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TRANSPORT ANALYSES -- GREAT LAKES AND SEAWAY
Vol. I: Summary and Miscellaneous

Harry Benford

THE DEPARTMENT OF NAVAL ARCHITECTURE AND MARINE ENGINEERING

THE UNIVERSITY OF MICHIGAN
COLLEGE OF ENGINEERING

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TRANSPORT ANALYSES --
GREAT LAKES AND SEAWAY

VOL. I: SUMMARY AND MISCELLANEOUS

HARRY BENFORD

Report to Department of Commerce
Maritime Administration
** Contract No. 1-35487 **

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and Marine Engineering
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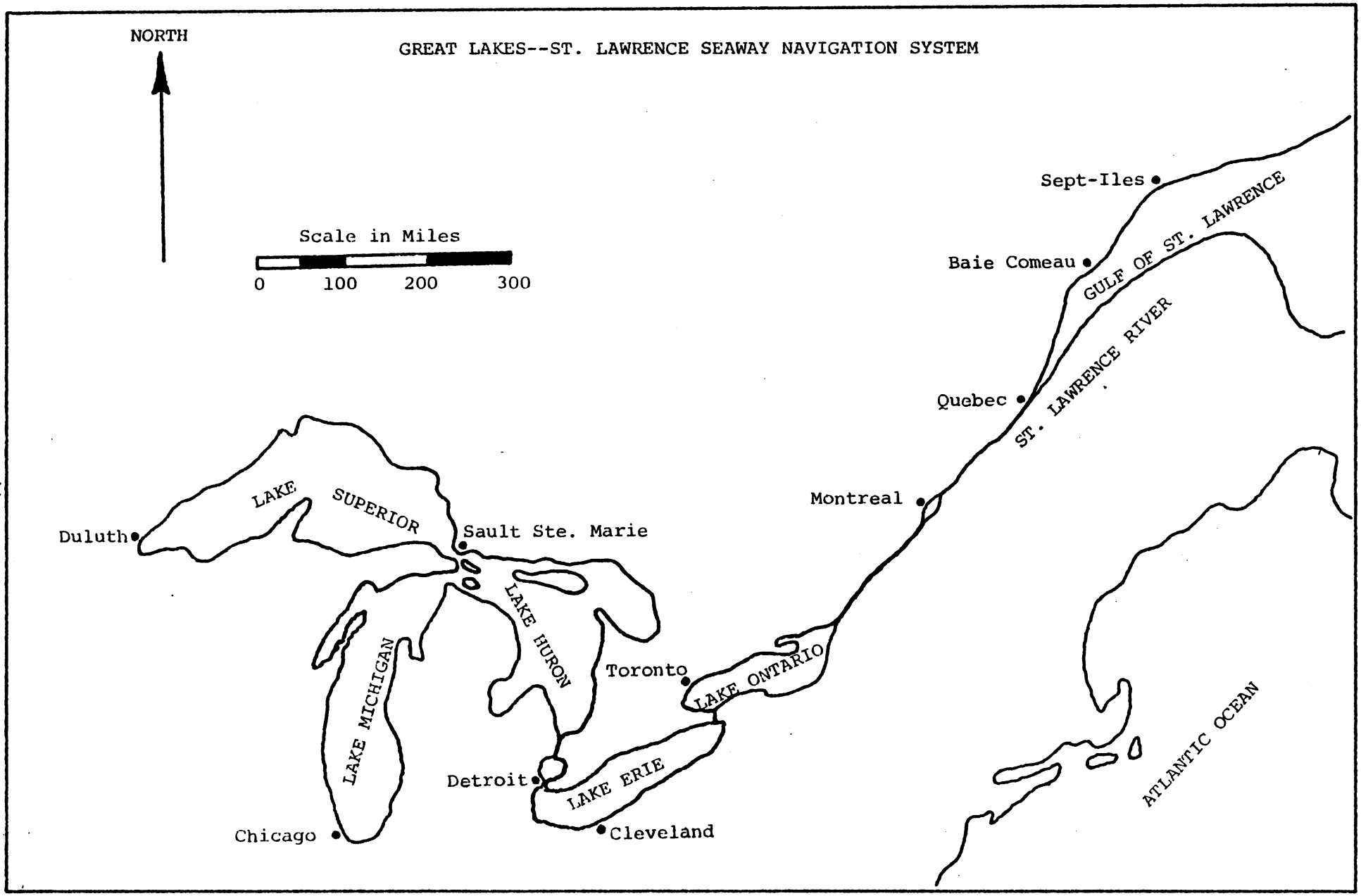
NORTH
GREAT LAKES--ST. LAWRENCE SEAWAY NAVIGATION SYSTEM
Scale in Miles
0
100
200
300
Sept-Iles
Baie Comeau
GULF OF ST. LAWRENCE
ST. LAWRENCE RIVER
Quebec
Montreal
LAKE SUPERIOR
Duluth
Sault Ste. Marie
LAKE HURON
LAKE MICHIGAN
Toronto
LAKE ONTARIO
Detroit
LAKE ERIE
Chicago
Cleveland
ATLANTIC OCEAN

ABSTRACT

This is the first of five volumes submitted to the Maritime Administration in fulfillment of the third phase of a contract signed in April 1971. This volume summarizes the contents and principal findings of the present series; it describes our team's several successful efforts to transfer newfound knowledge to practicing engineers, business managers, and appropriate governmental employees. It describes refinements applied to our earlier work. Finally, it outlines probable future beneficial commercial developments and suggests some areas of research that could best advance those developments.

The major topics covered in the present series include Great Lakes transport studies based in part on our own earlier work. Included here are mine-to-blast furnace analyses, optimization of fleet make-up, and methods for predicting time requirements for transiting ice congested areas. The problem of delivering bulk materials to up-river steel mills is treated here as well. Another important series of topics relates to commerce through the St. Lawrence Seaway: influence of ship size on transport economics and energy use, and alternative systems for moving general cargo. We also take up questions of possible environmental damage arising from winter navigation. Finally, we provide a useful compendium of information on costs and weights of dimensionally enlarged bulk carriers.


FRANK A

ACKNOWLEDGEMENTS

The successful completion of a task of the scope represented here requires the cooperation and encouragement of many individuals in addition to those whose names appear as authors of these reports. We are particularly grateful to the numerous members of the marine fraternity who helped in so many ways: through giving us information (often confidential), through providing passage on their ships, and through documenting repeatedly the usefulness of our work. Foremost among these were engineers and managers from the following organizations:

American Ship Building Company
American Steamship Company
Bay Shipbuilding Corporation
Cleveland Cliffs Iron Company
Finnlines Ltd., Helsinki
Hanna Mining Company
Hannah Marine
Lake Carriers Association
LASH Systems, Inc.
LesStrang Publishing Company
Marine Consultants and Designers
McDowell-Wellman
Pickands Mather and Company
R.A. Stearn, Inc.
St. Lawrence Seaway Development Corporation
Sea-Land Services
U.S. Army Corps of Engineers
U.S. Coast Guard
U.S. Steel Corporation, Great Lakes Fleet
Wärtsilä Shipyards, Helsinki

Within our sponsoring agency, we owe thanks for the cooperation given us by Paul Mentz, Virgil Rinehart, and Francis Dashnaw. We also appreciate the continuing interest Marvin Pitkin has shown in our work.

Within our own walls, several students have given yeoman service. These include Charles F. Beyer, Christopher T. Clement, Thomas G. Gooding, Jeffrey E. Greenblatt, James H. Keyte, John T. Lehman, James B. Mackie, John S. Pfeifer, James E. Swigart and David J. Witmer. Although his name does not appear among the authors of this series, Prof. Movses Kaldjian worked closely with our team. He handled much of the administrative work and provided frequent and valuable guidance regarding our computer programs. Prof. Anthony Atkins also deserves recognition for his continuing advisory service.

Kathie Malley, our ever gracious and efficient secretary merits a special word of thanks for her good work. Her initiative and steady reliability have been essential ingredients to the completion of our work and the preparation of this report.

Finally, special recognition goes to Prof. Horst Nowacki, who was co-director and chief sparkplug of our team until last June, when he resigned his position to accept a chair at the Technical University of Berlin. Those of us who remain are united in a determination to continue to develop the sort of sound yet imaginative analytical techniques that Horst Nowacki pioneered.

Harry Benford
Volker H. Elste
Benedict J. Stallone
Peter M. Swift

CONTENTS


HAMBURG-AMERIKA LINIE

CHAPTER 1

PERSPECTIVE

These five volumes bring to a conclusion our three-year study of the economics of winter navigation on the Great Lakes and St. Lawrence Seaway. Although we expect to continue our team effort, our attention will now be broader in scope and only indirectly concerned with ice operations.

The present series of reports contains much that should be of use to federal agencies and private firms involved in commerce on the Great Lakes and St. Lawrence Seaway. We present for the first time a comprehensive analysis of the economics of ships designed for Seaway service. As illustration of our analytical procedure, we examine and compare alternative strategies for moving unitized cargo to and from the Midwest, both via the Seaway and via rail. We include here an assessment of the potential benefits (at the micro-economic level) of improved Seaway features such as larger locks. Our earlier reports on intralake economics are supplemented with methods for analyzing mine-to-blast furnace transport systems. In particular, we bring new light to the problem of servicing industrial facilities that are located on confined waters beyond the reach of the newer, larger ships. We include here, too, some conclusions and a resulting recommendation based on a study of environmental concerns relating to winter operations.

Integral with all our work is an awareness of this nation's long-term energy needs. Our reports include summaries of the relative fuel consumption demands of the various alternative transport strategies, in both intralake and Seaway trade.

We are pleased by the extent to which our research findings are being applied by industry. Our computerized Extended Season Program (ESP) is being used by most of the major shipowners on the Lakes, and we can expect similar exploitation of the Seaway program discussed here. When we first proposed these studies to MarAd in November 1970, Great Lakes operators were, in general, openly skeptical. Most are now persuaded that

winter navigation offers them important economic incentives. Their questions are not whether to operate in winter, but rather how best to go about it. We believe our research findings have been an important element in effecting this change in attitude. We commend the Maritime Administration for backing our research, for encouraging the publication of our results, and for making our computerized program available to the industry.

We may mention in passing the film An Inconceivable Commerce, dealing specifically with winter navigation on the Lakes. This 60-minute documentary was produced by the University of Michigan Television Center under joint support from the Maritime Administration, the Lake Carriers Association, and the University of Michigan. It is available on loan from any of the sponsoring groups. At this writing the Television Center is engaged in preparing a 30-minute condensation that will also be available. Additionally, TV film clips are being prepared for nation-wide distribution. This educational activity is aimed at winning public support, without which the extended season cannot reach its full potential.

The rest of this volume contains summaries of the four associated volumes, a review of our efforts to diffuse our research findings, and an outline of what appear to us to be the most profitable areas for future research in marine transport economics, given probable changes in the demands of commerce.

CHAPTER 2

HIGHLIGHTS OF VOLUME II: INTRALAKE TRADE

The second volume of the current series builds on work (previously reported in Refs. 1-3) dealing with economics in the design and operation of Great Lakes bulk carriers. The central intent of the earlier studies was to help decide how best to exploit the potential benefits of winter navigation. A prerequisite of that work was a detailed techno-economic analysis of ordinary, non-winter, navigation. It is on the latter preliminary work that much of the present study is based. Specific topics include mine-to-blast furnace transport costs, optimization of fleet make-up, and methods for predicting the time required to move one or more ships through an ice-congested area with icebreaker assistance.

The mine-to-blast furnace analysis explains how to predict all elements of cost in the complete transport system. This includes railroad transport and stockpiling costs as well as water transport and all interface handling costs. The inventory costs of stockpiled materials are not overlooked.

The fleet make-up study deals with techniques for maximizing the benefits of winter navigation through rational scheduling of ships for winter lay-up. This technique is based on the concept that the extended navigating season allows the shipowner to exploit to a maximum the transport capabilities of his most efficient ships--and place correspondingly reduced reliance on his less efficient units. The concept was outlined in an earlier report (Ref. 1). In the new report, the technique is illustrated with a case study based on a typical existing Great Lakes fleet. In the sample case, an annual before-tax saving of nearly $400,000 is shown to be attainable through application of our fleet optimization technique.

The chapter on operations in ice presents computer-assisted techniques for predicting the probable time required for one or more ships to move through an ice congested area. The computer program is arranged to predict the probable sequence and timing of events as ships of various description enter ice covered areas of various degrees of severity, in random times


J. L. MAUTHE

of arrival. Icebreaker operating policies are incorporated into the program, which will as a result help point the way to optimal deployment of icebreakers in any given geographic area (not necessarily confined to the Great Lakes).

The second volume of the current series also considers the problem of how best to carry raw materials to steel mills located on confining rivers that preclude service by the newer, larger ships. The advent of the 1000-foot ore carrier has placed such mills at a disadvantage. We have considered six likely alternatives and have developed methods for predicting comparative transport costs for each. These alternatives are:

*Replication of existing service (using 600-foot ships from upper lakes to mills)

*1000-ft ship and conveyor system (with and without federal subsidy for conveyor system)

*1000-ft ship and towboat-barge fleet loaded from stockpile

*1000-ft ship and self-propelled barge fleet loaded from stockpile

*1000-ft ship and towboat-barge fleet loaded directly from ship.

To clarify our analytical techniques, we present a case study, namely that of Cleveland's steel mills located five to six miles up the Cuyahoga River. For that particular service, the replication of existing service is shown to be the least promising of any of the alternatives. The conveyor system also seems to be among the least desirable, unless the federal government is willing to subsidize the initial investment--which is a possibility that may be justified because the conveyor system would free the government of continuing expenditures for dredging the Cuyahoga. Among the other alternatives the direct-loading towboat-barge system appears to be the most attractive, although its competitive edge is not really pronounced. Nor are the cost differences between alternatives

great enough to permit these conclusions to be applied to mills on other river locations. Nevertheless the analytical techniques proposed here should prove useful to state and federal agencies as well as private firms in planning future port improvements around the lower lakes.

CHAPTER 3

HIGHLIGHTS OF VOLUME III: SEAWAY AND OVERSEAS TRADE

The third volume examines a variety of ship types involved in Seaway and overseas trade. It develops mathematical models for bulk carriers, break-bulk general cargo ships, container ships, and three alternative ships for container feeder service between the lakes and deepwater ports.

Use of the models is demonstrated in a series of sensitivity studies, which themselves lead to certain useful conclusions. Among these are the following:

*In the case of ships engaged in moving bulk commodities through the Seaway, year-round navigation would allow savings of up to 12.5 percent in required freight rates. Even larger savings could be effected by moderate deepening of the system and a major enlargement of the locks. For example, a 1200-ft by 150-ft bulk carrier with 28-ft draft could effect savings of 38.5 percent over ships of the current maximum size (730 ft x 75 ft x 25.75 ft).

*The Seaway has proven disappointing in its ability to attract the important and lucrative commerce in manufactured goods moving between Europe and the Midwest. Our projections show that a well-designed Seaway feeder service could offer unitized cargo freight rates between 25 and 50 percent lower than those currently charged by the railroads. If the shipping season were extended to 350 days per year, the rail rates could be beaten by 40 to 65 percent.

*The most attractive vessel for the Seaway feeder service would appear to be a barge carrier whose barges would be pre-loaded with standard containers. Although a tug-barge container carrier could offer slightly lower required freight rates, it would be at the cost of discouragingly long delivery times.

*Important economic gains would result from any changes leading to


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quicker turnaround times for ships using the Seaway. Fewer delays, faster locking procedures, and shorter times in port are all worthwhile objectives. In the case of unitized cargo, if current port times could be halved, required freight rates would be reduced by 22 percent. (We are pleased to note here that the ports of Duluth, Chicago, and Detroit are all working in this direction by expanding and otherwise improving their container terminals.)

*Factors offering the greatest benefits to Seaway commerce are greater allowable ship size (for bulk carriers), extension of operating season, and reduction of turnaround time. Fuel prices and canal tolls appear to have relatively minor influence on overall transport economics.

*As regards energy intensiveness, the greatest potential savings should arise from increases in allowable ship size. Lower speeds also offer pronounced savings, but these may be wiped out by the resulting necessity of relying more on older, less efficient ships to maintain the same total transport capacity. Winter navigation, as might be expected, offers no direct benefits with respect to savings in energy, unless the only alternative is some form of overland transport.

* * * * *

In considering the conclusions outlined above, we must resist the impulse to go to the next step and make a series of recommendations. We have looked only at micro-economics, not macro-economics; we have not considered hidden savings, such as reduced inventory costs that arise from winter navigation; nor have we looked into the importance of uninterrupted service in influencing shippers to use the Seaway. Finally, of course, we have not considered the all-important matter of public costs. All of these neglected factors are outside the realm of our contractual responsibilities. We trust they will not be overlooked by our national and international policy makers; and we equally trust that our own modest contribution will be found useful in quantifying the costs and benefits of extending the season or improving the Seaway, or both.


HAPAG-LLOYD

CHAPTER 4

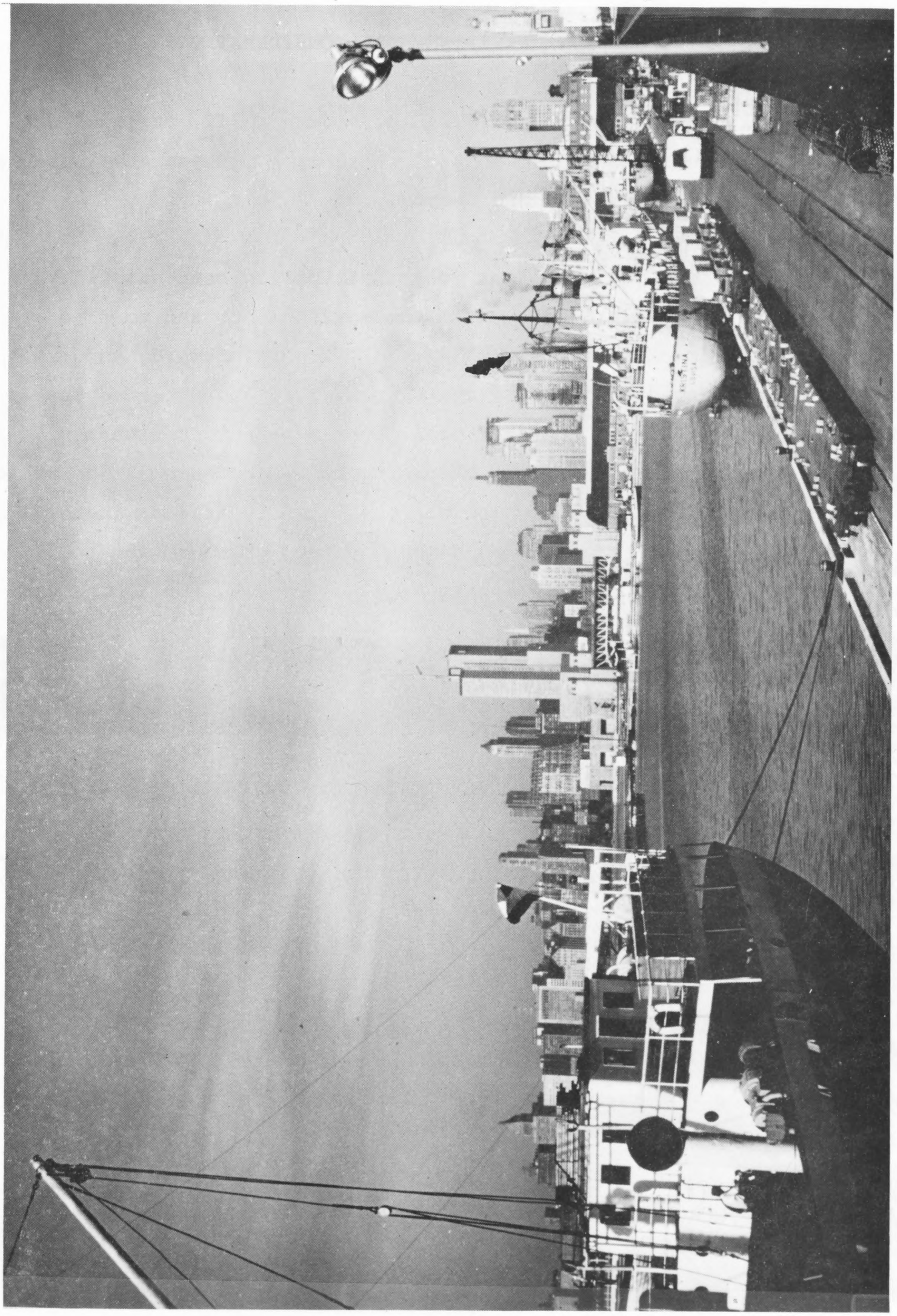
HIGHLIGHTS OF VOLUME IV: ENVIRONMENTAL CONSIDERATIONS

Our fourth volume was written by Prof. John B. Woodward III, an individual uniquely qualified to mediate the points of contention between environmentalists and industrial users of the Lakes and Seaway.

Proponents of winter navigation cannot duck their public responsibility to consider potential resulting damage to the environment, and to find means of minimizing or eliminating such damage. Prof. Woodward has listened to the expressed concerns of the Sierra Club, and other advocates of environmental protection. His principal aim has been to delineate environmental effects that seem to bear directly on ship design or operation. The important and emotional question of winter access to islands in the St. Mary's River is given only passing comment on the grounds that the problem will be solved by providing other means of access, not by changes in ship design or operation.

Prof. Woodward's contribution includes a framework of explicitly defined philosophical concepts with which most neutral observers may agree. These concepts provide a useful rationale for decision making in the face of controversial desires on the part of industrialists and naturalists.

Prof. Woodward concludes that the single most significant concern is that of possible pollution from spills of hazardous substances. Ice navigation poses the threat of punctured hulls, which may in turn lead to spills from damaged tanks or possible foundering of the ship. He recommends a research program aimed at finding the facts about possible hull broaching, leading in turn to improved structures and methods of operation.



CHAPTER 5

HIGHLIGHTS OF VOLUME V: DIMENSIONAL ENLARGEMENT OF GREAT LAKES BULK CARRIERS--WEIGHTS AND COSTS

The fifth and final volume of the series reports on studies carried out under a subcontract with Marine Consultants and Designers, of Cleveland, Ohio. The report explains how existing Great Lakes bulk carriers can be physically enlarged in any or all of their three dimensions. Methods are given for estimating the weights and costs of such enlargements and resulting transport capabilities. Hull enlargement is an increasingly common practice on the lakes and the report points the way to maximizing the economic benefits. Intended as a design tool, the report points to no specific conclusions or recommendations. Each ship and trade must be analyzed on its own merits.

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CHAPTER 6

HIGHLIGHTS OF REPORT NO. 156 (ANNEX TO EARLIER REPORTS)

Our Report No. 156 expands and refines the material presented in our earlier Report No. 152: "Great Lakes Winter Navigation--Technical and Economic Analyses: Vol. II: Computer Program Documentation and User Instructions."

Report No. 156 describes recently introduced modifications to our methods of evaluating winter operations and economics. Coverage includes both Great Lakes and St. Lawrence Seaway. In addition, the report contains a series of numerical examples that illustrate the increased versatility of the associated computer program, ESP.


PHILIP R. CLARKE
USS

CHAPTER 7

DISSEMINATION OF FINDINGS

We concur fully with the Maritime Administration's view that research is wasted unless the findings are made known to the industry, including interested federal agencies. This chapter outlines our multi-faceted effort to carry out this key phase of our responsibilities under the contract.

Perhaps our single most concentrated work along these lines was directed at encouraging widespread use of ESP (Extended Season Program for analyzing economics of Great Lakes ships). As a start, the program was converted from the original MTS* version to a form suitable for General Electric's time sharing system, thus reducing the running costs to public users. Under this arrangement, the user can conveniently access the G.E. computer via simple telephone connection to an on-site console. Members of our team traveled around the Great Lakes region with a portable console, giving demonstrations to interested members of the shipping community and associated government agencies. We gave demonstrations to all of the major ship operators on the Lakes (12), to three consulting firms, to a shipyard, to five federal agencies, and to another three state or quasi-governmental agencies. Among the foregoing, seven have already exploited the program and others confidently expect to do so. The program has been found useful for several purposes other than the analysis of winter navigation for which it was primarily intended. It is being used for general ship design purposes, and some operators are using it in everyday ship scheduling decisions. It therefore promises to be an important and useful resource to Great Lakes maritime interests for many years to come.

In addition to the on-the-spot demonstrations just described, we sponsored two round-table meetings to explain our work to larger groups. The first was held in Ann Arbor last March 29, and was attended by a dozen representatives of shipowners and federal agencies. The second was held at the Detroit Metropolitan Airport on November 25, with a like number of potential users on hand. The consensus of the latter meeting was that the ESP program

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*MTS: Michigan Terminal System

should be kept available and periodically modified to keep it up to date. (The November 25 meeting also produced a good number of suggestions from industry as to further studies and developments that deserve consideration for federal support.) See Appendices I and II for details of both meetings.

That the ESP program has already borne fruit is evidenced by its being prominently cited in two papers given before national meetings of the Society of Naval Architects and Marine Enginers: "Advances in the Developments of Commercial Ice-Transiting Ships" by Levine, Voelker, and Mentz; and "Integrated Tug-Barge Versus Ship--An Economic Comparison for the Great Lakes" by Tripp and Plude. The second paper was based in large measure on economic evaluations carried out on ESP.

Other related papers prepared by members of the team were presented at the Summer Computer Simulation Conference in Houston, at the December meeting of the Philadelphia Section SNAME, and the January 1975 meeting of the Great Lakes and Great Rivers Section SNAME, in Cleveland. A fourth paper has been scheduled for the national meeting of SNAME in New York next November, and a fifth is being published by the Journal of the American Concrete Institute in March. The feature article in the next Seaway Review will summarize the Seaway phase of our work carried out under the contract. Appendix III presents details of the aforementioned publications.

Over the past two years our Marine Transport Economics Team has sent spokesmen to five meetings of the Winter Navigation Board, four meetings of the Michigan State Chamber of Commerce Season Extension Task Force, and to the World Energy Conference in Detroit.

A clear measure of the attention given our work is the continuing demand for our reports. Some 150 copies of the five volumes summarizing findings from the second phase of our contract have been supplied upon request.

To help reach the widest possible audience, we suggested and helped produce the winter navigation film "An Inconceivable Commerce." It was

given its first showing at the 1974 Spring Meeting of SNAME in Chicago and is now available for use by schools and service clubs. Short TV documentaries are also being prepared by the University of Michigan TV Center and others. As a start, the University's Information Services recently produced a 75-second 16mm color/sound film story on the economic aspects of winter navigation for insert into newscasts. Over 40 copies of the film have been distributed. These have gone to all TV stations in Michigan plus all major port cities on the Great Lakes.

CHAPTER 8

A LOOK AHEAD

The accompanying reports bring to a conclusion our analysis of winter navigation on the Great Lakes. The reports also present an initial, similar assessment for the St. Lawrence Seaway. What further studies now seem appropriate?

Looking first at the Great Lakes, we find a high level of optimism for a continuing and expanding commerce in bulk commodities. The taconite trade promises long-term expansion, but the big new development should be in delivering low-sulfur coal from the western states to the mills and power houses of the lower lake region. In both cases questions arise as to the best transport systems for handling the trade. Some ships will be dedicated to the taconite trade and some to the western coal trade; some, however, should be made suitable for either trade. What are the best compromises to effect in such a dual-purpose ship. What will be the best way to cope with higher fuel prices? Should we consider a return to coal-burning ships and, if so, how best to minimize resulting air pollution? What shoreside facilities will be required to attain maximum efficiency at the ship-shore interface? What role can researchers play in helping to solve the problem of crew shortages on the Lakes? How can shipyards on the Lakes best modernize in the face of intermittent business in the future? What are the most economic ways to strengthen existing hulls for ice operations? How can we most effectively ensure against ecologically harmful spills arising from possible ice damage to Great Lakes bulk carriers?

The time has come to consider replacing the Davis or Sabin locks, or both, at the Soo. How large a ship should the new lock handle? Or conversely, given several alternative lock sizes, what will be the micro and macro economic effects on Great Lakes transport?

The question of energy conservation seems to be here to stay. Superficial reactions may result in reduced operating speeds. The question arises,

however, whether the fuel thus saved is greater than the added fuel required to produce and operate correspondingly more ships. This also raises the question of whether future fuel savings should be discounted in comparing with present savings.

Certain industrial concerns on the Great Lakes see a need for multi-barge flotillas to consolidate raw materials and distribute finished products, usually in bulk. Deciding how best to provide such a service requires a nice combination of technical development and economic study.

Looking next to the St. Lawrence Seaway, we see a facility of mixed success and uncertain future. The need for physical improvement is apparent, and the potential for greatly increased trade in finished products seems tantalizingly near. Our third volume in the current series points the way to important benefits to be derived from several proposed improvements in the Seaway, but these need more detailed study. Because the Seaway is under international control, long lead times and careful documentation are especially pertinent.

The promise of enlarged locks in the Great Lakes and Seaway raises questions of how a shipowner can best adapt his fleet to such changing conditions. Should he replace his older ships with larger units or might he better enlarge them? In either event, what is the best scheme for scheduling such major changes? Questions of this nature merit careful study, and we believe a team such as ours could propose logical methods that would help owners arrive at optimal solutions.

Arctic commerce is becoming increasingly important to our nation's economic welfare. Our studies of Great Lakes winter navigation have given us an insight into the mechanics of ice fracture and the physical aspects of ships moving through ice. Without going into specifics, we want to call attention to our potential for contributions to optimizing the economics of ice navigation, no matter where. Our related interests and capabilities in hull reinforcement are also pertinent here, (Refs. 4 and 5).

APPENDIX I:

MINUTES OF THE MEETING OF MARCH 29, 1974

MINUTES OF THE MEETING ON SHIP ICE-TRANSITING TECHNOLOGY

March 29, 1974

Rooms D & E, Michigan League

Ann Arbor, Michigan

Present:

Prof. Anthony Atkins	Dept. of Mechanical Engin., The Univ. of Michigan
Mr. Ralph H. Bertz	U.S. Steel Corporation, Great Lakes Fleet
Mr. Mike DiGiovanni	U.S. Army Corps of Engineers, Detroit
Mr. Norman A. Ehrlich	U.S. Coast Guard, Office of R & D
Mr. Volker H. Elste	Dept. of Naval Arch. & Marine Engin., The Univ. of M
Mr. John Horton	Cleveland-Cliffs Iron Company
Prof. Movses J. Kaldjian	Dept. of Civil Engin., The Univ. of Michigan
Mr. Jack W. Lewis	ARCTEC, Incorporated
Mr. Bob MacLauchlin	U.S. Army Corps of Engineers, Chicago
Prof. Horst Nowacki	Dept. of Naval Arch. & Marine Engin., The Univ. of M
Mr. George Palmer	American Bureau of Shipping
Mr. Virgil W. Rinehart	Maritime Administration
Mr. David C.N. Robb	St. Lawrence Seaway Development Corporation
Mr. Benedict J. Stallone	Dept. of Naval Arch. & Marine Engin., The Univ. of M
Mr. Peter M. Swift	Dept. of Naval Arch. & Marine Engin., The Univ. of M
Adm. Paul E. Trimble	Lake Carriers' Association
Mr. Hoyt Wilson	Pennsylvania State University (Traffic & Transportat
Prof. John B. Woodward	Dept. of Naval Arch. & Marine Engin., The Univ. of M

Call To Order.

The meeting on research needs in ship ice-transiting technology was called to order 0830 on March 29, 1974, by Nowacki. The meeting was addressed to the following principal questions:

1. What is going on in ice-transiting technology research that some of the participating parties may not be aware of?

2. What are the needs for more research and development in such technology?

The discussion was to concentrate on Great Lakes and St. Lawrence Seaway ice-transiting which corresponds to the main interest of the audience. It might also bring to use on the Great Lakes and St. Lawrence Seaway what we know about Arctic ice-transiting research. The main emphasis of this meeting should be on defining the research information we need. Throughout the meeting the shipping industry should be kept in mind as the end consumer of the research results.

A secondary purpose of the meeting was to bring all attending parties up to date on the work that is being done at the University of Michigan. The progress report of the University of Michigan group will serve as a skeleton of principal topics in ice-transiting research, emphasizing three major aspects:

1. Technical
2. Operational
3. Environmental

Another side purpose of the meeting was to have some introductory discussion of the forthcoming ice technology meeting between the United States and the U.S.S.R. Rinehart was asked to give a brief introduction of the U.S.-U.S.S.R. meeting.

U.S.-U.S.S.R. Exchange

Rinehart stated that the United States Coast Guard would provide a panel chairman for the American side. In the coming week an agenda for the exchange would have to be presented to the coordinator for maritime transportation, Marvin Pitkin, of MarAd. During the course of the meeting we should keep in mind the following:

a) Possible information to be traded in technical exchange between U.S.S.R. and U.S.

b) Why do we want this technical interchange?

c) What would we gain and what would the Russians gain from the interchange?

d) What kind of impact would this interchange have on 1) national economy and 2) national defense.

Instead of interrupting the meeting at this point, Rinehart suggested a short brainstorming session toward the end of the meeting.

Outline of Michigan Study

Nowacki gave a quick outline of the University of Michigan project. The project deals with the cost and benefits of commercial ice-transiting on the Great Lakes during the extended season. The study has been sponsored by MarAd for the last three years. The study has the character of a parametric study, and is intended to take into account many possible situations in addition to the actual situation in the extended season. It emphasizes technical aspects as well as economic conclusions. A great share of the economic conclusions is based on operating schemes which in turn are based on ship performance.

The three levels of the study are:

1. Individual ships
2. Fleet
3. Transportation system

Work has resulted in the first two volumes of a five volume series. Volume one deals with the methods of evaluation, volume two with the comprehensive computer program which addresses the economics of a single ship operating in the extended season. Volume three, which is being written, is a systematic variation on ship and system parameters leading up to economic performance measures. Volumes four and five deal with the structural design aspects.

Ship Synthesis Modeling

Swift gave a summary of the U of M work in ship design and economics. The weight and shipbuilding cost models are broken up into three primary components: hull, outfit & hull engineering, and machinery. Each of these components is subdivided into smaller, more definable elements. Other items that are modeled are the additional weights and costs for ice classification.

These include hull structure and machinery. Swift then proceeded to explain some details of the synthesis models. The types of ships being modeled at the University of Michigan include Great Lakes bulk carriers (weight and volume critical), ocean-going dry bulk carriers, containerships (line haul and feeders), tankers, SEABEE, LASH, and Great Lakes barge systems. Models not yet completed include SEABEE, LASH and barge systems. SEABEE and LASH models are suffering from a lack of weight and cost data primarily because these ships are new designs.

Containership Synthesis Model and Great Lakes-St. Lawrence Seaway Feeder System.

Elste stated that the various components being modeled include weights and their subcomponents, cargo capacity, dimensions, operating costs, construction costs, and some basic commodity movements. A first cut cost estimate was made for a container feeder service from Montreal to Cleveland, Detroit and Chicago, operating at a frequency of twelve days for nine months of the year. This estimate looks favorable when compared to present land modes of transportation. A preliminary study of commodity flow indicates a need for such a feeder service. Different modes of water transportation will also be studied. These include the LASH system, SEABEE and tug-barge systems. The overall result will be a comprehensive cost-benefit study of the Great Lakes-St. Lawrence Seaway Feeder System.

Simulation of Fleet Operations, Constricted Ports as Components of the Total Intra-Lake Transport System.

Stallone described the U of M work in this area. The simulation deals with the operation of vessels and icebreakers in ice-congested areas. The model is based on queuing theory and will analyze parametric influences in the operating environment, such as: ice conditions, number of icebreakers, powering of the vessels and speed of the breakers. In general, the GPSS program models the ice constricted segments of shipping routes in the Great Lakes, with the additional capability of handling a lock. Through parametric analysis the most important influences will be determined.

The second topic was constricted ports as a component of the total transport system, using the Cuyahoga River as a case study. This study identifies the problem, then looks at alternatives for transporting the cargo up the Cuyahoga River and how these methods are affected by an extended season on the Lakes. Using data from Stanley Consultants for reference, the following alternatives will be looked at: conveyor, existing river-size ships,

and barge systems.

Structural Analysis and Ice Strengthening To Date.

Kaldjian: The main purpose of the U of M structural design and analysis computer work is to obtain cost and weight estimates for ships in winter navigation. Cost estimates obtainable from operating experience were not adequate. Therefore, an extensive computer program was developed to calculate the additional weight and cost required to meet a specified ice class. The additional weights and costs are calculated for three different materials for reinforcements:

1. Steel
2. Reinforced concrete
3. Ferrocement

Much experimental work preceded the computer program, mainly in the areas of reinforced concrete and ferrocement.
Kaldjian then explained the details of the program's input and output.

Ship Performance and Powering Requirements in Ice.

Nowacki gave a brief survey of the available and missing information on powering requirements in ice for Great Lakes ships. The only moderately systematic model tests performed with Great Lakes bulk carrier hull forms have been those sponsored by MarAd on the Ryerson. The tests in sheet ice, which were done in Finland, dealt with a series of bow modifications and variations in ship proportions, a series of 9 models. However, this series covered only a sparse matrix of form parameter combinations and did not include vessel proportions corresponding to the largest, 1000' vessels now operating on the Lakes. Users of these test data have to grossly extrapolate when dealing with any major digressions from the Ryerson parent form. Information on ice resistance in ballast conditions exists for the Ryerson, but is otherwise badly needed. Test data on ship performance in broken channel, brash and mush ice are important and some have been obtained from ARCTEC model tests on the Ryerson, but, again, ice resistance for Great Lakes and Seaway ships can only be resolved by full scale testing. The present opportunity for such testing during the demonstration program should not be wasted.

Discussion on Ship Performance and Powering Requirements in Ice:

Rinehart suggested that a more systematic attempt be made in testing so that a complete matrix may be obtained.

Lewis noted some points that were made at the Warrenton meeting: 1) No Great Lakes ice data was presented and 2) A deficiency in the scaling laws was expressed.

Ehrlich presented some work recently done by the USCG. The Coast Guard have done model test work on ice resistance reduction by friction coatings. To date, no full scale tests have been obtained: however, the Coast Guard has been using model tests to examine hull coating and bubbler systems. One major problem is that one can't rely upon the ice in the field to give a complete matrix of conditions according to the test program plan. Wärtsilä claims a 50% reduction in resistance for tugs, which may be exaggerated slightly. It has been shown that the resistance is less, but what the relative reduction is of the coefficient of friction with the employment of the coating has yet to be determined.

A point was made by Nowacki that friction is more dominant in ore carriers because of their length.

The Coast Guard compared 100 different types of coating, all various compositions of polyester, epoxy and polyurethane. In order to keep the coating on the ship the problems of friction and impact resistance must be overcome. The Coast Guard is now adding teflon to the coatings. Ehrlich stressed the fact that the role of coatings is strongly underplayed.

Trimble, Lake Carriers' Association, stated that there is good ice data available in the St. Marys River and this is an area where the USCG could have run full scale tests on coatings. There are two 110-foot tugs available to test the coatings. He then asked if there has been an attempt to try full scale tests.

Ehrlich replied that full scale tests were tried but three difficulties have occurred:

1. They could not put the coating on
2. They need uninterrupted test time to fill matrices (cannot find the right ice and if they can, then they usually have problems in using the area).
3. Deterioration of coating is not yet known (wait until test results are obtained from the Mackinaw).

He also stated that the Great Lakes are not bad for certain kinds of ice, but it becomes impossible to fill the total matrix. The one advantage of model tests is that data are obtained fast, whereas full scale tests require too much time.

Lewis stated that there is no uniform ice on the Great Lakes, whereas the model tests are performed in uniform ice. He then went on to say that predicting resistance in a channel will be a major problem as we have varying thickness, and varying density of mush or brash ice.

Robb stated that we should concentrate on brash and mush ice and not sheet ice. Also, for the Seaway, we should look at single ships instead of convoys.

Lewis added that we have data on the Ryerson, Mackinaw and two other Navy icebreakers but no full scale test results on any commercial ship. We have to emphasize the lack of sheet ice and presence of mush or brash ice in channels.

Nowacki said that we need resistance data for ocean-going ships in broken channel ice in order to make projections on cost effectiveness.

Lewis stated that the tests of the bubbler system on the Fraser did prevent the vessel from getting stuck, although the vessel moved rather slowly at times. It is advantageous to keep the vessel moving even if it is moving slowly.

Ehrlich said that at the beginning of the tests on icebreaking resistance, the Coast Guard had problems with the model slipping due to the extremely smooth finish. Only later did they realize that this presented the solution to a different problem, i.e., the coating to reduce friction.

Bertz stated that it is better to move slowly in a restricted area rather than stop, since the restricted area is only a small portion of the total trip distance.

Robb expressed a need to define a critical season, i.e., when it would be beneficial to operate regardless of power requirements.

Rinehart said that not only do we have icebreaking problems, but also ice disposal problems.

Modeling of the Operating Environment and Transportation.

Stallone outlined the modeling of operating environment and transportation systems.

I. Operating Environment

A. Deterministic model - The ESP computer program models vessel transit time in Great Lakes routes using average ice condition and delays. This is done for three types of winters and for the regular and extended season.

B. Stochastic model - Modeling of vessels and icebreakers to allow variations of the principal components which result in random

operating processes.

C. The real time model which characterizes the components of a system through observed frequency distribution.

II. Transportation Systems Economics

A. Single ship model, ESP

B. Fleet analysis economics

C. Complete intra-lake transport system

Discussion of Operating Environment and Transportation Systems.

Ehrlich made the point that the Coast Guard is not given the proportion of funding to meet the increase in activity.

Trimble added that the basic reaction to the extended season by the Department of Transportation is that it's only a demo program and is primarily categorized under U.S. Steel. The Department does not recognize the value of such a program.

Rinehart stated that the Maritime Administration should take the role to convince the Department of Transportation of the value of the Extended Season Program.

Ehrlich emphasized that MarAd should take the lead role but not neglect the Coast Guard.

Nowacki said that the USCG could be made more aware of their crucial function through Lake Carriers' and MarAd.

Bertz expressed a need for coal shipment from the west through the extended season.

Trimble made the point that the Governor of Minnesota was asked by Lake Carriers' to give Great Lakes shipping a boost.

Nowacki raised the question, what are the gaps or handicaps for making a model study of the constricted segments of the operating environment such as the Seaway and Little Rapids Cut?

Robb replied that modeling levels of the ice regime are very complex in the Seaway and other reaches like the Little Rapids Cut, primarily because of the generation of a model for transits in broken track. Nowacki added to this the localized problems such as ice jam areas. Another problem is the hydraulic levels and flow constraints.

Rinehart stated that perhaps the model study of the St. Marys River will help out in the general area of ice control.

Wilson stated that the study at Penn State is totally ignorant of hydraulic levels and flow constraints. It assumes summer operation and no winter operation. Adding further constraints at this time would be impossible.

Competing Modes of Transportation.

A presentation was given by Woodward on the work done at the University of Michigan concerning the railroads. Robb offered their commodity origin-destination study to the University.

Swift raised the question, what will be the influence of the Canadian rail traffic on shipping? The railroads and ships could both benefit if an intermodal transportation system were designed.

MacLauchlin suggested that Dow Chemical could possibly quote some rail rates.

Advanced Concepts in Ice-Transiting Systems.

The Coast Guard has done much recent research in this field. Ehrlich mentioned the following areas of research: mechanical ice cutters, explosions in case of ice ridges, lasers, water jets, and Archimedes screw propulsion. The emphasis has to be placed on cutting ice, not on propelling ships through ice. USCG is the sole agency for advancing the state of the art.

Robb made it clear that thermal waste has to be put to use, especially in the Seaway.

Ship Structural Design.

Kaldjian introduced the subject by giving an overview of the project at the University of Michigan. Palmer brought up two points: 1) ABS has made an attempt to establish ice condition data in order to be able to correlate Lloyd's to ABS, but found it very difficult. 2) Information is needed on rudders, stocks, and propellers so that recommendations can be made.

Ehrlich asked the question are rules scheduled toward sheet ice?

Palmer replied that the rules are developed using pressure data and no information is available to correlate the ice type and thickness with pressure.

Kaldjian added that all the Finnish ships collect ice and weather data for certain routes.

Lewis agreed that the design of icebreaker strength is arbitrary because of the missing ice pressure data. The breaker Mackinaw and the Fraser were fitted with strain gauges to determine pressure distributions and impact loads. The Arctic is broken up into thirteen ice classes by region. The same should be done for the Great Lakes using crushing strength data for various regions.

Atkins added that one should convert the dynamic loads to pressures.

Ehrlich replied that some kind of information could be determined by analyzing topographical data from the pressure effect on the coating.

Trimble made the point of high midships stress in a channel when making a turn.

Kaldjian added that there are no impact loads when in a turn because of low speeds.

Ice Data Collection and Analysis Methods.

Atkins gave an explanation of the current Great Lakes ice representation being used in the University of Michigan study. The main problem is the lack of accurate data on ice thickness in the channel. Attempts are being made to develop a thickness equation in terms of freezing degree days.

He emphasized the need for more accurate and scientific approaches to ice strength, and suggested that toughness and cracking in ice should be studied more carefully.

Robb, concerning forthcoming data, stated that NASA are using pulse radar flights to collect accurate ice thickness data.

Lewis said that continuous ice profiles are collected by plane in Whitefish Bay and Lake St. Nicolet. What is needed is a centralization of all data.

Rinehart commented that with all this speculation one has to admire the courage of the American Bureau of Shipping.

U.S.-U.S.S.R. Exchange.

Rinehart gave an outline of the exchange. Last summer an agreement was made to cooperate in the area of transportation. A sub-topic of this is Maritime Transportation.

There are five areas of exchange:

1. Operation and requirements
2. Ice-transiting of vessels (technical exchange)
3. Cargo handling
4. Human factors
5. Loads on ships at sea

The proposed two-week visit of the U.S.S.R. representatives will include the following:

1. Session in Washington

2. Observe operations (N.Y. Harbor, etc.)

3. Final meeting in Washington

Discussion.

Palmer stated that the run into Leningrad has similar conditions to the Great Lakes runs, so the same problems should arise.

Rinehart added that we could benefit in the areas of ice survey equipment and port technology since their winter is probably tougher and the shipping legs longer. The total port system should consist of icebreaking, ice-transiting and ice disposal.

Swift suggested that the purpose of the interchange should be two-fold:

1. Collect ideas that the U.S. is not aware of,

2. To make further contacts (technical) and follow them up later.

Rinehart stated that the scientific interchange will be strictly scientist-to-scientist. He then asked if any of the members present at this meeting would object to showing the U.S.S.R. some lake operations if this could later be beneficial to the Lakes? No objections were raised. In conclusion, it seems that there is interest in inviting the U.S.S.R. delegation to the United States.

Miscellaneous Subjects.

Trimble brought up the point that labor practices between Canadian and American labor systems is a factor that could be included in the modeling.

Concerning the brief bilge water discussion, Horton suggested that one tank could be pumped at a time while the other tank is settling. The mud settles to the bottom while the oil and scum rises so pumping should take place a certain distance from the surface. Also, concerning the Cuyahoga River, the Kearney Report should have been implemented a long time ago.

Economics - Ship Related, Public Sector, Transportation Costs, Etc.

Swift explained the economics behind the Extended Season Program, with emphasis on the six measures of merit: 1) Required freight rate, 2) Cost of service, 3) Capital recovery factor, 4) Net present value, 5) Operating cost per ton, and 6) Yield. Questions raised by Swift were as follows: Are we justified in the approach taken? What are reasonable interest rates? What is the cost for the locks, etc?

Robb said that in extending the season one spreads the operating cost over a longer period. It can only improve your cost-benefit ratio.

Trimble made the point that there has been some talk of charges for the channel. In addition we have public costs, perhaps fuel tax and Coast Guard cost.

Robb stated that in their study public costs have been included. A new problem is the effect of nav-aids, i.e., daylight only. Right now there is no navigation at night on the Seaway. Transit time for the Seaway from Montreal to the Lake is at 22-24 hours. The St. Lawrence Seaway Authority controls the intermediate waters. Both the U.S. and Canada have to cooperate in the program. The constraints lie in the Canadian section. They close before the U.S. closes because ice forms first on the Canadian side. We have been making incremental improvements.

Swift said the solutions to the technical problems along the Seaway have been mapped out by the Seaway Authority.

Robb agreed.

Swift also stated that the transportation costs based on 8-, 9-, or 10-month operation will change drastically if the operations are increased to 24 hours a day. This will also affect the freight rates.

Robb expressed a need for a better definition of the transit times and their effect on freight rate. One should also investigate donkey engines for operation in the locks similar to the Panama Canal system. This would reduce operating costs.

Closing.

In conclusion Nowacki commented on the results of the meeting, especially with regard to those areas that require further research such as, performance and powering requirements in ice, advanced concepts in ice-transiting systems, ice data collection, analysis methods and conversion of dynamic loads to pressures. The meeting helped considerably in exposing areas that little or nothing is known about.

Rinehart suggested that a similar meeting be held in approximately six months.

APPENDIX II:

MINUTES OF THE MEETING OF NOVEMBER 25, 1974

Minutes of the Meeting with Operators and MarAd
to Discuss the Future of ESP (Extended Season Program)
and General Problems Within the Great Lakes Shipping Community

November 25, 1974
Metro-Airport Hotel

Present:

Mr. Charles Adams	St. Lawrence Seaway Development Corporation
Prof. Harry Benford	Dept. of Naval Architecture & Marine Engineering The University of Michigan
Mr. Frank Dashnaw	Maritime Administration
Mr. Volker Elste	Dept. of Naval Architecture & Marine Engineering The University of Michigan
Mr. Ray Francis	American Ship Building Company
Mr. John Horton	Cleveland-Cliffs Iron Company
Prof. Movses Kaldjian	Depts. of Naval Arch. & Marine Engin. and Civil Engineering, The University of Michigan
Mr. Jacques LesStrang	Seaway Review
Mr. John McCarthy	American Steamship Company
Mr. Robert McIntyre	U.S. Army Corps of Engineers, Chicago
Mr. Ron McLean	R.A. Stearn, Designers & Consultants
Mr. David Robb	St. Lawrence Seaway Development Corporation
Mr. Benedict Stallone	Dept. of Naval Architecture & Marine Engineering The University of Michigan
Mr. Peter Swift	"
Mr. David VanBrunt	U.S. Steel
Mr. Carl Warren	Hanna Mining

Call to Order

The morning session of the meeting was addressed to discuss the Extended Program developed by the University of Michigan and the afternoon session included a general brainstorming.

Dashnaw gave a brief introduction and welcomed everyone.

Benford discussed the background of ESP while later Stallone explained in detail the usage charges, and the breakdown as to which companies have used the program. A discussion of the custodianship of GE program resulted in a list of potential custodians.

(1) ARCTEC
(2) R.A. Stearn
(3) U. of M.
(4) Burt Kyle's office
(5) St. Lawrence Seaway Development Corporation
(6) Inland Steel
(7) Lake Carriers

Further discussion of the duties of the custodian revealed that U. of M. would be the only organization capable of handling this task. This would require two contracts (1) custodian and (2) update responsibility. Specifically these duties include:

1. Troubleshooting: advice on how to use program (coaching)
2. Make available cards or tapes and sample runs
3. Update - program changes
4. Pay G.E. rental charge

Frank Dashnaw will investigate the possibility of Canadian usage of the program.
The users are to be kept up to date on the changes to ESP, with MarAd paying for these changes. A letter should be sent to MarAd discussing this in detail.

Possible changes to ESP:

McLean (R.A. Stearn)

1. Adapt program to handle 3-leg voyages, i.e., load A, ballast, load B

2. Modify input procedure of service speed and shaft horsepower
3. Use of high-strength steel
4. Reduce input-output time and reduce phone charges
5. Analyze cubic limited ships.
6. Arrange to use some parts of the program separately, that is, weights route builder, etc.

McCarthy (American S.S.)

1. Switch trades mid-year
2. Single-year analysis
3. Lay-up at mid-year
4. Expand to include a whole fleet eventually
5. For single ship, look at a month-by-month operation

VanBrunt (U.S. Steel)

1. Water levels will be lower in a few years, so therefore input available harbor depths, and use the output to analyze the cost of dredging.

Concerning publicity:

We need help in political arena to get public support. MarAd can help and Jacques LesStrang can carry a story on ESP in next issue of Seaway Review. In addition, we (the G.L. shipping community) should get the U. of M. TV Center to show "The Inconceivable Commerce" on television, possibly a local cable station. More information should be fed to LesStrang, who hopes to feed it to Governor Milliken, who in turn will tell President Ford. Jacques LesStrang should be on the U. of M. mailing list.
We should put out a public relations special to discuss the following:

(1) Coal vs. oil.
(2) Ship vs. rail on the basis of cargo volume and energy utilization.
(3) How does pollution compare, ship vs. rail or truck?

LesStrang can use the Great Lakes Commission to get information to public. Frank Dashnaw will approach Burt Kyle. Dave Robb made the point that we can cooperate with environmentalists by bringing in U. of M. natural resources people.

Studies Through Which MarAd Can Help the Great Lakes Shipping Community

*Hull form and structural studies for over-size ships, 1300' x 130' x 60' depth

*Life raft for winter rescue

*Human factor in accommodation design, manning, crew reductions

*New machinery types, highly skewed propellers for ice transiting, bow propeller for ore carriers

*How to load new big ships under existing docks.

*Coke and oil slurry for ship bunkers, see B. & W.

*More bubblers in channels

*Auxiliary devices to speed up icebreaking

*Shallow water effects such as squatting - Clearance 30" or 24"?

*Dispatch model for backhaul trades, (coal may move in both directions)

*Container cargo as backhaul

*Winter bypass for Sault Ste. Marie (slurry & pellets)

*Improvements in Soo Canal and St. Lawrence Seaway in winter months. (Pier and shoreside facilities need refinements)

*Navigation aids for summer and winter.

*Better scheduling and queuing at docks - Eliminate bunching in critical areas.

*Service ships like airlines.

*Super-conducting MG. sets (now used by Chevron)

*Mechanical painting and a critical path for outfit and lay-up operation

*Bottom cleaning, is it necessary?

*Mud removal and sewage systems.

*Coal burning ships: How to control stack emission?
What to do about ashes?

*Ballasting, Lake Erie water pumped into Lake Superior, deck washing. (See Kearney report)

*2-part construction of ships, modular design for ship parts, shafts, rudders, machinery

*New surface coatings

*Connector ships for Cuyahoga River

*Data collection - M & R costs, delays

*Crew education:

Great Lakes Maritime Academy: will need more officers. Deck officers need instruction on pollution

*Develop gage system to tell officers when ship is overstressed in loading and unloading or at sea

The above statements were points brought up during the afternoon brainstorming session.

APPENDIX III

PUBLICATIONS ARISING FROM THE CONTRACT (1974-75)

*Stallone: "Great Lakes Shipping in Ice Congested Areas," 1974 Summer Computer Simulation Conference, Houston.

*Elste, Swigart and Swift: "Seaway and Overseas Trade--Great Lakes and Seaway Transport Analyses," SNAME Philadelphia Section, December 1974.

*Stallone: "Transshipping Alternatives for Upriver Mills," SNAME Great Lakes and Great Rivers Section, Cleveland, January 1975.

*Benford and Rinehart: "Economics of Winter Navigation in the Great Lakes and St. Lawrence Seaway," scheduled for presentation before SNAME annual meeting, N.Y. City, November 1975.

*Benford and Elste: "Toward an Improved Seaway," scheduled for publication in Seaway Review, spring 1975.

*Kaldjian: "Ferrocement Reinforced Steel Plate," SNAME Great Lakes and Great Rivers Section, Cleveland, January 1975. Department of Naval Architecture and Marine Engineering Report No. 167.

*Kaldjian: "Ferrocement-Steel Plate Composite Beams," Journal of the American Concrete Institute, March 1975, with Kahn and Townsend.

*Atkins: "Icebreaking Modeling," Journal of Ship Research, March 1975.

APPENDIX IV

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4. M. Kaldjian, W. Townsend, L. Kahn, K. Huang, "Great Lakes Winter Navigation--Technical and Economic Analysis, Vol. IV: Strengthening Steel Plates Using Ferrocement and Reinforced Concrete," University of Michigan, Department of Naval Architecture and Marine Engineering, Report No. 154, June 1974.

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This is the introductory volume to a five-volume series dealing with several aspects of commercial marine transport on the Great Lakes and St. Lawrence Seaway. This volume summarizes the principal points of the entire series and outlines probable future developments in related technologies. Topics include mine-to-blast furnace transport analysis, technical aspects of ship enlargement, optimization of fleet composition, methods for predicting times to transit ice covered waters and alternatives for delivering material to mills on constricted rivers. Other topics relate to methods for better exploitation of the St. Lawrence Seaway: winter navigation, feeder service for general cargo, and enlargement of locks, among others.

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