SYNTHESIS REPORT

FOR PUBLICATION

CONTRACT No: BREU-CT9 1-0489

PROJECT N“: BRITE-EURAM Project BE-4227-90 (ARGOSHIP)

TITLE: A STRUCTURED METHODOLOGY FOR SHIP PREDESIGN PROCESS

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REFERENCE PERIOD FROM: 1 DECEMBER 1991 to ~~30 NOVEMBER~~ 28 February 1994 95

STARTING DATE: 1 DECEMBER 1991 DURATION: 3 YEARS MONTHS: ~~36~~ 39

PROJECT FUNDED BY THE EUROPEAN COMMUNITY UNDER THE BRITE/EURAM PROGRAMME

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Abstract The ARGOSHIP project aimed at improving the technical quality of the ship predesign process and reducing the time to prepare tenders. These have been achieved either through the conception of a new approach for the design (methodology) and the development of a software prototype implementing the new methodology.

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1. INTRODUCTION

The ship design activity - which is crucial for the quality and effectiveness of the final product - is a field which need a technological intervention to attain a competitive edge.

Designing a ship is a complex problem, mainly due to the multi-aspect nature of the object involved. In fact the ship consists of a large number of interacting and closely cooperating sub-systems (steel structure, electrical plant, main engine, auxiliary machinery, etc).

Each of these heterogeneous subsystems is characterized by its own laws of operation and requires a separate course of action for specifying, designing and manufacturing it. However, the design of each subsystem has to take in full account its interactions with the others in order to satisfy all the imposed constraints.

The various design methods currently applied to ship design widely adopt a trial and error process employing continuous consecutive iteration in order to attain the optimum within the different constraints. The general principle of this design methodology is a straight forward sequential approach, which consists of a great number of choices often mutually related. The choice between the various possibilities is principally taken by means of successive iterations, where analytical methods are continuously verifying the selected consequences. This process accomplished with an increasing degree of refinement and accuracy together with a higher level of detail characterizes the ship design approach.

Broadly speaking, the design process is split into two main steps. The first referred to as "precontractual design" or, simply "redesign", deals with all the actions aiming at producing a well balanced technical-economical offer able to gain an order from the Shipowner.
This is a very critical activity. The decisions taken in this preliminary phase - which roughly represents 5% of the cost of the whole design cycle - are likely to affect heavily the 80% of the overall cost of the ship.

In the second phase all the actions are directed to univocally define the ship according to the agreed specifications, minimizing the overall ship cost; this phase is usually referred to as "postcontractual design" or, simply, as "design".

In the last years shipyards have focused their attention to the optimization of several combined activities pertaining to the second phase and a lot of effort has been devoted to the automatization of the production activities, mainly in the area of the hull structures.

Conversely, a considerably limited effort has been paid to the predesign area, despite its critical importance in winning the order. As a consequence, the overall quality of the pre-design activity is somewhat poor and can be mainly ascribed to:

- the lack of a clearly defined design methodology, mainly due to the lack of a global view of the design. With respect to design, particularly engineering design, this can be the technical answer to economic competitiveness and is an essential forerunner to efficient manufacturing. The common understanding of the design as a process and the capability to model it remain up to now rather restricted.

- the available tools are usually inadequately interlinked. They can rely on different software packages and tools, which are generally developed and applied as independent entities. Integrated packages remain an exception rather than the rule. Furthermore, in the common practice, procedures consolidated through years of experience cohexist with empirical estimations and personal judgments on the evaluation of some design parameters.

- many uncertainty areas are still present in the predesign activity both in the overall process and in the sub-systems, jeopardizing the competitiveness of the offer and the reliability of the final product.

- the calculations and other activities needed to prepare an offer require several weeks and as an indirect consequence of the poor quality of the process control, it is quite common that investigations on a bad solution take up a long time before being detected. The lack of time may thus prevent from investigating any new solution from the very beginning; the remaining short time is usually spent for modification, what is obviously very far from optimization.

2. TECHNICAL DESCRIPTION

In the first step of the project a description of the present predesign procedures has been performed. In each Partner's design department the various activities that made up the predesign procedures (design spiral) have been investigated for some types of merchant vessels. The different design" activities and their interactions have been identified. Then a deeper study of each single specialized area has been done.

Each partner has derived and collected procedures, algorithms, empirical rules and any other formulae and techniques used for calculations, describing the context of their use and the respective level of" detail. Subsequently, the capability of integration of all modules has been considered. All deficiencies and poor fitness of existing tools applied to solve the envisaged functions have been clearly shown.

In parallel three main research areas (costs, AI tools & techniques and Information Technology) have been identified and selected as being those likely to provide most valuable information and, as such, to be more benefical to the shipbuilding industry. The idea was to cross-fertilize the shipbuilding field by taking concepts and ideas from innovative and similar industrial environments fields and reconsider the process from a new, more general point of view.

The design knowledge which has come out from the first investigation on the current procedures has been selected and classified against a set of criteria expressing the various needs at the different levels of the design spiral. Then, two different steps of rationalization have been followed. First, all the collected material has been broken into elementary pieces and rearranged into specific technical areas of competence (i.e. strength, propulsion, configuration, cost). Such basic components, their interactions and their mutual organization have been analyzed. The knowledge derived so far led to the development of a new, structured, modularized and hierarchically ordered methodology with a rational control structure. Special attention has been paid to consider the interlacing and interaction with the methods, techniques and tools involved in the process. Due to the modular design the various modules making up the new process have been arranged in different levels of detail, each providing a significant a consistent set of information for the definition of the design.

After this first conception of the new methodology a rapid prototype has been developed to gain some feed-back on its suitability, hence providing hints for improvements. Backtracking features and a rough constraint propagation capabilities have been also introduced in this rapid prototype.

The new structured methodology has been adapted inside a proper system architecture.

The next step of rationalization has been based on the above mentioned evaluation criteria and it has focused its investigation inside the functions to critically anlyzing the way they work. In particular, an analysis of the points emerging from the critical analysis made at the beginning and a systematic set of interventions (corrections of existing functions performed by the present scheme or innovations) has been performed. In this phase, each piece of information has been viewed from either a naval and computing point of view.

New functions and tools explored in similar fields of interests have been integrated into the process, after a careful examination of their adequacy and a possible adjustment.

New pieces of knowledge have been created and formalized to cover still remaining gaps and deficiencies in order to make the overall process omogeneously balanced.

The whole resulting material covering the selected family of ship (tankers) has been assembled and organized into functional specifications.

A final prototype system has been developed to reflect and demonstrate the structured design approach introduced in the previous project activities, and illustrate the generality, neutrality and flexibility features inherently presented in the adopted approach. On the functional level, this system had to integrate some essential process control features, which proved to be technically implementable and practically useful, according to the experience gained from the first, rapid prototype.

The evaluation of the first prototype also revealed a number of additional features, functionalities and utilities important for inclusion in the final, industry-oriented prototype system. These additional requirements refer to the introduction of enhanced process management and control capabilities, as well as to particular information handling and presentation features. As a result of the above recommendations, some essential aspects related to the system logic have been conceptually and technically addressed in the final prototype.

With the development of the final prototype also the functions selected and tailored have been implemented and tested for validation.

3. RESULTS

The current state of predesign, where a certain number of relevant goals have been reached through the present project, when compared to the old predesign process has been sensibly improved, Specifically, the main results achieved are basically three:

- a new, structured ship predesign process, with a rationalized control structure and a hierarchical organization. The description of the methodology embeds functions and tools expressing specific naval know-how. An extensive work of adaptation and tailoring has been made by the Partners to fit the knowledge sources available to the new methodological context.

- the specifications of a complete S/W system capable of implementing the new predesign approach for a practical application of it. A general architecture for a software system capable to support the new predesign methodology has been developed.

- a S/W prototype implementing the new predesign methodology according to the above architecture. A selected set of the newly tailored functions/tools regarding the design of tanker ships has been integrated in the prototype and tests have been performed. The feedback coming from such activity has been useful for further improve the strcutured methodology as well as to refine the newly adapted functions/tools.

While the first two are conceptual, paper-based results, the latter has a very practical concern and, although it has been mainly developed for testing purposes, it is now available for an immediate use of the new methodology.

4. CONCLUSIONS

The results obtained so far solve some of the problems highlighted in the introduction, that is:

- the need for a global view of the whole process which results provided with a consistent, prioritized control structure and a flexible, modular organization,
- the need for the integration of tools and procedures,
- the reduction of the time required to prepare an offer,

As a result, all of these contribute to improve the technical quality of the predesign activity, hence increasing the competitiveness of the European shipbuilding industry.

But not everything has been successfully faced; some aspects are still to be solved, namely:

- uncertainty calculation areas within the predesign activities are still present,
- cost parameters have not been configured as design variables within the predesign process, hence the goal of obtaining a balanced technical-economical offer has not been achieved;

Nevertheless, further improvements are expected from the adoption of the methodology and the extensive use of the prototype (as it is or after an engineering of it to make an industrial product of it) for either the aspects already fixed and the ones not yet solved.

5. AKNOWLEDGEMENTS

The Consortium of the ARGOSHIP project (Project N. 4227, Contract N. BREU-CT91-0489) wishes to thank the European Community for the support received within the BRITE/EURAM programme (Directorate General XII: Science, Reasearch and development - Directorate C: Industrial and material technologies).