THE CHANGING SCENE IN MARINE DESIGN TECHNIQUES

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ABSTRACT

Describing the state-of-the-art in a fast-moving field is no easy task. My approach is to mention briefly where we have been, describe the direction we seem to be moving, and guess where current trends will take us.

My thesis is that this is a rapidly changing world, and rapid changes in ships and in ship design methods are also much in evidence. The two key, synergistic, elements in the changing realm of design methods are (a) engineering economics, and (b) computers. I discuss the disparate rate of progress in the two elements, hidden shoals (and a few unhidden ones), and then go on to list some of the pressures that are forcing change.

After a suitable disclaimer, I attempt some forecasting of things to come, and bring down the curtain with suggested ways to survive in the turbulent years ahead.

HISTORIC PERSPECTIVE

In his stimulating, if controversial, book Future Shock [1] Alvin Toffler quotes Kenneth Boulding as follows:

> The world of today...is as different from the world in which I was born as that world was from Julius Caesar's. I was born in the middle of human history, to date, roughly. Almost as much has happened since I was born as happened before.

As we look about us at the pace of change in today's world we can readily agree that Boulding's thought-provoking estimate of where we stand in history must be about right. In the area of our own technical interest we can readily claim that developments in ship technology are more than keeping pace with the rest of the world. We are assuredly coming along as fast as any of the other mature branches of engineering [2,3,4]. Ship designs are changing at a rapid rate; but ship design *techniques* are changing even more rapidly. Although seagoing ships have been with us for at least 8000 years, Simpson's Rule has been with us for only 2.5 percent of that time and model basins only half of *that*. Two mutually dependent developments are now effecting a complete revolution in ship design methods. I refer to (a) widespread application of engineering economics and (b) computer-aided design. The application of economics seems to have had its real beginning only 22 years ago [5]--or less than three-tenths of one percent of that 8000-year history. Computers came to our industry even later. You don't need to be terribly old to remember when the key ship design decisions were based on the most bizarre collection of dubious rules, most of them amounting to a hidden hand always steering you toward replicating the past. Young naval architects were chained to their hand-cranked calculators while they patiently awaited the demise of their seniors so that they might at last be promoted to a position where they too could make design decisions. And, when that time came they probably emulated their predecessors and resisted what they did not understand--namely change. As the old song put it, them days are gone forever.

THE SCENE TODAY

Describing the state of the art in ship design techniques is rather a difficult task--except to say that it is in a state of flux. A movie projector would be better suited to this presentation than an oil painting. I think we can characterize the situation only by describing trends rather than fixed conditions. In the broadest terms, the two previously enumerated key elements are moving ahead as follows:

The most visible changes are in ever-expanding applications of computers. These embrace not only all levels of technical design and analysis but also integrated production activities, cost estimating, and so forth.

Concurrent developments in economic analysis are receiving much less attention and are not keeping pace. Computer print-outs will continue to misguide and misinform until we provide better inputs bearing on such economic factors as taxes, inflation, and how to survive a tumultuous future. The more important the decision, the more apparent is this weakness.

One practicing naval architect (whose name I shall hold in confidence) defines the extremes that one may encounter in ship design:

> I have been exposed to virtually the entire spectrum of the design process in my 20 years in the industry--from fishing vessels where the "design" consisted of a few scraps of paper and generations of tradition, to the multi-disciplinary, multi-million dollar Navy design extravaganzas where every decision must be analyzed, traded-off, massaged and documented to the point that basic design issues are often lost in the process. Frankly, I prefer the former, though the latter is more lucrative.

If you would gain a good perspective on current trends in computer applications, let me recommend the collection of reports in Ref. 6, dealing with automation in shipbuilding. Of course nearly all those papers are concerned with computer applications to scheduling and fabrication; but computer-aided design is very much involved. Indeed, one of the most commendable trends we see today is the growing recognition that ship design is the handmaiden of ship production. (If you think that should be obvious, you don't know design offices as well as I do.) Papers such as those by Gallagher [7] and Thompson [8] illustrate how new techniques are reducing the need for draftsmen just as they have already reduced the need for loftsmen. At the same time the computer produces assembly drawings that make life easy for the shipfitter and eliminate conflicts between piping, wiring, and duct work. Structural designers are increasingly able to select scantlings on a rational basis rather than remaining tied to classification society rules [9]; and we are able to handle all manner of complex problems that were way beyond our capability in pre-computer times: dynamic structural responses, spectral analysis of ship motions, multi-mass vibrations, and pipe stress conditions [10]. (Strictly technical problems such as these are not tied in with economics and are therefore not affected by current shortcomings in the economic area. Unfortunately, the same is *not* true of creative preliminary design methods.)

On the other hand, we must admit that we have on occasion gone overboard in using computers [11]. Those amazing devices cannot solve all problems; they can be misleading unless applied intelligently and kept continually up-to-date. In my view a lot of the work that has gone into optimum search techniques has been wasted. We should ask the computer for a menu, not a decision. For the kinds of decisions that are settled better by eye than by numbers (such as general arrangements, habitability, aesthetics and other intangibles) interactive computer graphics allows a promising blend of machine computation and human decision-making. Developments in that line seem likely to overcome many shortcomings that are still evident in the all-machine approach.

A decade ago Drucker [12] pointed out a vital change then taking place in many industries. What was involved was a massive shift from a reliance on skills to a reliance on knowledge. Industries were, in short, learning to "work smarter." Thanks to our new found knowledge of practical economics, and by the grace of the computer, the marine industry is now rapidly shifting from an emphasis on skills (and past experience) to an emphasis on knowledge. The old combination of art and science still exists, but the proportions are now on the side of science. And that I think summarizes rather well the state of the art in ship design technology.

THE DANGER TODAY

What we see today is a rapid proliferation of highly specialized computer programs that we call upon collectively to help us design ships and manage their production [13]. This trend is inevitable and I do not argue against it. What I worry about, however, is the human link. Only one or two specialists are likely to understand any one of the many components of the total system. What assurance do we have that they understand the overall objective? What assurance do we have that engineering managers understand the limitations of any of the components? We must be careful indeed about human communications if we are to keep the computer beast under control.

Another potential danger is related to human frailty. As we develop yet more sophisticated computer programs we are apt to find them yet more difficult to change. This resistance can be at the micro-level, where changes are awkward to effect because the system is so complex and hence so little understood. It can also occur at the macro-level, where major changes in design may be heartily resisted simply because the existing programs would have to be replaced at great expense. Tomorrow's highly sophisticated design manager may become as loath to change as was his rule-of-thumb predecessor. His conservatism will not be caused by ignorance but, rather, by inertia.

This question of adaptability is extremely important because major changes are in store in the ships themselves, in shipbuilding equipment, and in the design process. Some of these are mentioned in the next section.

PRESSURES FOR CHANGE

Over the past two or three decades we have seen startling developments in ships and in the methods of their design. These trends are unlikely to diminish in the near future.

Although this paper is not directly concerned with ships *per se* we may want to spend a moment to consider *why* they are bound to change. A primary driving pressure is in changing patterns of world trade. As Bullock [14] puts it, "ships don't move cargoes; cargoes move ships." Many writers [2,14,15,16,17] remind us of the current calamitous condition of petroleum commerce and some go on to wonder whether tankers may not be a dying breed [18]. More cheerfully, there are new demands for ships arising in non-transport industries such as ocean engineering [11], floating airports [19]; and--in naval craft--a proliferation of new kinds of hulls to carry new kinds of weapons [10].

Other pressures that will change ships include our mounting concern for environmental protection [10,15,20,21], safety [10, 16,20,21], high cost of energy [16], high costs of dredging, ever-more-onerous regulations [10,19,20], and mounting pressures to make shipboard life more attractive--not only in creature comforts but in job satisfaction [9]. Buxton [20] makes this discouraging observation: "Although economics will remain the driving force rather than technology, there will be an overall decline in transport efficiency owing to political factors: cargo preference, job preservation, etc., which lower load factors and increase port time." Food for thought, indeed.

In the line of wishful thinking we may perhaps be allowed to hope that in the years ahead our more enlightened shipowners will broaden their definition of economics to recognize the intangible benefits of spending a few extra dollars for eye-appeal.

Recognizing that ship design is becoming increasingly concerned with producibility reminds us that new developments in shipyard equipment may also lead to changes in ship design [7,22].

Rounding out this discussion of pressures for change, we come to the matter of improving computer programs simply because (a) they require further refinement, (b) they are still pretty expensive, and (c) better computers and better techniques are becoming available [8,10]. Today's design methods (and computer programs) need more feedback from ship operators [23]; better predictions of income potential and operating costs [9]; better recognition of taxes and inflation, and better ways to estimate building costs. Clearly, too, there is much room for improvement in designing ships that are easier to build [3,10].

That completes my litany of the visible pressures for change. But change will arise even where there are no pressures. Let me cite some quotations from a recent book by Boorstin [24]:

> ...the great technological changes do *not* have a *why*. The telegraph was not invented because men felt aggrieved by the need to carry messages over the roads, by hand and on horseback. The wireless did not appear because men would no longer tolerate the stringing of wires to carry their messages. Television was not produced because Americans would no longer suffer the indignity or the inconvenience of leaving their homes and going to a theater to see a motion picture... technological revolutions (by contrast with political revolutions) really have no *why*.

* * *

Technology invents needs and exports problems.

* * *

About the only general conclusion we may reach from all this is that we must expect change; we must try to predict what changes will come along; but we must always expect to be surprised.

FORETELLING THE FUTURE (AND OTHER BLACK ARTS)

Any honest attempt to dwell on things to come should start with a disclaimer. Let me fall back once more on Boorstin [24].

> Great changes in technology--in the very world of advancing scientific knowledge and enlarging technological grasp--paradoxically remain (as they always have been) mysterious and unpredictable.

Thus warned, let us at least be brave enough to predict where current trends and visible needs are likely to take us. We shall adopt as our motto Clarke's Law [25]: "When a distinguished but elderly scientist states that something is possible, he is almost certainly right. When he states that something is impossible, he is very probably wrong."

My own view of the future of ship design methods is that we shall soon develop fully-integrated design and construction computer programs. For any of the usual types of ships these programs will have the capacity to start with a shipowner's functional requirements and--as a continuum--go through preliminary design (major dimensions, horsepower, etc), develop the hull form and arrangements, select scantlings, analyze strength, vibrations, motions and other technical concerns, select machinery components, select outfitting items, order outside materials, estimate costs, write the specifications--perhaps even the contract--estimate weights and centers, write bills of materials, plan production schedules in fine detail, turn out production and assembly drawings, manipulate flame cutters and other fabrication devices, keep track of inventory, keep financial accounts, pay bills, issue paychecks, and--above all--let the client know when his payments fall due. Mind you, I said these programs will have the *capacity* to do all that. What I also believe, however, is that the computer's work will be interrupted at key steps along the way. Some interruptions will simply be to make sure we are getting reasonable answers. Others will be to allow human judgement to interact with the computer in making those decisions where human judgment is superior [9,13,23,26,27].

Another major development that we may hope to see is a ship design/production program that is so versatile that we can offer tailor-made ships at mass-produced prices [11]. Numerical control developments are already moving in that direction [25] and should become practical in shipbuilding. I do not mean that a single program can be used for a wide range of ship types. Rather, I visualize a program that can readily handle any range of size and power for, let us say, ocean bulk carriers. Other programs will handle other common varieties.

The two major developments outlined above suggest several subsidiary changes. Shipyard work forces are likely to devolve into two categories: relatively unskilled production workers and highly skilled maintenance technicians [11]. There will also be a continuing need for engineers and technicians to keep the programs up to date [11] and to continue the struggle to lower the costs of computer time. A greater degree of parts-standardization can be expected, as can greater use of construction modules, and of purchased components [11,26].

ESCAPING FUTURE SHOCK

When I talk about escaping future shock I am not advocating an escape from the future, only the shock. For the naval architect and marine engineer, the secret of survival is to recognize that change is inevitable. If you do not choose to lead the way into new things, you must at least recognize the folly of resisting the inevitable.

Our computer programs must be designed as interchangeable modules, allowing a wide selection of design tools that will satisfy a wide variety of needs. Each module's applicability must be clearly defined, as well as its limitations. Each module must be designed for easy change and then must be periodically brought up to date.

As programs become more complex, specialization will hinder communication. Ways must be found to enhance exchange of information within the organization. The technicians who know the programs in the greatest detail must be able to explain their applicability to design managers. The managers, on the other hand, must be able to make the technicians understand the overall objectives of the project. Otherwise, like radar-assisted collisions in ship operation, we shall experience computer-assisted disasters in ship production. Perhaps we all need continuing lessons in expository writing and speaking as well as in computer language.

Rapid technological change brings with it an increasing likelihood that ship designs will need to be altered in mid-stream. Thus we shall need to gain a better understanding of the effects of disruption and how to minimize their distressing impacts on schedules and costs [28]. This suggests, too, that we need to try harder to look ahead and make informed guesses as to what little surprises may be in store as a result of shifting world affairs, new fuels, new kinds of machinery, new materials, new regulations (we may even shed a few old ones), new shipbuilding equipment--and on and on.

As implied earlier, we cannot make the best possible decisions until we deposit more economic information in our data banks. This is going to require a more enlightened attitude on the part of marine managers, both in shipyards and in fleet offices. Our stubborn unwillingness to share cost information is rather unique to the marine industry and severely curtails our ability to produce the best possible ship for any given service.

A most important ingredient in avoiding future shock is a well-trained team of technicians, engineers, researchers, and business managers [12]. Without such people change is inevitably beyond comprehension and so resisted. Some maritime nations are far better off than others in this respect. As is obvious from the setting of this conference, the importance of education and research is not unknown to our worthy hosts.

FINALE

The papers that you will later hear in the four technical divisions will, I am sure, convince you that we are indeed rapidly shifting from an industry of skills to an industry of knowledge. Even when that shift is essentially complete we must still expect to live in conditions of continuing transition. (Remember what Boorstin says about technology inventing needs and exporting problems.) So, our watchword should be to hang loose; consciously strive for self-renewal [29]; and carve nothing in marble, cast nothing in bronze--with the exception, of course, of these noble words.

Finally, let me compliment our hosts for their imagination and energy in organizing this international conference. They have succeeded in bringing together an all-star, cosmopolitan cast of the maritime industry's intellectual elite. We shall, I am sure, all gain new understandings and--equally important--new friends during these few days in Trondheim. And we shall leave convinced that "Technology is the natural foe of nationalism" [24].

ACKNOWLEDGEMENTS

Last December I wrote to several friends in the maritime industry soliciting their ideas on what constitutes the state of the art in ship design. The list of references (immediately following) cites many of the helpful responses to that appeal. In addition to those thus recognized, I wish to acknowledge helpful advice supplied by Stian Erichsen, Günter Grossman, Douglas Martin, Ronald Kiss, Robert M. Scher, and John B. Woodward III. To all of you I say: you never look better than when adorned with laurel wreaths.

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