired with static data in CIS). The design considers that the central system, called CISReal, is to be interconnected with adjacent systems and to enable mutual sharing of data in a centralized form. Primarily the project is focused on inner architecture of the system - data format, data protocols, unified terminology, unified numbering systems etc. In its final form the system is to be ready to share data with foreign systems on the basis of SIRI.

2. STRUCTURE

2.1 Concept of pan European multimodal journey planner

The White paper [1] sets several long term targets. Target 8 is to achieve three bundles of services – a pan European multimodal journey planning, booking and payments by 2020. As the market is very complex and the deadline close there should be a mass central support from the side of EU as such services importance can be compared to that of Schengen's free movement of people.

The easiest service and so the first one to be implemented of the three above is multimodal journey planning based on static (planned) and/or real time public transport (PT) data that is shared among a big number of various transport carriers or PT systems. The first challenge for such a European service is to collect static timetable data throughout Europe then to follow up with real time data where available. Such steps cannot be made without a proper pan European legislation act that poses a duty on every carrier in EU space to provide his/her schedules preferably to the local centre. More to proceed with pan EU data sharing the proper data format and communication protocols should be stated, based on European standards. As such the time till 2020 is suddenly very close.

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2.2 PT data distribution – distributed versus centralised

PT data distribution among so many PT players causes a significant problem of reliability and timing of the data and the proposed system of communication among each other raises high requirements on data amounts to be exchanged in real time and increases the complexity as well as cost of relevant software solutions. The distribution model expressed in NETEX and SIRI models [2] can be operational in the local contexts but for EU wide systems it cannot simply work. The main reasons for that is high cost of modification of PT carriers' existing systems and high cost of communication when operated. In this light it is much more convenient to "insert a new layer" into the organizational scheme of future EU wide PT services – national centres. The centralised solution brings strict and well functional organization, simplification of running processes, low cost implementation in PT carriers' systems, and concentration of data in EU on several systems only which has the valuable profit mainly for mobile apps developers on one hand and PT control centres on the other, the profits are described in detail further below.

2.3 European obstacles – lack of suitable regulations

Due to subsidiarity principle in the European Union it is rather obvious by the EU COM to leave shift to public transport targets to the regional/ local levels. The policy/ political goal (normative level) of the European Commission policies is in addition „not curbing mobility and transport" in the white paper 2011. So it is rather hard to pose a regulation on PT carriers' information system in European scale within the existing structure.

As the obstacles of regulation concern the existing PT carriers level it is inevitable to create a special new entity that can be regulated from EU level and at the same time to regulate PT information on national scales. Such a concept enables EU to set up the rules for data sharing, influence the operation of the new entities by a proper financially support and so to open the market of PT information for business driven solutions. The new entities – national PT data centres – can bring substantial value to the market as they could:

- collect all the relevant information in various data format,
- convert the data in the standardized format,
- distribute the data in the standardized format to local level carriers/control centres,
- share the data with the other national centres via a standardized interface,
- provide open data to relevant stakeholders (Traffic control centres, apps developers, booking and payment business partners and many others).

Creating a network of national centres as the new PT transport systems layer (its feasibility is described further on) is a very promising solution of pan European services provision and opening of the market.

2.4 The truth of open data phenomenon

Open data concept is a phenomenon these days and its benefits are more than obvious [3]. For a strong and self-operating entity, as TfL for example is, it is a logical step to open the already processed data to e.g. apps developers as the profits are visible [4]. The already spent money for TfL transport operation data processing means that are no big investments in opening the data.

Totally different situation is within a regional/national scale as there are many entities (carriers) with no centralised solution. To share their data in a proper form there should an extra entity (a centre) that provides a service of data collection, data processing and conversion and its distribution. If such an entity is paid for this service the data can be made open. If there is no financial support from public funds the data stays not-open as it is a subject of a business.

This fact has been proved within Czech Republic national concept being operated for more than 20 years. The actual debate of open data in national scale brings the unanswered question of who is to pay for making the data open as the existing data service provision is based on multimodal journey planner service provision paid by advertisement within the website.

Creating a network of national centres financially supported by EU makes PT data in EU scale open and enables various business driven services to happen.

3. NATIONAL CENTRES CONCEPT

3.1 Context

The centralised solution brings many benefits and is well experienced in the Czech Republic solution, which is a main, research, subject of this paper and is described below [6]. The centres are to solve the problems of data sharing in common data formats within national scale step by step and so the problems stay at the national level only and will not prospect into EU level. The scalability of data sharing is also convenient. The centres can share the data that is needed only (e.g. cross border PT transport data) and their amount is fairly low so the related operational costs in comparison with the existing concept of many-to-many data share (distributed systems).
The centres can redistribute the data on national/local level and so to enhance the integration of PT systems/carriers to better control the traffic and provide significant savings in fleet management. Also the benefits for users are to be born. As the network of national centres provide a limited number of potential data feeds and more the data is provided in a standardized format the coding of a mobile multimodal journey planner and other relevant apps is much easier and brings the potential of a broader use. Local mobile app providers can deliver new subscriber services in local context (as e.g. for TfL) but their apps can be operational also in international context; i.e. an end user can use its mobile application he/she is used to in local context, in his/her language and so to plan his/her trip in international scale easily even he/she is not well familiar with local PT transport (mainly when travelling abroad).
The national centres should be built on already existing initiatives (e.g. national platform IDOS for the Czech Republic [7], Transport Direct for UK [8], etc.) and profit from already existing regional sustainable mobility solutions, i.e. control centres incorporating other means of transport than public to support local mobility patterns change (e.g. MOBILITAMI, 9). Such initiatives should just incorporate standardised interfaces to be able to communicate with their local systems as well as other national centres within this new pan European network.
To start up the process and achieve the goal of 2020 the quick and thorough EU investments in building the national centres network as well as a supportive legislation and standards are crucial

3.2 Proof of concept – the results of the research project JSDV (6)

The concept presented above comes from the successful solution of CDV research. The project JSDV builds on the best multimodal journey planner in EU (IDOS, awarded in EU challenge in 2012) and the standardized solution respecting CEN standards [2]. The Czech Republic has the highest ratio of travellers using public transport (34,2 %, 10) which is mainly achieved by long term provision of reliable and nation-wide PT transport information through the hugely used web and mobile platforms of IDOS (65 M views of unique pages (i.e. cca 20 million of users) per month).
The scope of the project is a conceptually built-up telematic system with a standardized interface that enables the integration of data in real time for the benefit of carrier/system organizing several carriers (Integrated transport system (IDS)) or operator/manager of the road/rail. The project has designed and pilot-operated “the Central system with PT real time data” (CISReal)[5]. that should be operable in national scale. The title of the system comes from already operating system (CIS JŘ) that is the complex database of static/planned journey schedules with 20 year successful operation on national scale.

3.3 CISReal – a national PT data centre with the standardized interface

The basics of CISReal is to share real time operational data with the possibility to integrate the systems already running (but not in a standardized manner) and support official implementation of the guidelines for setting up the terms and conditions for a new (unifying) standard on how to provide the data and the duty to share specific data with the central system (CISReal). The system is designed in a unique way that respects the already implemented and operated aspects of the Czech Republic (existing national predispositions) and also the basic specification and elements of EN 12896 TRANSMODEL and CEN TS 15531 SIRI which assures European interoperability.
So, besides the pilot implementation, the standard for existing systems of the carriers to share real-time data with the central system has been worked out as a national standard, notified in Brussels . The standard is the corner stone of possible future step-by-step implementation of CISReal into nationwide

system. The standard has quickly become the backbone of actual public tenders on PT control and information centres in several regions for communication interface among various entities – a big city agglomeration PT carrier system and regional level systems incorporating local carriers' systems. The existence of the standard as the key output of the research enables a quick and rather low cost implementation of the interface into the existing systems of local carriers and as such stimulates the integration of PT information systems into a central PT real time data share solution.

3.4 CISReal capabilities

The proposed solution takes into account the import of dynamic data from connected periphery systems that are to be paired with static data of CIS JŘ. The interconnection of the two kinds of data (real and planned) is made in a modular database of complex PT information (with the possibility to add functional services) with standardized interface for data sharing with third parties. The central system is to connect to adjacent systems to get the data from but also to share the data with all the participating systems.

4. CONCLUSION

Cities have been the engine of human development for thousands of years and they remain at the heart of our economy today [7].
Given that today more than half of the population lives in cities, it is necessary to continuously improve the services offered to transport and proceed in implementing ITS systems.
It is necessary that the passenger is increasingly seen as a key partner and that the services offered should be continuously improved. The passenger is still just a man and so his requirements are different. It is therefore essential to continue research that is aimed at determining the real demand for services and classification of different types of passengers and their requirements and to quantify them.
An important step in determining these requirements is a centralized information system, thanks to this solution it will be possible to obtain historical data and the organization and planning of services offered could be improved.
The primary requirement remains on to allow the passengers to get reliable information in real time and ensure a possibility to use another connection at transport nodes. The obvious follow-up that could business driven is booking and payment services complemented with other relevant services. The centralized information system is thus the first step to be made to even think about this new market development, it is much more serious and complex if considering such a system in pan EU scale.
Real time information services are becoming a standard service in cities, now it is the time to set up the rules for such systems build-up and integration and the Czech Republic shows the great success of the solution in national scale and could be a reference to achieve EU targets efforts. To create a pan EU multimodal journey services it would be of importance to start quickly, preparing a proper legislative measures and EU budget support to be able still to tackle 2020 goals.

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PASSIVE SAFETY DEVELOPMENT OF PASSENGER CARS

Adam TOROK[1] - Tibor SIPOS[2] - Katalin TANCZOS[3]

Abstract: *Safety is the study and practice of design, construction, equipment and regulation to minimize the occurrence and consequences of accidents. Road traffic safety more broadly includes roadway design elements. Improvements in roadway and automobile designs have steadily reduced injury and death rates in all first world countries. In this article authors have investigated the development of passive safety in passenger cars by mathematical tools.*

Keywords: *passive road safety, statistical analysis, seatbelt wearing, airbags*

1. INTRODUCTION

The Commission has adopted an ambitious Road Safety Programme which aims to cut road fatalities in Europe between 2011 and 2020. The programme sets out a mix of initiatives, at European and national level [1], focussing on improving vehicle safety, the safety of infrastructure and road users' behaviour. Road Safety is a major societal issue. In 2011, more than 30,000 people died on the roads of the European Union, i.e. the equivalent of a medium town. Vehicle safety is identified as a key strategy by the EU towards addressing the EU-wide goal to reduce deaths by 50% by the year 2020. The key initiatives are not only pushing the car manufacturers to produce safer cars but to change drivers' behaviour to use the safety restraints systems to drive safer [2]. In this paper authors have investigated the development of passive safety instruments in passenger cars by mathematical tools.

2. METHODOLOGY

Based on National Statistic Office large quantity of statistical data were collected between 2002 and 2012 and analysed in this paper. In order to investigate the long term effect of developed passive safety not only the caused economical externalities can be calculated [3] but the cumulative accident index can be determined for each year:

$$CAI = \frac{\overline{\omega}_1 \cdot N_{fatal} + \overline{\omega}_2 \cdot N_{serious} + \overline{\omega}_3 \cdot N_{light}}{N_{fatal} + N_{serious} + N_{light}} \tag{1}$$

where: CAI **C**umulative **A**ccident **I**ndex,
ω_1 weight of fatal accidents (in this case ω_1=5),
N_{fatal} Number of fatal accident,
ω_2 weight of serious accidents (in this case ω_2=3),
$N_{serious}$ Number of serious accident,
ω_3 weight of light accidents (in this case ω_3=1),
N_{light} Number of light accident.

So it can be summarised CAI is an average weight of the accidents per year. The index can be by definition between 1 and 5. If it is closer to 1, then the accidents were less serious in that year. Furthermore the willingness of seat belt wearing (*Figure 1*) and airbag penetration (*Figure 2*) were investigated. The willingness of seat belt wearing is analysed in Hungary from 2002 on a yearly base [4, 5].

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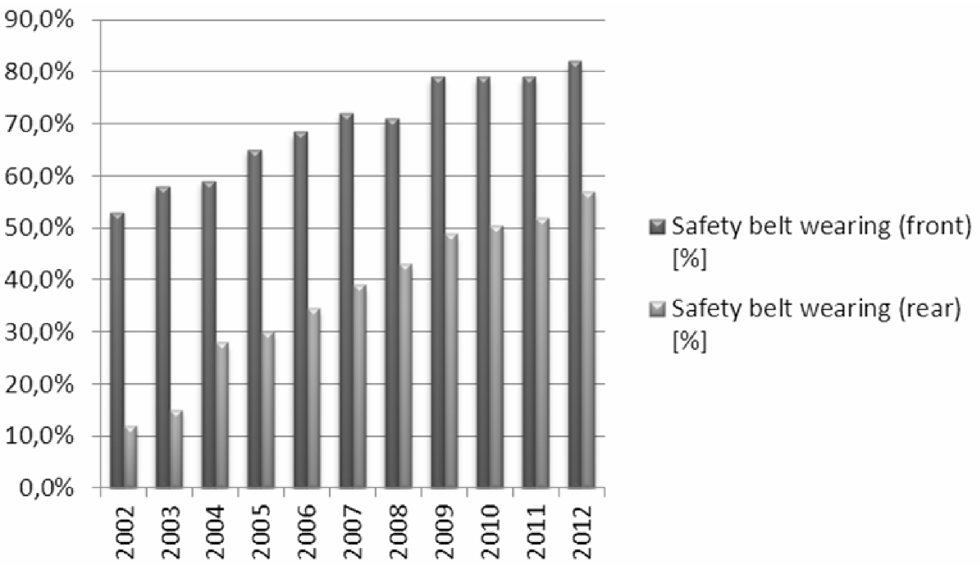

Figure 1 Safety belt wearing in Hungary between 2002 and 2012 (source: [1])

For airbag penetration the age of vehicle fleet were needed to be considered. As airbags are compulsory from 2004 in vehicles, authors investigated the Hungarian vehicle fleet.

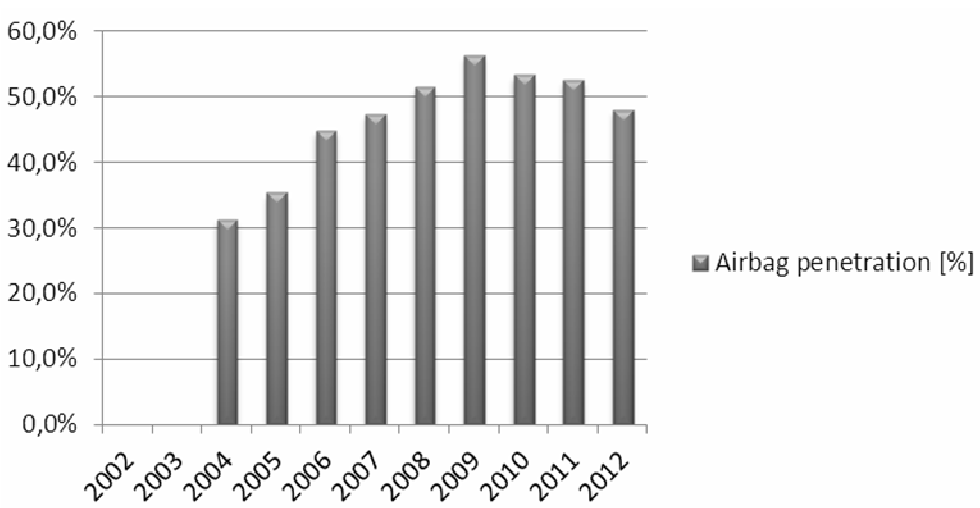

Figure 2 Airbag penetration in Hungary between 2002 and 2012 (source: [2])

As it can be sadly seen on *Figure 2* from 2009 according to economic crisis older cars were bought in Hungary and the penetration of airbags went down. One more question could be raised: is there any limitation of passive restraint systems? If yes, then have we reached it? Firstly the time series of CAI were analysed, the furthermore the correlation function between safety belt wearing and airbag penetration over fatalities.

$$\lim_{SBWR \to 100\%} corr\left\{N_{fatal}; SBWR\right\} \tag{2}$$

where: SWBR **S**afety **B**elt **W**earing **R**atio [%]

$$\lim_{ABPR \to 100\%} corr\left\{N_{fatal}; ABPR\right\} \tag{3}$$

where: ABPR **A**ir**B**ag **P**enetration **R**atio [%]

3. RESULTS

Not only the number of vehicles increased over the last couple of decades in Hungary but these vehicles became safer as well. Safer vehicle will cause less harm. As smarter vehicles will cause less accidents these conflicts could not be statistically detected [6]. Statistically the passive restraints systems have reached their limits as it can be seen on *Figure 3* the transient has reached its constant phase (be noticed that the definition of fatal accidents were changed in 1976 in Hungary therefore authors has shown the envelop curve):

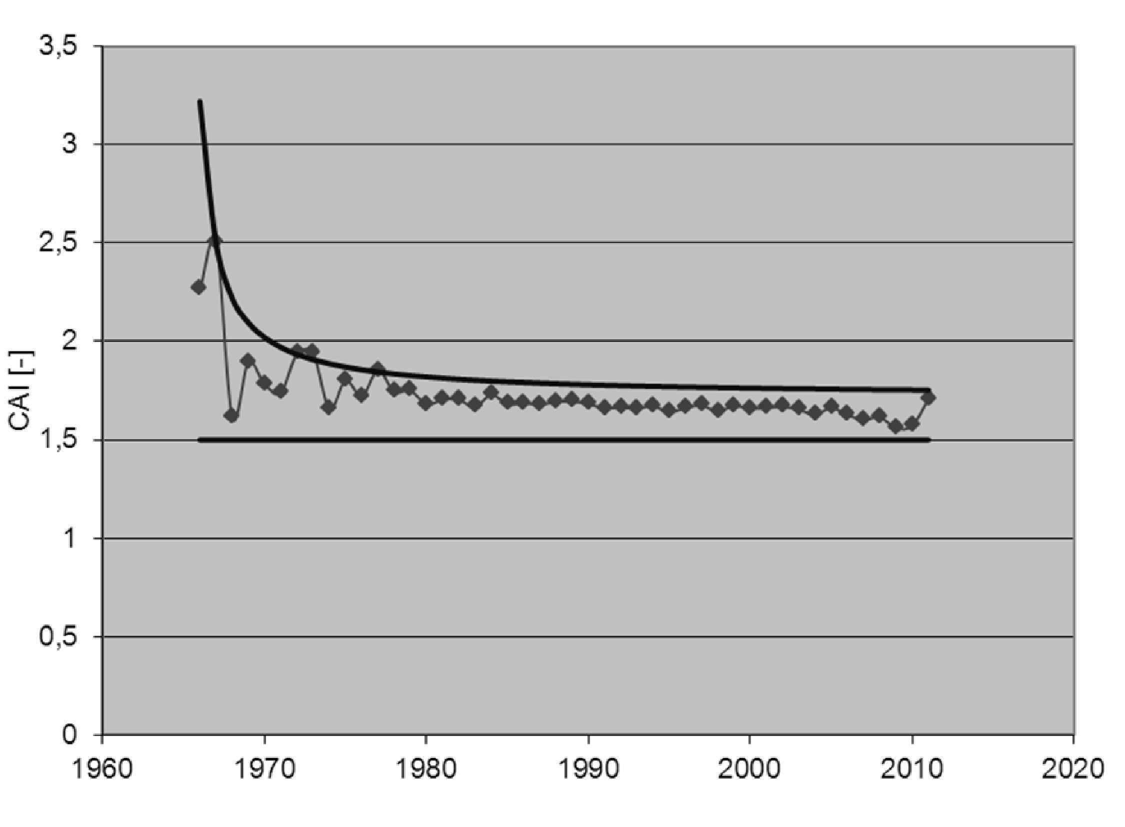

Figure 3 CAI over the last 45 yars
(source: own research)

Furthermore the safety belt wearing and airbag penetration were investigated over the number of fatalities. Authors were found that even with 100% of airbag penetration and 100% of safety belt wearing (*Figure 4*) there is still have to be some fatal road accidents that is need to be avoid somehow.

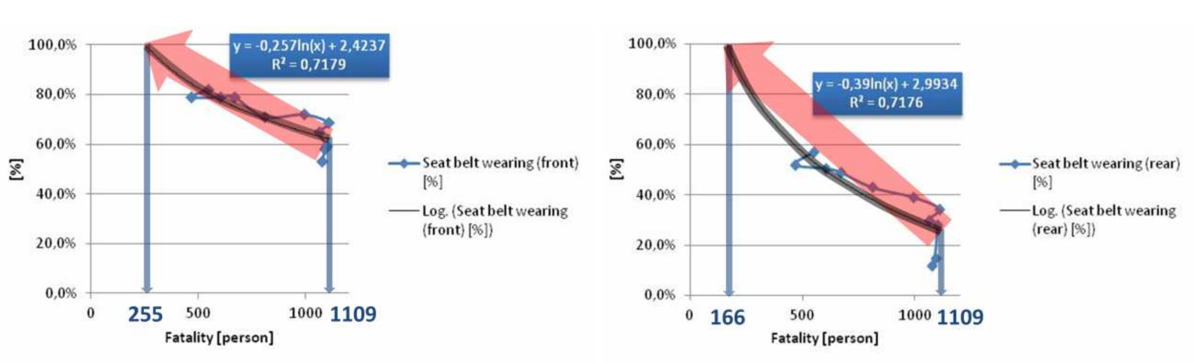

Figure 4 Safety belt wearing
(source: own research)

And same results were found for airbags (*Figure 5*):

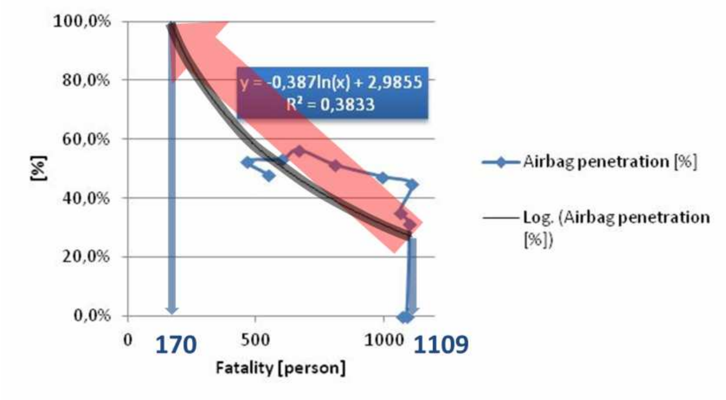

Figure 5 Airbag penetration
(source: own research)

4. CONCLUSION

Road safety has increased a lot but still lot to be done. A passive road safety measures are taken and have effects already that could be statistically proven. Nowadays passive safety measures are combined with active safety instruments. Not only these could influence the road safety but engineering (road and vehicle construction), enforcement (not only the risk of being caught but the amount of punishment) and education (to raise awareness).

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ACCIDENT PREDICTION MODELS FOR THREE AND FOUR LEG PRIORITY INTERSECTIONS IN PRAGUE

Veronika VALENTOVÁ[1]

Abstract: *In year 2012 almost 700 people were killed in the Czech Republic in road traffic accidents, approximately one third of them in urban area. In urban area there were 15 000 people injured as well. The most of accidents in towns and cities happen at intersections. For that reason countermeasures in intersection area are used. The first step of investigation of hazardous intersection is their identification. Statistical modelling is a modern approach based on the safety performance function. Results obtained with this approach are more reliable than using numerical definition of hazardous road locations. This study examines the results of prediction modelling of three and four leg priority intersections in Prague. Road and traffic data collected by TSK Prague and by own collection served as independent variables. Dependent variable was the number of accidents in these intersections in years 2009 and 2010. This data was from police accident records. The model was developed for almost 200 intersections. There were several models developed and compared. From these results some recommendations were derived. Significance of some variables depends on the duration of the investigated period and on the arrangement of the intersection.*

Keywords: *Safety performance function, accident prediction model, empirical Bayes, overdispersion parameter, expected number of accidents, intersection*

1. INTRODUCTION

Road accidents in the Czech Republic have been a social problem for many years as in other European countries. According to White paper published in 2001 [1], much has been done in road safety. European Directive 2008/96/ES on Road Infrastructure Safety Management [2] was adopted and implemented in national laws and strategies. However specified goals were not achieved. Identification of hazardous road locations and the influence of different types of arrangements on safety is way how to improve the safety performance of selected locations. The criteria of selection are different.

Traditional approaches, based on the numerical definition for identification of hazardous road locations and hazardous intersections, are still used. However, these approaches have not been successful enough. It can be due to many reasons, one of them can be the fact, that identified locations in different years or periods change a lot. Therefore, new approaches based on the safety performance function are dealt with in many countries and also in this paper.

Despite this, road safety modelling in Czech Republic is still in the beginning. In the last years in CDV, the first statistical model was made for roundabouts. The model was simple and the empirical Bayes approaches described by Hauer et al. [3] were not used. The state of the art methods have been used in project IDEKO, which deals with road segments for rural roads of regional importance [4].

In the year 2012, almost 700 people were killed in the Czech Republic in road traffic accidents, approximately one third of them in urban areas. In addition in urban areas 15.000 people were injured. The majority of accidents in towns and cities occur at intersections. For that reason, countermeasures in intersection area are used. The influence of these countermeasures is generally known, although there is much scope for improvement is in the objective evaluation of these measures.

This study attempts to find which properties of three and four leg intersection have the biggest influence on the road traffic safety. Safety performance function is investigated by statistical prediction models. Similar study was published by Bauer and Harwood [5]. In that study it is possible to find different models for three and four leg intersections. According to that study, significant variables should be different. State of the art method of using safety performance function is described in the report of project RIPCORD-ISEREST [6].

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One of the statements of this report is that disaggregated models are more reliable than aggregated. Validity of this statement is verified in this study. Study also shows the importance of the length of the time period used for accident analysis.

2. VARIABLES

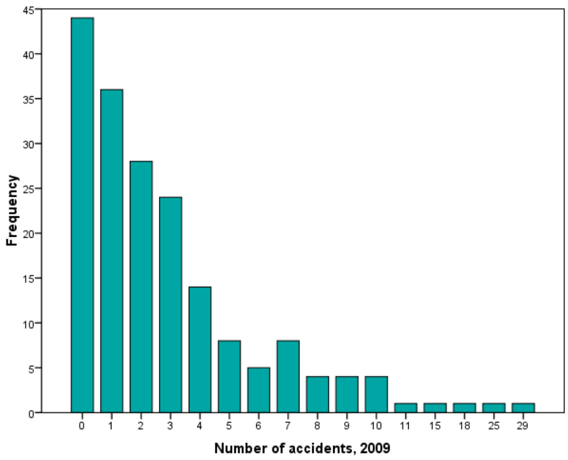
The model described in this study is for intersections in Prague, the capital city of the Czech Republic. The data used in the model were collected by the Technical Administration of Roads of the City of Prague (TSK Prague). These data were supplemented by police accident records and by own data collection.

The dependent variable was accident frequency. The independent variables were the exposure data and the data about intersection characteristics. These data are generally believed to influence road safety. Each variable is described below.

194 intersections were used for the study. TSK Prague collects the data because of its traffic engineering characteristics. In the data it is possible to find only specific group of intersections, which are unsignalized and are quite important for the traffic in the location. It is not recommended to use the results of this study for generalization. Descriptive statistics of all available variables are showed in Table 1.

2.1 Accident data

Accident data for two years 2009 and 2010 were obtained from the Czech Traffic Police. They include all accidents – injury accidents (accidents with slight, severe and fatal injuries) and property damage only accidents. Underreporting of injury accidents with motor vehicles is minimal; however this is not the case with property damage only accidents. Reporting rate is determined by the reporting threshold. Therefore, only accidents with property damage over 100 000 CZK (4 000 Euro) or accidents in which participants cannot make a deal about who caused the accident are in the police records. For the model, all accidents regardless of their severity were used. Accident data distribution in the year 2009 and 2010 is displayed on graphs in Figure 1. These graphs show the number of intersections with the specific number of accidents.



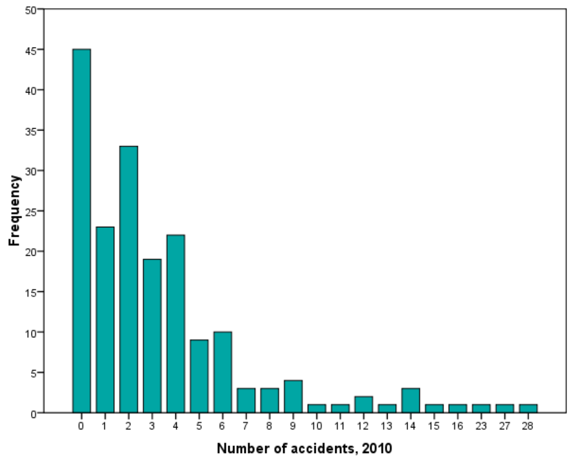


Figure 1 Accident data distribution, years 2009, 2010

2.2 Annual average daily traffic

TSK has been recording AADT on selected roads in Prague. This network covers all roads which are important for traffic in the area. Some of intersections are in the central part of the city, other are in residential, shopping or industrial zones. Traffic volume ranges between approximately 1000 vehicles per day to 85.000 vehicles per day. Histogram of this data was made and intersections with more than 30.000 vehicles per day on the major road were excluded. AADT was divided into intervals and the frequency of the interval occurrence is showed in Figure 2. Value of AADT 30.000 cars a day make up about 95 % of all values. Higher values are rare and are spread in wide range of volume.

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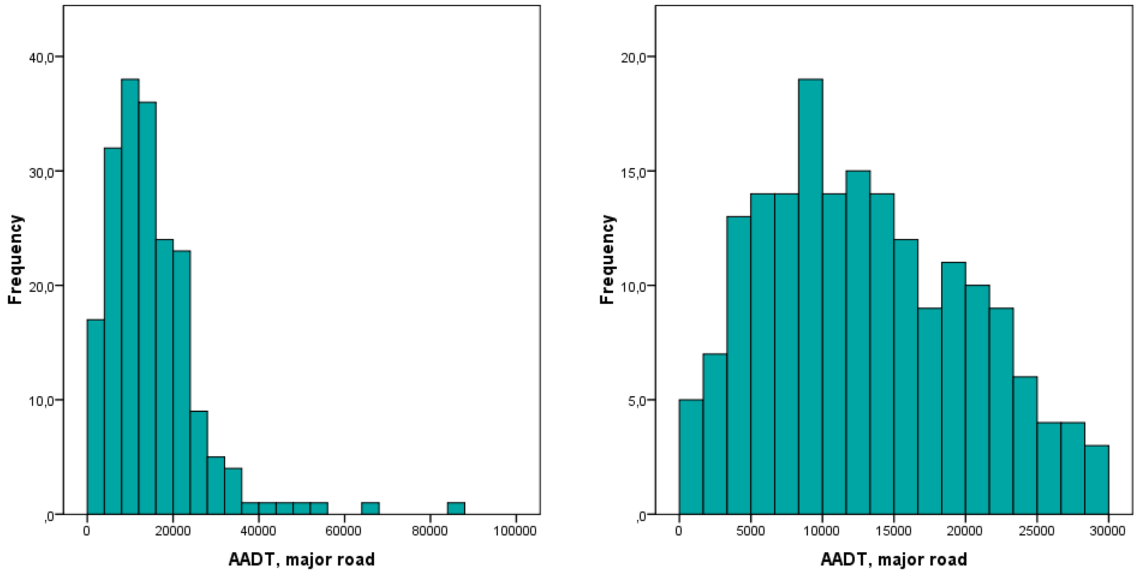

Figure 2 Histogram of AADT on the major roads (All values, values selected for modelling)

2.3 Percentage of heavy goods vehicles

Percentage of heavy goods vehicles were taken also from TSK records. It was counted for major and minor roads. The highest value is approximately 35 % for the major road and 75 % in one case for the minor road. Average value is around 7 % for the major roads and 5 % for the minor roads.

2.4 Number of legs

Only intersections with three or four legs were used. In total, 119 three leg intersections and 75 four leg intersections were included.

2.5 Left turn restrictions

In some intersections, there are legs with one-way traffic or some restricted intersection movements. In 57 cases, there are some restrictions which do not allow turning left in some directions.

2.6 Presence of tram traffic

Two variables for trams were available in the data. The first shows the number of legs of intersections with tram traffic presence. It is smaller or equal to the number of legs of the intersection. Overall, there were 62 intersections with tram traffic. Because of the low number of intersections with trams in more than two legs, binary information was used for the modelling.

2.7 Percentage of tram traffic

Tram volume was converted to percentage. Maximum value is about 110 % of the AADT on major road and about 193 % of the AADT on minor road. Average value is approximately 4 % for major roads and 3 % for minor roads.

2.8 Traffic islands

In some intersections, there are traffic islands that are used to separate the opposite traffic, emphasize the way for turning vehicles or to protect pedestrians crossing the road. Often multiple functions are assigned to them. 45 of intersections have some kind of traffic islands. The number of islands is mostly 0 or 1, higher number of islands is rare, so binary variable was used for modelling.

2.9 Priority

Right of way of all intersections is controlled by traffic signs. 46 intersections have major road in a bend. The rest of intersections have the major road direct.

2.10 Pedestrian crossings

As the studied intersections are in the city, many of them are equipped with pedestrian crossings. These were divided into groups of crossings across the major and minor road. There are 103 intersections with crossings on the major road and 118 on the minor roads. Test of their significance provided poor results, therefore binary variable (yes or no) was used.

2.11 Number of right turn lanes

Information about number of right turn lanes was available in the data too. According to graph in Figure 3 (frequency of occurrence of intersections with the specific number of right-turn lanes), it is obvious, that intersections with one right-turn lane make up 7 % and with two lanes 4 %. As a result, this variable was excluded.

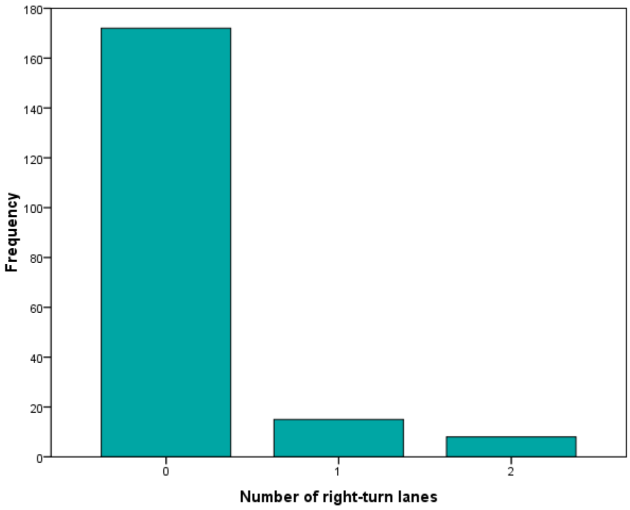

Figure 3 Number of right-turn lanes

Table 1 Overview of variables and their descriptive statistics

Type of variable	Name of variable	Abbreviation	Data type and unit	Descriptive statistics (min/max/mean/SD or frequencies)
Dependent	Accident data	**ACC**	count	0.00/29.00/3.22/3.93
Continuous	Annual average daily traffic - major road	**AADT_mj**	continuous [vehicles per day]	900/29504/12940/6969
	Annual average daily traffic - minor road	**AADT_mi**	continuous [vehicles per day]	100/14531/3515/3183
	Percentage of HGV	**P_HGV**	continuous	0.008/0.443/0.063/0.047
	Percentage of trams	**P_TRAM**	continuous	0.000/1.005/0.030/0.103
Categorical	Number of legs	**LEGS**	nominal	3 : 119, 4 : 75
	Legs with tram traffic	**TRAM**	binary Yes = 1; No = 0	1 : 62, 0 : 132

Categorical	Left turn restrictions	**LEFT**	binary No restrictions: 1; With restrictions: 0	1: 137, 0 : 57
	Traffic islands	**ISL**	binary Yes = 1; No = 0	1 : 45, 0 : 149
	Priority	**PRIOR**	binary In bend = 1; Straight = 0	1 : 46, 0 : 148
	Pedestrian crossing	**CROSS**	binary Yes = 1; No = 0	1 : 138, 0 : 56

3. MODELS

Statistical models, based on the described data, were developed in SPSS 17.0. Generalized linear models with negative binomial distribution and logarithmic link function were used. Accident frequency, from years 2009, 2010 and both of these years, served as dependent variable. Process used for development of model was described e. g. in [7].

3.1 Correlations relationships of variables

According to the theory of using statistical modelling for road safety evaluation, all used variables should be independent. Therefore, relationships between variables were also studied and variables with strong correlation were modified. Correlation was assessed using bivariate correlation calculation is SPSS with Pearson's correlation coefficient.

Obvious correlation is between number of legs of intersection and number of legs from which is possible to turn left. For intersection with three legs, it is usual that from two legs is possible to turn left. For intersections with four legs there are four possible left turns.

There was also correlation between the number of legs and traffic volume on the major road. This correlation is significant at the 0.05 level and its value is -0.144, Relationship is logical, more legs would produce more vehicles, so both variables are used in model.

3.2 Model form

The form of the prediction model used in this study was used in other studies [8, 9, 10]. Estimated number of accidents is a function of the traffic volume on the major road and minor road and set of risk factors. General form of the model is:

$$ACC = \beta_0 \cdot AADT\_mj^{\beta_1} \cdot AADT\_mi^{\beta_2} \cdot e^{\sum \beta_i \cdot x_i} \tag{1}$$

where: *ACC*, *AADT_mj* and *AADT_mi* are described in Table 1,

β_i estimated parameters,

x_i other explanatory variables.

Model was built by progressive form of building model. The explanatory variable with the highest influence was traffic volume, for that reason it was used first. Than every other variable in specified function form was included in the model and every model was evaluated.

Three different criteria were checked:

- Decrease of Akaike information criterion (AIC), a measure of the relative goodness of fit of a statistical model
- Decrease of overdispersion parameter
- Shape of cumulative residuals graph created according to Hauer and Bamfo [11].

Significance of each variable was observed too. Significance level was set to 0.10 for each of variables. As can be seen in Table 2, the model for 4 leg intersections in the year 2010 is not reliable. Significance of natural logarithm of annual average daily traffic is 0.147, although it is usually known, that this variable has the biggest influence on road safety.

Table 2 Final versions of models

Variable		2009			2010			2009-2010		
		3 leg intersections								
Shortcut		Estim. Value	95 % Confid. Interval	Sig.	Estim. Value	95 % Confid. Interval	Sig.	Estim. Value	95 % Confid. Interval	Sig.
Intercept		-7.974	[-10.90; -5.05]	0.000	-8.067	[-10.60;-5.53]	0.000	-7.074	[-9.53;-4.62]	0.000
ln(AADT_mj)		0.670	[0.36;0.98]	0.000	0.480	[0.24;0.72]	0.000	0.594	[0.33;0.86]	0.000
ln(AADT_mi)		0.303	[0.12;0.48]	0.001	0.469	[0.30;0.64]	0.000	0.327	[0.17;0.49]	0.000
P_HGV		-	-	-	0.560	[0.02;0.10]	0.004	4.350	[-0.20;8.89]	0.061
TRAM	Y	0.568	[0.16;0.97]	0.006	0.489	[0.09;0.89]	0.016	0.798	[0.41;1.18]	0.000
	N	0.000			0.000	-	-	0.000	-	-
CROSS	Y	-	-	-	0.392	[0.01;0.78]	0.047	-	-	-
	N	-	-	-	0.000	-	-	-	-	-
		ODP		0.514	ODP		0.431	ODP		0.552

Variable		2009			2010			2009-2010		
		4 leg intersections								
Shortcut		Estim. Value	95 % Confid. Interval	Sig.	Estim. Value	95 % Confid. Interval	Sig.	Estim. Value	95 % Confid. Interval	Sig.
Intercept		-3.626	[-6.71; -0.55]	0.021	-2.530	[-5.12;0.06]	0.056	-3.887	[-7.13;-0.65]	0.019
ln(AADT_mj)		0.321	[-0.01;0.63]	0.044	0.209	[-0.07;0.49]	0.147	0.410	[0.09;0.73]	0.013
ln(AADT_mi)		0.274	[0.12;0.43]	0.000	0.222	[0.08;0.37]	0.003	0.276	[0.14;0.41]	0.000
P_HGV		-0.078	[-0.14; -0.02]	0.007	-0.061	[-0.12;0.00]	0.059	-7.930	[-13.50;-2.36]	0.005
P_TRAM		-	-	-	-	-	-	0.044	[0.01;0.08]	0.019
TRAM	Y	0.497	[0.08;0.91]	0.019	0.576	[0.14;1.01]	0.009	-	-	-
	N	0.000			0.000	-		-	-	-
LEFT	Y	-	-	-	0.643	[0.21;1.08]	0.004	0.496	[0.10;0.89]	0.013
	N	-	-	-	0.000			-	-	-
PRIOR	B	-	-	-	-0.483	[-1.07;0.10]	0.106	-	-	-
	S	-	-	-	0.000	-	-	-	-	-
		ODP		0.432	ODP		0.345	ODP		0.431

Variable		2009			2010			2009-2010		
		all intersections								
Shortcut		Estim. Value	95 % Confid. Interval	Sig.	Estim. Value	95 % Confid. Interval	Sig.	Estim. Value	95 % Confid. Interval	Sig.
Intercept		-6.241	[-8.37; -4.11]	0.000	-4.925	[-6.86;-2.99]	0.000	-4.832	[-6.62;-3.05]	0.000
ln(AADT_mj)		0.534	[0.31;0.76]	0.000	-0.375	[0.12;0.57]	0.000	0.488	[0.29;0.68]	0.000
ln(AADT_mi)		0.295	[0.18;0.41]	0.000	0.310	[0.19;0.43]	0.000	0.264	[0.16;0.37]	0.000
LEGS	3	-0.391	[-0.68; -0.10]	0.008	-0.404	[-0.69;-0.12]	0.006	-0.382	[-0.65;-0.12]	0.005
	4	0.000	-	-	0.000	-	-	0.000	-	-
TRAM	Y	0.580	[0.28;0.88]	0.000	0.640	[0.34;0.94]	0.000	0.635	[0.37;0.90]	0.000
	N	0.000	-	-	0.000	-	-	0.000	-	
LEFT	Y	-	-	-	0.327	[0.03;0.63]	0.000	-	-	-
	N	-	-	-	0.000	-	-	-	-	-
PRIOR	B	-	-	-	-0.315	[-0.69;0.056]	0.10	-	-	-
	S	-	-	-	0.000	-	-	-	-	-
		ODP		0.526	ODP		0.495	ODP		0.560

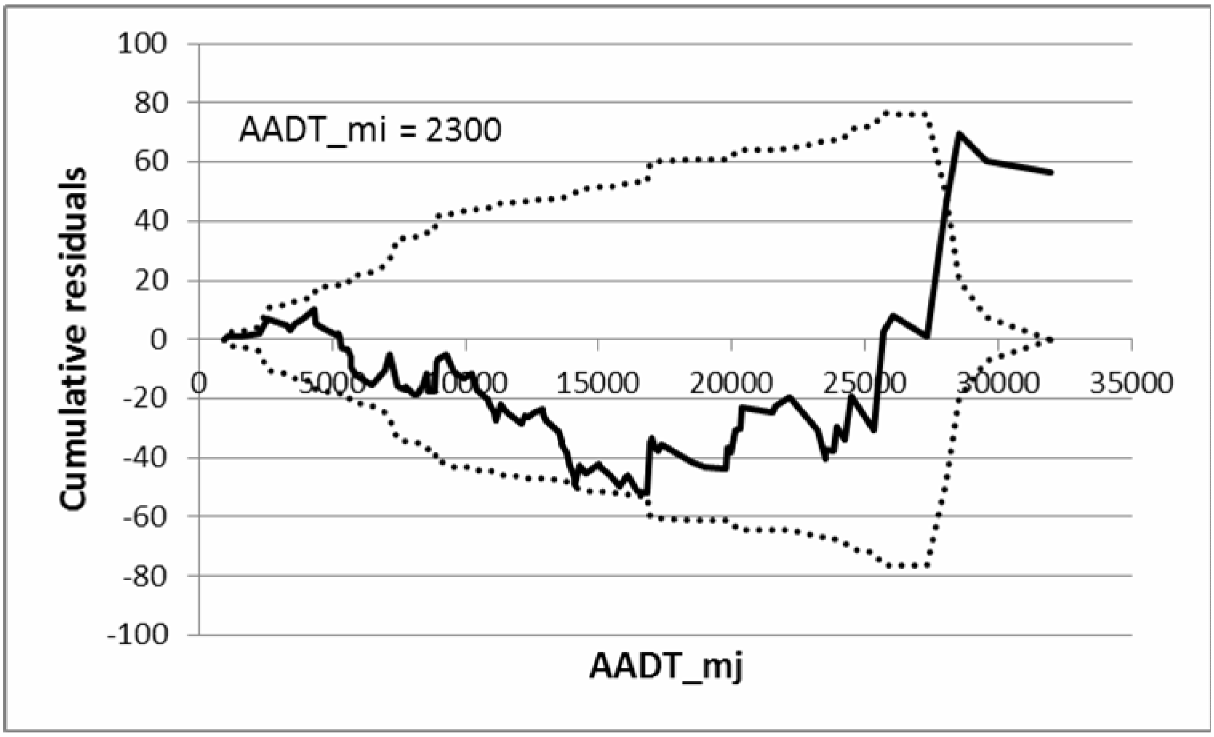

Figure 4 Cumulative residuals for 3 leg intersections for data 2009 - 2010

On graph in Figure 4, the value of *AADT_mi* is near the median of values of traffic volume on minor roads. The big jump, in the value of cumulative residuals in the interval of volume approximately 27 000 – 29 000, is caused by two intersections where 57 resp. 30 accidents happened. Graph of cumulative residuals of four leg intersections is in the Figure 5.

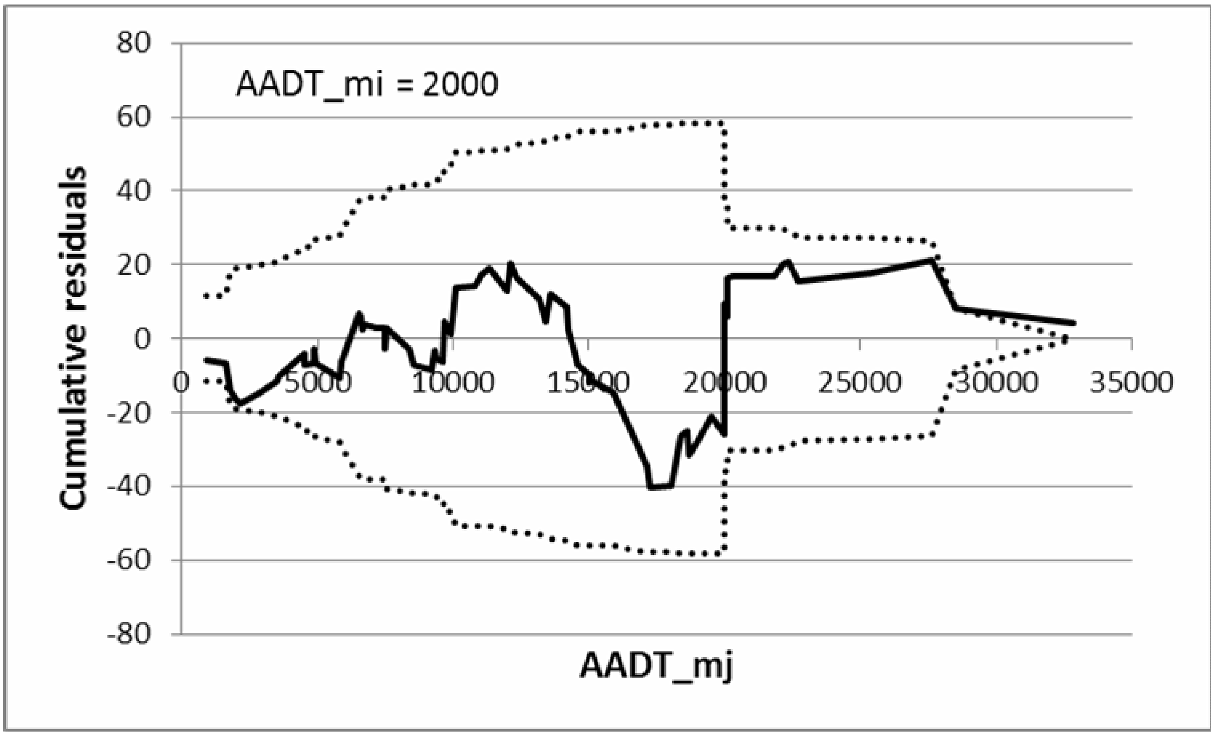

Figure 5 Cumulative residuals for 4 leg intersections for data 2009 - 2010

Final form of the model for three leg intersections is:

$$ACC = e^{-7.074} \cdot AADT_{mj}^{\ 0.594} \cdot AADT_{mi}^{\ 0.327} \cdot e^{4.350 \cdot p\_HGV + 0.798 \cdot TRAM} \tag{2}$$

Final form of the model for four leg intersections is:

$$ACC = e^{-3.887} \cdot AADT_{mj}^{\ 0.410} \cdot AADT_{mi}^{\ 0.276} \cdot e^{-7.930 \cdot p\_HGV + 0.044 \cdot p\_TRAM + 0.496 \cdot LEFT} \tag{3}$$

For both models, binary variables are set 1 for Yes and 0 for No.

The variables with the biggest influence are annual average daily traffics on major and minor roads. Graphs in Figures 6, 7 show the non-linear dependence between the number of accidents and the traffic volumes.

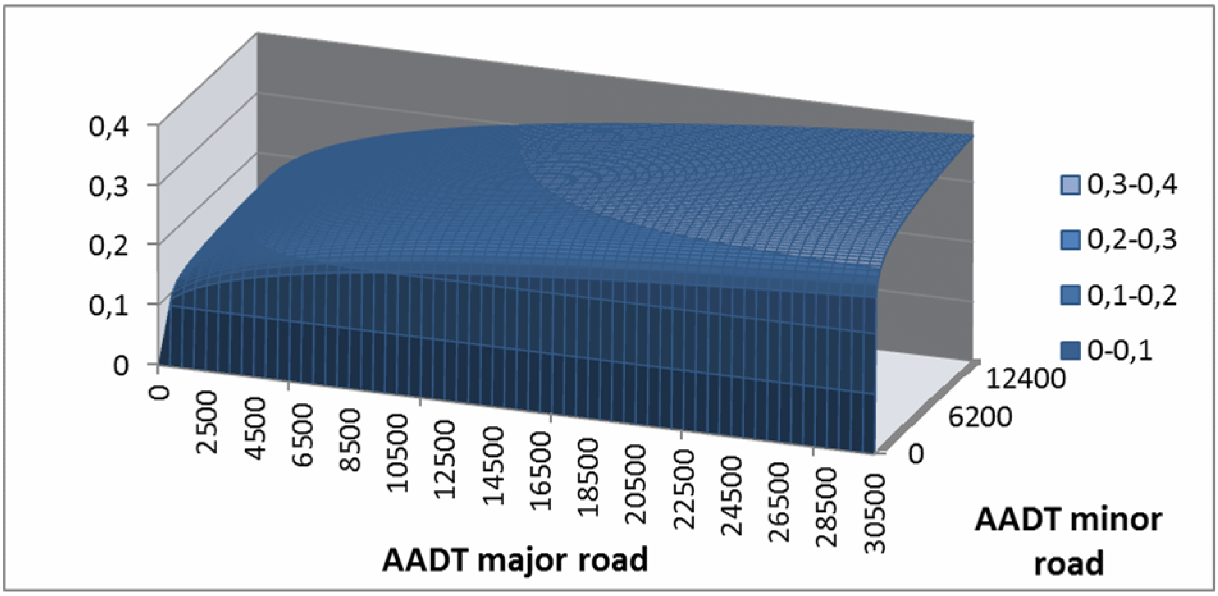

Figure 6 Expected annual accident frequency – 3 leg intersections

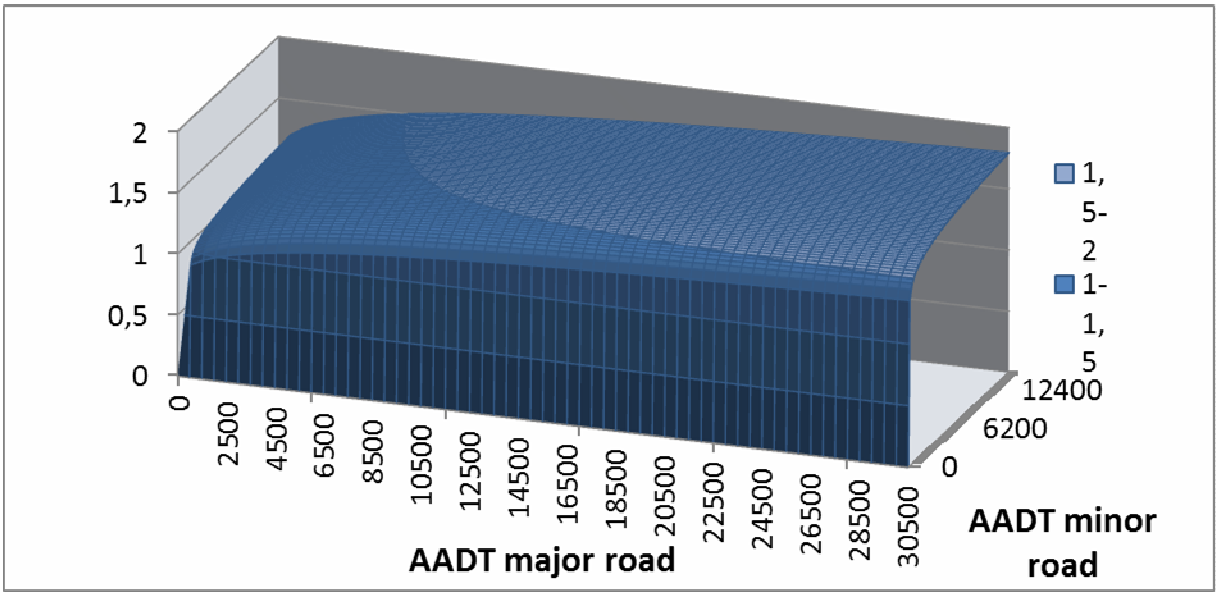

Figure 7 Expected annual accident frequency - 4 leg intersections

4. CONCLUSION

In the beginning of this paper is one important statement. In older studies is possible to find information about the differences between aggregated and disaggregated models [5, 6]. Cited studies were made for different data sets and some of them for different types of intersections. This study confirms this statement as shows data of overdispersion parameters in Table 3. The value of this parameter is higher for models of all intersections together than for separate models of each intersection type.

Table 3 The value of overdispersion parameter for each of models

	2009	2010	2009-2010
3-leg	0.514	0.431	0.552
4-leg	0.432	0.345	0.431
all	0.526	0.495	0.560

Another conclusion can be made for the analysis. Longer period gives more reliable results. Overdispersion parameter for two year period is near the value for the models in year 2009. But the model prepared for the year 2010 for four leg intersections is not reliable. The significance level of the variable with the highest influence on safety, annual average traffic on major road, is almost 15 %. For that reason, this model is not suitable. The only one possible conclusion is that the one year period is too short and longer period is necessary. This finding is very important for before-after studies. Often it is possible to find some study in which the effect of road safety measurement is evaluated after one year from entering to service. The random part of road accidents occurrence is very high and needs to be regulated by statistical methods, e.g. empirical Bayes method.

The results of this study show very significant nonlinearity in the number of accidents in addiction to traffic volume on major and also on minor road. The function rises steeply for low traffic volumes and its growth slows for higher traffic volume. These results are not consistent with the idea of accident rate, which is currently often used for these purposes.

The main objective of this study was to confirm or disprove the statement that disaggregated models are better than aggregated. Results confirm this statement. The difference in some variables can be caused by different number of three and four leg intersections as well as by interaction of variables. This knowledge brings new questions for further research.

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ELECTROMAGNETIC INFLUENCE RADIATION OF AIRPORT RADAR ON ENVIRONMENT

Milan VAŠEK[1]

Abstract: *The article deals with the calculation of the electromagnetic field of airport radars. Application of these algorithms allows obtaining information on the electromagnetic background.*

Keywords: *airport radars, electromagnetic background, environment*

1. INTRODUCTION

Radar emits energy to the surroundings and becomes a source of electromagnetic fields. May not exceed the limits, it is not dangerous to man (maximum emission limits set out in the legislation. Effects of electromagnetic radiation are mainly thermal in nature. Primary effects of electromagnetic radiation are the thermal effects on the body surface. Primary SRE operates at a frequency of about 3 GHz, the frequency PAR about 9 GHz, and so we will continue to devote the calculation of all the above variables.

2. THE CALCULATION OF THE ELECTROMAGNETIC FIELD

Radars are usually parabolic antenna with a rectangular or elliptical aperture. Physical quantity to determine the level of electromagnetic radiation used power density S [Wm^{-2}] or electric field strength E [Wm^{-1}]. Power density is the absolute value of the Pointing vector Π, which is dependent on the distance, antenna parameters, frequency and power level. According to the characteristics of electromagnetic wave behaves in the neighborhood and, depending on the distance from the antenna is a space before the antenna is divided into several zones (Fig. 1) [4].

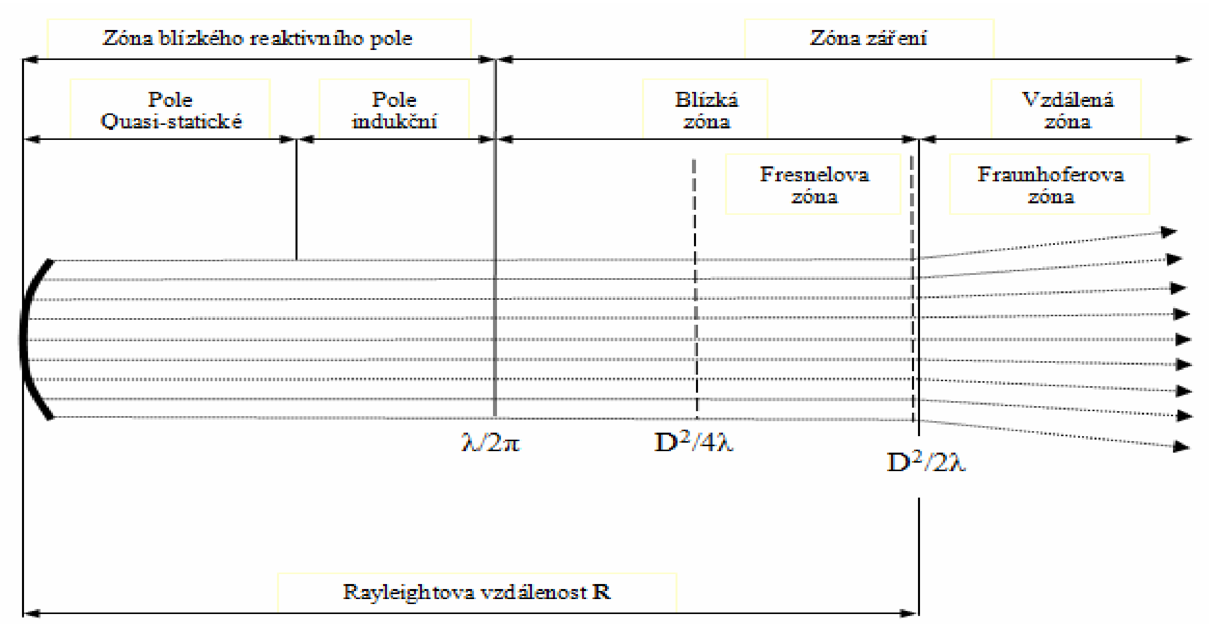

Figure 1 Zones of electromagnetic field

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2.1 Near zone radiation

In the near zone of radiation is character spherical waves and electromagnetic field is concentrated approximately to the volume, whose transverse dimension is given by the antenna size (1).

$$S_{bz} = \frac{4\eta_{Ant} P_{stř}}{A_s} \quad [Wm^{-2}] \tag{1}$$

where S_{bz} - power density in the near zone [Wm^{-2}]
A_s - actual antenna area [m^2],
η_{Ant} - aperture efficiency [0-1],
P_{str} - mean power [W].

For the Fresnel zone must be corrected according to equation (2) level of power density for distances $D^2/4\lambda < R < D^2/2\lambda$.

$$S_{bza} = \frac{S_{bz}\frac{D^2}{4\lambda}}{R} \quad [Wm^{-2}] \tag{2}$$

where S_{bza} - power density in the Fresnel zone [Wm^{-2}],
S_{bz} - power density in the near zone [Wm^{-2}],
R - the distance from the antenna [m],
D - the largest dimension of the antenna [m], radiant flux.

2.2 Distant radiation zone

Power density of in distant zone of maximum radiation level at the antenna is given by equation (3).

$$S = \frac{P_{stř} \cdot G}{4\pi R^2} \quad [Wm^{-2}] \quad \text{for} \quad D^2/2\lambda < R \tag{3}$$

where S - power density in the far field [Wm^{-2}]
P_{str} - medium power radar [W],
G – antenna earnings,
R - distance from the antenna [m].

Calculation of power densities is dependent on the value mean power P_{str}. For radars with the pulse mode P_{str} is calculated from equation (4).

$$P_{stř} = P_{imp} \cdot t_{imp} \cdot f_{op} \quad [W] \tag{4}$$

where P_{str} - medium power radar [W],
P_{imp} - radar pulse power [W],
T_{imp} - pulse duration [s],
f_{op} - repetition frequency [Hz].

2.3 The calculation of the moving beam

The antenna performs mostly circular or rocking motion.

2.3.1 Distant radiation zone

Suppose that a person is found at the X point in the distant zone at the position of maximum antenna beam (see Figure 2).

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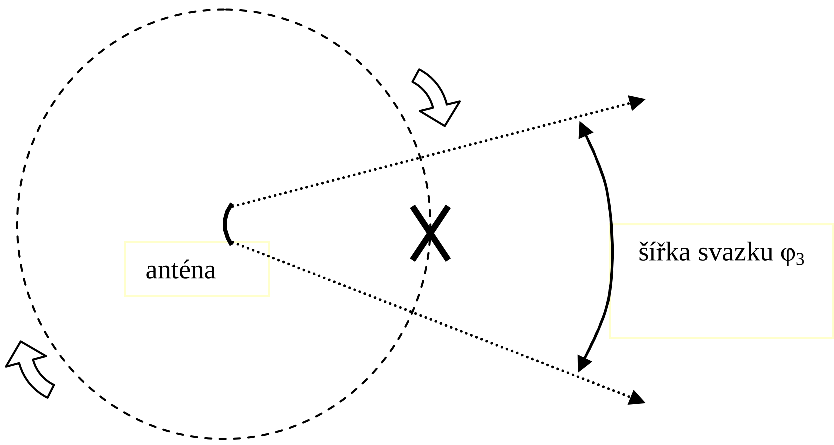

Figure 2 Rotate the antenna beam in the distant zone

Power density the rotating antenna S_{rt1} is calculated by equation (7).

$$f_{rt1} = \frac{\varphi_3}{\varphi_A} \quad \text{and} \quad f_{rt1} = \frac{\varphi_3}{360} \tag{5, 6}$$

$$S_{rt1} = S \cdot f_{rt1} \quad \left[Wm^{-2}\right] \tag{7}$$

where f_{rt1} - factor rotation in the distant area,
S_{rt1} - power density the rotating antenna in the distant area [Wm^{-2}],
φ_3 - the main antenna beam width at -3 dB compared to the maximum [°],
φ_A - Swivel Antenna value [°],
S - power density static antenna [Wm^{-2}].

2.3.2 Near radiation zone

Suppose occurrence of persons in the near zone of the maximum position the antenna beam at point X (Figure 3) Beam width is determined by the largest dimension of the antenna in the plane of rotation.

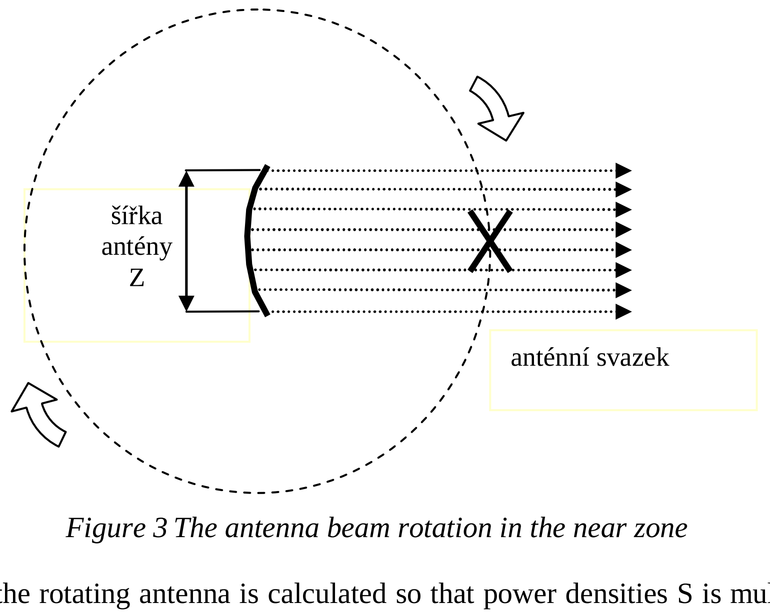

Figure 3 The antenna beam rotation in the near zone

Power density by the rotating antenna is calculated so that power densities S is multiplied by a factor rotation f_{rt2}. Rotation factor is calculated according to equation (8). Angle φ_A is the value of antenna beam swivel angle. Equation (9) expresses the factor calculation rotation of the antenna with a circular rotating. [2]

$$f_{rt2} = \frac{Z}{2\pi R \frac{\varphi_A}{360}} \quad \text{and} \quad f_{rt2} = \frac{Z}{2\pi R} \qquad (8, 9)$$

Power density in the near zone of the rotating antenna S_{rt2} is calculated by (10).

$$S_{rt2} = S \cdot f_{rt2} \quad \left[Wm^{-2}\right] \qquad (10)$$

where f_{rt2} - rotation factor in the near zone,
S_{rt2} - power density the rotating antenna in the near zone [Wm^{-2}],
Z - the antenna width [m],
R - the distance from the antenna to point X [m],
φ_A - antenna swivel angle value [°],
S – static antenna power density [Wm^{-2}].

3. SPECIFIC ENERGY ABSORPTION RATE CALCULATION

Specific energy absorption rate in the body (SAR) is the value of the power absorbed per kilogram [Wkg^{-1}]. Specific Absorption Rate is used to determine the maximum allowable values for equipment operating in the frequency range 100 kHz - 10 GHz. Power absorbed figure standing against the radar antenna gain, multiply the power density and area figures, see equation (11).

$$P_{abs} = S \cdot A_p \quad \left[W\right] \qquad (11)$$

Then calculate energy absorption rate per figure kilogram (12).

$$SAR = \frac{P_{abs}}{m_p} \quad \left[Wkg^{-1}\right] \qquad (12)$$

where P_{abs} - power absorbed figure [W],
S - power density [Wm^{-2}],
A_p - frontal area figures [m^2],
m_p - mass character [kg],
SAR - Specific energy absorption rate [Wkg^{-1}].

3.1 The measured absorbed energy

Specific energy absorption (SA) is the energy absorbed per unit mass of biological tissue. It is expressed in joules per kilogram (Jkg^{-1}). The value of measurement of absorbed energy is the product of the absorbed power and the SAR exposure times (13).

$$SA = SAR \cdot t_e \quad \left[Jkg^{-1}\right] \qquad (13)$$

where SA - absorbed energy measure [Jkg^{-1}],
SAR - Specific energy absorption rate [Wkg^{-1}],
t_e - exposure time [s].

3.2 The measured energy density

The value of specific energy density is given by the product of power densities and exposure time (14).

$$\omega_m = S \cdot t_e \quad \left[Jm^{-2}\right] \qquad (14)$$

where ω_m - specific energy density [Jm^{-2}],
S - power density [Wm^{-2}],
t_e - exposure time [s].

3.3 Measured the tissue temperature

Temperature of the tissue after absorbing specific power increases by Δt according to equation (15). Relative heat capacity is given here as the average value in relation to the total density of human tissue (2).

$$\Delta t = \frac{SA}{c_t \cdot 4180} \quad [^{\circ}C] \tag{15}$$

where SA - absorbed energy measure [Jkg^{-1}],
Δt - increase tissue temperature [° C],
c_t - relative heat capacity, c_t = 0.85.

3.4 The conversion of electromagnetic field values

For the electric field E [V/m] at a distance R from the source - the spread of free space, the equation (16).

$$E = \frac{\sqrt{30.P.G}}{R} \quad [Vm^{-1}] \tag{16}$$

where E - electric field intensity [m^{-1}],
P - medium power radar [W],
G - earnings antenna,
R - distance from the antenna [m].

For the conversion of the electric field E to power density S is valid the equation (17).

$$S = \frac{E^2}{120.\pi} \quad [Wm^{-2}] \tag{17}$$

4. CONCLUSION

Surveillance and landing radars are commonly used in aviation. Surveillance and landing radars are commonly used in aviation equipment. Even when working with high performance protection of operators and other airport personnel is realized. Devising of protective zones in which the movement of persons regulated. According to the article the design load can be calculated by the electromagnetic field from all sources in relation to the location of interest. The calculated values can be compared with reference values (health limits) and thus find their fulfillment or exceeded. An open question is the size of the set safety limits; the current legislation promotes a basis for thermal effects and does not take into account the potential risks of non-thermal effects or long-term effects the EMP weaker intensity.

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IMPLEMENTATION OF SAFETY INDICATORS IN GENERAL AVIATION

Peter VITTEK[1] - Vladimír PLOS[2] - Roman MATYÁŠ[3]

Abstract: *Safety is currently perceived as an operating indicator that shows the correct operation of the system. This system characteristic is very difficult to measure. Article discusses the use of reactive, proactive and predictive models to ensure a safe operating environment of general aviation. Using these models is directly related to the safety indicators creation, which allow a systematic safety data collection and the transition to the use of safety intelligence. But the main safety indicators function lies in the possibility of direct and indirect measuring the organization safety performance. In the case of general aviation it is required to access the implementation of the indicator relative to the size of organizations and their operating characteristics. Also very important is the development of the feasible implementation process for these organizations.*

Keywords: *safety management system, safety indicators, compliance-based oversight, performance-based oversight*

1. INTRODUCTION

In 2012, EASA has introduced a new concept of safety level oversight, which will create a better picture about the safety of aviation stakeholders. This change consists of applying the evaluation principles that focuses on the safety performance inspection of the organization. This is not therefore only the audit activities of regulator relating to monitoring compliance with applicable regulations, as is currently the case. It is named as the Compliance Concept Based Oversight (CBO). The process of introducing a new concept consisting in the safety performance assessment, which is known as Performance Based Oversight (PBO), will take place in the coming years through the whole spectrum of aviation stakeholders.

For proper PBO functioning it is important to find the right safety performance indicators that provide sufficient information in the first place for the regulator. In this case we are talking about a special set of indicators intended to create an appropriate safety image from the perspective of the regulator. On the other hand, it would be impractical, if a safety indicators could not serve for safety management organizations themselves. The introduction of appropriate indicators for regulators is needed to create another set of indicators that will be used in the operation of the safety management of the organization. Decay into more subgroups operational and process indicators it is also possible to create an image of safety at lower levels of decision-making. In terms of safety so we can better access to managing organizational units and their individual operational processes.

Safety performance indicators represent an important constituent of a safety management system involving the establishment, implementation and follow-up of corporate policies, acceptance criteria and goals related to safety. The systematic feedback of experience on accident risks is a cornerstone in any management system for prevention of accidental losses, and includes reactive as well as proactive means [1].

Basic and applied research of Laboratories of aviation safety is currently engaged in the development of safety indicators, which are directed to the whole range of organizations from national regulators, airports, airlines, air traffic management companies, maintenance organizations to smaller organizations such as aerospace manufacturers, aviation schools, aero clubs etc. The laboratory of aviation safety was established by the Department of Air Transport, CTU in Prague.

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The aim of this article is to introduce the basic principle of operation of safety indicators, presenting the current state of solutions in this area and the problems associated with the actual implementations for general aviation in the Czech Republic. In the section that deals with the various layers of the indicators can also monitor reactive, preventive and proactive models of safety indicators.

2. PRINCIPLES OF SAFETY INDICATORS OPERATION

Safety indicator is a value which is used to quantified evaluation of system characteristics, in our case, the quantified evaluation of the safety and the performance of safety management. The safety indicators implementing objective is to control the system by numerical values similar like in reliability. Safety indicators numeric expression show the extent to which the process, organization unit or whole organizational is safe and how effective is safety management system in the organization.

Because the indicators are defined directly in relation to individual organizational and operational units, provides direct targeting of safety measures directly at the place of potential errors in the operating system.

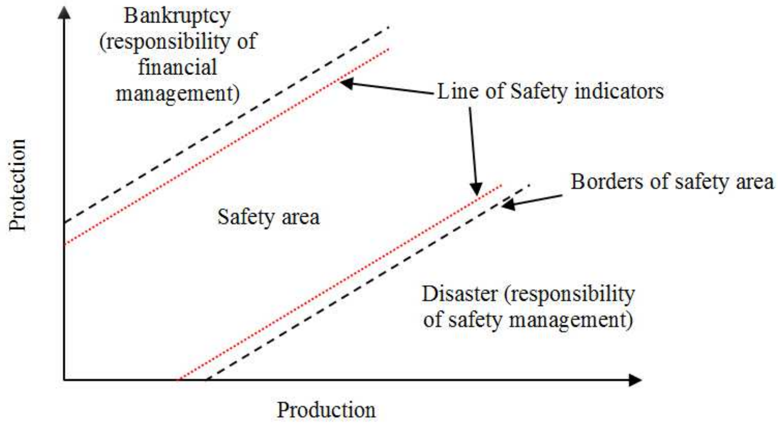

Figure 1 Diagram of safety area

Every organization has a safety area with defined boundaries, which exceeded means for the company bankruptcy or the accident realization. Gathering knowledge about the safety area and its borders is one of the preconditions for safe operation of the organization. Based on the collection of such knowledge it is possible to manage subsequently the whole system in terms of safety. Safety indicators at the border must be defined so that in case of exceeding the limit values they inform safety manager. Following the adoption of appropriate corrective action can be prevented from crossing the border. The next figure shows the possible consequences of behaviour within the safety area.

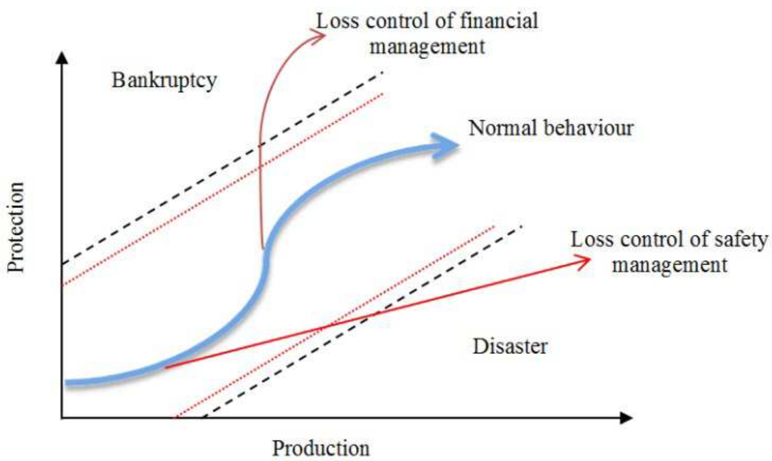

Figure 2 Possible consequences of behaviour within the safety area

Indicators evaluation is possible by using a simple numerical expression of the given event realization, or the percentage expression of the total events volume. For the right timing of taking corrective measures we can use two evaluation principles. The first principle is the single threshold measurement. When the indicator exceeds the specified limit value, the corrective measure has to be taken immediately to recover the safety of process and thus the indicator in a safe condition. The second principle is the multi threshold evaluation, which is based on the multiple thresholds existence. When we cross the first threshold, there is a necessary to review the procedure, but when we cross the second threshold value, we have to take corrective measure. Evaluation can also be performed on the basis of the evaluation of simple trend of the occurrence when we compare each indicator values in different time periods. Trends can be related to various characteristics such as density of operation, type of operation, the system changes, operational period, etc. to gain greater information value of the indicator.

3. OPTIONS FOR RESEARCH AND DEVELOPMENT IN THE GENERAL AVIATION

Safety indicators research in the general aviation has advantages in several perspectives. The first is that the environment is user sufficiently accessible in terms of the obtaining information possibility about the operating characteristics and principles of organizations functioning. Organizational systems of general aviation participants are simply to describe and range of operations is suitable for creating basic concepts for the safety management systems implementation and operation.

In the Czech Republic there are wide user base in the general aviation that provides plenty of room for research, for the systematic data collection, the examination of the application and flexible debugging user systems. General aviation is currently the subject of efforts of organizations EASA and EUROCONTROL. These efforts should result in overall professionalism of their operations. Organizations with good potential for commercial operation are therefore an attempting to comply with the stricter rules that are also applied to safety and included the safety management system and safety indicators implementation.

Building safety management and implementation of safety indicators in the field of general aviation must be generally performed without any support in the form of established tools and collected historical safety data. Another is the situation in professional organizations, working together with the excellent effect to use the established tools of safety management and historical safety information. International airports, air traffic control companies and airlines are already using advanced tools and they concentrate safety data into special databases. Based on these databases analysis and determine the most important and most common safety events, candidates for indicators can be determined in a short time. For further work with indicators it is usually needed overhaul of the structure of safety information databases.

4. PRINCIPLES OF SAFETY INDICATORS IMPLEMENTATION

Logical and user-friendly design of indicators for safety monitoring creates for a general aviation simpler way to evaluate safety and in terms of software solutions represents an important aid for the functioning safety management. On the other hand, puts additional demands on activities related to the data collection and evaluation. These activities are an integral part of working with safety indicators. To design, implementation and the actual execution of the tasks associated with indicators is necessary to ensure appropriate resources.

In comparison to large organizations, which economic management creates sufficient financial resources for quality managerial and administrative job positions, the financial and safety features of small businesses generally taken hold by workers who have sufficient operational issues knowledge and their operational and managerial functions are cumulated to a significant extent.

The safety management systems introduction into organizations such as in general aviation, it is therefore necessary to pay close attention when creating the implementation plan. The implementation plan must, on the one hand respect the basic standards imposed on the safety management system of the ICAO, EASA, Eurocontrol and IATA. These rules consist of two basic introduction of safety management processes, including hazard identification and risk management.

On the other hand, higher operating costs after the introduction of safety management systems should not cause organizations with financial difficulties. It is therefore necessary to create a solution that provides automated functions and assemble information for the evaluation, which will require non-economic interventions in the organizational structure for creating unnecessarily high number of administrative jobs.

5. PROBLEMS ASSOCIATED WITH THE INFORMATION COLLECTION

As mentioned in the previous chapter, smaller organizations do not have sufficient experience and background to operate system needed for the safety information collection and evaluation. Besides this problem based on the natural historical environment of general aviation organizations in the Czech Republic there is another problem associated with the overall safety culture level. In the current conditions, the accident investigation is carried out based on outdated principles and practices. Final reports subsequently do not provide adequate information base for building high quality safety indicators reactive model. air accident investigations data quality, sophisticated structure of additional information and effective system for sharing are essential conditions for the development safety. To improve the current situation, we recommend the implementation of the principles of investigation by Reason's model and other modern tools such as the FRAM methodology.

Another problem, which existence can be logically assumed on the basis of information from the previous paragraph is the problem of organizations that arise when working with incidents. Systematic data monitoring on incidents and errors, that preceded incidents, creates a very valuable inputs for further analysis and comprehensive safety management. For illustration we present in Figure 3 comparing the ratio of accidents and incidents in the Czech general aviation and other countries under the supervision of EASA. The graph shows a lack of information about incidents that help to build preventive aviation safety. To share information about incidents can not even speak. This fact is also associated with the safety culture level where safety information is considered secret, which disclosure would be punished. The organization can not easily learn from mistakes from other organisations and must improve on their own errors. The recital of EASA Basic Regulation promotes the concept of a 'culture of safety', which requires incidents and occurrences to be reported such that there is a non-punitive environment and protection of such information and of those who report it.[5]

Safety indicators also use information about critical steps in the processes that are collected through modern intelligent audit systems running on platforms of smartphones and tablets. Regard to the circumstances it is necessary that the implementation plans for safety management systems respect the gradual improvement and implementation of advanced tools at reasonable intervals.

For the risk prediction, as for accident investigation, we can talk about a development from technical, to human, and even to organizational causes. This does not imply that all features of risk assessment can be classified according to a technical–human– organizational 'scheme'. There are features that cut across these aspects, such as dependent failure analysis and uncertainty analysis [2].

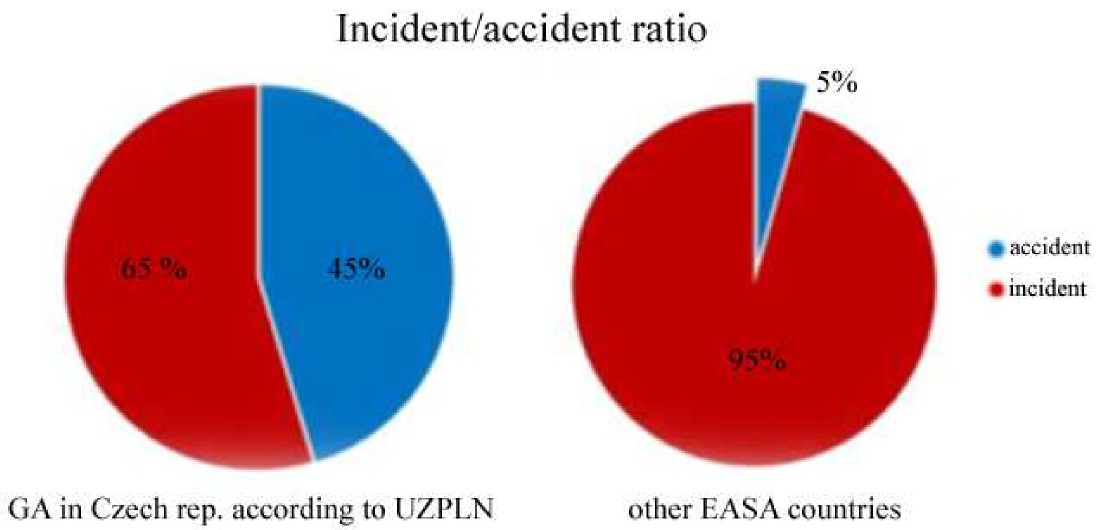

Figure 3 The ratio of reported incidents and accidents source – UZPLN, EASA

6. LAYERS OF SAFETY INDICATORS

Safety indicators can be divided into several layers, depending on the type of collected information which is used for analysis and safety management. Differences are also methods that are used in the collection. Safety performance indicators can be of a reactive, or a proactive nature, depending on the indicators characteristics. Reactive indicators (lagging indicators) are after-the-event type of indicators, while proactive indicators (leading indicators) assume measurements of underlying causes and contributing factors to accidental events, such as (inadequate) training, supervision, etc., and thus providing early warnings [4].

The simplest form with high information value is the use of safety culture indicators. Based on interviews with employees at all organizational levels, we are able to estimate the safety culture degree, which achieves the appropriate organizational level. Specifically it is all about control safety climate. Safety climate is a manifestation of safety culture, and you can define it as staff perceptions of the environment in relation to safety. Figure 4 shows the individual levels, which using is standardized according to research dating back to the 80 years of the 20th century. Safety culture indicators have several advantages. The greatest advantage is that for the data collection a special tool is not required to create. Only filling a questionnaire and its evaluation is necessary. According to the respondents we get an overview of the state of the individual departments, where we subsequently directed corrective measures. To improve the organization may choose corrective measures to achieve higher grades. We can also measure the shift through this questionnaire periodically. The indicators represent a proactive safety culture model. It does not focus on the causes and consequences of accidents but the approach of the staff to the perception safety. On the basis of implemented corrective actions improving the comprehensive safety climate.

The next layer is an indicator defined on the basis of accidents and incidents statistical analysis in accordance with the development trends and the selected monitored data structure. Safety indicators defined by statistical evaluation can be considered as a reactive tool of increasing safety. The problems with their implementation has been discussed in the previous chapter.

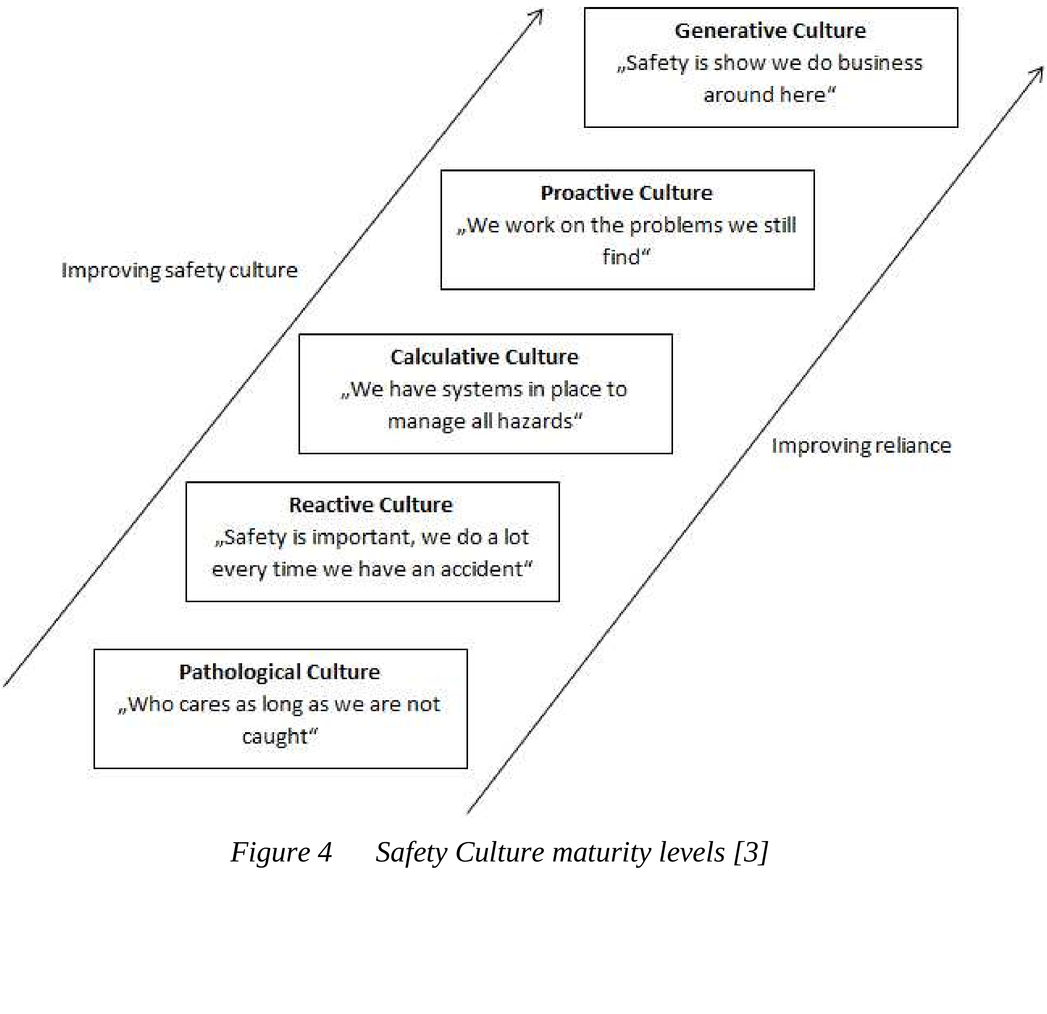

Figure 4 Safety Culture maturity levels [3]

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Operating Indicators are obtained by critical process steps monitoring. These indicators gain through process analysis, critical steps identification and identify their critical combinations leading to incidents and accidents. This analysis can be performed retrospectively on historical events, for the safety it is also valuable an the possibility analysis of future events involvement. Both forms of the process is carried out in the hazard identification process.
Another layer could be called compliance checks. This indicator is closely linked to the safety approach called CBO. We focus mainly on how the organization is committed to the regulation issued by the regulatory authority and the extent to which complies with and meets. Compliance with regulations is the primary but not the only and most important element in building a secure environment.
These base layers indicators presented in contemporary approach to the structure of safety indicators and their implementation.

7. CONCLUSION

For presentation of indicators for safety in general aviation can be used a parallel to the practice of medicine. Doctors assess the patient's condition in the first contact on the basis of simple of indicators such as body temperature, the pressure, the reaction of the eye pupils, protein in the urine, etc. For diagnostics the specialized tests are used such as blood tests, tissue samples, etc. Until recently, safety was considered as a system, which is not measurable. Another feature **-** the reliability of the technical systems can be measured based on the evaluation of reliability of the components and their functional structure. Nuclear power plants and Air navigation services operational safety can again be measured based on the data from electronic control systems evaluation.
Safety measurement in organizations such as airports, flight schools, maintenance organizations is difficult precisely because of the need to create a data collection system. In the following years, the organizations will be forced by legislation to create a tool for collecting and evaluating their safety data and sharing them across whole aviation. This approach will allow better oversight of organizations safety and also enable the timely start of treatment functions, which will be created according to the principles of safety management.

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STOPPING DISTANCE DEPENDING ON WEATHER CONDITIONS OF CENTRAL EUROPE

Ján VRÁBEL[1] - Zuzana MAJEROVÁ[2]

Abstract: *Rules of the road require the driver to drive at a speed that proved to safely stop the vehicle just before the barrier, which can occur suddenly. Safety of assailable road users proportionally depends on the speed of a moving vehicle on the road. In the village is an increased move of pedestrians and cyclists, not only on the sidewalks, which are reserved for pedestrians, but also on the roads. Improving the safety of the participants was the main reason for the reduced speed of vehicles in several European countries from the original 60 km.h^{-1} to the current 50 km.h^{-1}. Increasing speed increases the kinetic energy that operates in a collision with a pedestrian or cyclist. In our article we aim to show the importance of the decision to reduce the speed in the village. It focuses on stopping distances, which are determined by several factors affecting tire grip the road. One of main factors is the change in weather conditions. Stopping distance measurements were carried out in different types of weather conditions that are typical for Central European climatic zone countries. Measurements were performed on the same vehicle, a road of the same slope on snowy, wet and dry asphalt. We refer by our article not only to the difference braking distances which are necessary to stop the vehicle in different weather conditions, but also the need of use of the right kind of tires with sufficient tread depth in the summer as well as winter coats.*

Keywords: *stopping distance, weather conditions, road incident*

1. INTRODUCTION

Road traffic safety regulation require vehicle to be able to stop within visibility distance. The reaction pathway depends on the driver's speed of reaction, concentration, experience and immediate mental and physical condition. The driver does not change direction or speed of a vehicle during the phase from noticing obstacle to the stopping of the vehicle. The stopping distance of a vehicle is determined by several factors which affect tire grip such as weather conditions (e.g. rain, fog, lighting conditions), geography (e.g. slope traverse plane), speed, quality and type of tire. The driver scope is influenced by density of transport flux, the driver's view of traffic flow (e.g. saddle, peak), topography and environment.

The driver is required to drive only at a speed to be able stop before an obstacle is suddenly revealed ahead. The distance travelled by the vehicle from the moment of the obstacle appearing to the vehicle standstill is called trajectory required to stop a vehicle. It is influenced by the driver's ability to respond to the technical and structural status of the braking system, driver's speed and tire design.

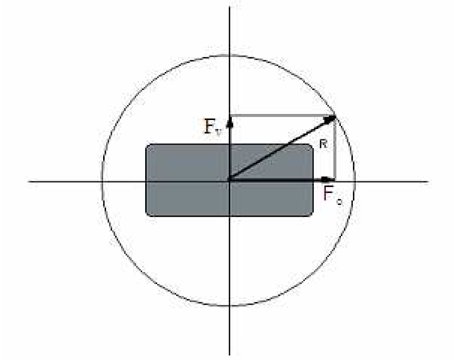

Figure 1 Force operations in tire's touchpad (friction circle) [1]

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When changing weather conditions, there is a change of the grip of the vehicle to the road. This is particularly characterized by the coefficient of adhesion of the touchpad. Figure 1 schematically shows the tire contact area with the road surface. In the tire's touchpad acts circumferential force ***Fo*** and lateral guiding force ***Fv***.
Vector sum of the two forces results in resultant force R:

$$R = F_t = \sqrt{F_o^2 + F_v^2} \tag{1}$$

where: Fo - friction force in the x-direction
Fv - friction force in the y-direction

If the resultant R is greater than the maximum friction force Ft between the wheel and the road in a given direction, there will be a skid. Assuming that the wheel is able to pass the same frictional force Ft in all directions, we get a friction circle. The friction circle expresses graphically tire's skidding limit.

There are three cases:
1. force R is smaller than the friction force Ft, there is no wheel skid,
2. force R is as large as friction force Ft, the wheel is just on the limit of the skid,
3. force R is greater than the friction force Ft, there is a wheel skid.

For the resulting coefficient of tire's cohesion μ, thus for the coherence factor in the longitudinal direction μ_o and for the factor of cohesion in the lateral direction μ_b, there is the equation:

$$\mu = \sqrt{\mu_o^2 + \mu_b^2} \tag{2}$$

The value of the coefficient of cohesion, depending on the road surface.
In Figure 2 the dashed line shows a sudden drop of the coefficient of cohesion when it begins to rain.

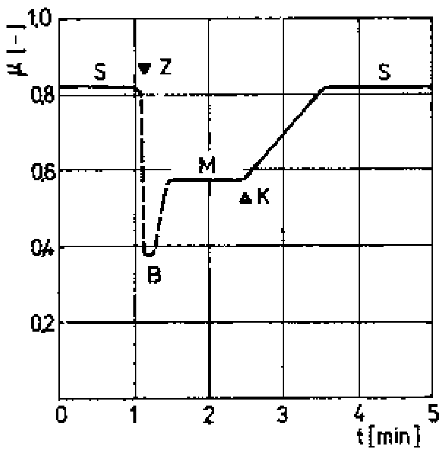


Figure 2 Progress of coefficient of cohesion during the short rain [1]

where S - dry road surface,
Z - top of Rain,
B - slippery mixture of dust with water,
M - washed wet road surface,
K - after rain.

In addition to various technical parameters and coefficient of cohesion there is also impact of weather conditions on stopping distances. This article discusses the conditions that are typical for the Slovak Republic in the summer. For the purposes of this article, the measurements were made at the airport in the village of Rosina near Žilina.

2. PRACTICAL MEASUREMENT

The aim of this article is to measure, evaluate and compare the mean achievement of a fully developed deceleration and stopping distance in this action in practical measurements with the vehicle Citroën C6 under different conditions (Figure 3).

Studied conditions, the change of which has a direct effect on actual achieved vehicle deceleration achieved were:

- coefficient of cohesion between vehicle tires and the road surface,
- initial vehicle speed at initiation of braking,
- tire inflation,
- jacket temperature and brake disc.

Figure 3 Photo of vehicle Citroën C6 from the measurements in wet conditions

2.1 Measuring equipment

As measuring and tracing device during braking deceleration was used Correvit from Corrsys Datron company. This device consists of four main parts, namely of a microwave sensor, brake sensor, the evaluation unit, the control panel (Figure 4 and Figure 5). To identify any additional information we used a device for measuring the initial rate - lightbar, cones, measuring tape, camera, camcorder, touch thermometer, caliper and notebook.

Figure 4 Attachment of microwave and brake sensor on the vehicle

Figure 5 Evaluation unit and control panel

2.2 Measurement methodology

After installing the measuring device on the vehicle Citroën C6 required input data were set to Corrrevit. The sampling frequency of the system was set to 200 Hz.
The experiment was conducted in two modes depending on the approach speed 50 km h-1, with the tires inflated to the pressure specified by the manufacturer of automobile 2,4 bar, on wet and dry asphalt. Tire size was 245/45/R 18100 W. Tread depth on front tires was 5.1 mm and 6.9 mm for the back tires. Three measurements were performed for each speed of approach on dry and on wet surfaces.

3. EVALUATION AND COMPARISON OF MEASURED DATA

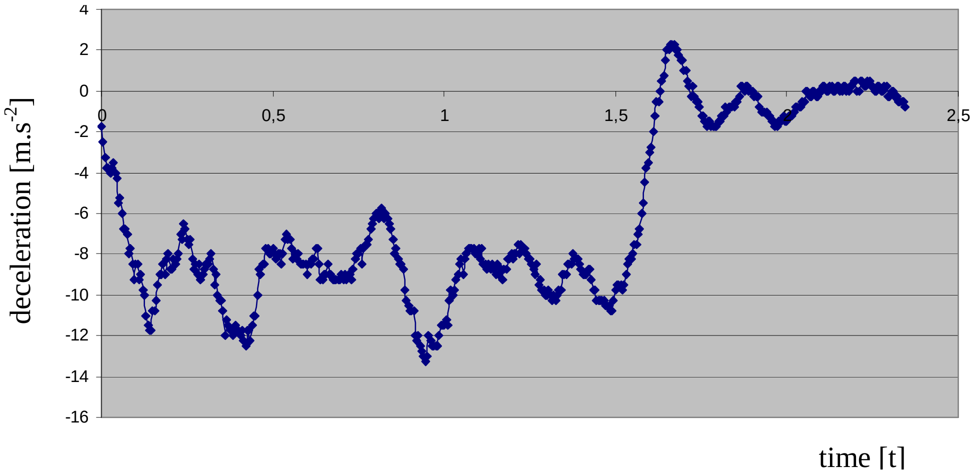
Table 1 presents data of the speed at the beginning of fully developed deceleration, calculated the mean data of fully developed deceleration, time data and path travelled by the vehicle during this time.

Table 1 Measured and calculated data, approach speed 50 km h-1, dry asphalt

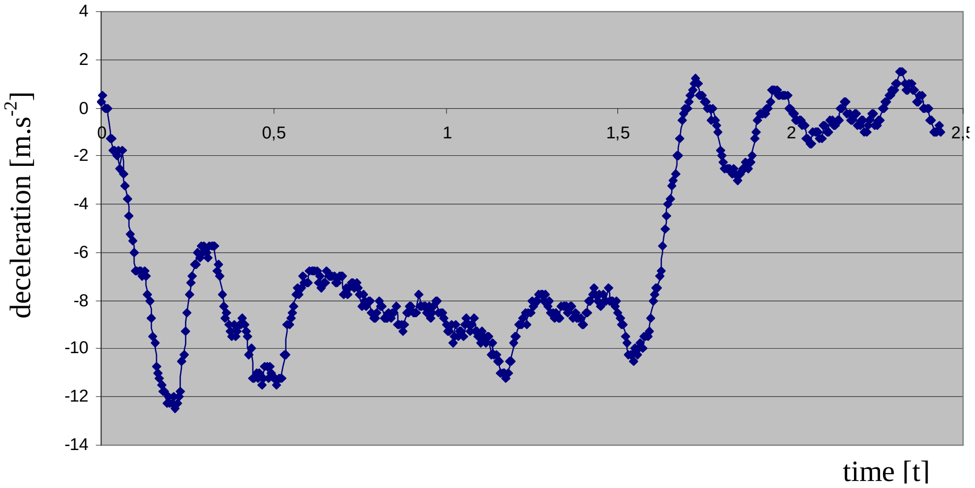
	experiment	Speed at the beginning of fully developed deceleration [km / h]	Braking track [m]	The braking time [s]	The calculated value of fully developed deceleration a [m/s2]
cramped by manufacturer (2.4 MPa)	1.	46,17	9,34	2,145	8,81
	2.	46,89	9,95	2,235	8,53
	3.	48,87	10,41	2,215	8,85

The following graphs show relativity of braking deceleration and time from the moment of braking for the given mode. In the title of the graph is given in parentheses speed of approach, the climatic conditions.

Picture - course of braking deceleration in time from the moment of braking experiment No. 1 in dry conditions



Picture - course of braking deceleration in time from the moment of braking experiment No. 2 in dry conditions



Picture - course of braking deceleration in time from the moment of braking experiment No. 3 in dry conditions

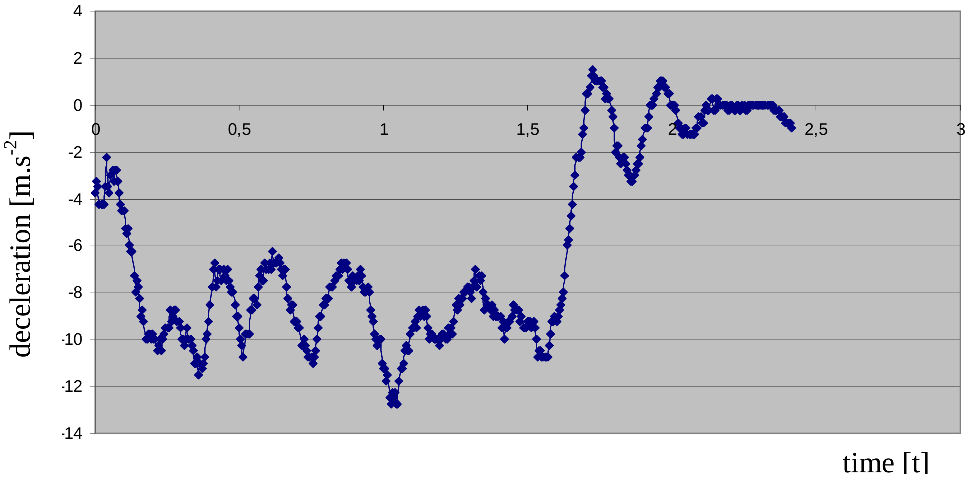
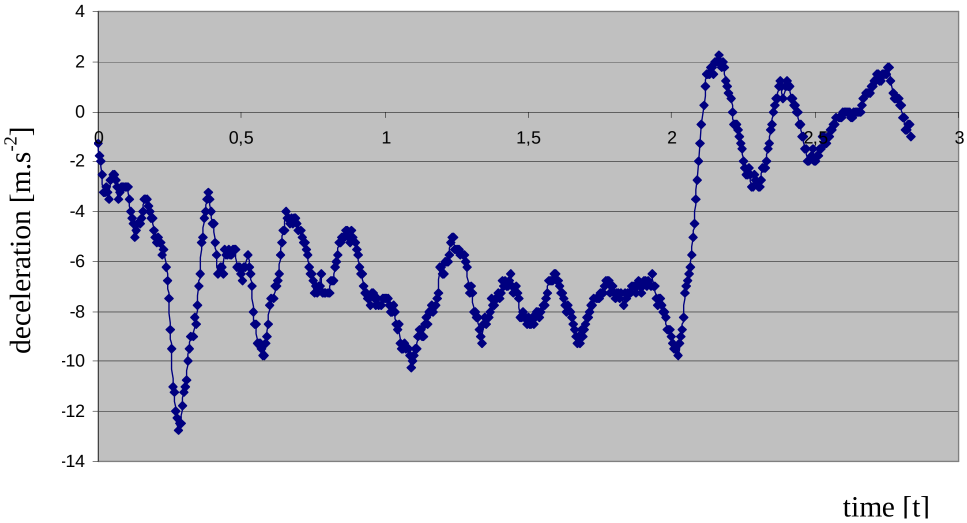


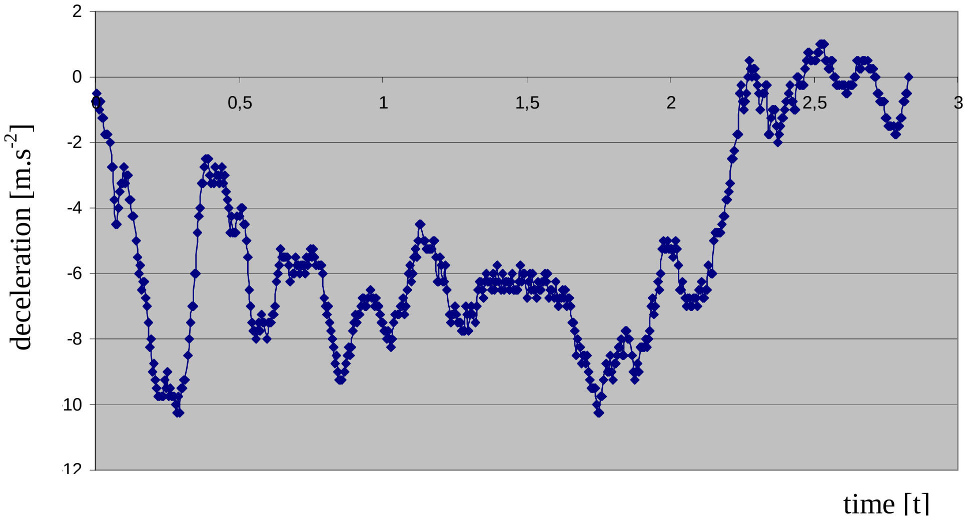
Table 2 Measured and calculated data, approach speed 50 km h-1, wet asphalt

	experiment	Speed at the beginning of fully developed deceleration [km / h]	Braking track [m]	The braking time [s]	The calculated value of fully developed deceleration a [m/s2]
cramped by manufacturer (2.4 MPa))	1.	50,31	13,81	2,635	7,07
	2.	49,68	14,4	2,63	6,61
	3.	50,85	14,87	2,775	6,71

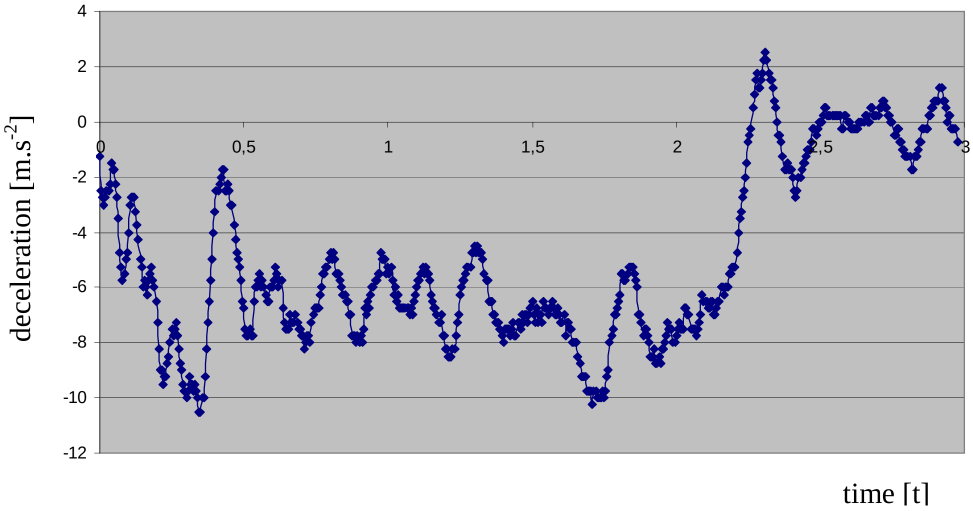
Picture - course of braking deceleration in time from the moment of braking experiment No. 1 on the wet surface.



Picture - course of braking deceleration in time from the moment of braking experiment No. 2 on the wet surface.



Picture - course of braking deceleration in time from the moment of braking experiment No. 3 on the wet surface.



4. CONCLUSION

In the first group of measurements (50 km h-1, dry asphalt) is the average braking distance obtained at the specified system Correvit at the specified inflating 9,9 m. In the second group of measurements (50 km h-1, wet asphalt) is the average braking distance obtained by the system at the specified inflating 14,36 meters.

From mentioned facts it is clear that if we take the value of 9,9 m in dry conditions as a basis, i.e. 100%, the braking distance is extended approximately by 4,46 m in absolute terms. If we would like to express as a percentage, so the stopping distance of the vehicle in wet conditions extended by about 45%.

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