Synergetic effects of National Technological Infrastructure in ITS development

Prof. Dr. Sc. Zvonimir Radic[1*], Prof. Dr. Sc. Hrvoje Gold[2],
Assoc. Prof. Dr. Sc. Ivan Markezic[2]
1. ISOT, Kralja Zvonimira 67, HR-10000 Zagreb, Croatia,Tel/Fax: +385 1 465 11 60
E-mail: Zvonimir.Radic@public.srce.hr
2. Faculty of Traffic Sciences, University of Zagreb, Vukeliceva 4, HR-10000 Zagreb, Croatia

ABSTRACT

The national ITS is the complex technological system consisting of subsystems developed in other national infrastructure systems. The permanent nonfundamental trait of all infrastructure systems in technology is their ability to produce strong and desirable synergetic effects when interacting with other technological systems. It may be proved that the acceptable feasibility of building large, complex intelligent transport systems may be realised by a foregoing development of technologically consistent and feasible National Technological Infrastructure producing synergetic effects. In transitional countries the components of the National Technological Infrastructure exist only partly, satisfying short-term feasibility criteria and without any relevant synergetic features.

KEYWORDS

System, Synergy, Intelligent Transport System, National Technological Infrastructure, Transitional Conditions

INTRODUCTION

At the 6th World Congress on Intelligent Transport Systems (ITS) in Toronto 1999 [1] the urgent necessity has been stressed to standardise the programs and structures of those large, complex and expensive systems in the early stage of research and development, because the spontaneous and disciplinary oriented development would result in inappropriate interfaces between particular elements of the systems themselves, and between the systems and their environments. Improvements of such interfaces would mean unacceptably expensive reprogramming and restructuring of already implemented systems. The requirement generated additional demands for better system-based insight into the phenomenon of the “technological environment” as the basis for building one of the largest and most complex infrastructural technological system in the world – ITS.

The general systems theories applied to complex technological systems – which appear as the results of introduction of information/data teleprocessing and other infrastructural programs into existing infrastructural technological systems – reveal their homomorphic and isomorphic features. The fact helped in creation of the concept of National Technological Infrastructure as the basis for building any other complex technological system in the country.

The permanent nonfundamental trait of all infrastructural systems in technology is their ability to produce strong and desirable synergetic effects when interacting with other technological systems. The fact calls for introduction of such systems into the National Technological Infrastructure, especially from the point of view of building more complex systems. The models and classification of technological systems based on their synergetic features, may substantially accelerate the creation of the National Technological Infrastructure by directing the national technological resources into the field, and may substantially facilitate the development of ITS.

CONCEPT OF INFORMATIONAL SYNERGY IN TECHNOLOGICAL SYSTEM

In reference [2] the basic concept of synergy has been developed. The definition is given generally as follows:

The synergy means the behaviour of integral, aggregate, whole systems unpredicted by the behaviours of any of their components or subassemblies of their components taken separately from the whole.

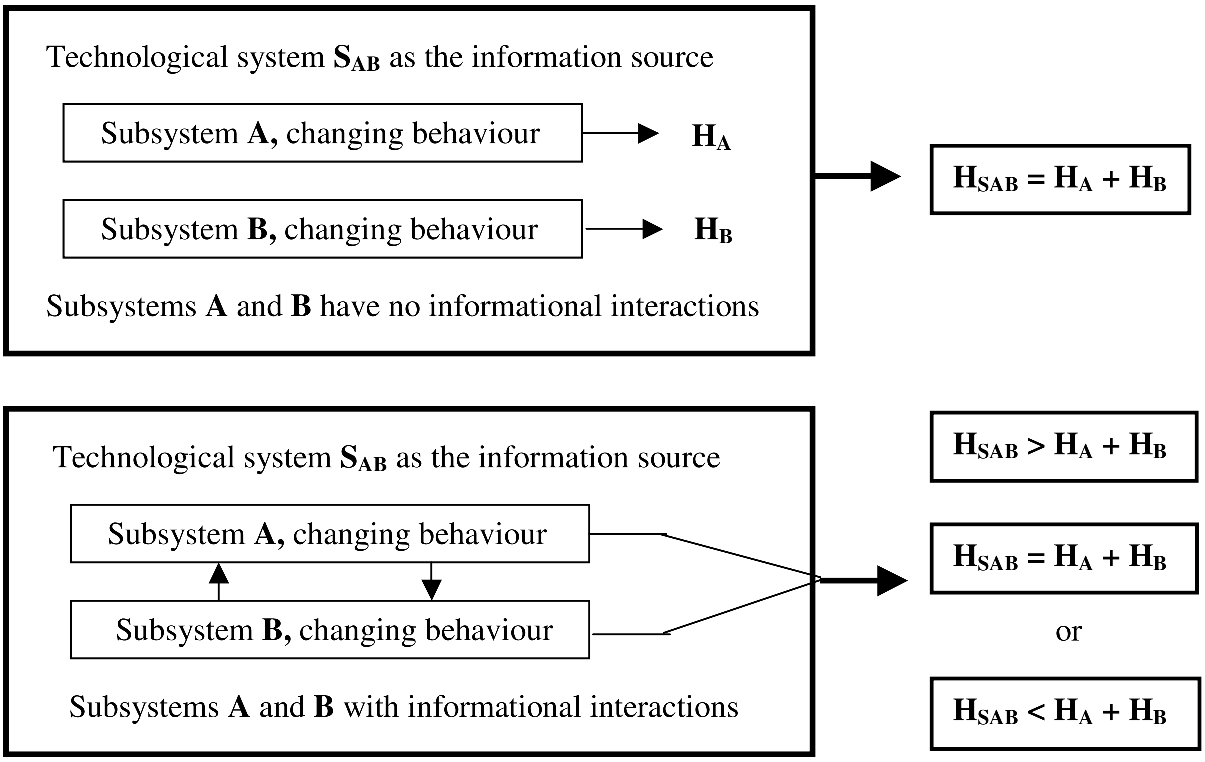

Figure 1 - The technological system as the complex information source with synergetic effects

The definition of information developed in reference [3] is based on the informational synergetic effects in technological systems, and is very useful in further discussion. According to the reference: “The information is the symbolic expression of the change in behaviour of a technological system, which provokes the change of behaviour of another technological system receiving the expression, or the change of relations between the two systems".

If the symbolic expression of the change in behaviour of a particular system does not provoke the change in behaviour of the system receiving it, the symbolic expression is not information but data.

Using the above definitions of both terms the informational synergy is illustrated in Fig. 1.

A technological system S_{AB}, composed of two subsystems A and B in the case of no informational interactions between the two subsystems (the upper structure in the Fig. 1) as the information source generates the quantity of information

$$\mathbf{H_{SAB} = H_A + H_B.}$$

If the two subsystems A and B of the system S_{AB} start to realise information interactions between each other, the respective information source, shown in the lower structure of the Fig 1, may generate the same or different quantities of information. The quantities remain unchanged in the case the interactions are ineffective. Generally the information source produces a different quantity of information:

$$\mathbf{H_{SAB} < H_A + H_B,}$$

in the case of undesirable synergetic features of the subsystems, or

$$\mathbf{H_{SAB} > H_A + H_B,}$$

in the case of desirable synergetic features of the subsystems.

The strong and desirable synergetic features of the subsystems A and B generally means that the subsystems are complementary in their development and support each other strongly by exchange of technological information. In that case the technological system S_{AB} changes its behaviour much faster producing

$$\mathbf{H_{SAB} >> H_A + H_B.}$$

STRUCTURE OF ITS FROM THE SYNERGETIC POINT OF VIEW

In reference [4] the national ITS as the system consisting of subsystems developed in other national infrastructure systems, and depending on all other (well developed) infrastructural systems in the country, was discussed (Fig. 2).

The discussion revealed parts of a number of technological systems as the building bricks for ITS. Some of the identified systems were: National Education System (all levels), Wireless and Wireline Communication Centres and Networks, Driver's Pre-Trip Information Centres, Driver's On-Trip Information Centres, Traveller's Trip-Relevant Information Services, Traveller's Personal Information Services, Broadcasting Radio Centres, Weather Information and Data Systems, Tourist Information Centres, Traffic Relevant Tourist Information Centres, Emergency Information Processing Public Centres, Information Centres Relevant to

Transport Planning, Tourist Guidance Services, Local Transfer Services, Public Data Banks, Law Enforcement Agencies, etc.

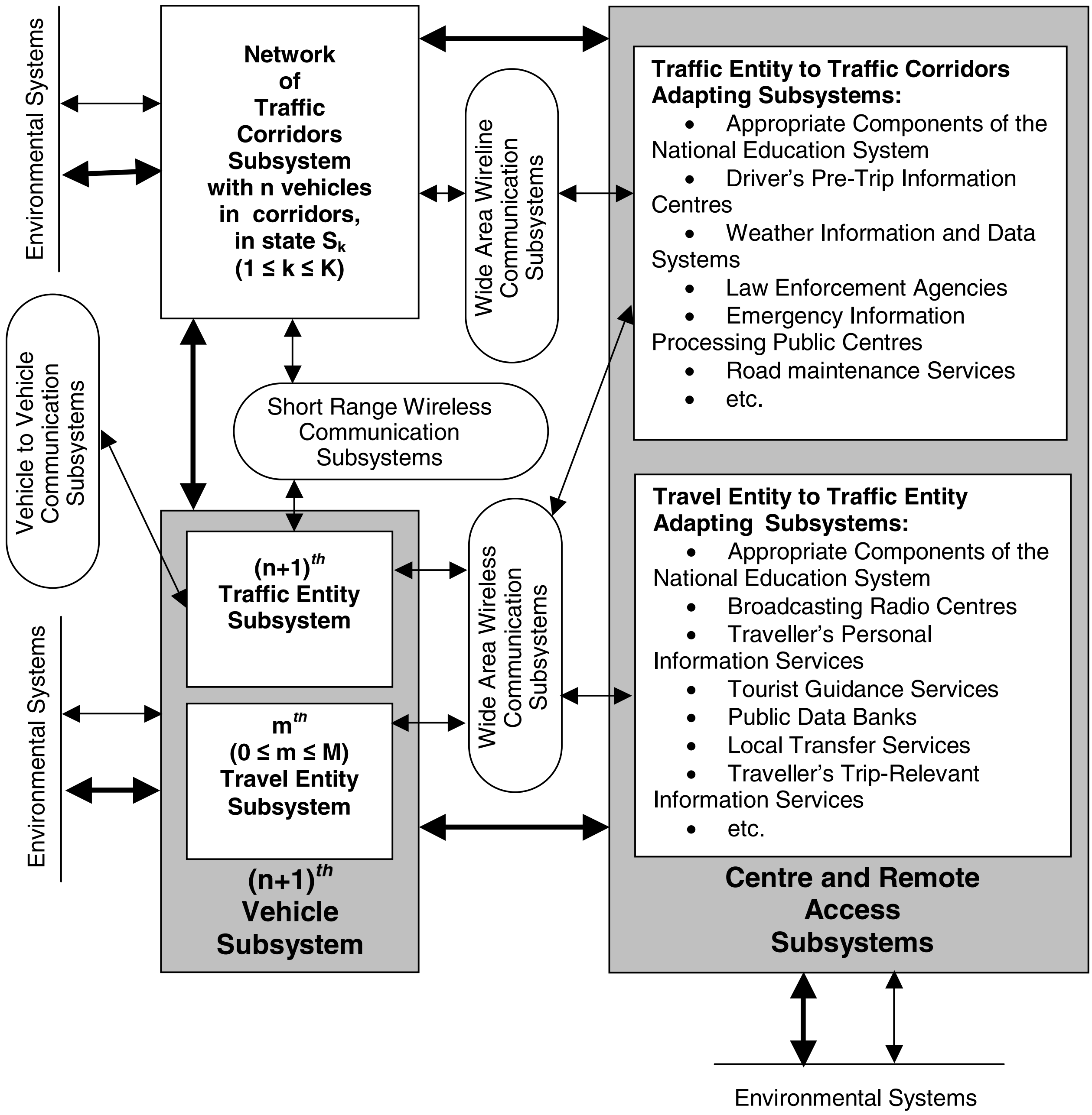

Figure 2 - The national ITS as the system consisting of subsystems developed in other national infrastructure systems

The classical disciplinary approaches to the building of complex technological systems by introduction of information/data processing and other infrastructural programs into existing technological systems are limited to narrow disciplinary theoretic concepts and methodologies. The approaches face a lot of difficulties in development of such systems discussed in references [5] and [6]. The general system based insight into the field facilitates the disciplinary recognition and solution of problems based on synergetic criteria, too. The respective methodologies help to introduce the broad definition of infrastructural technological system, which includes the Man as its basic element. This was the main reason for substitution of technical models of the systems by much more complex technological models in quoted references.

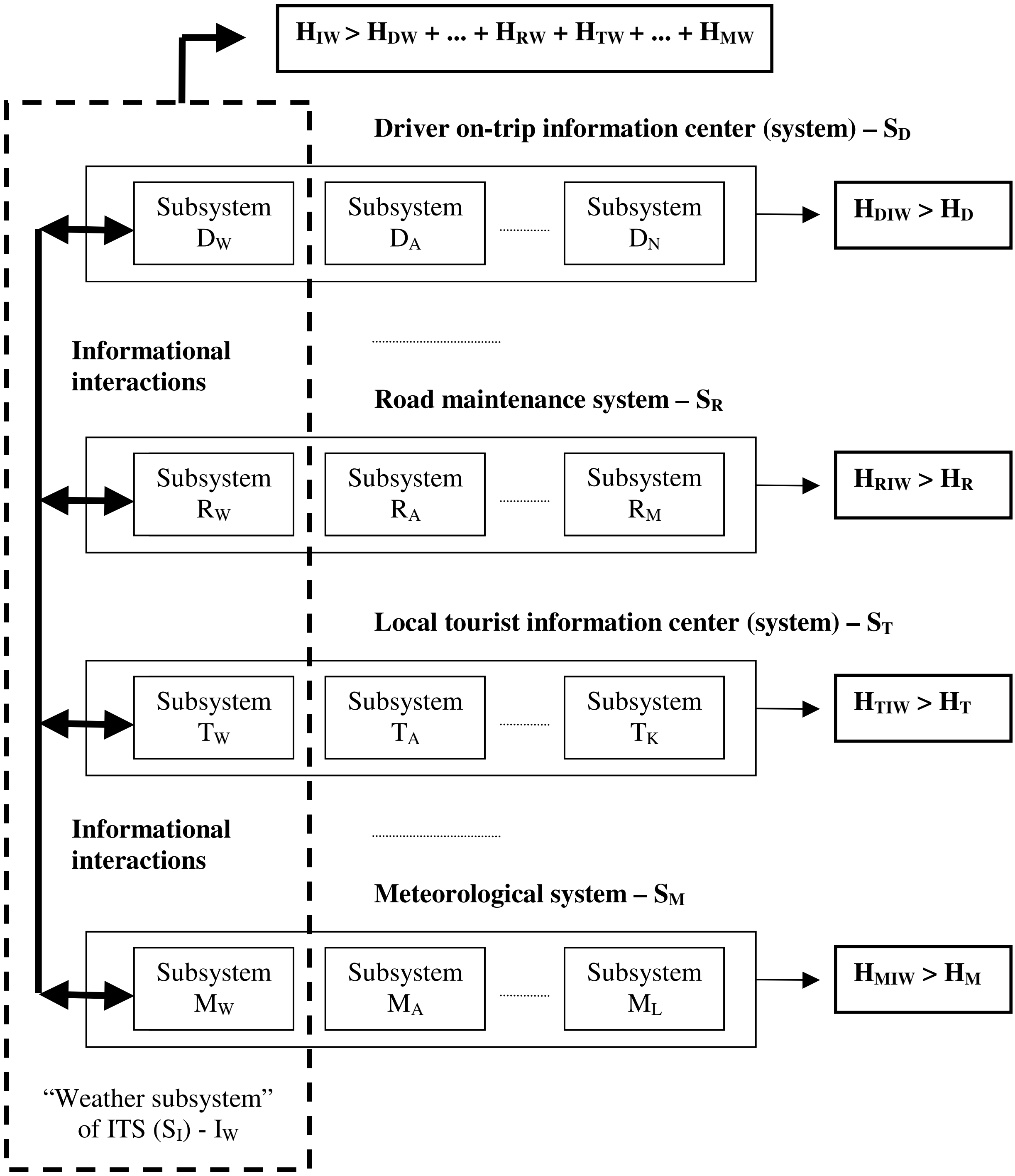

Figure 3 - Informational synergy produced in National Technological Infrastructure by building National Intelligent Transport System

The significance of the result rises owing to the fact that the existing infrastructural technological systems are, actually, designed using a number of disciplinary criteria, which can hardly be consistent in such a degree to produce strong and desirable synergetic effects, if interacting with other technological systems.

In the development of the new model of National Technological Infrastructure, the main hypothesis was: technological systems, which produce strong and desirable synergetic effects if interacting with other technological systems, belong to the particular set of systems composing the National Technological Infrastructure. It may be proved that the acceptable feasibility of building large, complex intelligent transport systems (appearing as the result of introduction of a number of infrastructural programs into existing transport systems) may be realised by a foregoing development of technologically consistent and generally feasible National Technological Infrastructure.

Some components of the National Technological Infrastructure as systems, with their "weather subsystems" interconnected by informational interactions into the "weather subsystem" of the national Intelligent Transport System, are shown in the Fig. 3.

The set of technological systems, having in their universe of discourse the "weather subsystems" (concerned with weather forecasting and all other weather related activities), are denoted S_D, S_R, S_T and S_M (Driver in-trip information centre, Road maintenance system, Local tourist information centre and Meteorological system, respectively). The set may consist of all relevant systems existing in the country.

The first level of the universe of discourse of each system consists of subsystems represented before their interconnection by informational interactions with other respective subsystems. The "weather subsystems" are denoted D_W, R_W, T_W and M_W, respectively.

H_D, H_R, H_T and H_M denote the quantities of relevant information generated by respective systems before the interconnection of their "weather subsystems".

H_{DW}, H_{RW}, H_{TW} and H_{MW} denote the quantities of relevant information generated by respective subsystems D_W, R_W, T_W and M_W before their interconnection by informational interactions.

Interconnecting the "weather subsystems" D_W, R_W, T_W and M_W in order to build a new structural entity: the "weather subsystem" of the new Intelligent Transport System S_I, denoted I_W, we change all informational relationships among the systems involved.

If we denote by H_{DIW}, H_{RIW}, H_{TIW} and H_{MIW} the quantities of relevant information generated by respective technological systems after interconnection of their "weather subsystem", and by H_{IW} the same for the ITS "weather subsystem" I_W, than we can state as follows:

$\mathbf{H_{DIW} >> H_D}$,

$\mathbf{H_{RIW} >> H_R}$,

$\mathbf{H_{TIW} >> H_T}$,

$\mathbf{H_{MIW} >> H_M}$,

and

$$\mathbf{H_{IW} \gg H_{DW} + ... + H_{RW} + H_{TW} + ... + H_{MW}.}$$

This is valid if the systems have strong and desirable synergetic features, which means that the systems strongly support each other in their development, and that the development of the each single system is complementary to the development of all systems involved.

The operational feasibility of the systems involved depends on their long-term infrastructural functionality as the components of the National Technological Infrastructure.

THE STATE-OF-THE-ART OF SYNERGETIC ITS DEVELOPMENT IN TRANSITIONAL COUNTRIES

The technological development of transitional countries occurs by using their own national resources at the same time as by technological cooperation with complementary countries. The last means the exchange of equivalent technological information among those countries, normalised in their values [3].

The efficiency of use of the national resources in the development of national technological systems strongly depends on a number of supporting technological systems developed in the country to facilitate the use of the resources. The same is valid for the effectiveness of technological cooperation among complementary countries, and for the efficiency of their common technological effort.

The supporting technological systems belong to the special class of technological systems called infrastructural. These are, for instance: educational, telecommunications, post, transport, informational, technical maintenance, meteorological, and many other systems. The most complex of all such systems is the national ITS.

In transitional countries, the design and building processes of the necessary National Technological Infrastructure do not follow appropriate system-based methodologies and the development and maintenance processes follow, generally, the disciplinary criteria. This is the reason why the systems produce a number of problems (in the systems themselves and in the environment) concerning: technological incompatibility, worse effectiveness and efficiency, ecological inadaptability, etc.

With their functionalities based on short-term feasibility criteria, the existing infrastructural systems turn to become commercial undertakings loosing their strong and desirable synergetic features. This heavily burdens the efforts to accelerate the technological development in general. At the level of infrastructure the consequences are: the lack of some vital functional infrastructural systems and the slow-down of development of an efficient and effective National Technological Infrastructure.

From the point of view of ITS, the loss of synergetic features of existing components of the National Technological Infrastructure, the application of short term feasibility criteria in all new investments into the infrastructure, and the lack of some vital infrastructural components – push the ITS projects towards the “recycle bin” of the infeasible investments.

CONCLUSION

In the fast developing countries (US, etc.) there exist the National Technological Infrastructure, which produce synergetic effects when using their components (subsystems) as building bricks of the new, complex national technological systems. The fact facilitates substantially the development of Intelligent Transport Systems (ITS).

In slow developing countries, i.e. transitional countries, the systems exist only partly, built commercially without any infrastructural mission, satisfying short-term feasibility criteria, and producing no strong and desirable synergetic effects. This is the main cause of low feasibilities of ITS projects in transitional countries.

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