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DANISH SHIP RESEARCH LABORATORY

and

SERVICE PERFORMANCE QUALITY OF SHIPS AND OCEAN PLATFORMS*

Research & Development efforts during the life cycle

by

DANISH SHIP RESEARCH LABORATORY**

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ABSTRACT:

Service performance quality is planned from the very beginning of the life cycle of ships and ocean platforms. The paper deals with the involvement of R & D in all phases from conceptualization and feasibility studies, via design, construction, and delivery. The service life phase is also having immediate benefit from R & D involvement. The paper shows by a cash flow, cost benefit analysis, that the recovery rate of investment in R & D is very satisfactory. The main point is, though, that the outcome of R & D involvement is especially important for successful, coming generations of vessels and platforms of even more complicated design.

CONTENTS

Introduction

The impact of Research and Development on a ship or an ocean platform during its life cycle is distributed over the entire cycle. The greatest benefit from past experience is obtained when the past experience is channelled to the new design via a filtering, purifying, and intensifying passage over the sciences.

This means that the past experience should be looked at over the wide horizon of the science of the profession, and not considered and used as individual events of independent nature. Each new experience can either be explained by the existing know-how or it can be related to existing know-how by research efforts.

When all existing know-how and the latest research is put together, it forms a strong basis for the development of new designs. In most cases the need for new constructions, either ships, offshore or ocean platforms, is relatively urgent because of the nature of operations and of market trends. The instant funds are allocated, the work is initiated and proceeds quickly.

That means short time for development of the design in question. But the development proceeds also quickly, provided it is referring to a living and up-to-date research tradition. In order for development to proceed as quickly as necessary for each individual design, it is also required that R & D is brought into the process as early as possible, even from conceptualization. R & D must be involved during the whole life cycle of the design, not only because of the continuous impact it gives, but also because of the objective methods used by R & D to collect and generalize the experience always gained during a process.

Objective methods are the only ones which can provide a realistic and concise transfer of past experience to future applications. When new ship or platform concepts are made, when they are being studied for feasibility, when they are being designed and constructed, it is always a matter of predicting their behaviour in the future service life. To guarantee and maintain the service performance quality during the life time of a ship or platform in an operational way, it is necessary to involve R & D.

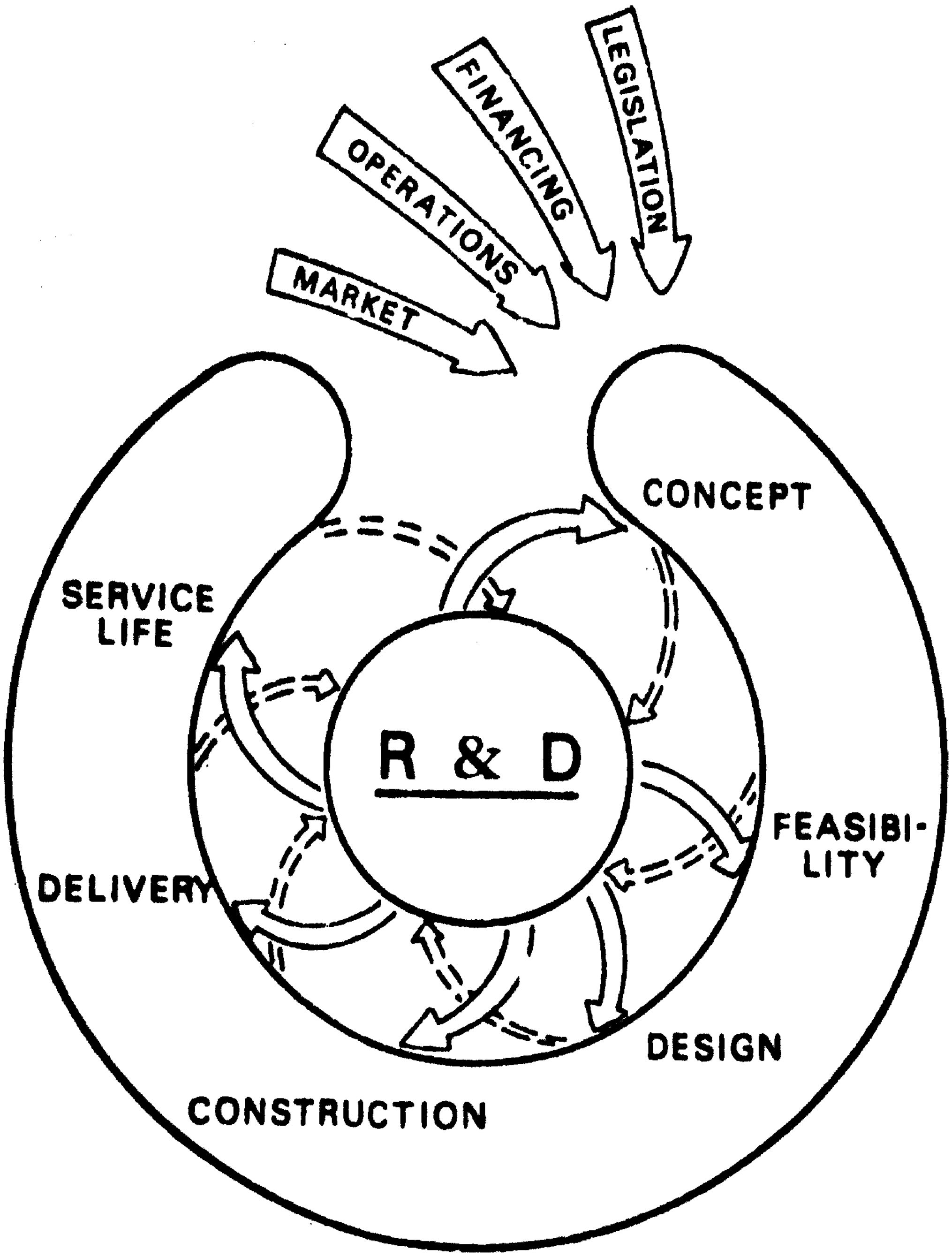


Fig. 1 LIFE CYCLE

The life cycle of a ship or ocean platform

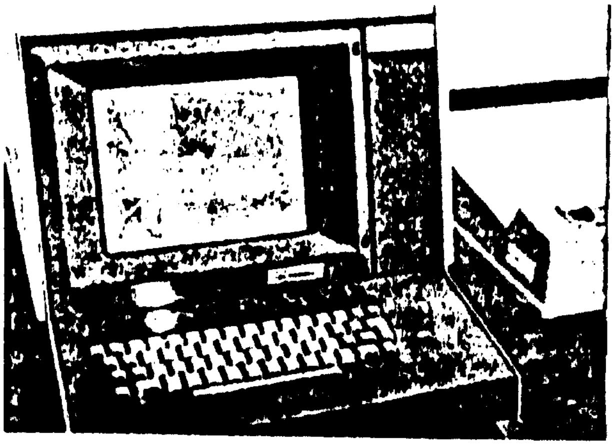
The life cycle of a ship or ocean platform is in general terms the same in all cases independent of type or intended application. The various phases of the cycle differ, of course, from case to case, and some of the phases almost disappear completely in many instances.

Figure 1. depicts diagrammatically a life cycle of a ship or ocean platform. Operational needs in the prevailing market conditions and legislative bounds from rules and regulations go together and allocate funds for the new construction. Conceptualization of what is needed for the mission is the first phase of the life cycle. After conception, a feasibility study is to be made to see if the mission objectives are met with, or if adjustments are necessary to make the project liable within the given bounds of physics, technology, economy, and time. The third phase is the design phase, where all details are selected and composed from standard supplies or developed specifically for the purpose. Development is involved also to a large extent in the mere composition of elements.

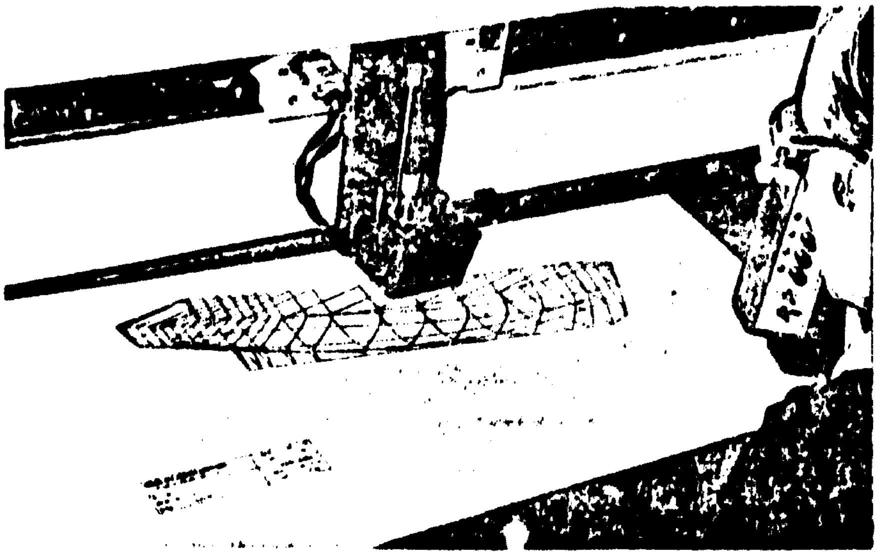
Construction is the next phase during which normally no R & D is done specifically on the ship or platform. Much follow-up measurement and analysis are going on to control the final service performance quality. The construction phase ends with delivery trials. They should be as extensive as possible because of the extraordinary chance they present to evaluate the design when it is on its very top performance.

The longest phase of the life cycle is the service phase for the ship or platform. Service performance investigations are to be made with regular intervals or in some respect continuously, in order to maintain the performance quality which deteriorates creepingly without being noticed unless it is closely watched. The service life phase is also the most important phase to sample and analyse experience for R & D for new designs which will be chosen in the future.

Finally, before the ship or platform is scrapped, disconnected, and maybe enters the raw material cycle again, concluding tests of the life cycle would be useful to measure the end qualities.



COMPUTER
INTERACTIVE
GRAPHICS



INITIAL, SMALL SCALE
MODEL TESTS

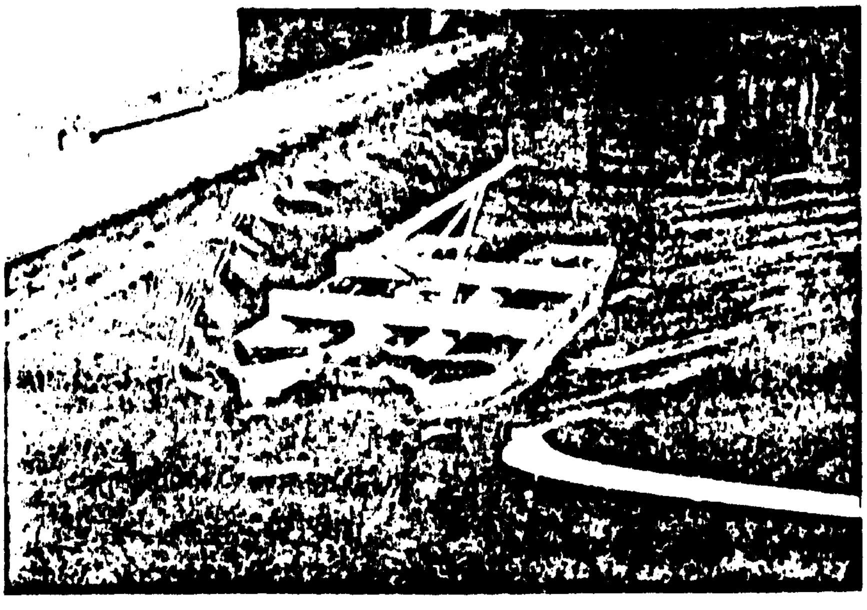


Fig. 2 CONCEPTUALIZATION

Conceptualization

The general character, even of relatively specialized sciences, and the fund of know-how, either being qualitative or quantitative and collected by R & D, is a valuable aid in selecting a concept for a ship or platform to serve a given mission.

In a physical world it is unavoidable to comply with the laws of nature even by the most advanced technology means. But deep understanding and long time experience with the subject matter permits, though, technological solutions to almost any problem which could arise in the field of operations at sea, moving ships, and stationary platforms for various purposes.

Based on the existing know-how and the R & D in progress, it is possible to devise a specially well suited concept for the intended application. The better the concept is, the less development is needed in the following steps of the life cycle.

It is not so that concepts for specified missions can be devised by automatic computers based on mathematical methods.

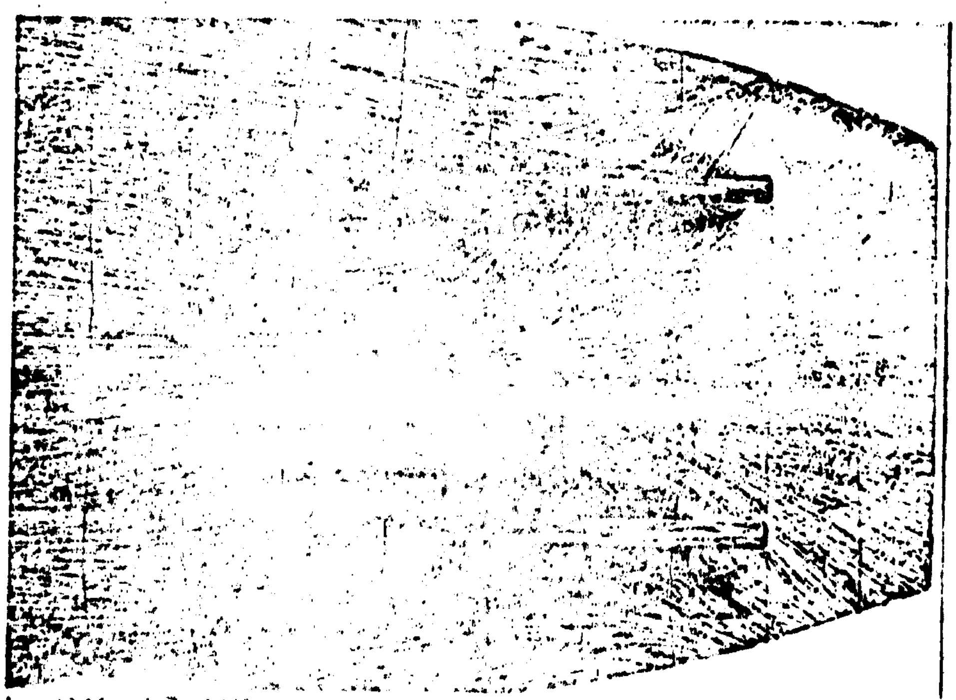
Such means can, however, to a large extent provide easy and accurate data and information, especially using interactive computer graphics. Also physical models can provide such information, which can guide the concept selection in all interaction with the market needs, legislation, and funding possibilities for the new design.

In case such R & D services do not lead to the answer directly, the effort spent may form the best possible basis for the definition of the goal oriented R & D, which is then needed to reach a concept for the task.

The quantitative information collected and produced at this early stage of the ship or platform life is obtained and kept in a rational form. This is vital in order to facilitate a rational application during the following stages of the life cycle, not the least during the feasibility study and the first design phases.

It is thus possible to involve measures of service performance quality right from the process of the conceptualization.

SIDE VIEW



LOOKING UP

Fig. 3 FEASIBILITY OF STERN BULB IN TERMS OF SEPARATION OF FLOW

Feasibility

The concept of the new design must be tested to evaluate its capability to fulfil the mission objectives. The feasibility study is a combination of technical and economical aspects of the service life of the new design after the final design and construction has been completed. It is a matter of evaluating the various degrees of service performance qualities intended in order to complete the mission.

Mathematical models of the behaviour of the new design is again involved. For cargo liners, e.g. computer calculations for optimum carrying capacity and speed is studied in terms of cost benefit analysis of investment versus service performance cost. The analysis is made for the liner-routes considered and the parameters of the concept studied are evaluated in relation to the optimum. Several sets of operation conditions are easily considered in terms of technology and expected market developments.

Also mathematical models of the physical behaviour of ships and platforms are very useful in the feasibility evaluation studies. The motion behaviour of, say, semisubmersible platforms in the local environment considered gives strong evidence to the decision making which follows the feasibility study. Physical model tests in laboratory ocean environments will throw much light on the subjects considered. It might be the boarding of deep diving bells into the base vessel or the interaction between several surface units, say comparative studies of offshore terminal concepts, deep sea mining operations, energy transmission to ocean thermal energy platforms. It might be capsize modes of fishing vessels or subdivision of Ro-Ro ships.

The feasibility of specific hull geometries may be studied in flow visualization tests using windtunnels before decision is taken to adopt the concepts. In some cases reduced scale testing in natural environments would be used as pilot plants for feasibility assessment of a project of larger scale and its service performance quality in terms of transition, operation and survival in the future service life.

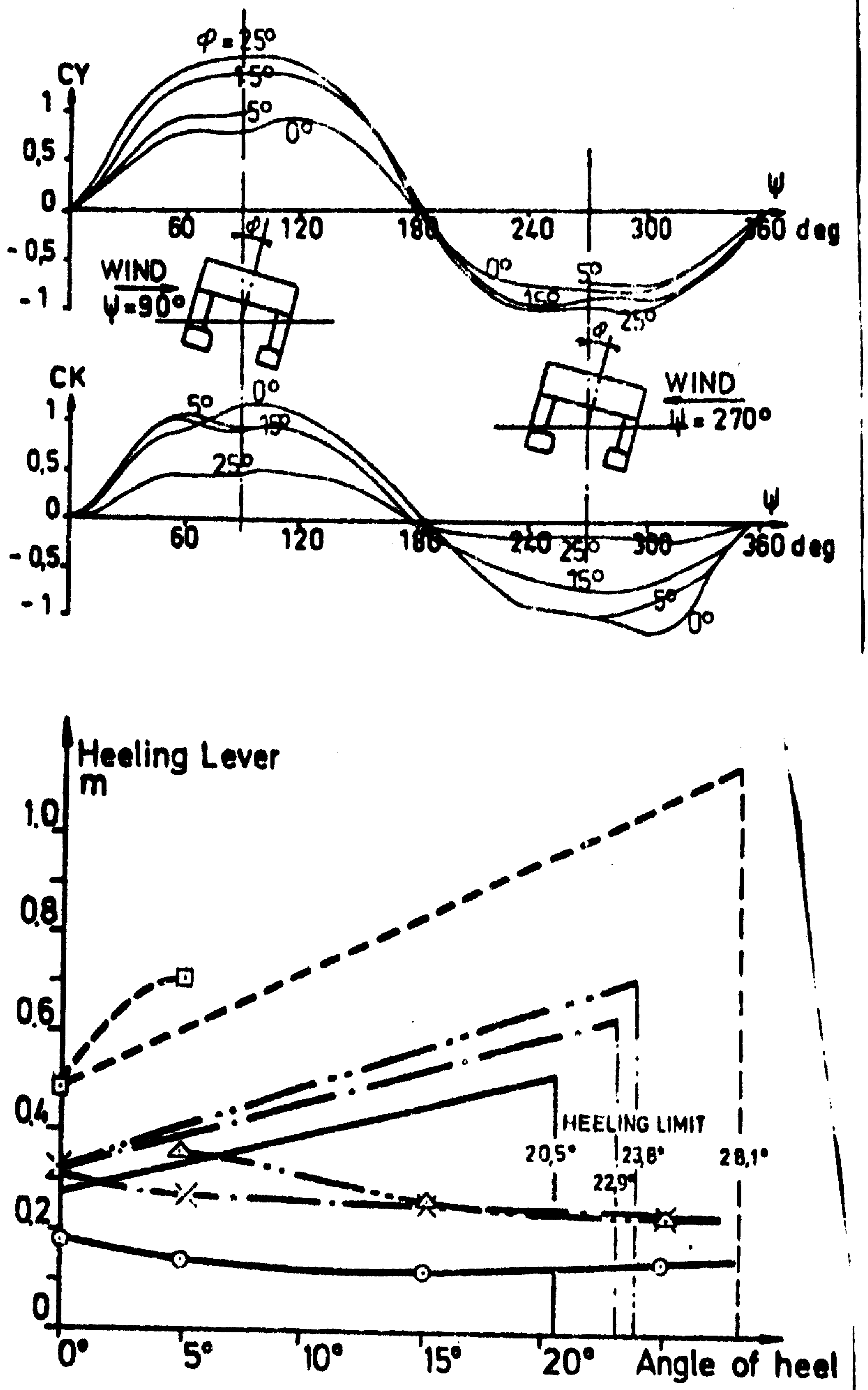


Fig. 4 NORM VERSUS MEASUREMENT IN DESIGN PHASE

Design Phase

The R & D services involved in the design phase is not related to the main design concepts which have been decided upon during the conceptualization and the feasibility study phases. But there is still much to be gained from R & D on the detailed development of the new construction. This is even more so as the lower the element is in the hierachy, the more general knowledge can be referred to directly. It might be the assessment of propulsion qualities of various hull geometry alternatives proposed by the previous phases of the life cycle or directly by R and D to the present stage as depicted in Fig. 1. Relatively small improvements in service performance quality can often pay back relatively large R & D investments many times. See the section on R & D cost and benefit.

Structural strength often benefits much from R & D during the design phase. This refers both to the assessment of loads and the stress and strain analysis of the steel structure. Norms and standards legislated by authorities do normally permit structural strengths to be based on loads determined from advanced methods as an alternative to standard loads. Load determination of high quality can be made both by advanced computer programme and by physical model tests. Both methods can also be applied for stress and strain analyis of steel structures.

During the design stage it is also possible to study the performance quality of the final construction in terms of levels of noise and vibration, e.g. in living quarters and instrumental areas or in terms of fatique loads. Computer programmes are the best suited here.

The many certificates to be assigned the new construction are also prepared during the design phase. They contain the above discussed structural strength matters but also several forms of survival safety, e.g. against capsize. The certificates are issued and signed to testify that the construction complies with norms and standards. As above the results from R & D services are being approved alternatively to simple norms. An important contemparary case is the wind heeling forces on semisubmersible platforms. The platforms approved for much higher payload when R & D services provide results to document that standard loads are in excess for the construction in question.

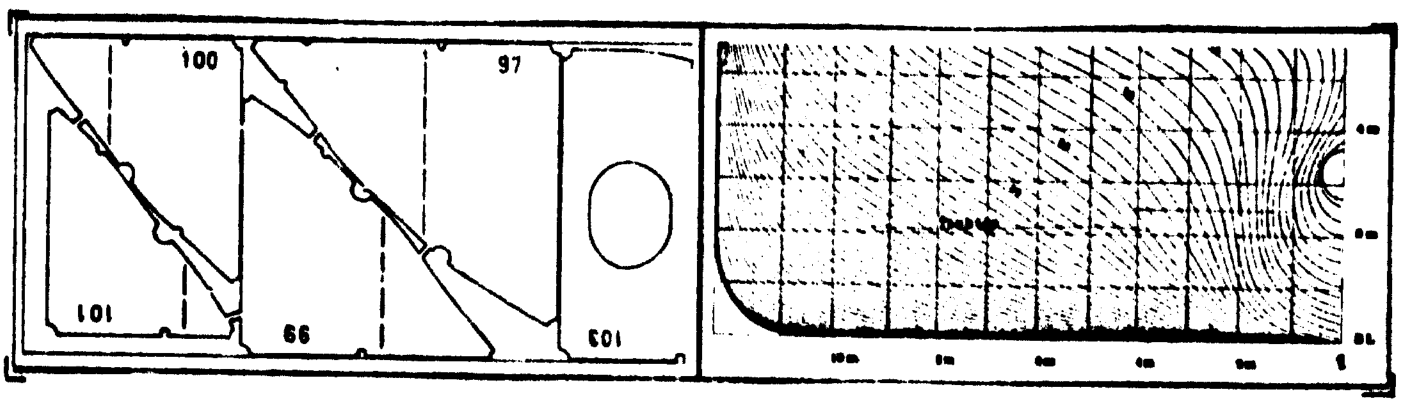


Fig. 5 COMPUTER PREPARED
HIGH QUALITY PRODUCTION AIDS

Construction

The construction phase of the lif. cycle is mainly located in the production workshops of shipyards and ocean platform construction sites. There are, though several aspects which rely on the presence of R & D personnel. We are not concerned with the important work of developing the construction work and the construction site. We are concerned with the progressing state of the particular ship or platform we follow for its particular application.

In order to ensure the desired service performance quality of the construction it is highly recommended to instrument and test any critical subpart as soon as possible. This relates to a high degree to aspects of noise and vibration. Vibration exciters of various kinds may be adopted on selected locations to cause vibration response which can be measured and analysed. Necessary improvements can be recommended from the results and the intended quality in this respect be kept under control.

The same is valid for other aspects of service performance quality such as basic floatability and stability tests made as soon as the structure is afloat.

Important and precise production aids are offered for the construction phase as direct spin off from the early involvement of R & D services in the life cycle of the project. The computerized data of the geometry of the construction, used for many other purposes in conceptualization, feasibility studies and design phase. are directly accessible for preparation of production aids for constructural details. The data are being refined by mathematical smoothing processes before application and yield quickly tractable data sets for preparing templates or drawings or N.C. data for production machinery or special results for supporting of individual steel sections, propeller fabrication etc.

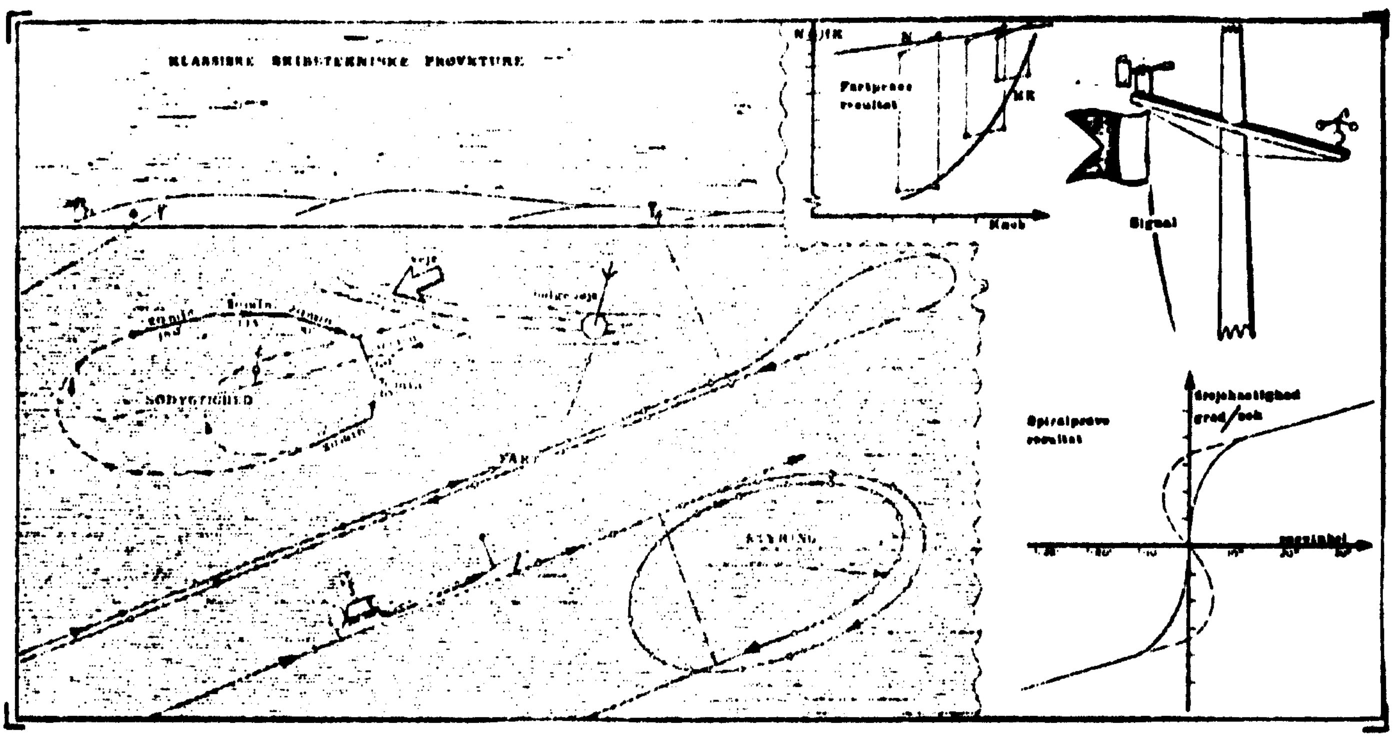


Fig. 6 DELIVERY TRIALS WITH EXTENSIVE MEASUREMENTS CONFIRM THE SERVICE PERFORMANCE QUALITY

Delivery

The first complete existance of the construction is the delivery phase where production in the yard or workshop ends and the service life has not yet begun.

This phase rends itself a superb opportunity to verify all the man, aspects of service performance quality to which the construction was planned and designed. This is the opportunity to let R & D verify the intended qualities by quantitative means using gauges and sensors and exciters and analysis instruments. A high ranking R & D institute can do that with no waste of time, provided they have been involved from an early stage and have all the background data computerized.

The outcome of such measurements are of several kinds.

Firstly they are perfectly applicable to decision on contract compliance and secondly they form basic figures for application during the service life of the ship or platform. There are two aspects of this, one is as basis for day to day decisions during operation, either in terms of transit, daily production, in survival situations or as reference for the maintenance of service performance quality.

Yet another application of the delivery phase is the quality specifications of the vessel or platform being documented by the delivery test results. They are invaluable both in dealing with chartering and in possible law suits which could come up due to accidents to the ship or platform:

The final but not the least important aspect of the data sampled during delivery trials and the appropriate analysis which follow is the application for future projects of similar kinds and the contribution to the general professional know how, so important for future contracts.

A well planned databank on delivery trial results prepared in connection with the data and assumption- and prediction-methods from the early life of the project forms an invaluable support for future work. There is no need to fear redundancy in such a data bank. All data, even from sisterships or platforms, are worthwhile to collect. They enter from independent sources and contribute to the reliability of the set.

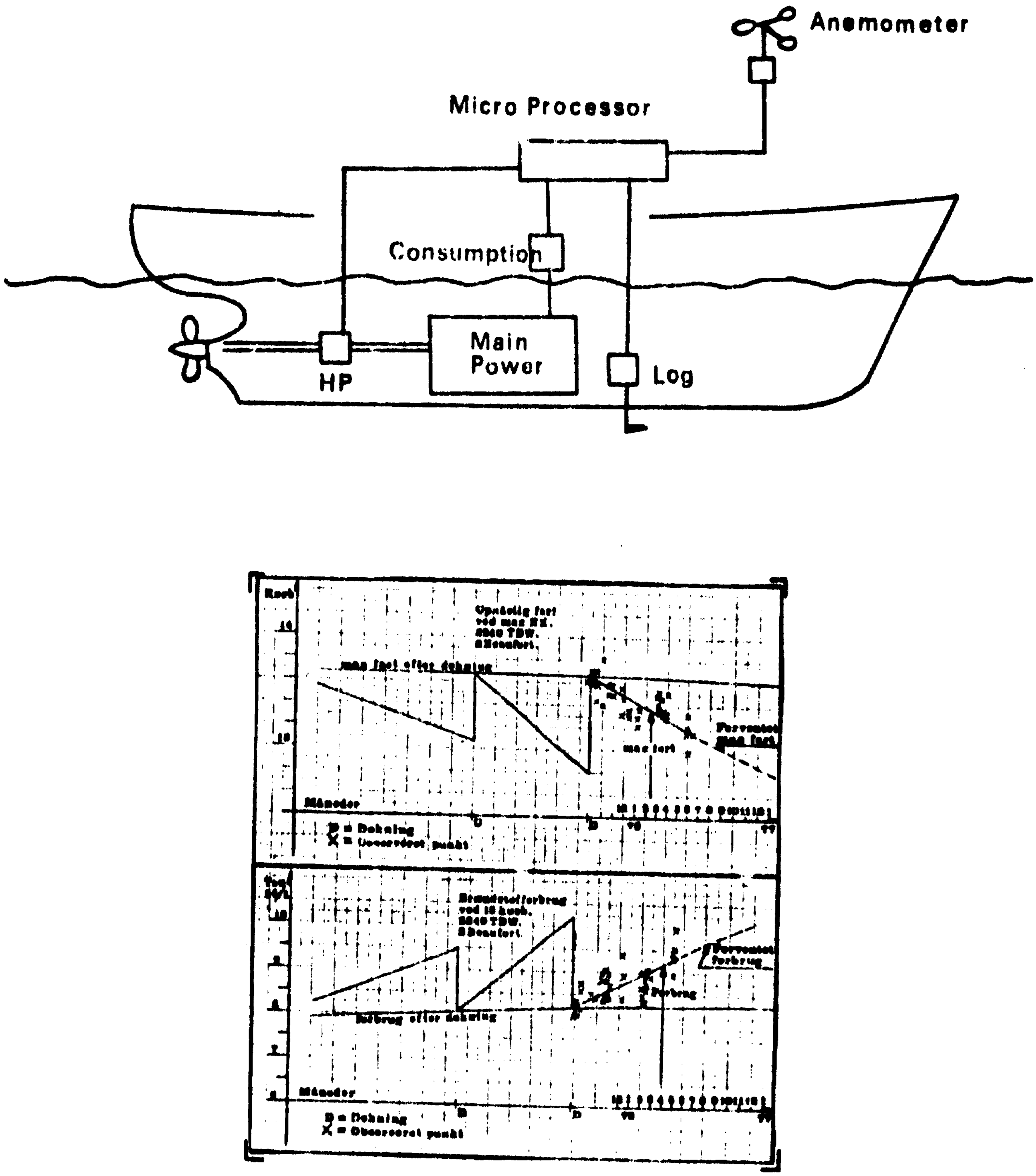


Fig. 7 PROPULSION SURVEILANCE

Service life

There are wo main reasons for inv lving R & D in th. service life of the ships cr platforms. One is the resulting contribution to maintenance of the service performance quality, the other is the important data sampling for the next generation of ships or platforms or even hitherto unseen constructions for ocean services and operations.

One important aspect of service performance quality is the maintenance of payload without sacrificing operational safety. It is e.g. a matter of keeping control with the structure's own weight and location of centre of gravity, which latter is moving upwards all the time due to additional weights coming onboard. It can be kept under control either by special tests at regular intervals or by online dynamic state parameter identification microprocessors. A similar case is the ever ongoing breaking down of propulsion efficiency due to fouling and deterioration of hull and propeller. A first class surveillance system of microprocessors sensing speed and propulsion power and fuel consumption keeps watch on propulsion economy and recommends docking intervals etc.

Yet another similar case is the structural stress and strain surveillance system also best on microprocessor form. It helps the navigation in heavy weather by warning excessive loads. In close relation hereto is the inc usion of computerized w atherforecast in an integrated hull structural strength, overall safety and propulsion economy system. Such a system will also provide data samples for future developments in easily applicable form, and for decision making of service termination. Data sampled in this way, directly under service conditions represent a very realistic input to future work on new concepts and the related feasibility studies. They were dealt with above in terms of physical models and computer-interactive graphics and need service analysis results to be as realistic as possible for decision making. The sampled data are going to be used by R & D and must be collected under R & D's guidance in order to have the full benefit from them.

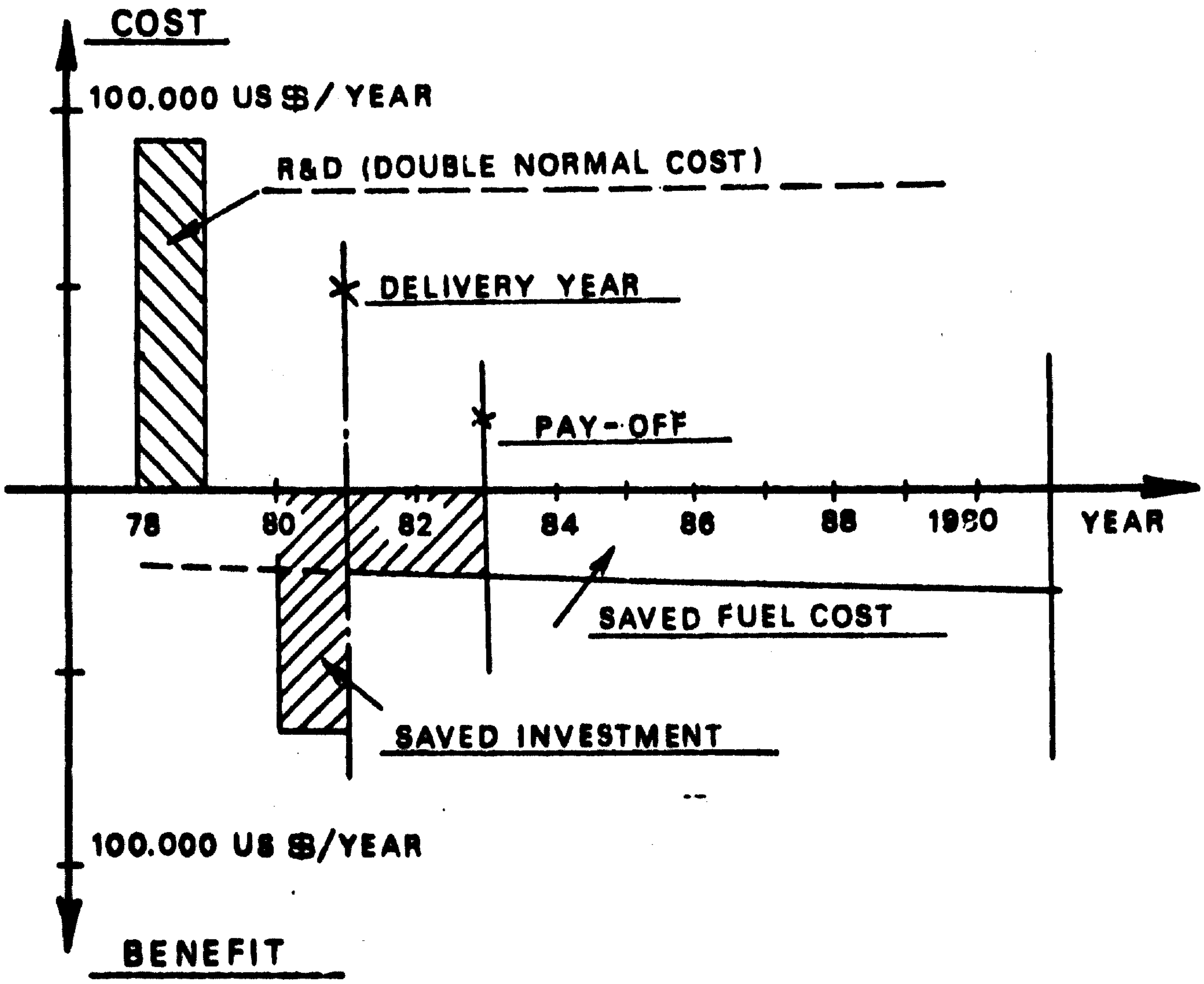


Fig. 8 SIMPLIFIED CASH FLOW DIAGRAM
SAVING OF 200 HP OUT OF 20.000 HP
BEFORE TAX AND USING IEA (OECD)
1978 OIL PRICE PREDICTION

R & D Cost-Benefit

In the previous chapters many cases have been considered of the involvements of R & D in the many separable phases of the life cycle of a ship or platform. It has been argued that important progress could be made that way both in terms of immediate advantages and in terms of future benefit.

In order to elucidate the economic aspects of the involvements of R & D a simple case has been considered below. It deals with the involvement of R & D alone in the design stage of a ship. The propulsion quality is considered around a main powerplant of abt. 20.000 HP. The installation price is abt. 300 US $ per HP for main diesel power for ships, and the oil consumption is about 0.165 kg per HP hour. Cost of R & D is varying much depending on conditions and for how long a part of the project R & D has been involved. The longer involvement the less additional service cost because of information already available.

Considering one per cent improvement in propulsion performance a cash flow diagram in Fig. 8 has been prepared. It is based on the fuel oil price prediction by the International Energy Agency of OECD 1978 expecting from 1.5 to 3 per cent unit price increase above general inflation until the turn of the century.

One per cent reduction in installed power corresponds to a saving of investment of about 60.000 US $. The annual consumption rate for one per cent of the total power is at 1978 prices and assumed 300 service days per year above 20.000 US $ annually.

The simplified cash flow diagram of Fig. 8 gives values before tax and in excess of general inflation. Assuming a 10 year service period of the ship, a one year construction phase and the R & D work being done just now, is seen that a break even two years after delivery can carry an investment in R & D of about 90.000 US $, which is much in excess of the effort normally needed to improve the propulsion performance 1 percent. The reduction in main power plant investment is counted over the construction phase year.

A normal effort to improve propulsion performance is about 45.000 US $. The improvement obtained can be much more than 1 per cent, but even at that low value it is seen that without counting the reduced investment in main power, the break even is within 3 years of service in the simple presentation.

In other, more complicated cases, it becomes more complicated to evaluate cost and benefit for R & D, but there seems good reason to believe profitability in the short term, i.e. for each individual ship or platform. The impact of R & D in the long run is supposedly much larger.

Conclusion

The present paper dealt with the importance of involving R & D in the entire life cycle of ships, offshore and ocean platforms. It was argued that the involvement was an advantage from the very beginning, the conceptualization and the feasibility of preferred concepts against the mission objectives. Examples were given of subjects which R & D could well service in the individual phases of the life cycle leaving an immediate profit and long term extension of know-how. Finally, a cost benefit analysis presented in cash flow form indicated the high recovery rate of R & D investments.

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