Handling Engineering Design Experience

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Abstract. *The paper presents trials in handling of engineering design experience in industrial and academic communities. Advanced CAD/CAM and other computerized supporting tools are applied on different hardware platforms in a network environment, relating to shipbuilding. First, the ship construction process is briefly summarized with emphasis on current design methods and tools. Next, the handling of design experience with respect to increasing importance of remote education and of remote interaction among a number of different internal and external participants with distributed responsibilities, has been investigated. Finally, a framework of a design experience collection in ship construction based on the Web technology is provided for network-aided design team collaboration in shipbuilding, as well as for higher-level distance educational purposes.*

Keywords. ship construction, CAD/CAM, network, WWW, HTML, STEP, PHP, JAVA, information technology, virtual models, models, distance education.

1. Introduction

The paper briefly presents the basic activities: the participants, the distribution of responsibilities and the information flow of a ship construction process [1]. From the industrial point of view, such processes normally involve wide area design teams working at different sites worldwide in a complex technical and social environment [2]. Such processes and teams needs much information from various sources and of different kinds, and require intensive communications [3]. Different computer supported tools available at present are applied for implementation of a user-friendly environment for network-aided collaboration and experience exchange in engineering, considering different elements often encountered in ship construction.

2. The ship construction process

The construction process is triggered by a newbuilding construction tender. After intensive negotiations, calculations, newbuilding construction project and approval to sign a contract can follow. The local environment in the shipyard is heavily affecting the ship construction process. First, the construction development and planning, the technology development and personnel planning are the activities, which assure the feasibility of a newbuilding contract. The main ship particulars as well as the principal functions and operational requests on contracted ship are not defined in the construction department but in the main design office. The machinery room and the ship outfit are defined in other departments in the shipyard. The ordering requisition processing, ordering of material, acceptance, delivery and storage are also apart from the construction office. The construction technology and procedures workouts are defined elsewhere and affect very much the construction process. Strength calculations and checking are sometimes performed in the construction office itself. But often, independent external specialized consulting offices perform the calculations in other department within the shipyard, or. Methods involved at present in strength calculations are based on different FEM modeling and solving tools on digital computers.

The success of the construction department is a direct consequence of how promptly it can receive, launch and handle all the on going information from or to the rest of the shipyard. Such an internal information interchange can be viewed as a local area problem. In the construction office itself the following preparations take place: construction documentation, drawing, specifications, workshop hull drawings, ship sections plan. Participants outside the shipyard permanently influence the entire construction process. The shipowner who ordered the ship has also his specific request and frequent modifications to the design and construction. Different manufacturers

and suppliers affect the construction process too by their special offers.

The Classification Societies have an outstanding role in the ship construction. First of all they define the rules for ship construction and survey of the ship construction in the design phase as well as the structure under the ship construction and erection. The materials and workmanship are approved by Classification Societies. Every ship construction document used in classification process has to be approved by the experts of the Classification Society. All this activities with external participants, which are also subjected to Classification Societies inspection, can be denoted as wide area communication problems.

The important goal of remote cooperation in construction office is the elimination, or at least reduction of the amount of paper drawings. Prerequisite for such an approach is the possibility to electronically approve and control the documentation and document flow. It appears that a complex PIM (Product Information Management [5]) or PDM (Product Data Management [6]) electronic replacement for traditional control and approval methods is required. But, the production documentation for most of the complex structural parts still has to be prepared mostly on paper and no electronic or digital replacement can adequately replace the traditional workshop practice in shipyards so far.

Even this short consideration about activities of a construction design team placed within a shipyard proves how intense information flow using various communication means takes places within the shipyard as well as with the wider production environment.

3. Current design methods and tools

The design methods at present in an experienced ship construction office whenever a complex ship is under development, needs a very intensive communication with a large number of different participants of the whole ship design and production process inside and outside the shipyard. The exchange of design data models among heterogeneous CAD systems is a difficult task because the systems involved have different data structures suiting to their own functions [1].

Existing computerized supporting tools such as PDM or PIM, can serve individual design activities as well as local team collaboration, mostly fulfilling communication needs in contacting different participants in different countries, even continents. However, the team in the shipyard has to rely on all available communication tools, since not all of the participants in the shipbuilding process can afford the most recent communication technology. Moreover, many of the cooperating groups are using different IT platforms and supporting software tools. The enormous data interchange in ship design, construction and production is accomplished so far by using all the available communication means like telephone, fax, ordinary mail, special delivery mail, messengers, direct communications, personal communications, travelling on the places of interests, bussines trips, face-to-face meetings, etc. Such an extremly diversified information flow and costly, time-consuming communication process, require a higher level of standardization and unification, in order to improve the entire construction process. Moreover, it is not only the information quantity what is a problem. The variety of technical data and their presentation makes an additional problem. Besides the textual information, most of the technical interchange relates to text, images, sketches, drawings, articles of mixed contents, seldom video and audio files, animations or sound, etc. Complex IT tools and huge organizational efforts are required to handle the variety of communication means, diversity of technical needs, tortuous documentation flow and authorization in context of PDM or PIM.

Different departments and cooperating external companies in shipbuilding use various CAD systems and the results are at present usually delivered or interchanged as paper drawings [4] or files in some mutually agreed format. The 2D geometrical model, which is designed, let say by AutoCAD systems, is usually manually re-modeled as a 3D finite element model within a FEM pre-processor when it is required. Or a 3D hull model can be manually reconstructed for the production purposes. Such a data exchange includes topological changes of geometrical models [1].

Current CAD systems mostly serve as tools for specification and handling of geometric information. In mechanical engineering and naval architecture domains, where geometrical modeling plays a crucial role, the primary goal of CAD tools is the digital representation of geometrical shapes on a computer.

Despite the progress made in CAD systems (Parametering, features, etc.) CAD is still basically geometric and graphic oriented. From the design process view, CAD tools have certain limitations, including:

- Limited possibilities with regard to representations, with practically no functional or structural representation, and with no links between them,
- Limited possibilities for incorporating complex knowledge (know-how) of design engineer in ship construction processes,
- Do not offer a framework for design – rather gives the designer a set of functions and procedures through which is the designer supposed to find his own way of usage.

Specialized integrated IT tools in shipbuilding are planned to reduce time and cost of ship design and production within a shipyard, relying on continuous flow of accurate, just in time, complete and consistent information (create once – use many times), based on standardization methods and successful management of design process [5]. Product Information Model (PIM) comprises a set of functions to control the development, approval and release of design data in a project, which can be used for projects both within and outside the design department in a shipyard and according to the authority rules of the yard [5].

4. Design knowledge handling

A CAD system helps a designer only in documenting his artifact geometrically. The design of an artifact, however, is more than a mere representation of the artifact itself. Important design decisions, significant features (functional, geometric, etc.) of an artifact, and their derivation and interdependencies encountered during a design process are integral parts of the design of that artifact. Much of this design knowledge is still valid and applicable in the next iteration of the same design, if not elsewhere. However, a CAD system should have a very active role in similar situations where this knowledge is relevant, at least in the next iteration of the same design. Without the ability to somehow represent the design of an artifact this information is lost with existing CAD systems.

Therefore, a system for design knowledge and experience recording, storing, and retrieving, should be developed and implemented in an environment for network-aided design team collaboration and remote education. A prototype of such a system on the basis of the Web technology is developed on the Faculty for mechanical engineering and naval architecture in Zagreb. The Web information technology has been chosen as a collaboration platform because of the following advantages:

- Web technology is widely known and standardized,
- For the "end users", it is very easy to learn the usage of the web technology,
- Web tools run on all major platforms and have a high degree of compatibility with various kinds of applications,
- Web (HTML) pages can serve as "containers" for links to various kinds of information (text, technical drawings, calculations, normally accessible with respect to restrictions in authorization and authentication of the individual user),
- Dynamically scripted pages (e.g. Java, ASP, PHP) can be utilized for data processing and numerical calculation. Interactive approach using numerical capacities on the server can speed up calculations and reduce hardware requirements.
- Finally, the dynamically scripted pages may help in continuous improvement and expansion of the entire web project.

5. Networking methods and tools

Information processing is essential in design and manufacturing. The growing acceptance of Internet in enterprises has a significant impact on engineering collaboration. In recent years, the Internet has become the worldwide information platform.

The growth of the World Wide Web has also influenced engineering cooperation by using many new tools based on Web technology. The original use of Web was to facilitate the distribution of all kinds of information through the network. Web tools run on all major platforms and have a high degree of compatibility with different applications [2]. It is important to note that the Web as a system does not require the Internet. In fact, a distributed information system based on the Web can be constructed on any local-area or wide-area network. The application of Internet technology within a department using an internal network based on Web technology denoted as Intranet is well received in the public [3], since it offers commodity and security.

No collaboration can take place without messaging and notification services, end E-mail is the standard tool for these. E-mail is the most popular Internet tool today (in many cases the most important reason to connect to the Internet). It brings many advantages in network-based collaboration.

HTML (Hypertext Markup Language) is a code used to make documents readable across a variety of platforms and software. HTML operates through series of codes placed within an ASCII document. A “web browser” launches specific kinds of formats to be displayed on the client's screen. That is, translates these codes – allowing interactive features. Interactivity can be achieved both on client and server side using different tools, such as Java script, the open source scripting language PHP (Hypertext Preprocessor) or ASP (Active Server Pages). Hypertext documents obtained in such a manner by dynamically written web pages, help web developers to improve site’s functionality. This approach allows interchange between client-server and server-client, increasing the overall performance, enhancement and error checking.

6. System implementation

A system for handling engineering design experience in ship construction has been implemented on the Faculty for Mechanical Engineering and Naval Architecture, Department for Naval Architecture and Ocean Engineering. The system is accessible at present via Internet at URL address www.fsb.hr/kziha/shipconstruction. The paper presents different objects and methods pertinent to network-based cooperation in engineering, primarily implemented for research, training, and production, as well as for educational purposes in shipbuilding. The implemented system is planned to be open for permanent development by means of available network based tools. The prototype system for storing and retrieving the design knowledge in ship construction is structured as a single Web site. The site is created with "Microsoft Internet Developer 6.0", applying user interfaces coded in HTML, Java, and PHP.

The design experience in ship construction is available in different patterns, as follows:

- Textual information presented in form HTML, or as converted Microsoft Word document, as well as in "PDF" format for each particular topic and significant substructure
- Graphical information presented in appropriate formats such as "JPEG", "GIF" or "WMF":
- Illustrations Fig. 1,
- Various graphical symbols for user interface and thumbnail usage, Fig. 2,
- Scanned technical drawings, photo-realistic visualizations, Fig. 3
- Photos either normally scanned or digitally obtained Fig. 4,
- CAD drawings and schematic converted to "WMF" format Fig. 5.
- FEM mash or result presentation, Fig. 7.

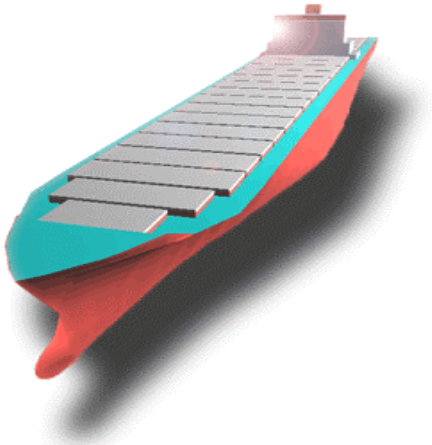

Fig. 1. Graphical illustration

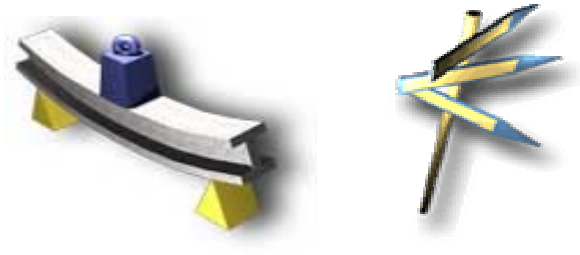

Fig. 2. Graphical symbols

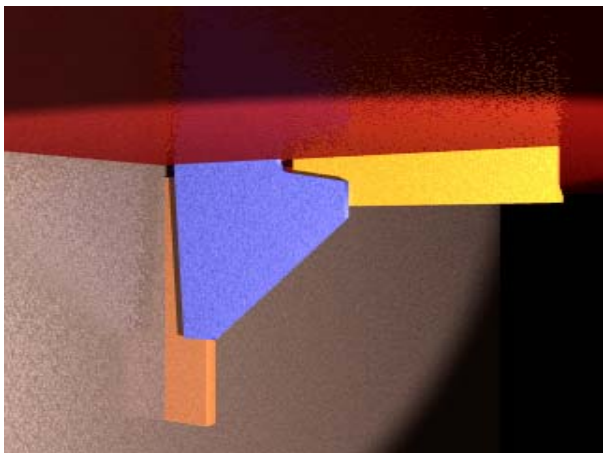

Fig. 3. Standardized scantlings photo-realistic view

Fig. 4. Real photo of a structure

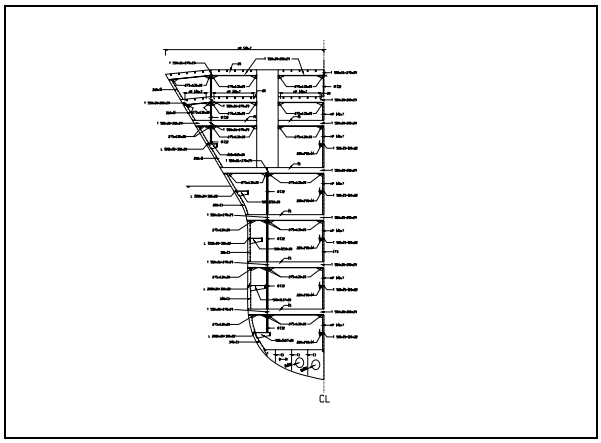

Fig. 5. AutoCAD drawing in WMF format

- 3D models presented mainly in "JPEG" format created in "AutoCAD 2000" or similar CAD/CAM tools, and processed through "Adobe Photoshop" where necessary, Fig. 6.

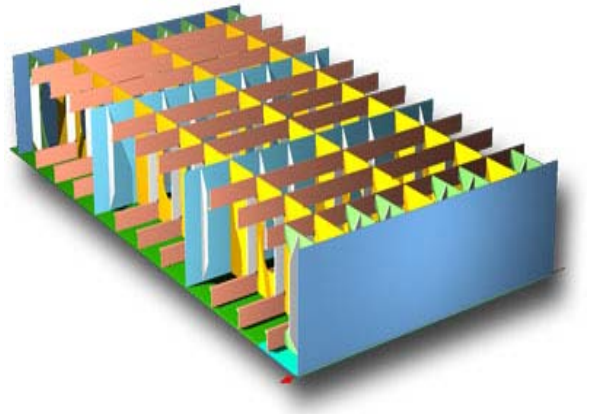

Fig. 6. 3D colored structural model

- Animated sequences, e.g. stored in "GIF" format or using some particular graphic tool. For illustration purposes, the bandwidth of common internet connection has to be carefully accounted for

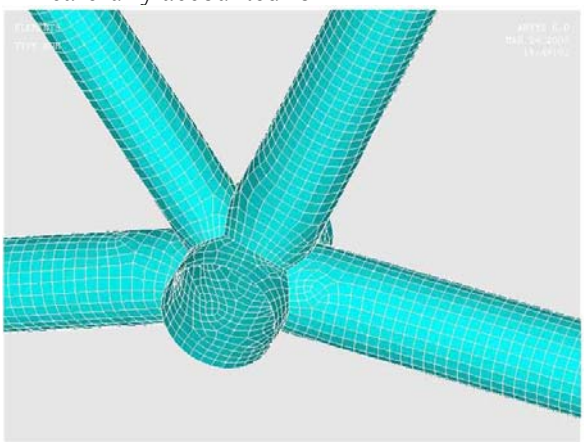

Fig. 7. FEM mesh of tubular structure

- Links to specific files - "Word" documents, "AutoCAD" files, databases, PowerPoint presentations, other web sites etc.
- Audio information, where available or necessary for special purposes or clarifications

The security issues are of utmost importance in industrial environment. The security can be applied either to the whole system or to the part of it. Particular security and protection is provided for military topics involved in the chapter of the construction of war ships implemented in the current system. Direct user checking by inspection of their applications via Internet, as well as individual access permission for the users registered in the user's database is implemented.

7. Conclusion

The process of ship construction in Croatian shipyards is at present a matter of a local team with very intensive communications with all the other departments in the shipyard, as well as with a great number of different institutions, sub-contractors and suppliers worldwide. A large amount of various technical data has to be transferred in different directions locally and globally, on small and long distance, using various communication and transportation means. The information of interest is of various kinds: textual, technical drawings, databases, photographs, prints, slides, audio, video, movies, animations, presentations, etc. For such an intensive information exchange, all available network and software resources have to be employed. An efficient cooperation needs also very powerful hardware of top performance and high capacities with all respect, supported by a highly efficient communicational infrastructure.

The international standard ISO10303, also known as STEP, employing basically the EXPRESS language, is already coming into application. The UML or XML languages are developing for the exchange of design data and manufacturing information, as well as for design processes and design knowledge presentation in engineering. The efficient application of advanced features requires highly motivated, fully educated and permanently trained users. Technicians normally can use Web platform, but need additional skills in developing applications using advanced network communication facilities. Moreover, a professional information technology staff for hardware/software, safety or authorization administration is a desired support for network based remote cooperation in the construction office. In spite of many efforts to use computerized tools for paperless exchange of the design and manufacturing data, the paper drawings and other printed documentation still play an important role in the construction office, particularly in production.

The network-based remote cooperation teamwork system requires high security standards, authorization by access to data and authentication of the users. Remote approval of technical documentation both as functional access or object (data) access of legal and expert authorities and information flow control are important issues, which can be resolved by implementing appropriate Product Data Management or Product Information Management.

A remote cooperation system for education and ship construction experience interchange, alongside the declared principles and desired features is designed, developed and implemented on the Faculty for Mechanical Engineering and Naval Architecture, Department for Naval Architecture and Ocean Engineering in Zagreb, accessible via www.fsb.hr/kziha/shipconstruction.

The following topics are covered so far: The construction of merchant ships, The construction of war ships, Fatigue of the ship structure, Ultimate strength of the ship structure, Longitudinal strength of the ship structure, Croatian standards for ship construction, On-line calculation procedures, Important links related to ship construction, Typical technical drawings, Virtual gallery presenting ship's substructures, Photo and photo-realistic gallery comprising pictures from shipyard construction practice.

Some other topics, like the construction of inland waterway vessels, dynamic aspects of ship construction, direct calculations, etc, are planned to be included. The current system for storing and retrieving the design knowledge and experience in ship construction domain is structured as a single Web site. The division to major chapters is done according to common engineering practice in ship construction.

The amount of graphical information is dominant compared to textual. The Web site structure grows rapidly with number of files and hyperlinks between them. Managing big and structurally complicated Web sites requires a dedicated teamwork and a lot of special knowledge that goes beyond the skills of a typical engineer.

From a CAD system's perspective, the Web has also some disadvantages as a collaboration platform. Until recently, the Web supported only bitmap graphic formats. VRML technology should enable a change here. However, CAD files are usually very big, thus normally difficult to transfer, (sometimes in peak hours even impossible), and faster communication links are required. The security issues are of utmost importance in industrial environment.

The system for handling design experience in ship construction, and elsewhere, may survive only if it is sufficiently attractive and useful for the engineering community, either for remote education or for specific research and experience exchange. Therefore, the graphical appearance, fast response, interesting topics, state-of-the art subjects and the permanent maintenance and development are the most desired prerequisites.

However, the implementation and maintenance requires broad consensus and support from the creators and the users, including the support of the top management, both in shipbuilding industry and in the academic community.

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