AD-A063 261 UTAH UNIV SALT LAKE CITY DEPT OF COMPUTER SCIENCE F/G 9/2

RECOMMENDATIONS FOR COMPUTER UTILIZATION IN SHIPBUILDING.(U)

DEC 78 R F RIESENFELD N00014-77-C-0157

UNCLASSIFIED NL

| OF |

AD A063261

END

DATE FILMED

3--79

DDC

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Recommendations for Computer Utilization in Shipbuilding.		5. TYPE OF REPORT & PERIOD COVERED Final Report 1 Feb 77 - 15 Nov 78
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Richard F. Riesenfeld		8. CONTRACT OR GRANT NUMBER(s) NØØØ 1477CO157
9. PERFORMING ORGANIZATION NAME AND ADDRESS Department of Computer Science University of Utah Salt Lake City, Utah 84112		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 10 Dec 78
11. CONTROLLING OFFICE NAME AND ADDRESS Office of Naval Research 800 North Quincy Street Arlington, VA 22217		12. REPORT DATE 21 Nov 78
		13. NUMBER OF PAGES 44p
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) NØØØ14-77-C-Ø157		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Unlimited

This document has been approved for public release and sale; its distribution is unlimited.

DDC

RECEIVED JAN 1979

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Companion Report to: "Computer Science R&D in Support of Ship Design, Production, and Repair," by R. Chen and E. Cuthill (DTNSRDC 78/104).

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Computer Aided Design, Shipbuilding

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

As the conclusion to a study of the use of computers in shipbuilding, this report contains selected observations from key site visits and some specific recommendations for a program of further ONR funding in computer science. This document is a

404 949

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

S/N 0102-LF-014-6601

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

79 01 12

Recommendations for Computer Utilization in Shipbuilding*

Final Report

by

Richard F. Riesenfeld

University of Utah

10 December 1978

Abstract

As the conclusion to a study of the use of computers in shipbuilding, this report contains selected observations from key site visits and some specific recommendations for a program of further ONR funding in computer science.

*The work reported herein was funded under ONR Contract N0001477C0157.

Table of Contents

Introduction

The objectives of this study have been to survey the ship building industry and to recommend a five year plan of research and development based on these findings. This document is intended to accompany a comprehensive volume of facts,data,recommendations, and references pertaining to CAD and shipbuilding which was prepared by Ruey Chen and Elizabeth Cuthill of the David Taylor Naval Ship Research and Development Center (DTNSRDC Report 78/104) as the final report under a simultaneous contract provided by the Office of Naval Research Information Sciences Program. Since these coordinated, complementary study reports have been prepared as companion documents, the reader is referred to the Chen-Cuthill report for background material and references. The information in that report is part of the basis for the opinions and recommendations contained herein.

This report contains some selected impressions from key site visits, a summary of general impressions, and finally some specific recommendations for further ONR funding during the next five years. A five year budget for research and development is given by broad category in the Chen-Cuthill report.

Information Seeking Activities

Under the funding provided for by this contract, a large spectrum of projects, types of sites, kinds of forums, and opinions were sampled mainly by the principal investigator (PI), except at times of conflicting overcommitment when a representative was sent. The greatest effort was given to the foreign visits to Northern Europe and Japan, where the PI was able to draw on professional relationships and friendships to set up very worthwhile private meetings and briefings. Also the advice of Professor Horst Nowacki of the Technical University of Berlin was sought several times. He is a recognized international leader in the area defined by this contract.

During the course of this contract information gathering trips were made to Kockums Shipyard (Sweden), Central Institute of Industrial Research (Norway), Aker Engineering Group (Norway), Det Norske Veritas (Norway), British Ship Research Association (Great Britain), Sun Shipyard (United States), Avondale Shipyard (United States), and Cali Associates (United States). In Japan visits were made with Mitsubishi Heavy Industry, Mitsui Engineering and Shipbuilding, Nippon Kokan K.K., Sumitomo Heavy Industry, and Ishikawajimaharima Heavy Industry. Also attended were the SNAME Conference on Mathematical Hull Definition (Annapolis), ACM-SIGGRAPH- 78 (Atlanta), REAPS-77(New Orleans), REAPS-78(St. Louis), and an ICAM Workshop in Washington. Personal meetings were held with Drs. A. R. Forrest (University of East Anglia), C. A. Lang (Shape Data, Inc.), S. A. Coons (University of Colorado), D. Cohen(University of Southern California- Information Sciences Institute), M. Sabin (Kongsberg, Ltd.), J. M. Lane (Boeing Commercial Airplane Co.), R. P. Dube (Boeing Computing Services-IPAD Project), I. Braid (Cambridge University), H. Nowacki (Technical University of Berlin), C. Eastman (Carnegie-Mellon University), D. Greenberg (Cornell University), David C. Evans (Evans and Sutherland Computer Corp.), E. Catmull (New York Institute of Technology), W. J. Gordon (ONR-London), B. Herzog (University of Colorado), I. E. Sutherland (California Institute of Technology), F. Yamaguchi (Kyushu Institute of Design), and T. Kunii(University of Tokyo). Including a workshop prior to the contract, there were four special ONR sponsored meetings or workshops associated with this survey effort, the last meeting being the time of dissemination for this document and the Chen-Cuthill report. In addition to these meetings and direct personal contacts, the PI engaged in numerous telephone conversations as well as considerable reading that related to this contract.

Overview

Beginning in the early 1960's, the shipbuilding industry had a very early start in bringing computers into the design and manufacturing of ships. It was one of the leading industries for the approach of using computers to house a general integrated database model of the product. Slowly the necessary analysis and process packages that are required for the design and production of a ship took their form as integrated program modules around a common database which would eventually become the master definition of a ship. Leading graphics applications were part of this new methodology. Geometry was being moved from the loft and drawing board to the computer as new techniques and algorithms emerged. The databases which defined ships were pushing forward the forefront of the computer knowledge and hardware capability of the time. Analysis programs were growing in sophistication and size in order to improve the value of the computer modelling approach.

By linking computer technology with numerical control vast improvements in production came about. This brought about improved quality and reduced costs through automation and less material wastage. Inventories could be controlled better, estimation and financial calculations were facilitated, and better ship performance was possible. Computers brought more, better, and faster access to crucial data at critical decision points in the design and production process.

But, at the end of the 1970's, the shipbuilding industry appears to have lost some of its drive to invoke the newest computer technology. It is rarely thought of as a contributor of innovation to computer science. Shipbuilding seems to have reflexed under its overriding tendencies as a very old and traditional field. Major systems commitments are not in evidence as they once were.

The reasons for this general decline in the rate of technological advance in the industry are probably directly related to the worldwide depression in the shipbuilding market. The push for modernization may have given way to the push for financial survival. Also, the necessary competitive forces may not be present with enough strength to bring about the desired advances in new technology. The shipbuilding industry is subject to many factors beyond those of the free market, including national interest and national pride. Although the economics of the shipbuilding industry has been the subject of other reports and is not the subject of this report, it is conjectured that its poor economic conditions are affecting the field's drive to acquire the newest computer technology. Domestically one cannot overlook the characteristically poor relations between the government and the shipbuilding industry as a factor as well.

Whatever the underlying indirect causes may be, it is clear that the shipbuilding industry could benefit from new research in computer science, and the transfer and application of present computer technology. A field which once was at the forefront in computer applications has stalled in its drive to adopt, absorb, and offer new ideas in computer principles. Largely it employs systems which are not based on the modern software and hardware tools and methodology that computer science can offer. Only in the foreign travels was there a discernible level of excitement and commitment about CAD and futuristic possibilities. A carefully constructed program of research and development for this area is appropriate as a stimulating and remedial action.

The basic improvements and advantages that better computer technology can bring to the shipbuilding industry are essentially the same ones the computers have already helped to bring about: shorter design and production times, better inventory procedures, higher production quality, less material, better analysis and estimation, better final performance. Also, automation can improve labor relations through improved working conditions, and greater profit margins because of improved efficiency and less waste.

Under the section entitled recommendations, we specifically identify some topics that would be of direct benefit to the shipbuilding process.

Recommendations

The companion Chen-Cuthill report identifies the following computer science areas as requiring additional research and development:

- design and management of very large databases
- computer graphics
- design automation
- production automation
- distributed computing
- software acquisition, development, and maintenance

A $7.4M, 5 year program is outlined and recommended there. In this supplementary recommendation, some particular computer science topics within the above categories are cited as topics which would offer particular relevance for promoting the application of computers in shipbuilding.

1. Parallel computation. Very clearly the conventional computer architecture will change giving way to some challenging and powerful systems. Whatever forms the new computers take on, they are very likely to exhibit highly parallel structures. This trend can be expected because the cost of processing units is drastically diminished, and because the ultimate limit of miniaturization is going to become a factor. Speed and performance will come from replication within new computer organizations. Thus it is recommended that we anticipate this opportunity by funding research to learn of intelligent ways to exploit parallel processing in the context of computer systems which support shipbuilding. Most of the existing software systems are highly modularized according to application function, and might lend themselves to a suitable problem decomposition. An innovative parallel processing structure could have considerable benefits in reducing design time and maintaining database integrity by providing an extremely responsive system for design and analysis. It could be highly applicable to

multifunctional systems like those which occur in shipbuilding environments.

2. Associative processors. Many computing tasks connected with shipbuilding are involved with maintaining and interrogating relationships within a geometric model. Such tasks can lend themselves to hardware support by associative processors or associative memories which might constitute a portion of a hybrid memory organization. Regardless of the final form of a nontraditional computer organization, research can be begun immediately on representations and algorithms for using associative memories in the context of shipbuilding and its computing problems. This hardware might be especially valuable in solving interference problems and other relational questions.

3. Laser-based technology. For several years now a large screen (more than 1 meter square), highly accurate, nonrefresh computer display has been commercially available which is capable of high detail, high resolution, and extremely large total information presentation. The laser-based technology display, produced by Laserscan of Cambridge, England, has selective erase and a photographic hardcopy. Although the writing time is relatively slow (about 90 sec), it has many features, such as its vast capacity for detail and resolution, which appear to be well suited for applications in shipbuilding. It is recommended that its utility in this area be studied as a device which could vastly improve the graphical communication between the designers and the computer based model.

4. Low cost computers. Microprocessors are becoming as common as wristwatches. The main challenge is to figure out how to use them creatively and effectively. ONR should initiate research in distributed processing which is particularly aimed at utilizing the economies of the microprocessor and other low cost devices as computing elements in the computing environment of shipbuilding. Some portion of the research could also examine the potential of other alternative machine architectures. This recommendation is inspired by the availability of a

technical resource rather than the identification of a specific problem.

5. Databases for engineering design. There are many commercially available database systems, many of which are supplied by the major computer manufacturers. Most of these systems were developed with business applications primarily in mind, although they are used in scientific applications as well. There is a clear need for the development of database systems that are specifically oriented toward the needs of interactive engineering design. Such applications tend to be neither strictly hierarchical, nor strictly relational, but they have some aspects of both present. Large databases for engineering design should have a facility for supporting user interaction as well as for graphical display of the model being designed. Major support should be given to research that can provide more experience and more knowledge in the area of large engineering databases.

6. Programming languages suitable for shipbuilding applications. The predominant computer language that is in use today for the implementation of computer systems for shipbuilding is still Fortran. There are some newer systems which have adopted PL/I as the implementation language. Without assailing the historical achievements of Fortran, let it be said that there are more modern languages that overcome some of the egregious deficiencies of Fortran and that may be considerably better suited to implement shipbuilding systems. It is not established that PL/I, which generally require an IBM computing environment, is the best replacement choice for Fortran. Research is required in the area of general programming languages suitable for shipbuilding systems. Are languages like Pascal or C appropriate, or are special ones necessary? What are the special requirements that shipbuilding imposes on a programming language? An amenable, powerful, and appropriate programming language could genuinely liberate the software designer to build new and modern systems.

7. Software engineering tools. The massive systems programming effort that is

normally required for the implementation of a large computer software system gives rather large inertia, large resistance to modernization, to such a system. Not only can this factor inhibit software systems development, it can also result in the maintenance of obsolete hardware to support a previous overcommitment. New systems must be implemented with modern, high level, portable software engineering tools that decrease the investment in a particular system. Software must be flexible and disposable in order to respond to a field of exploding technological change. This subject should be studied with a direct interest in applying it to shipbuilding needsfor more modern computing computing environments to support multi-user interaction and multiporcessor functions.

8. High quality computer graphics. High quality computer graphics has matured rapidly in the last five years. High precision color displays are practical, available, and relatively inexpensive. Color is an attractive tool for associating and distinguishing information during a visual presentation. Color encoding can be very useful for studying relations between various systems. New hierarchical algorithms are needed for making computer graphics more useful in large engineering databases. Research support must be given to its further development and application to designing ships. The importance of graphics in the design and analysis of ships should not be understated. Graphics provides the most powerful channel of human communications with computers. It can be a useful factor in reducing design time and yielding better designs through more usefully and rapidly presented information.

9. Automatic handling and robotic aid. Artificial intelligence (AI) is already having a serious impact on production technology, but it is also evident that it can be extended vastly in the future through use of more robotics and other intelligent tools. This area can be used to improve productivity, reduce construction time, reduce the number of hazardous jobs, and improve working conditions and morale. It can also reduce waste through intelligent programs for optimal nesting of parts

and more precise part production and assembly. AI can be used for more automatic handling and for more skillful robotic aid in fabrication. Continuing funds in this direction is surely consistent with the ONR mission.

10. New surface models. Designing ship hulls is still done principally by specifying and altering characteristic curves, rather than through direct specification of the hull surface itself. It seems that experimentation with new surface models that can be directly specified might lead to a more three dimensional conception and interaction in ship hull design. What would be the effects on the design process? Would it lead to better designs or shorter design time?s Can ship design be achieved in three dimensions? Funding for the investigation of these questions should be provided.

11. Outfitting a ship and the interference problem. Outfitting a ship accounts for a major portion of its final cost. Many complex and potentially conflicting systems must be specified and modified in the course of conflict resolution or other design alterations. Significant reductions in overall cost and design time could be realized through improved computer assistance in analysis, layout, and production of the ships internal systems like piping. This could also lead to more detailed specification and possible savings in materials by more optimal design. This should include automatic documentation, in addition to repair and replacement instructions for various components. The interference problem might yield more readily to specialized approaches using associative processors, for example.

12. Computer geometry. Computer geometry is a legitimate, important, and difficult area whose proper identification has hardly come about. Many problems that confront shipbuilders are problems encompassed by this area. Computational geometry is devoted to the development and evaluation of constructive algorithms for performing geometric operations and tasks within a computer. Geometric modelling is concerned with providing adequate representations which are

amenable to design. Computer aided geometric design includes the interaction with these models. All of these areas are vital to shipbuilding both in the large component definition phase and in small part definition including outfitting. Researchers of these types are sparsely represented in computer science departments. More funds for research and more emphasis is needed to attract and train more researchers in these subjects. This should be an area of high importance simply because geometry is intimately involved with many items procured for and contracted by the Navy.

13. Basic design process, Incentive money. The use of computers in the basic design process must be studied more thoroughly and more fundamentally. What are its principles and how do computers change the traditional process? Should there be radical changes in the functions performed by naval architects and should the computing environments for modern naval design be markedly different from our present installations? How can we rely on computers to reinforce design constraints and how can they help designers resolve the inevitable conflicts? Is this a place for distributed, devoted processors which are individually assigned to monitor some constraint enforcement? Strong support must be provided for creative explorations into the use of computers in the design process, particularly relative to the essential issue of understanding how to deal with the multiple, and perhaps overly, constrained design situation. This problem has aroused attention among researchers in artificial intelligence, and it should be pursued with an interest in shipbuilders' problems. Not only should it be taken on at an elevated, abstract level, it should be studied "bottom up" as well by using small attainable goals. Specific, restricted design problems should be chosen for combined assault between university and shipbuilding groups. Modest incentive money should be available for the initial pursuit of such specialized design problems, so that a simple mechanism is available for supporting this kind of approach.

14. Conduits for computer technology. Computer science is a subject of

unprecedented and unabated explosive growth. Its blinding technological change threatens to render all but the most tenacious and devoted members obsolete with each year's major advances. People outside the mainstream of computer technology information have an even more overwhelming assignment, if they are committed to remain apprised of the latest developments and its intelligent use. Because this problem is really special in computer technology, it is recommended that some direct channels be provided from key sources of information to the shipbuilding community. Some simple and accessible conduits for the most recent computer technology should be established to facilitate the transfer of information and methodology from centers of relevant computer science research to members of the shipbuilding community who are interested in its application. This channel should, of course, yield communications in the other direction which also allows problems of particular interest to shipbuilders to flow to computer scientists.

15. Designing for manufacturability. The link, the interface, and the implications that computer *aided* manufacturing bears on computer aided design are issues of direct relevance to shipbuilding. Designing *for* fabrication is essential and this issue must be taken in account as early as possible in the design stage. Similarly, achieving a design that lowers maintenance costs should be a goal. Generally, this point can be expressed in terms of the fusion of the CAM and CAD processes. This issue is sometimes called "designing for manufacturability." Regardless of phrasing, this is an area of self-evident value in shipbuilding, and its funding for further understanding is important to the Navy.

16. Integration of Models. As shipbuilding systems are currently organized, there exist several disparate models among which translation is not automatic. There is a geometry model for specifying shape. A finite element model is used for various structural analyses. A graphics model requires different attributes from the geometry model, and often needs elimination of distracting detail. There are other models, some acknowledged more formally than others. Through better

and more universal models it is possible to develop a single overall master model from which all other models can be derived on an automatic and current basis. The effect would be large, for there could be one genuine *definition* as the top node of a hierarchy of models. Improvements and alterations would be effected correctly immediately. Coordination could be improved and design cycle time reduced.

The above recommendations comprise a ready list of projects whose funding, in the opinion of the PI, would advance the utilization and benefits of computers in the shipbuilding industry. It is surely not an exhaustive list, but it is offered as a list that would effect the current design and production processes in shipbuilding. These recommendations would have a positive impact on safety, total cost, efficiency, production, and performance. Advances in these areas could lead to appreciable reductions in the overall time required to design and produce a ship and to reductions in cost by lowering labor and material components. It could lead to measurably improved performance through superior quality in designs for the ships of the future.

Selected Trip Reports

In this section we include the trip reports from Northern Europe, Japan, Sun Shipyard, and REAPS-78. All but the last report the activities of the PI. The REAPS-78 meeting was attended by Andreas Weichbrodt, a naval architect from the Technical University of Berlin who is presently studying computer science and computer graphics in a graduate degree program at the University of Utah. It should be mentioned that most of the important meetings were established on a bilateral basis. The PI of this report was generally asked to give views, opinions, and other information in his area of specialty in exchange for the information he was seeking.

European Trip Report
For ONR Survey

Malmø, Sweden

The first visit was at the Kockums Shipyard situated along the sea and marked by a high crane bearing the name Kockums which is visible from any point in the city of Malmø. The director of their computer systems Mr. Kai Holmgren, who was my primary contact there, was out of town on the day of my visit, so he asked one of his employees who specialized in surface definition to act as my host for the day. I explained my interest in Kockums through the talk that Mr. Holmgren gave at the REAPS Conference in New Orleans in June of 1977. There he described the System Q and the Steerbear System which has been marketed for a computer based shipbuilding system. The integration of the financial with the scientific modules over a common database, and their careful inventory control attracted me to find out more about this system. It also was notable in that it is available in PL/1 or ALGOL versions, which is not true of many of the other commercial systems.

After some introductory explanation about the diversified endeavors of Kockums and an overall view of the company, we discussed their current activity. The European shipbuilding industry, like the rest of the shipbuilding industry, is badly depressed. Kockums, the only remaining private shipyard in Sweden, was building a large liquid gas tanker on the speculation that someone would become interested in it and make an order for it before its completion date. If that gambit is lost it was assumed that Kockums would have to be nationalized in order to solve the financial problems.

During our discussion about their problems of designing with computers, they brought out that the basic operations in geometry had to be done efficiently and correctly. That is, one must be able to compute intersections with planes and lines together with cruved surfaces and problems of that kind. Also there still were some remaining areas of difficulty in the design of the ship hulls. One region of difficulty was the propeller in the stern of a ship that had to be defined with fillets of a constrained radius. In general the system was not powerful enough to assist in that properly. The Steerbear System is actually a batch system, rather than an interactive realtime system. We had some interesting discussions on what kind of input is most appropriate and best used. We also discussed what role graphics might take in their operations. They were particularly interested in using graphics in connection with their finite element analysis, a place where the designer can learn a great deal about a problem from visual presentations.

After lunch we had a walking/bicycle tour of the shipyard which was very modern and immaculate in its layout and appearance. The Swedish labor unions are very strong, and the impact on the facilities at the shipyard was evident. The shipyard featured a fabulous recreational center that was built for all of the employees. During our discussions about manufacturing of ships, some interesting statistics came up. Basically the commission and fabrication of a ship can be described as a process that begins at a very narrow point of initial contact and eventually swells to a maximum width when all the individual pieces have been designed and are being manufactured. Then the process contracts again until finally there is just the finished ship at the very end. As is often mentioned, a ship contains one to two million parts. It is also an interesting statistic that it requires about

80,000 to 100,000 operations to build a ship where an operation is some basic task in the range of 1-20 man-hours.

In the afternoon I spent time speaking with Per White, a man from their sales force. He worked in the United States for some years before returning to Sweden. He offered some of his contacts in the U.S. to me for my aid in pursuing this survey.

Generally my feeling was that the Kockums visit was a good visit, especially as an education for me in what goes on at the shipyard and what some of the basic concerns and problems concerning computers are in the production of ships. Unfortunately, but understandably, the bleak economic situation for the shipbuilding industry tends to dampen the enthusiasm for technological innovation. Rather they seem to be pre-occupied by the question of financial survival, leaving little energy for technological adventure.

Oslo, Norway

The next stop was Oslo, Norway where my host and former student Frank Lillehagen booked a very rigorous schedule for us to follow. We began soon after our midday arrival with a working lunch where we discussed several of the ongoing projects at the Central Institute for Industrial Research. This laboratory has a history of much activity in the shipbuilding industry particularly in connection with the Autokon system. The first day we received reports on the research projects involving picture processing, robotics, holography and the CAD projects at the CIIR. Frank Lillehagen was the head of the CAD group there, and interestingly we observed how his project was growing very rapidly in terms of manpower and budget. His group also included a couple of students from the University of Oslo who were interested in pursuing theses related to the topic of CAD. The CAD group at CIIR, in addition to being intensely active, also enjoyed a close liasonship with various industries in the Oslo area.

The next day I went to visit the Aker Engineering group, which was very much involved in the development and marketing of the Autokon. There I was brought up to date on their recent activites and interests in shipbuilding. Basically, the Autokon system has been well accepted and is in a fairly stable situation, although they continue to add refinements to that. Generally the main interest in the Aker group now is in developing their engineering capacity in the direction of application to problems connected with the oil exploration endeavors in the North Sea. That idea is not a novel one, and so efforts to convert shipbuilding capacity to rigs for the North Sea oil exploration are also becoming too competitive and crowded. Nevertheless there is more business there than there seems to be in shipbuilding.

Following the visit with the Aker Engineering Group I traveled to Computas, a subsidiary of Det Norske Veritas, one of the world's ship classification societies. Essentially, Computas is the computing division of the Det Norske Veritas. Computas was located in the beautiful modern building located with a very scenic view on the harbor. At Computas I was greeted with rather keen interest and many questions about my travels and objectives. They also asked me to give a presentation of my own work, which was similar to the one I presented at Kockums.

In comparing aerospace with shipbuilding, someone observed there that performance and slim margins are stricter requirements in aerospace than in shipbuilding and may account for some of the more advanced practices in aerospace. In Norway, they tend to be application-oriented and have very good ties with the academic world. Also they point out that the economic necessities are stronger in Norway perhaps than other countries involved in shipbuilding. This is a small country which really must succeed in the industries to which it commits itself. CAD, they claim, is not considered a threat in Norway. Rather it is viewed as a methodology which enhances job content and position. There was also some speculation that the small shipyards, which are mostly accustomed to manual methods, might become interested in desk-top computer methods. They remarked that Lloyds has developed a structural analysis package for the HP9830, and that may be just a harbinger for things to come for the smaller shipyards.

They were quite proud of their structural analysis efforts and elaborated on that package to some extent. It is important to recognize that a milimeter of extra thickness in the basic steel that is used in a ship can result in many millions of extra dollars in cost of the ship. Their structural analysis program could accept 120,000 nodes in a finite element analysis, and they can do vibration analysis with 1,000 degrees of freedom. They claim to have provisions in their package for during perturbation calculations inexpensively. Therefore they can look at results of minor changes without having to make major reinvestments in computation.

In summary, Computas was very friendly, interested in my activity, and rather skillful in extracting information from me at the same time I was getting information from them.

Newcastle, England

The next stop was at the British Ship Research Association (BSRA) in Newcastle, England on Tuesday, 13 September. At BSRA I was hosted by Dr. Mike Todd who was most gracious and showed genuine interest in my visit there. At first I was given a brief background on BSRA which is an organization funded largely by the government in order to aid and promote successful shipbuilding in Britain. Since 1968 they have been involved in the development of NC technology and they supported the introduction of Autokon. They were responsible for analyzing the performance of the system. "2CL" software was adopted and advanced by BSRA. 2CL (two continuous and one linear axis) is an APT-like language used for NC. BRITSHIP is a result of previous work at BSRA, and it is used by three-quarters of the major yards in U.K. From 1971-74 they had been working on the concepts of a system for structural design. At that point the funding for BSRA underwent a change and became more project oriented. At any rate, SSDS (Ship Structural Design System) was developed there. They are still working on improving this now, and at this point they feel they cannot judge its success because it is too new.

Mike Todd and I engaged in some rather wide ranging and open conversations during which he expressed some of the following views. Computer scientists do not know about design and are therefore not capable of developing a good CAD system. Also in the U.S., there has been too much emphasis on graphics in CAD systems and we should concentrate on understanding the general nature of CAD systems. Design costs on a merchant ship account for only 1-3% of the overall costs. Much of the actual "design" is done during production. Computers can only add to the expense, but one hopes that the product will be better in the end. CAD is rather expensive because it implies a reorganization of the whole traditional design and manufacturing process. If that were not true then we could simply computerize the pencil and get the job over with. Increased safety regulations and occassional failures put more pressure on us for better designs. Essentially computers lead to better not cheaper designs, he felt.

Any large CAD system needs a good taxonomy of components. Here computers through the invocation of database technology can provide rapid and convenient associative reference to parts. The parameters for communicating with

CAD systems must be rational and intuitive pieces of information. They are currently reworking a hull definition system so that the parameters are given more in terms that the designers are wont to think about.

Dr. Todd also observed that international cooperation has not been as successful as it ought to be. Since CAD is very expensive, more world cooperation may be necessary.

Later the next day I met with George Ward who is involved in naval architecture development. With him I discussed some types of analysis packages that are used in the engineering process and where some graphics technology might be introduced. In the area of structural analysis he said there is a need for better finite element packages. He felt there really was not much pressure in this area to develop a great deal of new stuff. Vibrational analysis also uses the finite element method. He said they were seeking to get more experience in modeling, particularly in modeling dynamic systems which are much more complex. He felt that it was hard to know the limitations of modeling restrictions. When has one pushed the model too far? Will the prediction still be valid? In this business they are always trying to assess the marginal gain if they increase the capacity of a particular component. They would like to be able to have a unified model for the entire ship. Right now this is not possible. Now they use computers also to analyze hydrodynamic problems. In this area they are just getting into 3-D flow problems and in this connection a good 3-D model would help them. They observe that the design of steering and maneuvering mechanisms is an area of much experience, and they would like to see it become a more exact science. He mentioned that in some of these analysis and simulation methods they actually use analog computers.

He made some observations about the organization of shipbuilding in

Britain versus other countries. In Britain he remarked that most of the shipyards rely upon BSRA for most of their research and development. In Sweden, shipyards like Kockums have more expertise in their shipyards per se. This is also true in Norway, France, and Germany. Their research organizations tend to be smaller there. The governments work closely with the shipyards, as do their universities. In the U.S. there seems to be a stronger reliance on consultants, where very much of the technical expertise tends to reside. In all cases there seems to be not enough communication among the nodes representing the shipyards, universitites, and governments.

In another discussion the need for more development and application in the area of automatic programming came out. In building ships there are many similar parts that differ by just some scale in one direction or just have various parametric differences. In these cases it is felt that programs to do these should be generated automatically and its design should be rather quick and straightforward.

BSRA is using BCPL as a programming language for some of its applications and they are getting some acceptance on this from some of their users. They provide a compiler with it so the shipyards can make alterations as they see necessary.

One of the principles governing the design of SSDS, an integrated system that is supposed to aid in the design all the way from the preliminary design phase to production, is that the application programs are ship-specific and that the database programs and analysis programs are general. Their approach is to provide the general database support and the analysis programs on a major host computer at BSRA. The other specific design applications should be done on satellites remotely at the particular shipyards involved. They feel that this will lead to a design process with more cycles and eventually a better product.

Leaving Newcastle, I flew to Norwich to spend time discussing current research directions with Dr. Robin Forrest. We were also visited that day by Dr. Malcolm Sabin who drove there to meet with me. The next day I stopped at Cambridge University to visit with Dr. Ian Braid who is heading the Computer Aided Design Group at the Computer Laboratory and also to meet with Dr. Charles Lang who is head of Shape Data Limited, a company that is involved in writing small CAD software packages. Departing through London I had a chance to visit with Dr. William Gordon at the London ONR Office.

As I departed Heathrow Airport, my general impression of the shipbuilding industry of Northern Europe was that it was badly depressed. Only in Oslo, where shipbuilders have turned their directions to other engineering projects stemming from the North Sea oil exploration is there a reasonable degree of activity and spirit surrounding CAD.

Visit to Sun Shipyard
Chester, Pennsylvania

On this day I met Ruey Chen at the Sun Shipyard where we were hosted by Gene Schorsch, Vice-president of Engineering and Technology. We chose to visit the Sun Shipyard because they were representative of a smaller, very flexible and forward looking organization. In talking about applications of computers to shipbuilding Gene suggested the following areas. Piping is a very important area that needs more automation. Also estimation is an important area for computer application, especially with the heightened competition of the industry. In scheduling and coordination of the parts for assembly computers can be extremely valuable. Gene observed that most commercial packages are not generally applicable to the organization of the particular shipyard. Therefore extensive revision of either software or the shipyard, usually the former, is necessary to marry the two. He also reminded me that the real money is in the cost of the production of the ship and not in the design. (He did not mention that much of the cost of production of the ship is determined by decisions made during the design phase.) Here's a statistic: Sun spent more than one million dollars on software development. In 1974 Sun dropped FORTRAN in favor of PL1 and they feel that they gained six man years in the decision to use PL1. In reference to that decision he remarked that Sun acts very independently.

The marking of parts is an important problem in shipbuilding they feel. Sun uses punch marking, but that gives rise to vibration, noise, and other problems. Computer control of marking is not the best method they feel.

Gene says that a master system for ships is not a good idea in the United States. Yards are very different in many areas and that makes it difficult to adopt a single universal system. Also there are business reasons to avoid a common computer center. Privacy from the government is a very important factor in the reasoning to avoid a large government central installation. They also remarked that the difference between metric and English units was somewhat of a problem in adapting the Steerbear system which is used at Sun.

For the rest of the time with Gene Schorsch we were taken out to the construction area to observe the actual fabrication of a ship. His view was that I could not really fully understand the problem of computerizing shipbuilding without having really seen what goes on inside the ship. So there I was treated to an extensive tour of the ship including going down into the tanker sections of an oil tanker that was being assembled at their site. Later in the afternoon Mr. Barkley Fritz, manager of engineering computing center, showed us the computing facilities and expressed their support for our survey. We also reiterated some of the points that were discussed during the morning.

At Sun I also showed a couple of films that I had made concerning some of our own work at the University of Utah. They were very enthusiastic about the possibilities of using this in the shipbuilding industry, but they did not have a clear mind of how to accomplish it. As a site visit it was one of the most interesting.

ONR ACTIVITY REPORT

26 December - 29 December, 1977

Trip to Japan

There are 7 major shipbuilders in Japan, namely Mitsubishi Heavy Industry (MHI), Mitsui Engineering and Shipbuilding, Nippon Kokan K.K. (NKK), Sumitomo Heavy Industry (SHI), Ishikawajimaharima Heavy Industry (IHI), Hitachi Heavy Industry (HHI), and Kawasaki Heavy Industry (KHI). Through the very kind professional accommodations of Mr. Y. Hattori of NKK, who is the leading figure in the promotion of computer graphics and computing activity in the shipbuilding field in Japan, I was able to have visits with the personnel in the first five of the shipbuilders named above. Mr. Hattori used his contacts to establish my itinerary which was made of many private briefings and presentations that would have been very difficult to arrange by myself. Then he took a week from his desk in order to escort me personally to all the meetings he had arranged. I was also accompanied by Mr. Koji Izumida, a former student of mine, who works under Mr. Hattori at NKK.

Although the Orient represents a formidable cultural barrier, I really develop exhuberance about my field when I visit Japan because computer-aided design is regarded as a very important activity to the economy. In Japan my work is well-known and there seems to be a feeling of gratitude toward people who spend their energy trying to contribute to this area of science. The Japanese are very interested in communicating, in learning new developments, and in demonstrating their impressive achievements in this area. The discussions never centered around whether to promote CAD, only on how to promote CAD.

On 26 December I met with Mr. Sumio Kohtake of IHI at the NKK headquarters in Tokyo. I received an extensive slide presentation of the operation at the Chita Shipyard, the most modern shipyard in the world. Through the maintenance of safety, IHI believes that it can find improvements in construction as well as reduced costs. The best way to achieve this is to use mechanization and to build standardized ships. The Chita Shipyard has a very modern layout that is designed to allow in-shop fitting of large block systems that are later carried to the dock to be pieced together to form a ship. The idea of the large block system is to decrease labor and improve working conditions by transferring the work to what traditionally was the preceding stage of production. The limitation on this kind of approach is basically the steel mill facility. Steel stock cannot be made any larger. In order to assemble these large blocks they use 350 ton Goliath cranes that they built themselves. In order to move the large blocks they use 200 ton trolleys in order to get the assemblies from the shop to the dock. In this approach, blocks, like the engine room or the pump room, are completely outfitted and then moved to the dock as a complete assembly, the largest weighing 680 tons requiring both cranes simultaneously.

Building the hull in this way as a block, they are able to minimize the scaffolding, which is a hazardous structure, and increase the construction work safety record. It is also easier to increase the mechanization within the shop environment. By manufacturing these large blocks in the shops, it is simpler to control the erection works, that is the scheduling, since only the large blocks have to be pieced together in the final stages. And finally, the quality is upgraded considerably by putting this construction in a shop environment.

In their schemes of shipbuilding they acid clean and paint the parts of the ship in the shop, rather than at the dock. This process is highly mechanized, leading to the elimination of dangerous and undesirable cleaning and painting chores after construction.

Again it was mentioned that the layout of the shipyard is critical, for transporting materials during construction is in fact a major cost of building a ship.

Some of the major arguments for mechanization and automation that were presented were that it is a very effective method of improving the working environment, that it is very helpful in stabilizing quality control at a high level, and that it increases productivity too. The labor unions seem to be in favor of automation because it leads to better working conditions and it is the only way to eliminate very undesirable jobs that may have to be performed in unhealthy environments. Their automatic equipment included numerically controlled cutters, marking machines, bending presses using a thousand tons of force, very fast and accurate welding systems,NC jigs, and a tower painter that travels around the ship. The most unique equipment that they showed in the slides was a block turnover rig that was designed for inverting large 200 ton blocks so that workers did not have to weld overhead or perform other tasks in uncomfortable or unsafe positions. This device looked like a large squirrel cage that accepted a block and rotated it 180 degrees so that it could be moved in the inverted position.

IHI's philosophy on software is "all starts and ends with design." Design sits in the center of a triangle whose vertices are material, production and scheduling. The design module generates information which is needed to activate the modules that take care of production control and material handling. The work force is well organized into small working groups which are autonomous in the labor division within each group. These are called multi-functional workers, and their experience indicates that these groups show increased productivity, which results in better worker morale.

The computerization of their operations not only include design but material control and production engineering. Their approach is highly integrated and really quite a top-down attack. Their computer system has a financial module as well.

Their hull design system is an example of their philosophy of computerization. Their system, which is good for all of their yards, aids them in every phase of the hull design from basic to detail to production. Utilizing this approach they feel that they have been able to increase accuracy and quality. Computerization and standardization go hand in hand in the way they approach shipbuilding. Standardization means that the workmanship becomes standardized, the code system becomes uniform and simple, and the design process becomes more standardized. They also use standardized computing figurations so that there is only one software effort within all of IHI, so that each shipyard can use the same software. They can manage to do design in one office then send out that kind of information to locations through communications links.

The representative of IHI said that graphics was one of their largest problems, particularly because graphics equipment has been very expensive in Japan. There are considerable tariffs placed on imported graphics systems. Also they feel that the data base systems that they have acquired through IBM, namely IMS, are not highly suited for interactive design work.

The next visit was on 27 December at the head office of MHI in Tokyo. MHI is a very diversified corporation whose name is familiar to people in many corners of the world. As a company their policy has been one of methodical adoption of new technology rather than one of marked innovation.

They feel that this has been a prudent and profitable attitude toward computers, and it is an attitude which they hope to maintain in the future. Their record in bringing computers into the shipbuilding industry has been good, and there may be some recognizable sense in being second to implement the technology, thereby benefiting from the costly errors of their forerunners. Their company has 12 major sites in Japan, all of which have at least one computer. At the head office, the Nagasaki Shipyard, the Kobe Shipyard and the Hiroshima Shipyard, they have large or very large scale computers for both technical and business computing. These "four blocks" have been linked since 1971 in a tele-communications network. Just now they have been adopting the use of the so-called "J-1" lines which allow 312 to 552 KHz. Their aim in adapting these new high-speed lines is to reduce communications costs, unify their communications system, improve performance and liability, save on transmission line control functions, and to be flexibly adaptable for future growth.

MHI builds a great diversified line of ships including cargo ships, bulk carriers, LPG carriers, container carriers and ULCC's. They view their investment in computing as one that has paid off in allowing them to change their production quickly, at low cost, and with high quality. Their computing systems have helped them very much in optimal planning, and in labor saving approaches. Throughout it has helped them improve quality and accuracy in their products.

They use computers in a very extensive way in the design and production of ships. Their comprehensive system has simulation models which help them in the very beginning to understand the performance that certain specifications will lead to. They also are able to estimate the cost of a future ship and component costs like personnel costs with a special module in their system that supports these calculations. As in most shipbuilding systems another system is organized as a large collection of modules that orbit an integrated data base. Other systems exist for aiding the production of special kinds of ships like tanker ships or bulk carriers. It was not clear how integrated these special systems were. They also have some individual programs to perform some special kinds of analysis which seemed to be not integrated at all. Their programs for outfitting and piping seemed to be relatively advanced. The pipe program uses special languages to aid in the specification and in the graphical interaction. On the production end of the system they are able to drive an N/C pipe bender from these specifications through these special languages. MHI is giving some attention to the use of computers on board ships to support navigation and record keeping on the ship after it is launched, but those directions are not in the primary scope of this survey.

Of the problems that MHI have encountered in connection with introducing computers into their shipbuilding business, they mention personnel problems as the first one. Apparently the company has not developed an overall policy for helping people whose careers are adversely affected by use of computers. They recognize the need to establish a program of job rotation, retraining and education, and general counseling. Their network system has allowed them to communicate but they still feel that there is not enough compatibility and standardization among the various sites in order to fully benefit from the network possibilities. This has also hurt them in establishing a unified and centralized database, and it obviously has cost them in terms of efficiency. They now have a special team that is supposed to promote this kind of integration and standardization among the various sites on the network. The company is beginning to give some attention to the general area of data and program security, for that is an area that has been neglected so far. One interesting aspect of this study is that the information that people provide is largely subjective-there are very few measurement and evaluation schemes in operation. MHI would like to change that for their own case.

For the future they are concerned that the low profitability of shipbuilding in a depressed market may impinge on their program to improve their computer facilities and promote the degree of application of computers throughout their shipbuilding business. They argue the point that their business would be even less profitable without computers. In the future they are looking for other application areas for the CAD expertise which they feel they have acquired. The microprocessor is an intriguing element to them, and they would like to find a wise way to introduce this device into their company. They also are striving for more integration between their technical and business computing and information systems. Their final goal is to make computers a utility for the people of the company, just as water or electric power is a utility now. But all of these aspirations require an upturn in the economic conditions for shipbuilding.

The afternoon of 27 December was spent visiting Mitsui Engineering and Shipbuilding Company. This company is generally regarded as the most innovative and resourceful among the shipbuilding firms in Japan, a position that the company holds largely because of the foresight and imagination of our host Mr. Aya. Recognizing the depressed economics of shipbuilding in the early stages, this company underwent significant changes in their name from Mitsui Shipbuilding Company and placed engineering in its name before shipbuilding to relate to the public its objective to become a generally diversified engineering company. The expertise of this company has been used to diversify into markets ranging from marine systems to environmental systems to computer graphics. In all of these fronts they seem to be rather successful financially. For these reasons this company enjoys one of the most secure positions of all of the shipbuilding companies in Japan. In the company's headquarters we spent the afternoon talking about computers, computer graphics, and their uses in industry, and in particular shipbuilding.

The ROTAS System which is implemented in their Chiba Shipyard is considered to be one of the advanced steps toward making shipbuilding an assembly line process. The general philosophy is to make ships on an automated assembly line. One of the outstanding features of this process is that it manufactures the egg-box components of a ship in an automated assembly line procedure. In order to achieve this they use automatic longitudinal positioning devices and automatic vertical fillet welding machines to set up the egg-boxes for the bottom of the ship and to weld them in place. These components are then sent down the assembly line where they are rotated for convenient welding positions and set into position very precisely. They claim that the effect of this process is to substantially reduce their labor needs, improve the overall quality, and reduce production costs as they improve their working conditions and environment. The second outstanding features of this highly automated shipyard is their computer controlled pipe processing shop called MAPS for Mitsui Automated Pipeshop System. Under this very advanced procedure the whole pipe shop is basically under computer control and programmable. The stock is fed to the assembly line where it is carried along and cut under NC control according to specifications. Then the flanges are fitted automatically and welded and finished under computer control. Then the pipes are sorted by machine and finally they are bent on an NC pipe bender also under computer control.

Mr. Aya is a very strong proponent of computer graphics and interactive systems. As was mentioned before, computer graphics equipment is very expensive to buy in Japan because the government places a high tax on imported equipment. Reacting to this situation Mr. Aya began a project within Mitsui to develop their own computer graphics processor and terminal. It is a limited color system that uses a beam penetration tube as a display device. Clearly they want to promote this peripheral to people who are interested in using it in their CAD applications.

The schedule for the 28th was to spend the day at SHI to visit their programming facilities near the Oppama Shipyard and then to visit the shipyard itself. This was about an hour and a half by train from Tokyo traveling westward around Tokyo Bay. During the remainder of the morning, Mr. Yoshio Mito briefed me on their computing operations at SHI. Their computing systems seemed to be quite similar in their functions to those that have been developed and used by the other shipbuilding firms in Japan. They were completely devoted to IBM systems, a decision which probably brought on some additional problems for them. For the general objective of providing an integrated interactive design database which is capable of supporting interactive computing activities, the choice of IBM systems presents some difficulty. One major problem is that the IBM support for computer graphics is expensive and awkward. A second serious problem is that IBM equipment, right from the hardware design and support, is not particularly well-suited to support interactive computing. Another problem for the shipbuilders and particularly for SHI is that they have adopted the IMS database system which requires them to do the remainder of their programming in either COBOL or PL/1. Obviously the shipbuilders have generally chosen PL/1 when they found themselves in this situation, but that too presents difficulties. At any rate IMS is a system which was not developed for use in shipbuilding and is probably not the optimal database system to use for interactive design. And PL/1 is a very large, complicated and not especially fast running language to use for their systems development. However, Pl/l doubtless is a superior choice to FORTRAN, and it is a reasonably defensible choice in this situation. PL/1 is a powerful language and probably contains more than the shipbuilders need, rather than less.

As we began our bus/walking tour of this shipyard, an unusual characteristic was ubiquitous-this shipyard was very clean and inviting at every location that I had visited. We began at the place where the materials for the ship begin, their computer controlled stockyard. The materials arrive on a dock where it is unloaded from the delivery ships by large magnetic cranes. At this point the steel stock is examined automatically by a TV camera which is capable through its computer control of reading in the specifications and identification number for each arriving sheet. Then the material is automatically transported by computer operated conveyers and cranes to a designated position in the stockyard. Delivery of the steel plates from the stockyard to the fabrication ship is also carried out completely automatically.

Once the stock is brought from inventory to production use, it is automatically picked up and carried to a shop blasting room to remove rust and then it is automatically spray painted and passed along by a collocator, an electric flatcar, which deposits and stacks each steel sheet, which may measure 40 meters in length, at exactly the right place. As the sheet comes out of the automatic painting apparatus it is automatically reidentified. Since the computer has in its memory the correct identification of the part in the first place, it is simply painted on automatically once again on top of the new paint that the sheet just received.

Now the actual production begins. Large man-operated overhead magnetic cranes pick up the fresh stock that was neatly piled by the automatic collocator and deposited along a large area of steel webbed flooring in preparation for the cutting process. Then the NC plasma cutting machines partition the large steel formats or sheets into parts that are useful for making ships. This plasma cutting process is one of the most remarkable processes in the shipbuilding industry, for the results produce edges that clearly look machined rather than cut by heat methods. The cuts are accurate and very smooth, thereby reducing the welding costs significantly during the fabrication process. At this site they also have a 1500 ton press for bending the steel formats into various shapes that are needed to fit the hull and other parts.

At Oppama they use a special technique that allows them to join some pieces of steel by welds that are made on only one side of the sheet. I did not see this one-sided welding process in operation because it was very close to the national New Year holiday, but it seems like an idea that has considerable merit. There were some questions in my mind about the durability of these joints, but I did not get any information on that. The one-sided welding process saves them considerably in the fabrication process because it is expensive in space and time to turn over large, heavy steel constructs so that they can be welded on the underside. Overhead welding is a process fraught with dangers and faults.

Sumitumo is very proud of its egg-box assembling system. The egg-box construction is used in the deck and shell of oil tankers, and it has been a fabrication problem and an assembling problem for naval architects to find an economical solution. Their approach to this problem, like Mitsui's, is to fabricate the egg-box in the shop under a process that gives them more accurate control and one that can be done more automatically. The result is a component that costs them less in steel and in man-hours as compared with conventional methods.

In order to carry out the general strategy of manufacturing very large and heavy complete assemblies for the major components of the ship in the shop, it was necessary for them to develop a platform carrier to carry the assemblies form the shops to the construction site. For this purpose they have a 700 ton flatbed self-traveling carrier that can move these gigantic components. Some of these components are so heavy that they require both Goliath cranes working in unison to support and lower them into place.

The building dock is another innovative feature of this shipyard. It has dual entrances and three gates. One gate at either end and one movable gate that can be set at any of four intermediate positions between the two end gates. This arrangement gives them the capacity to build one and one half ships simultaneously. When the first ship is completed, it gets floated out through the exit on one end of the dock and the intermediate gate gets moved to allow enough room for the beginning of construction on the second ship. Then as the second ship is being completed, there is still room to begin construction on a third ship on the other side of the intermediate gate. Finally the second ship is floated out through the gate closest to it and by moving the intermediate gate between the one-third and two-third stations the process continues.

Having concluded a visit to the most modern shipyards in the Tokyo area, and one of the most modern in Japan, we headed for the train station to begin the rush hour ride back to my hotel in Tokyo.

The next day, 29 December, was spent with my host Mr. Hattori and my former student Mr. Izumida at NKK's Tsurumi Shipyard, Yokohama. During the morning I had the pleasure of meeting with the graphics and computer aided design group at NKK. They presented their current work on an IBM graphics system and showed me some of their experiments with curve and surface design that had applications to hull form. Then we entered into a discussion of appropriate divisions of labor within an efficient distributed graphics system. Their aim was to adapt some of the principles that were published by Foley while he was at North Carolina and by Van Dan at Brown University. This dicussion was interesting to me and I found that their approach led to rather flexible and convenient graphics systems from the point of view of the user. It did require however a fairly sophisticated amount of systems programming and development in order to attain their goals. Under the leadership of Mr. Izumida this group has managed to do some of the most advanced applications work using recent developments in curve and surface schemes that I have seen in any shipbuilding company. It will be very interesting to see what the eventual impact of this work is on the design and production process at NKK. Right now business is sufficiently depressed so that most of these studies are in fact rather academic.

For lunch we retreated to the NKK executive club located just a few minutes away from the shipyard. My marvelous host for this day and preceding week, Mr. Hattori, began the discussion with a review of the use of computer applications in Japanese shipbuilding industries, a reveiw taken from a recent paper he had written. This was a very informative overview of the major developments in Japan over the last 15 years. Subsequently, the group asked me to describe some of my observations and findings during my travels, particularly from my European trip where they knew many of the people and places I had visited.

A Review of the REAPS Technical Symposium

27 - 28 June 1978

Bel-Air Hilton
St. Louis, Missouri

by

Andreas Weichbrodt

Representation and Organization

REAPS is the abbreviation for "Research and Engineering for Automation and Productivity in Shipbuilding." It is a loose organization of shipyards and shipbuilding oriented industries as well as research institutes for shipbuilding and engineering. Founded only a few years ago, the membership has increased from year to year. The number of attendants at the regular conference is growing considerably each year.

Even with their increasing numbers, the current conference did not seem to represent all the parties involved in shipbuilding and naval architecture. Universities were not represented (except myself), and research institutes were the minority. Most attendants either belonged to shipyards or supplying industries. A remarkably small representation of the international parties attended. Japan headed the list for foreign visitors with five followed by three Canadians. In addition to these were single attendants from Norway, England and France, contributing to the international flavor of the conference.

Registration and organization was well organized with necessary changes being instated in a very informal and flexible fashion. Delays were acceptable since the discussion time was never exploited.

Attendants who were used to receiving a complete collection of all the papers of the conference lectures were somewhat disappointed. Only very few lecture materials were distributed , and those were mostly provided by the authors themselves.

Technical and Scientific Contents

The points of interest were split into two groups: CAD and CAM (I concentrated on CAD). The tendency was expressed very often, however, to integrate CAD across the entire design production process. This is a goal for the future but not achieved at this time in any country.

The headlines of some of the lectures for this conference promised many interesting applications for computer graphics to be explained. In actuality most of those lectures expressed some vague ideas for the future with considerations to be regarded for further developments.

The Japanese lecturers explicated more details about their integrated systems (HICAS-P, MAPS-GP) and gave a reasonable idea of what they have achieved with aspirations for the future. They showed some excellent computer graphics applications in piping design and production. Nesting was also mentioned as a practical application for computer graphics; but since storage tubes are used, they present a problem since only poor solutions are available in American shipyards, and those need the assistance of an operator (with no computational support).

Still the conference showed a strong tendency to higher integration of the computer systems (goal: design and production with one and the same system) and towards more interactivity in order to support the designer in his creative efforts in the work. The need for one comprehensive and well organized database was stressed, and some interesting applications of computer graphics were mentioned. Eventhough applications and needs were hypothesized, it was difficult to discover the convenience and the extent of utilization of computer graphics.

General Impressions

The conference tended to be organized as more of an "insider" conference, because of its inability to attract substantial international and academic attention. Rather than a brainstorming session with many new and challenging ideas, the American lecturers explained only very vague ideas of a graphics future and their aspirations. Generally, the Japanese lecturers revealed more about their present developments and achievements, but their presentations were poorly managed, diminishing the understanding of people unfamiliar with the particular area. That foreign shipyards are much farther advanced and improved than their American counterparts in the utilization of integrated computer systems became obvious.

The impression of more highly advanced technology in Japanese shipyards was evidenced in brief deiscssions with the appropriate peoples during breakes and after meetings. Because of the inactivity during discussions in the auditorium, questions of particulars were answered in private talks.

According to the titles of some of the lectures, the expectation was for informative talks and interesting proposals for the application of computer graphics; especially since the importance of interactive and integrated computer graphics was stressed. Expectations faltered, however, as the talks only lightly touched upon a few precise ideas about the applications of computer graphics in the naval architecture and shipbuilding fields.

In private talks, people revealed some interest in graphical animation of lifts and sketches and agreed that the simulation of assembly ways could be of some use in the design and production process.

That most of the attendants were unfamiliar with the picture system of Evans & Sutherland was most surprising. Furthermore, they did not have any plausible application of such a system.

In retrospect, the conference was interesting, and I was pleased to be once again a part of a gathering of people involved in naval architecture. Unfortunately, for those working in naval architecture, the conference probably proved to be somewhat unattractive.