TRANSPORTATION RESEARCH RECORD 669

Waterborne Commerce and Inland Port Development

TRANSPORTATION RESEARCH BOARD

COMMISSION ON SOCIOTECHNICAL SYSTEMS
NATIONAL RESEARCH COUNCIL

NATIONAL ACADEMY OF SCIENCES
WASHINGTON, D.C. 1978

Transportation Research Record 669
Price $3.40

subject area
05 water transport

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Library of Congress Cataloging in Publication Data
National Research Council. Transportation Research Board.
Waterborne commerce and inland port development.

(Transportation research record; 669)
1. Inland water transportation–United States–Congresses.
2. Harbors–United States–Congresses. I. Title. II. Series.
TE7.H5 no. 669 [HE627] 380.5'08s [386'.0973] 78-31230
ISBN 0-309-02806-X

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Study of Upstate New York Public Ports

Gunnar Hall, New York State Department of Transportation

An unconventional study approach resulted in new perspectives on port objectives and the state role in port development. Real, measurable port benefits are used in the study and are contrasted to those commonly used in earlier studies. The detailed freight demand analysis, or market analysis, necessary to identify these benefits and the general applicability of the approach at local, state, regional, and national levels are discussed. Study recommendations that relate to port development, financing, and marketing and conclusions about the state's role in port development reflect the responsiveness of the study to issues of local and statewide concern. Focusing on the upstate New York ports as means to provide the best possible service to shippers and consignees has encouraged coordination among these ports and provided a basis for state port development policies.

In September 1976, the New York State Department of Transportation (NYSDOT) completed a study to identify and address the major needs and potentials of the upstate New York public ports of Albany, Buffalo, Rochester, Oswego, and Ogdensburg. Some of these needs had been identified in 1972 during the preparation of New York's Master Plan for Transportation. In several public hearings on the master plan, it was claimed that state and local investment in ports had resulted in uncoordinated development; in the construction of unused or lightly used, expensive facilities; or in the taking of traffic away from other ports and from other transportation modes that the state was assisting to sustain its economy.

All upstate New York ports were reported then as operating at a deficit and without the financial resources to meet their capital needs. Historically, port authorities had been established to allow efficient port management at a time when ports were profitable. Their jurisdictional boundaries generally do not reflect the areas receiving the greatest benefits from the ports, and many industries that have vital interests in the ports are not represented by those responsible for deciding on the port's continued operation and development. Their governmental structures vary from one to another but, in general, they are separated from direct local government control and are therefore without the financial and political base needed to meet their changing requirements.

As port agencies faced financial problems, these circumstances made it difficult to obtain local financial support. Several municipalities expressed concern over port deficits supported by their own property taxes, and the state was increasingly called on to provide loans and grants for new facilities and for rehabilitation of existing ones. It became evident that state initiatives in regard to ports were needed, both to promote sound and coordinated port development and to assess the justification for an already significant and possibly expanding public support of port operations.

In the fall of 1974, state funding for a study of the upstate public ports had been approved. It was decided to design the study from an overall transportation perspective consistent with the NYSDOT approach to planning for other transportation modes. This differed from the single-mode concern that was found to be prevalent in other port studies that had been reviewed. Not surprisingly, the final conclusions and recommendations of the study were also different from and somewhat contrary to those of many previous port studies.

The study was carried out by a consultant, Frederick R. Harris, Inc., under close supervision by NYSDOT. F. R. Harris and NYSDOT were assisted by an advisory-liaison committee composed of members of the various port authorities, regional planning boards, metropolitan transportation organizations, and other concerned agencies, including those state agencies concerned with commerce, the environment, and the state budget.

OBJECTIVES

The department sought recommendations in three interrelated areas:

1. Coordinated port development--to identify service, equipment, and facility needs for effective handling of existing and potential freight traffic;
2. Financing--to define the appropriate levels of user charges, the regional economic benefit, the level of public financial support, and the distribution of the cost of this support among state and local governments; and
3. Upstate port management--to select the organizational structure and staffing patterns that will most effectively meet the requirements of current and future port operations.

The basic study objective was to maximize the benefits of waterborne commerce for the upstate regions. It was not to promote the development of upstate ports but rather to determine how upstate ports can best promote the development of the upstate port regions. NYSDOT did not assume that what is good for the ports--as facilities or employers--is necessarily good for their localities or the state's economy.

The underlying assumption was that the reason for any port is to serve the territory to and from which waterborne commerce moves at the lowest possible total system transport cost. The effectiveness of each port should be measured not against any other port (for example, not in how much faster or more efficiently it can move containers through the port) but in how well it meets the needs of shippers and consignees in its least cost hinterland--an area that may not be the same as that represented by the authority or local government responsible for managing the port.

A port needs to have only those facilities and provide only those services for which there is a tangible requirement. Thus, whether a port is just like any other or whether it does or does not have a particular type of equipment often becomes irrelevant. What is important is that the port carefully identifies and equips itself to meet its service area's needs. Then it will be able to demonstrate its economic contribution in real terms and develop public acceptance and support. It will also be in a much better position to finance its port operations out of realistically structured revenues and perhaps to fund its own future development.

The state must keep in mind that water transport is a capital-intensive industry. For each new job created on the waterfront, others may be lost in trucking or railroading. The net effect of promoting cost-effective water transport is to make industry more competitive. In general, development of jobs at the plant sites is promoted rather than development of jobs in the transport sector.

Port benefits are essentially the reduction in total transport costs that accrue to shippers and consignees compared to the costs they would incur by using the best alternate mode of transportation. This is a departure from the traditional approach to port benefit assessment. Other studies have determined port benefits as expenditures made in the region because cargo and vessels used the port.

The American Association of Port Authorities and the Maritime Administration have basically used a formula that consists of the following elements:

1. Port and terminal expenditures (pilotage, tug hire, line running, dockage);
2. Government charges (immigration service, entrance and clearance fees);
3. Labor (stevedoring, clerking, checking);
4. Repair (by ships using the port for service and material);
5. Supplies (dinnage, laundry, ships stores);
6. Bunkers (purchase of fuel and water);
7. Port terminal income (car loading and unloading, demurrage); and
8. Rail and motor freight revenue credited to the local area.

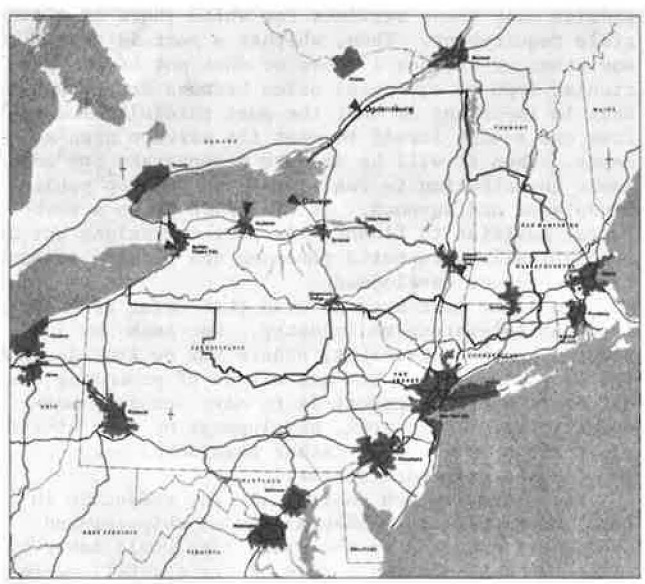
The study of upstate New York ports did not recognize as benefits many of these expenditure items since they are often more than offset by decreased expenditures in other sectors of the economy. Even less did the study accept any formulas stating, a priori, port benefits as a value per megagram of various types of cargo moving through the ports.

APPROACH

To maximize the benefits of the upstate ports, we needed to identify benefits: who benefits and how much. With the above definition of benefits, this required a very detailed freight demand or market analysis, a level of analysis that had apparently never before been attempted. But we felt it was both necessary and worth the cost because of its flexibility as a port analysis base and because of its many useful by-products.

Briefly, the first phase of the study defined a preliminary market potential and regional distribution of port benefits. Phase 2 examined the results of phase 1 in terms of certain noneconomic restraints on the ports' ability to achieve their potential. Finally, the last phase focused the results of the earlier phases on the three areas: port development, financing, and organizational structures.

Figure 1. Preliminary market area for upstate New York ports.



Since the market analysis is the second major departure from the traditional port planning approach, some characteristics of the analytical logic used may be warranted.

What is called the preliminary market area for upstate port services is shown in Figure 1 and includes 44 counties in upstate New York and portions of Connecticut, Massachusetts, New Hampshire, Vermont, and Pennsylvania. One preliminary market area is used for the analysis of all the ports. Within the boundary of this market area, waterborne transportation through an upstate port is likely to be the least cost alternative for some commodity or shipment being transported. The area outside would be served by other modes or routes through other ports.

The actual market area of each port may change over time because of fluctuations in transportation costs, and it will differ depending on the type and value of the commodity handled, the technology of the modes used, and the foreign origins or destinations. For these reasons, it was necessary to describe a preliminary area large enough to encompass reasonable fluctuations in the extent of both the current and potential market areas of the ports.

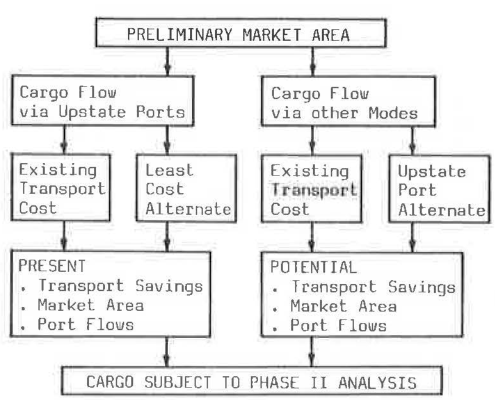
Figure 2 shows the process used to determine current and potential commerce and the regional benefits of upstate ports during phase 1. Although very simple in principle, it is a demanding process in practice because a very large data base must be subjected to essentially a multimodal minimum path analysis.

First of all, we focused on the existing port potential--traffic that now moves and that should be moving through the ports but for one reason or other is not. We did not ignore future growth but included future traffic only when it could be identified by shipper, cargo type, and other specifics.

All 1974 waterborne flows to shippers and consignees within the preliminary market area were determined and made part of a computerized data file. The analysis of flows that now use the upstate ports is shown on the left. The least cost alternatives through nonupstate ports were defined for each shipment in order to determine current cost savings and the likelihood of losing any of this traffic to other ports.

The similar but much more difficult analysis of traffic that now uses other ports--be that New York, Baltimore, Houston, or Seattle--is shown on the right in Figure 2. The data base here was a combination of U.S. Bureau of Customs data, made available commercially through the Journal of Commerce, and shipper interviews. For each individual shipment of 1633 shippers and consignees, the total cost of the existing routing, from the upstate shipper or consignee to the foreign port, was first determined. The overland mode used was not available from the customs record.

Figure 2. Phase 1 of market analysis.



A truck-rail comparison therefore had to be computed, and the least cost alternative was assumed.

The total cost to the shipper was then compared with routes similarly computed through one, two, or three upstate ports. This gave us an estimate of potential cost savings caused by rerouting. All commodity flows found to be least cost when assigned to an upstate port were combined to form the preliminary commodity flow list or traffic potential for the ports. Consequent cost savings are combined to form the potential regional benefit for each port on a preliminary basis.

Since the primary aim was to promote New York industry, most attention was focused on the traffic originating in or destined to the upstate area. Through traffic, which would only marginally benefit and in some cases disbenefit the upstate region, was identified in a manner less rigorous than traffic to New York shippers and consignees.

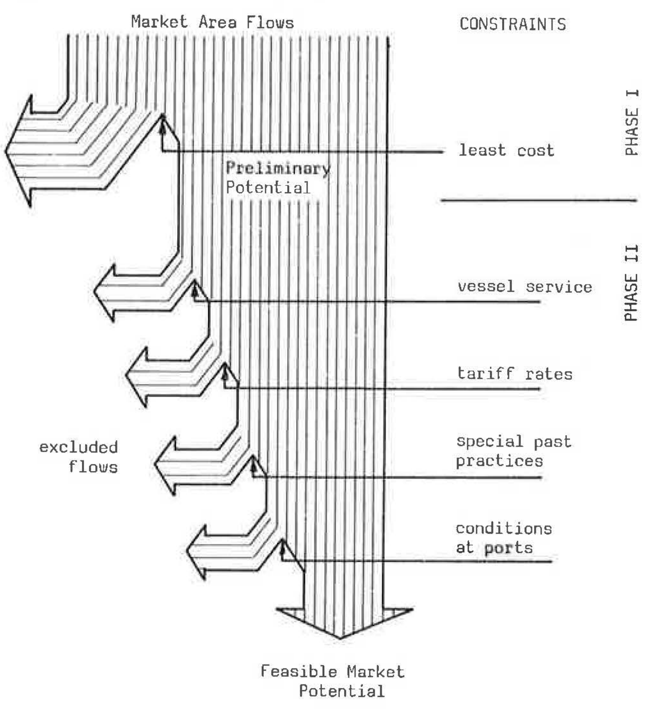
To illustrate the level of detail, total transport systems costs were considered to consist of seven main cost elements:

1. Vessel operating costs;
2. Seaway, Hudson River, and harbor pilotage and tariff charges;
3. Port user charges;
4. Vessel loading or unloading costs;
5. Overland carrier loading or unloading costs;
6. Overland carrier operating costs; and
7. Inventory costs (the cost of the need for a larger inventory because of time in transit).

The analytical process of the second phase of the market analysis consists of a "squeeze-out" procedure, shown graphically in Figure 3, whereby those commodity flows found to be least cost when routed through one of the upstate ports are subjected to four service constraints:

1. Overland and ocean carrier service factors;
2. Overland and ocean freight rates;

Figure 3. Phase 2 of market analysis.



3. Unique shipper or consignee service factors; and
4. Constraints of the current marine, physical, and operational conditions of the upstate ports.

This brief outline of the analytical logic is intended to give a basis for evaluating the usefulness of this approach in other states and regions. We believe it can be accomplished at reasonable cost for different geographic scales of study. It is detailed enough to answer plan and policy questions on an individual port basis and identify impacts on a local scale; it is expandable from a nucleus study to adjacent areas and, similarly, studies in different areas can be merged and thus provide larger scale coverage at major cost savings. Finally, it can be kept current through computerized annual updates at small additional costs.

RESULTS

The result of the market analysis was a substantial increase in identified port potentials. The analysis demonstrated the value of our upstate ports for the economy of New York State.

In 1974, the availability of the upstate ports saved New York shippers and consignees $9.1 million in transportation costs. Equally large additional savings would have been realized if traffic now moving through other ports had been routed through upstate ports. Further savings can also be expected from future traffic that has been specifically identified but is not now moving at all.

Major capital improvements and a coordinated marketing approach will be required, however, to make full use of our ports in the future. About $14 million will be needed for a container and a dry bulk facility at Albany. Because of western coal coming into New York through the ports of Buffalo and Ogdensburg, new bulk handling facilities may be needed at these ports as well. Investments in facilities for each port to develop its special potential were subjected to a detailed financial analysis and found to yield high benefits to the state as well as to individual ports.

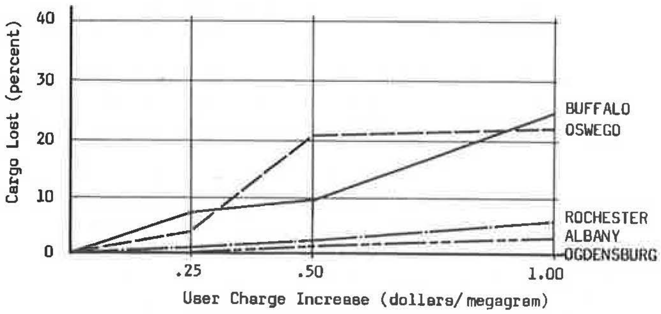
The study showed that the trend toward increasing public port deficits can be reversed. The table below gives three options for the adjustment in user charges in cents per megagram that is necessary to make the ports self-sustaining:

Port	A	B	C
Albany	12	23	23
Buffalo	0	9	25
Rochester	0	0	4
Oswego	0	0	0
Ogdensburg	8	17	32

Option C is the increase that would be required to cover all operating and capital costs, including a reasonable payback of previous grants to the ports. Option B would cover operating costs plus payback of state or county loans, and option A would cover operating costs only. Note that required user charge increases average at most $0.32/Mg. This is substantial compared with existing port charges but a very small amount of the door-to-door total transport cost to the shipper.

Through the assessment of alternative transportation costs, the study identified the savings per megagram of each individual shipment. An aggregation of these results by port is shown in Figure 4. The figure shows two things: first, the percentage of existing and potential traffic as a function of total

Figure 4. Percentage cargo lost versus port charge increases.



transport savings from shipper to foreign port. For example, for the port of Buffalo, about 7 percent of the potential cargo saves less than \$0.25/Mg, 10 percent saves less than \$0.50/Mg, 26 percent saves less than \$1/Mg, and 74 percent saves more than \$1/Mg.

Since Buffalo would have to increase its average rates by \$0.25/Mg to be fully self supporting, we can see that 7 percent of the identified traffic no longer would be least cost if this additional charge were implemented. Thus, the graph is also a representation of cargo likely to be lost as a function of user charge increases.

A closer examination of the Buffalo situation revealed that all the traffic loss due to a \$0.25 user charge increase would be from potential flows--traffic that does not presently move through the port.

Other recommendations of the study included state assistance with common problems through participation in the proposed Upstate Ports Council and formation of a shippers association but no change in the functions or responsibilities of existing authorities.

STATE ROLE

On the basis of this study and the relatively brief experience of NYSDOT in port planning, some general conclusions have been drawn as to an appropriate state role in this area.

States should recognize that ports within their boundaries, like any other transportation facilities, are only means to achieve a more basic objective--in this case, to maximize the benefits of waterborne commerce for all shippers and consignees within their jurisdiction. However, the study found that it is generally in the state's interest to promote the development of the small upstate New York public ports and to maximize their use, and these are certainly concerns of individual port authorities.

A state department of transportation can assist small ports by undertaking planning, marketing, and engineering studies that such ports seldom can afford on their own. Much of NYSDOT interaction with small ports is now handled through our membership in the Upstate Ports Council established as a result of this study. The council provides a forum for the discussion and resolution of mutual problems of the ports in the areas of operations, marketing, facility development, tariffs and port charges, shipper negotiations, and public information.

For the ports to provide necessary services and facilities on a timely basis, they must have a sound financial foundation. This study showed that increased user charges can and should provide this foundation. We see few benefits in making the ports dependent on the public purse. Our role is one of encouraging gradual adjustment of user charges that minimize adverse impacts on our shippers and at the same time allowing the ports to become self-sustaining operating agencies.

These are some port-related activities now seen as consistent with the NYSDOT mandate for planning and development in water transportation. No doubt, as we gain more experience, and as we and others identify new, necessary, and useful state activities, our role will change. At this point, some of the groundwork has been done that will permit us to adapt to new conditions and demands in a responsible and effective manner.

CONCLUSION

The initial study objectives were more than fulfilled. In addition to being a valuable guide for state port policy development, this study provides NYSDOT with additional insights for broad freight, regulatory, and state-local relations concerns. But most important, the study provides valuable guidance to individual port authorities that have now managed to reverse the earlier discouraging trends regarding port deficits.

The study has been given considerable attention in the design of port studies for the New England and the Great Lakes regions. Ultimately, we would like to see the U.S. Maritime Administration maintain a data base for the whole country similar to the one used in this study that could be accessible to New York and other states for low-cost periodic study updates.

We should focus on the ports not as local, state, or regional assets (which they indeed are) but as means to provide the best possible transport service to shippers and consignees. Only then can we encourage coordination rather than competition among the ports and prevent the costly construction of unnecessary facilities and wasteful soliciting of traffic that should move via other modes and ports. Only then can rational state and national policies be developed in regard to future port development.

ACKNOWLEDGMENT

The opinions and judgments expressed on policy issues in this paper are mine and do not necessarily represent those of the New York State Department of Transportation.

Publication of this paper sponsored by Committee on State Role in Waterborne Transportation.

Abridgment

Projecting Commodity Movements for Inland Waterways Port Development

Charles O. Branyan and George D. Mickle, Memphis State University

The inland waterways are receiving greater interest as an energy-efficient, low-cost mode of transportation in a national economy of future energy shortages. As these advantages come to bear on the decision of both shippers and transportation planners, water transportation will likely assume a greater role in the total transportation infrastructure.

Water transportation along the inland waterways has shown significant increases over the past years. As an example, internal domestic waterborne commerce for the United States increased from a total of 173.1 million Mg (190.8 million tons) in 1950 to 361.6 million Mg (398.6 million tons) in 1967 and to 475.4 million Mg (524.0 million tons) in 1976. This represents a 174.6 percent increase between 1950 and 1976 and a 31.5 percent increase between 1967 and 1976.

To accommodate such increases, inland waterway ports are faced with the necessity of planning for port development. Any such planning must consider future commodity movements. This study is one such effort to project such commodity movements for the specific port of Louisville, Kentucky.

THE PROBLEM

In order to plan for port development, it is necessary to project commodity movements for the future. This study was specifically designed to project such commodity movements to the year 2030, starting with a projection for 1985 and projecting tonnages each 5 years thereafter until the year 2000 and each 10 years thereafter (a total of eight projection periods). It was desired to make such projections by major commodity groups as well as for total tonnage estimates.

PRELIMINARY ANALYSIS

The investigators decided to use both time series and regression analysis in attempting to project commodity tonnages. Use of these two approaches required the collection of both historical data pertaining to commodity movements and historical and projected data for any factors that could be considered to be possibly related to commodity movements.

The first step was to identify and define the commodity groups that would be used in the projection process. The framework used in this classification was based on the Commodity Classification for Shipping Statistics of the U.S. Army Corps of Engineers (1). Six commodity groups were selected for both incoming and outgoing waterborne commerce moving through the Port of Louisville facilities. These include (a) coal and lignite; (b) crude petroleum; (c) gas, jet fuel, and kerosene; (d) fuel oils; (e) aggregates; and (f) general cargo.

Collection of historical data followed. U.S. Army Corps of Engineers data were obtained for the period 1950 through 1976 (1). Before 1949, the Corps did not compile data on waterborne commerce on an individual principal port basis. The year 1950 rather than the year 1949 was chosen to allow for the resolution of any possible first-time reporting discrepancy in port statistics for 1949. Selection of these years as the historical base provided 27 years of data.

An analysis of Louisville commodity totals indicated that barge shipments of crude petroleum were lost to pipelines in 1974. Coal and lignite shipments were either nonexistent or of minimal value before 1965. Therefore, shipments of crude petroleum were not considered further. Since the base of historical data for shipments of coal and lignite did not include a sufficient number of years where data were available for the dependent variable, only a time series equation was computed for this commodity group.

The next step in the preliminary analysis was to identify a set of independent variables that could logically have some relation to commodity movements through the Port of Louisville. In selecting these independent variables, it was necessary to consider whether a reliable forecast value of any variable selected would be available for the term of the projections desired. Variables were desired that would include such economic indicators as population, employment, and income. Independent variable data were obtained from Bureau of Economic Analysis (BEA) projections of regional economic activity for the United States, the state of Kentucky, and the Louisville-Indiana Standard Metropolitan Statistical Area (SMSA). These data were compiled from two reports. The first BEA report was published in 1972 for the U.S. Water Resources Council. The second publication (2) was prepared by BEA under contract with the Tennessee Valley Authority (TVA). On the recommendation of BEA representatives, the TVA statistics were chosen over the earlier figures. In some instances, a series of area statistics appearing in the 1972 report were not duplicated in the latter report. In these cases, the earlier reported series was used. Since the latter publication is, in effect, a disaggregation of the 1972 BEA regional report where the majority of the national figures remained the same in both publications, it was believed that no serious bias would be injected into the data. Projected data for the years 1995, 2010, and 2030 were missing. At the suggestion of BEA staff members, the missing values were interpolated on the assumption of exponential growth.

A total of some 14 such series of data were identified. Six of the variables dealt with income variables, five with population variables, and three with employment variables, as given below:

Variable	Area
Total personal income	United States
	Kentucky
	Louisville-Indiana SMSA
Per capita income	United States
	Kentucky
	Louisville-Indiana SMSA
Population	United States
	Kentucky
	Louisville-Indiana SMSA
	Kentucky portion of Louisville-Indiana SMSA
	Jefferson County
Total employment	United States
	Kentucky
	Louisville-Indiana SMSA

In addition, two more variables were added: time and gross national product (GNP).

DETAILED ANALYSIS

The first step in the detailed analysis was to compute a series of time series equations based on the 27 years of historical data available for the 12 commodity classes selected for analysis. Four equations were computed: a straight line; a second degree curve; an exponential curve; and a second-degree exponential curve.

Based on the equations, forecast values were computed for each of the 12 classes, a total of four sets of projected values for each commodity group. As expected, some of the equations were obviously inappropriate for forecasting to the year 2030 and were discarded. Of the 52 sets of forecast values, 31 were retained for further evaluation.

The next step in the analysis was to consider a series of multiple and simple regressions. Historical data for the selected independent variables were available only for the years 1950 and 1960 through 1976, a total of 18 years. Three groups, previously mentioned, were not considered in the multiple regression analysis, which left 12 groups to be considered. The BMD stepwise regression computer program was used in the analysis.

An initial run was made for all 15 selected independent variables. Values of the multiple coefficient of determination (R^2) ranged from a low of 0.5916 for total local movements to a high of 0.9918 for receipts, gas, jet fuel, and kerosene, with six having values of 0.95 or higher, three with values between 0.90 and 0.95, and only three less than 0.90.

The independent variables exhibited a high degree of multicollinearity. The lowest value of a simple coefficient of correlation between independent variables was 0.796. The highest was 1.0. Of the 105 possible simple coefficients of correlation, 31 had values equal to or greater than 0.99, 20 had values between 0.98 and 0.99, 27 had values between 0.95 and 0.98, 15 had values between 0.90 and 0.95, and only 12 had values less than 0.90. The existence of such multicollinearity casts doubt on the reliability of the individual regression coefficients. In this run, of the total of 106 regression coefficients, 64 or 60.38 percent were considered to be not statistically significant because of the high values of the standard errors as compared with the values of the regression coefficients.

The next step was to structure the regression equations in such a manner as to diminish the effects of multicollinearity as much as possible. This step resulted in five separate computer runs in addition to the initial run. Computer runs 1 through 3 are multivariable equations, and runs 4 and 5 are essentially simple regressions. GNP is the independent variable in run 4; the independent variable in run 5 depended on the initial computer selection of the one variable to be entered into regression.

Computer run 1 was made by using only three independent variables, one each from the variable groups of income, population, and employment. The three variables used were selected on the basis of least simple correlation to each of the other two variables. Variables selected were total personal income in the Louisville-Indiana SMSA, population of Jefferson County, and total employment in Kentucky.

Computer run 2 used selected independent variables from the initial run. In an attempt to restrict the inclusion of highly intercorrelated variables, the F-level test of significance for inclusion was set at a more restrictive 0.5 as compared with the level of 0.01 for the initial computer run. This resulted in the selection of seven independent variables. These independent variables were again used in computing regression equations for each of the 12 commodity groups.

Run 3 was essentially a modification of run 2. In this run, a maximum of three independent variables was included in the regression equations. The stepwise program was allowed to continue to the maximum of three variables only if the next selected independent variable was from a group (income, population, or employment) not already included. This meant that equations might have only one or two independent variables.

Run 4 was a simple regression that used only GNP as the independent variable. This run generally resulted in higher values of R^2 for the receipts groups than for the shipments group of commodity classification.

Run 5 used the results of the initial computer run and all 15 independent variables but stopped after the first step. In essence, this was a simple regression that used as the independent variable only the first variable entered into the program for each commodity group.

Forecast values were then computed for each commodity group by using the equations computed in each computer run. This resulted in several sets of forecast values for each commodity group. Between 7 and 10 sets of forecast values were obtained for the various commodity groups including the time series equations retained for further evaluation and the regression equations. The range of forecast values for the earlier years is not excessive since, for example, forecast values for receipts of gas, jet fuel, and kerosene for 1980 range from a low of 3.033708 to a high of 3.69907, a range of 0.665362. This represents a variation of 9.9 percent maximum from the midpoint of the extreme values. However, for the year 2030, the same relative variation is 31.7 percent. These results are not surprising since we are trying to forecast values for 55 years ahead based on a data set of only 18 observations. The range of values of total megagrams for a few selected periods is given below:

Range	1980	1990	2000	2030
High	11.916 82	16.798 74	23.650 15	54.953 98
Low	4.667 64	9.390 39	10.690 73	13.243 92

Up to this point the analysis had been a computational approach relying on mathematical methods to obtain forecast values. Beyond this point, nonmathematical procedures based on the knowledge and judgment of the analyst are necessary inputs.

In this stage of the analysis, such factors as the values of R^2 and the standard error of the estimate, the proportion of Louisville tonnage to national tonnage, the proportion of each commodity group to the total Louisville tonnage, and other forecasts available on a national basis were considered. Based on this analysis, a forecast equation was selected for each receipt category, for each shipment category, and for local movements. These values were aggregated to predict total receipts, total shipments, and total tonnage. The projections selected are given in Table 1.

The projections presented are made on the basic assumption that the economic activities experienced by the Louisville area between 1950 and 1976 will continue into the future. Of course, any projections made into the future for a period of 55 years are subject to extensive revisions as such economic activities may change. Therefore, in using the projected values, a relatively high degree of confidence can be placed in the projected values for the early years, but forecasts for the latter years of the projection should be viewed with caution.

CONCLUSION

The methods used in this analysis are not new or exotic. The investigators made no attempt to force a set of data into any preconceived model for analysis. Rather, the procedures used have ensured an

Table 1. Projected waterborne commerce at the Port of Louisville between 1980 and 2030.

	Megagrams (000 000s)							
Commodity Group	1980	1985	1990	1995	2000	2010	2020	2030
Total receipts	8.766 37	11.535 99	13.124 39	15.316 25	17.278 37	22.503 28	29.873 89	39.019 26
Coal and lignite	1.561 02	2.193 26	2.580 73	3.300 19	4.249 78	6.553 63	10.290 95	15.421 67
Gas, jet fuel, and kerosene	3.272 26	4.013 07	4.278 91	4.753 89	5.212 92	6.341 30	6.378 89	6.394 28
Fuel oil	0.778 64	1.042 56	1.358 12	1.725 32	2.144 16	3.136 75	4.335 89	5.741 58
Aggregates	1.505 82	1.996 95	2.219 68	2.361 69	2.200 13	2.265 44	3.475 35	4.747 41
General cargo	1.648 63	2.290 15	2.686 95	3.175 16	3.471 38	4.206 16	5.392 81	6.714 32
Total shipments	1.125 05	1.407 93	1.694 62	1.983 77	2.274 41	2.857 76	3.442 06	4.029 98
Coal and lignite	0.706 20	0.976 11	1.246 04	1.515 95	1.785 87	2.325 71	2.865 54	3.405 38
Gas, jet fuel, and kerosene	0.021 07	0.011 70	0.006 13	0.003 03	0.001 42	0.000 25	0.000 04	0
Fuel oil	0.081 45	0.072 97	0.064 47	0.055 98	0.047 49	0.030 51	0.013 54	0
General cargo	0.316 33	0.347 15	0.377 98	0.408 81	0.439 63	0.501 29	0.562 94	0.624 60
Total local movements	0.095 01	0.101 75	0.110 65	0.121 69	0.134 89	0.167 74	0.209 20	0.259 25
Total	9.986 43	13.045 67	14.929 66	17.421 71	19.687 67	25.528 78	33.525 15	43.308 49

Note: 1 Mg = 1.1 tons.

orderly collection and analysis of the factors considered relevant to the study as limited by the availability of projected values for the selected factors. It is believed that these study methods could be applicable to other, similar studies that may be undertaken in the future.

ACKNOWLEDGMENTS

This study was funded by the U.S. Army Corps of Engineers, Louisville District, and conducted by the firm of Allen and Hoshall, consulting engineers, of Memphis, Tennessee. The methodology and opinions expressed in the paper are ours. They do not represent any official opinion of the U.S. Army Corps of Engineers or of the firm of Allen and Hoshall.

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Publication of this paper sponsored by Committee on State Role in Waterborne Transportation.

Abridgment

Statewide Waterborne Commerce and Port Development Planning

Rodger P. Kester, Missouri Department of Transportation

The majority of our country, both in geographic territory and population, is accessible via its inland, coastal, and Great Lakes waterway system. Yet the approaches to port development of the states possessing elements of this vast transportation system vary from benign neglect to extensive funding, construction, and operation of ports and port facilities. This paper briefly describes Missouri's approach.

The state of Missouri is strategically located on the nation's 40 322 km (25 000 miles) of navigable waterways. The Mississippi River system comprises almost 14 516 km (9000 miles) of this total, with over 1613 km (1000 miles) being either within or bordering on the state of Missouri. Missouri's waterway system is complemented by good highway and rail networks covering the state. On this waterway system, Missouri possesses in St. Louis the largest inland waterways port in annual tonnage. Yet, even possessing this complete transportation system and large port, most port development has just happened in Missouri instead of being created.

Missouri's involvement in port development began with the new Missouri Department of Transportation (DOT), created in July 1974 as one of the 14 state departments under reorganization. Within the state DOT, the plan of organization is based on modal divisions, including the Division of Waterways. In addition to the constitutional and legislative powers of the department, the division is responsible for the administration of Missouri's port legislation concerning the creation of port authorities.

Under this legislation, cities and counties situated on or adjacent to or embracing within their boundaries a navigable waterway are authorized to create port authorities. On approval by the Missouri Transportation Commission, these port authorities become political subdivisions of the state and possess the powers granted by these statutes. Additionally, statutes mandate the development and implementation of a statewide waterborne commerce and port development plan. This plan has just been completed by A. T. Kearney, Inc., and provides the basis for this paper.

DEVELOPMENT OF RIVER PORTS

River ports, unlike deep-sea ports, are made up of collections of large processing plants in basic industries and distribution facilities for bulk products. Most river port development has been initiated by private companies. However, local port authorities have enhanced development by creating riverside industrial parks. These parks have been built with local public money and represent a significant investment for most communities. Aggressive local support has been a prerequisite for their success.

Instead of containing large cargo terminals and warehouses designed to transfer cargo from one mode of transportation to another, river ports primarily consist of a series of riverside manufacturing facilities and storage terminals supported by captive cargo docks. Users of barge transportation tend to be companies in heavy processing industries whose shipments originate and terminate at large, capital-intensive production plants and storage terminals. Because of a lack of adequate port planning, this situation often precludes the use of established public cargo-handling facilities and thus causes strip development of private "one plant-one dock" facilities up and down rivers. As an example, 72 of the 86 cargo docks in the Port of Metropolitan St. Louis are dedicated to a single user.

Although the private sector has initiated most river port development, public bodies have also been active in stimulating river-related economic growth. An extensive survey conducted during this study found no standard approach to public involvement in port development. Some states have concentrated development activities in statewide corporations or government departments; however, most states have followed less centralized approaches that allow counties and municipalities to form local port authorities.

Local port authorities offer several distinct advantages for industrial development interests. They are ongoing organizations that specialize in planning and promoting river-related economic development. In addition, port authorities typically are vested with public financing mechanisms used to prepare property for industrial tenants (general obligation and industrial revenue bonds). They typically have eminent domain powers to consolidate land parcels and occasionally are able to provide tax shelters as an incentive to attract new developers.

Some states, particularly in the southern United States, have aggressively used local port authorities as tools to help draw new industry to their areas. In isolated cases, some port authorities have even expanded successfully into a wide range of non-river-related activities, e.g., the hospital construction activities of the St. Paul Port Authority.

Since World War II, prominent port authorities have elected to build riverside industrial parks in addition to establishing public cargo transfer docks. These parks offer a host of advantages to prospective corporate tenants including flood-protected sites, road and rail connections, water and sewer systems, electric power lines, natural gas pipelines, and industrial security.

Many of these services--particularly utilities--are difficult to find in river valleys or even in developed urbanized areas. This fact, combined with the opportunity to share service costs, has been a strong locational incentive for companies seeking new waterside plant sites.

Recent increased public concern over water pollution, environmental protection, and employee safety has enhanced the desirability of the industrial park over scattered individual developments. Parks tend to prevent wasteful "strip development" of rivers by concentrating plants in small areas and thus permitting people to use the greater bulk of riverfront land for parks, marinas, and other recreational or agricultural purposes. In addition, parks with numerous tenants can justify the purchase of sophisticated safety equipment such as oil-spill cleanup devices and fire-fighting equipment. For these reasons, waterside industrial parks should continue to act as magnets for new river-related industrial facilities.

Concentrated park development also opens the door for substantial improvements in transportation productivity through the use of efficient, jointly shared cargo dock facilities. The 1976 Maritime Administration study of the Port of Metropolitan St. Louis found that new park developments could achieve a one-third reduction in port operating costs through the use of shared barge-handling docks that are linked to park tenants by material-handling connections such as conveyors and pipes. Parks offering such options should have a competitive edge over other, more traditional parks or industrial sites in attracting future tenants.

In the past, port industrial parks have taken a long time to develop and have required extensive capital expenditures. Local property owners have made these investments by allowing general obligation bonds to be issued. Because such bonds are paid for by local property taxes, the issuances are subject to voter approval and a number of years may elapse before a public consensus can be formed for such an investment.

Construction costs have doubled in the past decade and consequently river port development represents a major investment decision for medium- and small-sized communities today. In fact, many rural counties in Missouri would have to pool their financial borrowing power to undertake new port development on their own. This large increase in cost has been one of the major reasons for the recent increase in state involvement in port development.

States that take a decentralized approach to port development have traditionally passed port authority enabling legislation and then followed a hands-off policy, allowing local groups to shoulder the development burden. Recently, however, state agencies have begun playing a more active role by preparing statewide development plans, providing technical assistance to newly established port authorities, and acting as liaison between federal agencies and local ports. In several instances, states such as Kentucky and Louisiana have provided outright money grants to local port authorities. In almost every state, economic development departments are helping to market local port development sites. For example, a portion of Oklahoma's $400 000 annual promotional budget, a Tulsa hotel sales tax, and the port's own advertising funds are used to promote the Port of Tulsa. Recent trends in industrial development indicate that states with river development opportunities will continue to play a more supportive role in the future.

Three keys to successful port development begin to emerge from this discussion. They are aggressive local interest, financial commitment, and skilled direction in the beginning. Aggressive local interest and financial commitment stand behind nearly all successful river ports. Without local support most port development efforts have failed. In addition, the presence of a skilled port director during early stages of planning and development has been crucial to fledgling port authorities. Because port development usually involves heavy facility construction, the critical decisions that affect the success of a port are made before building begins. Once dock facilities and other structures are in place, it is normally too late to go back and correct mistakes.

RECOMMENDATIONS

Based on the foregoing discussion of river port development and the statewide study, Missouri is pursuing a much more active approach toward port development than in the past. It is believed that, since the approach is not necessarily state specific, some of the ideas would be applicable and beneficial in furthering port development in other states.

Numerous activities recommended in the study have either been implemented already or are in the process of being implemented. These recommended activities are in five functional areas: organization, planning and administration, finance, promotion, and national issues.

Organization

1. Missouri will retain its existing port organization based on local port authorities. Other states have been successful in using this approach, and there is no apparent gain in establishing a statewide port authority or some other organization.

2. The Missouri DOT is encouraging the formation of a port authority association. Port associations in the state of Washington and in other areas of the country have proven effective in solving mutual problems faced by local port authorities. A similar association in Missouri could speed overall port development.

Planning and Administration

1. The Missouri DOT provides planning and managerial guidance to interested port authorities. Information activities will include the sponsoring of seminars and the preparation of operations manuals on site selection, engineering, and industrial park administration. These are but a few of the areas in which local port authorities may require assistance during the initial development period.

2. Next, the state DOT provides technical assistance to port authorities and interested local government agencies on request and on a regular basis. Where direct staff assistance is reasonably practical, DOT personnel support local port staff functions. For example, the staff helps prepare grant applications and review engineering reports. To foster this, a DOT representative calls periodically on each of the port authorities.

3. The Missouri DOT ensures that all state agencies affected by port development have a chance to review and comment on proposed developments while they are still in the early planning stages. Interested parties are occasionally left out of early planning. Consequently, strong protests from the excluded interest groups create problems that could have been avoided before considerable time and money were invested. Conservation, natural resources, agriculture, and highways are some of the agencies that are included as interested parties.

4. The Missouri DOT acts as liaison between federal agencies and local port authorities. DOT members have established many contacts with the U.S. Army Corps of Engineers, the U.S. Department of Commerce, the U.S. Department of Transportation, and other agencies. The state DOT fosters and uses these contacts to help local port authorities in their dealings with other government agencies.

Finance

1. The state DOT has asked the Missouri Legislature to amend the existing port act so that port authorities can issue general obligation bonds and levy limited local taxes. Both would be subject to local voter approval when the general obligation bonds would be used for initial construction and the tax revenues would be sufficient to cover early administrative costs.

2. The state DOT has asked the Missouri Legislature to appropriate funds for temporary "seed" grants to local port authorities. The authorities could then use the money as matching funds for federal grants to help pay for construction and development. The Missouri DOT will be responsible for allocating the money to local port authorities based on applications for worthy projects.

Promotion

The Missouri DOT and the Division of Commerce and Industrial Development are developing and pursuing a promotional marketing program focused on river-related industrial development opportunities. The program will include trade journal advertisements, direct calls on corporate officials, and responsive assistance provided to parties interested in locating in Missouri.

National Issues

Nationwide interest groups have placed a spotlight on several special issues whose outcome could have a dramatic effect on Missouri's port industry. These issues include Missouri River development, waterway user charges, and the replacement of Locks and Dam 26 at Alton, Illinois. The environmental sensitivity of the natural habitats along the Missouri River and the possible increased consumption of river water from upstream reservoirs in conjunction with unfavorable navigation characteristics and a short operating season may discourage large industrial development along the Missouri River.

Waterway user charges, which appear inevitable, may come either as a fuel tax or as segmented tolls. The enactment of segmented tolls would increase the costs of barge transportation on the Missouri River to the point that navigation would effectively cease and a greater burden would be imposed on the Mississippi above St. Louis. Therefore, the fuel tax approach appears to be the lesser of two evils for Missouri barge shippers.

Congress may approve this year the replacement of Locks and Dam 26, which has become a transportation bottleneck. Although nonreplacement most likely would spur short-term attraction of companies to St. Louis and points south to avoid shipment through Locks and Dam 26, the resulting long-term depression of the barge industry would probably do more harm than good to barge shippers in Missouri. Also, possible failure of the facility would be extremely harmful to Missouri shippers. Clearly, the state of Missouri has a strong vested interest in these national issues and will lobby vigorously for their favorable resolution.

CONCLUSIONS

In addition to these recommended activities, the study identified 17 industries and six locations that have a potential for port development in Missouri. Capitalizing on the identified opportunities could more than double Missouri's port industry. By the year

2000, barge cargo, river-related property taxes, and shipper savings for export grain could be increased substantially. Primary and secondary employment could be increased by as much as 75 percent. A 9 percent increase in employment and a 7 percent increase in the property tax base are possible for the state's total economy through river port development. Clearly this represents a substantial economic stimulus for Missouri.

While river port development generates a wide range of general economic benefits, financing for the proposed development program has been analyzed conservatively and as a business proposition for state government. Spreading new plant opportunities evenly between the years 1980 and 2000 resulted in an approximate increase of $1 270 000/year in state tax revenues and an increase of $1 350 000/year in local property taxes. A benefit/cost analysis (using a 10 percent cost of capital) was then performed on these time-phased cash flows. If this is viewed strictly as a business venture between now and the year 2000, state government could invest up to $9 000 000 annually in port development and recover it completely through increased state revenues. Clearly, the opportunity is there; all that needs to be done is to pursue it, and that Missouri will do.

Publication of this paper sponsored by Committee on State Role in Waterborne Transportation.

Abridgment

Effects of Technological Improvements in Loading and Unloading Containers and Shipborne Barges on Design of Equipment and Inland Ports

Herbert R. Haar, Jr., Port of New Orleans

The inland waterway system of the central United States is serviced by the Port of New Orleans, the second largest port in the nation, and by the Port of Baton Rouge, the fourth largest U.S. port. This system includes some 31 000 km (19 000 miles) of waterways that converge at New Orleans and has resulted in a total freight movement through the lower Mississippi of 368 million Mg (405 million tons) in 1975. The value of the trade in 1975 was $19 billion. This movement was accomplished by both ships and barges. In 1975 there were 13 366 ocean-going vessels and over 190 000 barges moving over these waterways through the New Orleans area.

LASH/SEABEE

The LASH concept was developed by a New Orleans firm, Friede and Goldman, Inc. In addition, Avondale Shipyards, located in the port area, has constructed 20 LASH vessels, and Equitable Equipment Company, located in the port area, has constructed over 3000 lighters or LASH barges. Currently, there are 13 LASH vessels operated by 5 different steamship companies and 3 Seabee vessels operated by one steamship company--all operating from the Port of New Orleans.

LASH/Seabee developments have truly been spectacular. In a period of just 5 years, over $500 million has been invested in LASH motherships and lighters for operation out of the Port of New Orleans. Another $225 million will be spent on construction of LASH motherships in the near future. The Port of New Orleans is now the largest LASH port in the world, and this revolutionary trend is continuing at a rapid pace.

In 1975, LASH cargo movements in the Port of New Orleans accounted for 7 percent of the total general cargo, and projections indicate that before the year 2000 one-third of the total general cargo throughput will be handled by this mode. This is truly a remarkable revolution considering that in 1969 no cargo was using this mode.

CONTAINER HANDLING

Until recent years, conventional general cargo wharves in the Port of New Orleans were not designed for handling containers. Since the Port of New Orleans owns land with areas sufficient for the marshalling of containers along the Inner Harbor-Navigation Canal, a master plan for development of 113 hm^2 (280 acres) was prepared. The France Road Terminal, ideally located at the intersection of the Inner Harbor-Navigation Canal and the Mississippi River-Gulf Outlet, is half complete. The terminal is served by roads, railroads, and I-10.

The movement of containers is not limited to full containerships. Containers move on inland waterways by barge to be loaded on LASH or Seabee vessels. They move by rail, highway, or air to be loaded on the decks of many types of vessels.

A convenient form of shipment of containerized cargo involves what is referred to as roll-on/roll-off (ro/ro). Containers or "piggybacks" can be driven onto or from vessels via specially designed ramps and piers. This form of container movement eliminates the need for a crane, and vessel turnaround time is excellent. The ro/ro operation represents progress in door-to-door shipment of general cargo. The effect of this new mode of shipping on the port has been in the form of modifications to general cargo wharves where there is sufficient area for the marshalling of the containers. The facilities at Dwyer Road and Florida Avenue on the Industrial Canal have been augmented to accommodate the ro/ro operations.

In order to supply the throughput of containers to the vessels previously discussed, intermodal facilities for handling containers have evolved in the port area. Many of the rail yards that previously contained boxcars loaded with breakbulk cargo now contain trailers on flatcars and containers on flatcars.

SHALLOW DRAFT RIVER PORTS

The effects of progress made in the transshipment of cargo on the design of inland ports are somewhat similar to the effects on the design of ocean ports but on a smaller scale. On the Mississippi River, the ports of Greenville and Memphis provide good examples of well-planned inland ports.

The Port of Memphis is a regional port 1175 km (730 miles) from the mouth of the Mississippi River. It is located at one of the large metropolitan areas in the mid-South. The organization of the Memphis and Shelby County Port Commission resulted from a navigation project designed to close off the Tennessee chute of the Mississippi River at Memphis, thereby making available almost 2023 hm^2 (5000 acres) of land for industry and more than doubling the harbor frontage in Memphis.

The principal function of the port commission is developing waterfront industrial areas and getting industries to locate on them. It planned and constructed the access road, railroads, utilities, and sewerage and drainage facilities in the industrial areas. The port commission constructed a public terminal that has been leased to a private company. Three other public terminals are contingent on action by the U.S. Army Corps of Engineers. Recommendations have been made by the Mississippi River Commission to the U.S. Army Chief of Engineers that an additional 400 hm^2 (1000 acres) be provided by dredging and maintaining a $27 million general navigation channel extending from the existing Tennessee chute harbor channel to the west of the landfill on President's Island.

Total freight handled through the Port of Memphis in 1976 was over 10 million Mg (12 million tons).

The Port of Greenville, Mississippi, is a subregional port on the Mississippi River 864 km (537 miles) from the mouth.

The Port of Greenville is a U.S. port of entry with a resident collector of customs; it offers facilities to serve industries that handle direct shipments to and from foreign markets. Total cargo handled at the port in 1976 was about 2.4 million Mg (2.7 million tons).

CHANGES IN FUTURE DESIGN OF NAVIGATION STRUCTURES AND PORT LAYOUT AND EQUIPMENT

The impact of barge-carrying ships on port systems and inland waterways is tremendous. The original barge-carrying ships were large and required 11.3- to 12.2-m (37- to 40-ft) channel depths. These vessels are getting larger and will eventually require 16.8 m (55 ft) channel depths. The approximate vessel dimensions for the first motherships are as follows (1 m = 3.3 ft):

Dimension of Vessel	LASH	Seabee
Overall length, m	262	266.7
Breadth, m	36	32.2
Draft, m	11.2	11.6

Thus, in many ocean ports, channels must be deepened to accommodate barge-carrying ships. Channels of 17 m (55 ft) or greater are recommended. Locks through which the motherships must pass ought to be properly sized.

Ideally, inland waterways should be available from the hinterland to the ocean port so that a sufficient number of barges can be fleeted, thus justifying the calling of a barge-carrying vessel.

Barge fleeting areas must be provided in close proximity to ports. Inland waterways should be increased in depth from 3.67 to 4.88 m (12 to 16 ft) and increased in width from 45.7 to 91.4 m (150 to 300 ft). Ship locks should be designed with widths of 45.7 to 61 m (150 to 200 ft), lengths of 366 to 457 m (1200 to 1500 ft), and depths over the sill of 15.2 to 18.3 m (50 to 60 ft). Barge locks should be designed for 33.5-m (110-ft) widths, 366-m (1200-ft) lengths, and 4.9-m (16-ft) depths over the sill.

At coastal ports, general cargo breakbulk wharves must be designed longer, wider, and with deeper water [12.2 to 13.7 m (40 to 45 ft)] alongside to service larger ships. They should have the following design criteria: front apron of 12.2- to 15.2-m (40- to 50-ft) width; 41-kPa (850-lbf/ft^2) uniform live loading capacity; adjacent marshalling area of 2 hm^2 (5 acres) or more depending on the type of cargo to be handled; rail service on the front apron and to the transit shed; and a transit shed per dual berth facility of approximately 14 000 m (150 000 ft^2) of area with an open (without column) construction, lighting of 163 lx (15 fc), a sprinkler system throughout, offices for U.S. Customs agents and shipping clerks, and comfort stations for longshoremen and other personnel. General cargo-breakbulk wharves should have a minimum of two contiguous berths measuring 229 to 274 m (750 to 900 ft) each.

At coastal ports, container facilities should have two contiguous berths of 213 to 274 m (700 to 900 ft) of water frontage. The water depth alongside the berth should be 10.7 to 15.2 m (35 to 50 ft). Design criteria for container berths should include minimum open apron width of 30.5 to 45.7 m (100 to 150 ft); crane for container transfer in the range of 40.6-Mg (40-ton) capacity with a cycle of one box every 2 min; apron crane rails of 15.2 to 30.5 m (50 to 100 ft) gauge and loading capacity of 34 to 41 Mg/crane wheel (75 000 to 90 000 lb/crane wheel); apron uniform live load of 41 to 49 kPa (850 to 1000 lbf/ft^2); upland area for container storage of 7.3 hm^2 (18 acres) per berth; paving for uniform live loading of 95.8 kPa (2000 lbf/ft^2); lighting of 32.3 to 53.8 lx (3 to 5 fc) at the container terminal and 215 lx (20 fc) on the wharf apron; a column-free consolidation shed of 4645 to 9290 m (50 000 to 100 000 ft^2) of area with rail access and truck loading docks; a truck weighing scale; and complete perimeter security and intermodal exchange yard in close proximity to the container terminal.

At coastal ports, roll-on and roll-off facilities should be designed according to criteria similar to general cargo-breakbulk wharves. In addition, a ro/ro terminal should have a fixed ramp or portable ramps designed to accommodate the specific vessels to be calling at the facility. The wharf should have a height above mean water level of 1.8 to 2.7 m (6 to 9 ft), and a minimum of 4 hm^2 (10 acres) of marshalling area should be provided with an intermodal exchange yard in close proximity to the ro/ro facility. Other specialized facilities such as bulk terminals, grain elevators, oil terminals, container-handling equipment, dry docks, shipyards, and ship repair facilities can often be left to the private sector to develop. However, they should be considered in the planning when requirements are determined for the long-term development plan of a port.

At coastal ports, the impact of technological changes in transshipment of materials in bulk has been widespread. Dry bulk vessels, oil tankers, and oil-bulk-ore carriers have increased dramatically in size. This in turn has led to a worldwide requirement for deeper channels to ocean ports. Coastal port terminals that handle bulk materials require larger areas for cargo consolidation and require high transfer rates (with a minimum of pollution) to ensure a rapid vessel turnaround.

A well-planned inland river port would be strategically located to serve an industrial or agricultural complex by providing the transfer facilities to accommodate cargo movements by water, truck, rail, and pipeline. It would provide adequate ship anchorage and fleeting areas. It would consist of a variety of cargo docks: multiuser and multipurpose, private and public. The docks would be designed for heavy loading. The port would be equipped to transfer either breakbulk cargo or containers to or from the various modes of transportation.

On the land side of the cargo docks, a well-planned inland port would consist of numerous industries and an intermodal facility. Preferably, these industries would be located so that the by-product of one industry could be used as feedstock for an adjacent industry. The industries would be located where there would be joint sharing of flood protection levees; drainage; sewage and wastewater treatment facilities; water, gas, and electric service; road access; rail services; and barge fleeting facilities.

CONCLUSIONS

The effects of progress in vessel design and the effects of progress in transshipment technology have been such that port facilities of 10 to 15 years ago are now obsolete. This progress has required new design criteria for coastal ports, inland ports, and waterways.

Changes in port terminal design are required not only so that coastal ports can remain competitive with other world ports but also so that inland ports can become competitive in world markets. The design changes consist of deeper access channels to coastal ports to accommodate larger vessels, especially bulk carriers; different types of coastal terminals to accommodate full-container, barge-carrier, and ro/ro vessels; expanded waterways to inland ports; larger locks to accommodate barge traffic on inland waterways; and, finally, concentrated industrial development or industrial park development around inland ports to take advantage of container, LASH, and intermodal transshipment possibilities.

All coastal ports have been affected by the need to accommodate larger vessels and container ships. At coastal ports, a major impact of transshipment progress has been that a need for more space for the accumulation of cargo and port development has shifted to areas of less urban congestion. Coastal ports with connections to inland waterways have been affected by increases in barge traffic associated with cargo transshipment via barge carriers such as LASH and Seabee.

At inland ports, a major impact of transshipment progress has been a need for concentrated development in areas of greatest present and potential industrial and agricultural development. This concentrated development consists of public and private multiuser docks and industrial parks.

Long-range coordinated planning is necessary to deal with technological changes in vessel design and transshipment progress. The time frame for improvements such as deeper channels at ocean ports and larger locks along inland waterways may be in the range of 20 to 50 years. Likewise, inland industrial park development may take as long or longer.

A long-range, phased development plan is the first requirement of orderly port development for coastal and inland ports. This long-range plan should be supplemented and updated by short-range implementation plans for 5 to 10 years.

Long-range planning requires coordination with the federal government so that necessary access channels, locks, interstate waterways, roads, and railroads that connect with the planned port facilities can be funded nationally. Close coordination is required with the state and adjacent municipalities for the promotion of port-oriented industry, secondary highway development, and for utilities and municipal services required for the operation of the port and the associated industries.

In order for the port to react to rapid changes in technological improvements and to the demands of commerce, adequate financing is essential. To obtain this financing, the port must sell to the municipalities the economic benefits to be derived from port operations and industrial development. Port authorities must also encourage the national development of waterways so that the nation can continue to benefit from this cost-effective, energy-efficient means of transportation.

ACKNOWLEDGMENTS

In preparing this paper I have been assisted by a number of people who have contributed significantly to the final product. E. S. Reed, the executive director of the Port of New Orleans, and H. G. Joffray, associate port director, reviewed the paper and made a number of constructive suggestions that were incorporated into the text. Herbert Ashton, a Washington, D.C., transportation consultant; Vernon L. Ljungren, chief engineer, Port of Seattle; Paul R. Lowry, Memphis State University; Paul Sheffield, Memphis Port Director; and Milton P. Barschdorf, Greenville Port Director, served as reviewers of the original outline and the final draft, and their comments and suggestions were invaluable in arriving at the final treatment for the paper.

Pierre Cordell-Reeh, chief of the Planning Department of the Port of New Orleans, provided invaluable aid and assistance in editing and organizing the material. Joe Alost, an engineer in the Planning Department of the Port of New Orleans, did much of the research and coordination with various entities in developing the data and was extremely helpful overall in putting the material together. I am particularly indebted to all of these individuals for their assistance, which made the project possible.

Publication of this paper sponsored by Committee on State Role in Waterborne Transportation.

Inland Waterways in the Soviet Union and Some Comparisons With U.S. Waterways

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An overview of the existing inland waterway system in the Soviet Union and its features and trends of development is presented. The major characteristics of commodity flows, channels, fleets, and ports in the United States and the Soviet Union are analyzed and compared. An economic estimate considers such specifics of U.S.S.R. waterways as the time lag between expenditures and utilization of capacity; the value of waterways in pioneering and developing Siberia and the Arctic area; distribution of costs and benefits in multipurpose projects; and other aspects. The main differences between the U.S.S.R. and U.S. inland fleets are evaluated, and major existing waterways and future projects under consideration in the Soviet Union are described.

The inland waterways system of the Soviet Union consists of more than 145 000 km (90 000 miles) of navigable channels, canals, reservoirs, and lakes, which makes it the longest system in the world--3.5 times longer than the U.S., 5.5 times longer than the German, and 10 times longer than the French waterways systems. However, U.S.S.R. waterways cannot match U.S. waterways in quality. Table 1 (5, 6) compares some of the characteristics of the two inland waterways systems.

The U.S. waterways system in general has much greater traffic density. It should be noted, however, that actual U.S.S.R. traffic density should be doubled because the waterways are frozen during nearly half of the year. The U.S. network contains a greater percentage of canals and canalized rivers. About 87 percent of U.S.S.R. waterways are open rivers where channel depths have been maintained by dredging and river training. A distinguishing feature of the U.S.S.R. waterways system is the great variety of its navigation conditions. For instance, the controlling depths of waterways range from 0.9 m (3 ft) in the so-called domestic rivers to 5 m (16.5 ft) in the major part of the Volga-Kama system. In comparison, the U.S. network is much more uniform.

The condition of U.S.S.R. waterways can be explained in large part by the special hydrologic features of the country and its general transportation peculiarities, e.g., diversity in the hydrologic regimes of the rivers, high seasonal variations in discharges and water levels, the vastness of the Siberian territory where water transportation is virtually the only mode of cargo movement, and the shortcomings of the highway network.

Therefore, it is necessary to single out the European part of the U.S.S.R. waterways system where from the 1930s has been formed what is called the integrated deep-water system of inland waterways (IDWS). The IDWS is highly similar to the main part of the U.S. network, perhaps more similar than any other developed waterways system in the world. The region serviced by the IDWS includes the most developed economic areas of the Soviet Union, those with a relatively high level of industrial and agricultural production.

The shipping of cargo on the IDWS is at the center of the inland water transportation operation of the Soviet Union. The IDWS represents the interrelated segments of canalized river and canals with controlling depth from 3.65 to 5 m (12 to 16.5 ft). Three standard lock chamber sizes are used: 30 x 300 m (100 x 1000 ft), 30 x 150 m (100 x 500 ft), and 16.5 x 150 m (55 x 500 ft). A fuller description of the IDWS will be given later.

During the last 15 years, the total length of the U.S.S.R. waterways system has increased by a factor of 1.2 and waterways with depths of more than 2.5 m (8.3 ft) have increased by a factor of 1.5. Thus, the change in the network of inland waterways was more qualitative than quantitative. In the future, the greatest attention is expected to be paid to improving and standardizing navigation conditions on the existing network and to increasing the percentage of canalized waterways.

WATERBORNE COMMERCE

Inland waterways in the Soviet Union and in the United States are a component part of national, multimodal transportation systems. However, the structure of these transportation systems and the role of waterways in them are somewhat different. Table 2 (1, 3, 4, 8) gives a comparison of the factors that tend to dictate the commodities and types of movements for which each transport mode is best suited. Obviously, these parameters are very conditional. Nevertheless, they indicate that, although areas of water transportation operation in general are similar, the relative effectiveness of water transportation in the Soviet Union is higher in comparison with truck transportation and lower in comparison with rail transportation. In the United States, modal shares are much more balanced than in the Soviet Union where rail traffic predominates (Tables 3 and 4). Domestic waterborne commerce in the United States accounts for nearly twice as much of the nation's megagram-kilometers of intercity cargo (9.3 percent) as it does in the Soviet Union (4.9 percent). In part, this can be explained by the limited duration of U.S.S.R. navigation. The rate of growth in waterborne commerce in the Soviet

Table 1. Characteristics of U.S. and U.S.S.R. waterway networks.

Network	Total Length (km)	Depth ≥2.75 m		Canalized Rivers and Canals		Network Density (km/1000 km²)	Waterborne Traffic			
		Kilometers	Percent	Kilometers	Percent		Teragrams	Megagram-Kilometers (000 000 000s)	Density (Gg/km)	Average Haul (km)
United States	41 130	24 000	60	29 000	72	4.3	511	398	12	770
Soviet Union	145 160	48 000	30	19 000	13	6.5	450	226	3	500
U.S.S.R.-European integrated system	12 400	12 400	100	10 000	78	-	270	158	22	580

Note: 1 km = 0.62 mile; 1 m = 3.3 ft; 1 km² = 247 acres; 1 Tg = 1 102 311 tons; 1 Mg·km = 0.68 ton-mile; and 1 Gg = 1102.3 tons.

Table 2. Characteristics of U.S. and U.S.S.R. modes of commodity transportation.

	Carrying Unit Capacity (Mg)		Speed (km/h)		Fuel Consumption (L/1000 Mg·km)		Cost[a] (¢/Mg·km)	
Mode	U.S.	U.S.S.R.	U.S.	U.S.S.R.	U.S.	U.S.S.R.	U.S.	U.S.S.R.
Inland waterway	1 000-60 000	300-7500	5-13	10-20	6.8	9.0	0.1-0.5	0.16
Rail	1950	2000	40	40	12.7	12.9	0.3-1.5	0.16
Truck	10-15	6	85	50	45.0	26.0	1.0-2.4	4.0
Pipeline	-	-	-	-	-	-	0.06-0.75	0.07
Airline	-	-	750	750	-	-	9-12	9

Note: 1 Mg = 1.1 tons; 1 km = 0.62 mile; 1 L/Mg·km = 0.44 gal/ton-mile; and 1 Mg·km = 0.68 ton-mile.
[a]Official exchange rate of $1.39/ruble.

Table 3. Mode shares of U.S. and U.S.S.R. 1974 intercity freight.

	U.S.		U.S.S.R.	
Item	Megagrams	Megagram-Kilometers	Megagrams	Megagram-Kilometers
Freight (billions)	5.4	4085	7.5	4680
Modal share, %				
Rail	31.1	34.9	47.0	80.0
Truck	36.2	18.7	42.8	6.3
Oil pipeline	15.4	19.5	3.4	6.8
Waterways				
Coastal and Great Lakes	7.8	17.7	1.4	2.0
Inland	9.3	9.3	5.2	4.9

Note: 1 Mg = 1.1 tons; 1 Mg·km = 0.68 ton-mile.

Table 4. Length and density of U.S. and U.S.S.R. modal networks.

	Length (000s km)		Density (000 000s Mg·km/km)	
Modal Network	U.S.	U.S.S.R.	U.S.	U.S.S.R.
Rail	324	172	4.2	26.3
Truck	1100	500	0.7	0.6
Oil pipeline	360	40	2.2	7.9
Inland waterways	41	175	8.9	1.6

Note: 1 km = 0.62 mile; 1 Mg·km = 0.68 ton-mile.

Table 5. Percentages of principal commodities in U.S. and U.S.S.R. waterborne commerce in 1974.

	Including Construction Materials		Excluding Construction Materials	
Commodity	U.S.	U.S.S.R.	U.S.	U.S.S.R.
Petroleum and petroleum products	41.5	12.0	46.8	24.0
Coal and coke	14.7	6.3	16.6	12.6
Iron ore and iron and steel	9.3	2.7	10.5	5.4
Sand, gravel, and stone	11.5	51	-	-
Grains	2.8	1.5	3.1	3.0
Logs and lumber	2.7	19.0	3.0	38.0
Chemicals	5.6	0.3	6.3	0.6
Other	11.9	7.2	13.7	16.4

Union has, however, been relatively high. In the United States, inland water barge traffic has increased over the past two decades at a compound rate of slightly more than 5 percent/year; in the Soviet Union the rate for the same period was 6.6 percent.

The types of commodities moved by water are similar in both countries (Table 5), particularly if sand, gravel, and stone are excluded. Though these commodities make up an unusually high percentage of the megagrams of U.S.S.R. waterborne cargo, they do not exceed 10 percent of total megagram-kilometers. Relatively few bulk commodities account for most waterway traffic in both countries. Amounts of grain and coal are practically the same, but relative megagrams of petroleum and lumber are lower and higher respectively in the Soviet Union.

In recent years, the role of U.S.S.R. inland waterways in foreign trade has increased significantly. Crude oil and petroleum products, coal, iron pyrite, metals, and lumber are all exported. The railroads and the main waterways have numerous points of intersection where cargo is transferred from one mode of transportation to another. Coal from the Ukraine and Asia; Siberian, Kozachstan, and Northern Caucasus grain; northern and Siberian lumber; Ural and Bashkir iron pyrites; and iron ore from the Kola Peninsula and the Ukraine are shipped by combined rail and water transportation. However, the interaction of river and rail transportation has been inadequate up to now. This is explained by the absence of the necessary coordination in the operation and also the low capacity of railroad-port transfer nodes.

A significant portion of freight movements has been carried by mixed river-seagoing ships. These ships, which have drafts of 3.6 to 4.5 m (12 to 15 ft) and may be compared with the miniships system in the United States, are a distinctive feature of U.S.S.R. inland navigation. The operation of ships adapted to navigation both on inland waterways and on the coastal maritime routes has resulted in an increase in the range of shipping and the complete bypassing of seaports.

Another feature of U.S.S.R. water transportation is relatively developed passenger movements. Though passenger traffic on inland waterways makes up slightly more than 3 percent of total traffic (151 million passengers in 1974), the corresponding revenue reaches 15 percent. There are two types of passenger movements: business and pleasure. The first is developed in large urban centers and in regions that have inadequate highway systems. The most common vessels used for these movements are hydrofoils and other high-speed ships. The second form of passenger traffic is vacation traffic, which is served by the conventional luxury vessels and is becoming more and more popular.

CONDITIONS AND TRENDS IN THE FORMATION OF THE WATERWAYS NETWORK

The development of the U.S.S.R. river network and the improvement of navigation conditions on the rivers are being based primarily on the multipurpose use of water resources. This approach is analogous to U.S. development of the Tennessee River and Columbia River basins, but it is extended in the Soviet Union over a much larger geographical scale.

On the navigable U.S.S.R. rivers, in the last 30 to 40 years, a number of hydroelectric power plants have been built to form large reservoirs that regulate seasonal runoff in many river basins. The backwater from dams on the one hand and the augmented water flow during the navigation period on the other have permitted basic improvement of navigation conditions. For instance, after construction of the cascade of reservoirs on the Volga, the controlling water depths have increased from 1.6 to 3.65 m (5.3 to 12 ft) for a distance of 1187 km (1900 miles).

Simultaneously, the multipurpose use of water resources has created the prerequisites for building interbasin connections--navigation canals that join the river basins or the river and marine basins and also approach the large industrial centers.

For many years, economic justification of waterway development in the Soviet Union had been in a rudimentary stage. Decisions had been made based on political rather than economic considerations. But, since the early 1960s, an economic assessment has become a required part of any proposal. Waterways planners have quickly found that traditional methods are not sufficient to justify waterway improvements. Analysis of economic effectiveness has revealed that a number of proven structures with unquestioned importance for the U.S.S.R. economy are not economically feasible when a standard economic evaluation is applied. In response to this situation, a sophisticated methodology has been developed for determining the economic effectiveness of waterways.

The formation of a water transportation network entails relatively heavy capital investments. The approach to the capital investment estimate has to contain a full presentation of expenses and benefits to be expected while taking into consideration the economic features of waterway development. These economic features are

1. The long time lag between expenditures and complete return of capital investment because of the extremely slow buildup of structures to the designed capacity;
2. The value of waterways in the pioneering and developing of certain regions of the Soviet Union, particularly the country's North and Northeast, development of which (in addition to the direct effect on transportation) helps industrial, agricultural, and social formation in contiguous territories; and
3. The linkage between waterways development and two other systems in the national economy: (a) a unified transportation network and (b) the multipurpose use of the country's water resources.

The capacity of structures for ship passage that may be built in the future can be increased only in discrete steps, and this means these structures must be built with large excess capacity. The time required to make full use of this excess is 10 to 15 years and often longer. Hence, the objective feature of hydraulic engineering construction for transportation purposes is the "freezing" of capital investments for much longer periods of time than is the case in other branches of the national economy.

The regional development value of waterways and the great indirect economic effect inherent in them (as applicable to other branches of the national economy) evolve in the course of economic development in many regions of the country, particularly in the East and the North where such development would be unthinkable without waterways. River transportation was imperative for the development of Yakutsk diamonds, for the creation of an oil and gas industry in Siberia, and in many other cases.

The U.S.S.R. inland waterways are used by many organizations for purposes other than transportation. These include the lumbering, fishing, gold mining, and building industries, trade organizations, farms, sports societies, and others. The waterways are invaluable for providing recreation facilities (there are 100 000 privately owned small boats in the Soviet Union).

The majority of those who participate in a water management complex begin to derive economic benefits immediately after a hydroelectric installation begins operation. Water transportation often fails to show a reduction in expenditures as a result of the start-up of the installation and in fact suffers a loss now and then. Channel depths are not increased, lakelike navigation conditions prevail, and the lock must be passed. The fleet must be strengthened for these conditions and is delayed en route.

Water transportation does not begin to derive the full economic benefit of hydraulic engineering construction until the "cascade" of hydroelectric installations is completed because not until then do depths increase over the entire route. It can take as long as 10 years to build these series of hydroelectric installations. The entire cascade of installations, not just a particular one, must be reviewed during the planning stage if a correct assessment is to be made of the economic effectiveness reconstructions will have on water transportation. This is necessary for purposes of correctly apportioning the so-called cascade effect among the individual installations in the cascade.

Research has shown that only about 50 percent of the cost of maintaining the waterways should be allocated to commercial shipments. Based on this concept, the costs allocated to support the activities of other sectors of the economy are excluded when the effectiveness of river transportation is calculated.

The first stage in the creation of an integrated deep-water system in the European part of the Soviet Union has now been completed. Its base is the Volga-Baltic waterway, the Volga and Kama rivers, and the Volga-Don waterway. Conditions over most of the length of these waterways are such that the waterways can be used by ships of up to 3.6-m (12-ft) draft. However, in the chain of hydroelectric reservoirs there are still three reaches with open flow: those on the Volga and Kama rivers and on the Don River downstream of the Volga-Don Canal. The limitations on water traffic in these bottlenecks are to some extent similar to the situation at Locks and Dam 26 on the Mississippi River. The effects of depth and capacity limitations on these reaches include a reduction in fleet capacity, additional shipment costs, and a reduction in the economic effectiveness of operating large, self-propeller vessels and tows. If the last of the cascade dams were operational, the controlling depth of the entire IDWS would be increased by as much as 4.5 m (15 ft). However, after these dams were already under construction, questions about their efficiency were raised. The objections have been based mostly on the large amount of land to be inundated. The decision was finally made to proceed with construction, but slowly, with relatively small annual appropriations.

The U.S.S.R. inland waterways are extremely important to the development of the economic potential of Siberia, the Far North, and the Far East. Water transportation usually plays the role of the pioneer in exploiting the vast natural wealth of the country's eastern regions and in many cases is the sole mode of transportation available.

Multipurpose hydraulic construction, however, is not as influential on the network of waterways in the eastern regions as it was on those in the European part of the country. The principal approach to improving shipping conditions in the eastern regions is one of increasing dredging works combined with partial regulation of river runoff. The result is that today the depths along the main reaches of such major waterways as the Ob', Irtysh, Yenisey, and Lena rivers can accommodate large tows with drafts of from 1.8 to 3.0 m (6 to 10 ft). Still, the steplike nature of the channel dimensions along the rivers in Siberia and in the Far East remains. The shallow bars in Siberian rivers hamper the development of shipments in sea-river types of vessels as well as the provision of transportation to the Arctic coast.

The increase in the length and the improvements in the navigation conditions of the waterways were accompanied by an increase in the volume of waterway maintenance, most of which was in the form of dredging and river training. The volume of dredging increased by a factor of more than 2 in the past 15 years and reached 250 million m^3 (9.8 billion ft^3) in 1975. The U.S.S.R. river-dredging fleet includes suction dredges, which make up 70 percent of the total fleet and have unit capacity of up to 2500 m^3/h (98 250 ft^3/h), and multibucket dredges that have unit capacity up to 600 m^3/h (21 180 ft^3/h). The total dredging fleet capacity exceeds 150 000 m^3/h (5.3 million ft^3/h).

The total capital investment in the development of waterways in the past 15 years has been 955 million rubles ($1330 million) of which 25 percent went into the dredging fleet, 20 percent into strictly navigational structures, and 45 percent into navigational structures of multipurpose projects. Waterway operation and maintenance costs increased 76 percent over this 15-year period and reached about 200 million rubles ($280 million) in 1974. In total about 3300 million rubles ($4600 million) was appropriated for navigation in the past 15 years. According to the U.S. Army Corps of Engineers, $7725 million was appropriated in that period of time in the United States. Note, however, that direct comparison of these figures is very difficult.

Waterways improvement, operation, and maintenance works are financed by the U.S.S.R. state budget, and the waterway network is toll free. The problem of waterways user charges has been studied in the Soviet Union and, so far, all fees have been rejected on the following grounds:

1. Waterways are used for many purposes, including recreation, military, fisheries, water supply, and hydroelectric generation, so that it is extremely difficult to single out commercial navigation.
2. The truck and railroad industries also have a number of subsidies that approximately balance the competitive capability of all three transportation modes.

In general, the current status of the network of inland waterways in the Soviet Union is that of unfinished reconstruction of the most important links, and therein lie the main drawbacks: the steplike nature of depths along the main rivers; the wide gap between maximum and minimum depths, which hampers standardization of transportation equipment; and the lack of communication between some river basins and others (Table 6).

Table 6. Characteristics of major U.S.S.R. waterways.

Waterway	Length (km)	Depth (m)	Locks: Number	Locks: Average Lift (m)	Locks: Chamber Size (m)
Volga River	2000	3.5	6	16	30 × 300
Kama River	1180	3.5	2	25	30 × 300
Don River	500	3.5	1	26	16 × 150
Dnieper River	920	3.5	6	19	30 × 300
Moscow Canal	128	5.5	7	8	30 × 300
Volga-Don Canal	101	3.5	13	10	16 × 150
Volga-Balt Canal	850	3.5	7	13	16 × 300
White-Baltic Sea Canal	222	3.2	19	6	13 × 140
Ob'-Irtysh rivers	6200	2.0-3.0	2	15	18 × 150
Yenisey-Angara rivers	4000	3.0	4	90	18 × 90
Lena	3800	2.2	-	-	-
Amur	2800	2.0-3.0	-	-	-

Note: 1 km = 0.62 mile; 1 m = 3.3 ft.

MAJOR U.S.S.R. WATERWAYS

The Moscow Canal was built in 1937 for multipurpose use including water supply for the city of Moscow and a deep-water connection between Moscow and the main network of waterways. The canal runs a total of 128 km (79 miles) and has five single-chamber locks and two double-chamber locks. The chambers are 30 m (99 ft) wide and 300 m (990 ft) long, and the depth on sill is 5.5 m (18 ft).

The introduction of the Volga-Don navigable canal resulted in the connection of the Volga and Don river basins. Of the total length of 101 km (63 miles), in the artificial section there are 56 km (35 miles) and the remaining 45 km (28 miles) belong to the reservoirs. In the canal there are 13 single-chamber locks that measure 16 x 150 x 4.5 m (53 x 495 x 15 ft).

The Volga-Baltic waterway (1964) joins the waterways of the Volga-Kama basin to Leningrad and the Baltic and White seas. The total length of this waterway is about 850 km (527 miles). On a 350-km (217-mile) canal portion of the waterway, seven single-chamber locks that measure 16 x 300 x 4.5 m (53 x 990 x 15 ft) with a total head of 93 m (307 ft) were constructed. The special feature of the canal is the absence of paved banks. Instead, equilibrium bank slopes have been formed under the effect of the ship waves during operation of the canal.

The White Sea-Baltic Canal connects the Volga-Baltic waterway and the White Sea. Its total extent is 222 km (138 miles), and it contains 19 locks that measure about 13 x 140 x 3.3 m (43 x 462 x 11 ft). The White Sea-Baltic Canal was the first one created under the Soviet system, mostly by the labor of prisoners. Many of its hydroengineering structures were built of wood. In recent years, work has been done on capital repairs and modernization of the structures. The canal now has more military than commercial significance.

Capital improvement of the navigation conditions of the main European rivers--the Volga, the Kama, the Don, and the Dnieper--has been carried out, as stated above, on the basis of building hydroelectric complexes for multipurpose use. Currently, six multipurpose reservoirs have been built on the Volga River, two on the Kama, and six on the Dnieper. All of these complexes include dams with head ranges from 12 to 30 m (40 to 99 ft), hydropower stations, and two chamber navigation locks that measure 30 x 300 x 5.5 m (99 x 990 x 18 ft). The capacity of some locks of this system is currently insufficient. The required increase of lock capacity is to be achieved by building additional chambers that in some cases will be relatively small and intended for small, high-speed passenger vessels only.

THE INLAND WATERWAYS FLEETS AND PORTS

The qualitative changes in the navigation conditions of the U.S.S.R. inland waterways during the past 20 to 25 years have permitted basic changes in fleet classes and capacity.

The following are the main differences between the U.S.S.R. and U.S. inland waterways fleets:

1. A significant part of the U.S.S.R. fleet consists of self-propeller vessels including sea-river ships. Currently, the proportion of self-propeller ships is about 30 percent with respect to the amount of freight and about 55 percent with respect to productivity (megagram-kilometers). After numerous studies, this proportion has been accepted as an optimum. The largest capacity of a self-propeller vessel is 5300 Mg (5830 tons).

2. The tonnage of a tow and subsequently towboat power is much lower in the Soviet Union than in the United States. The largest tow in the Soviet Union is 7500 Mg (8250 tons) with a 1000-kW (1340-hp) boat compared with 60 000 Mg (66 000 tons) and 7463 kW (10 000 hp) in the United States. Average U.S.S.R. towboat power is 2.7 times lower. A study has been conducted of the expediency of operating tows with a freight load of 16 000 to 27 000 Mg (17 600 to 29 700 tons) with a 2985-kW (4000-hp) boat. It is common opinion, however, that further enlargement of tows in U.S.S.R. conditions would be inefficient. An average unit barge loading in both countries is similar. Unlike the U.S. operational pattern, in the Soviet Union a towboat is usually permanently assigned to a specific tow.

3. In the Soviet Union, fleet parameters such as watts per megagram of capacity, speed, and fuel consumption are significantly higher than in the United States.

4. A major part of the U.S.S.R. fleet must have the stronger (subsequently more expensive) hulls in order to navigate on the lakelike multipurpose reservoirs.

It is interesting to note that general trends in inland waterways fleet development are similar in both countries. Table 7 gives changes in some of the fleet parameters during the past 10 years (as a 1974 to 1964 ratio). A rapid increase in power and a corresponding increase in tow-vessel size are the most significant trends in commercial fleet development.

The U.S.S.R. passenger fleet predominantly includes modern two- and three-deck ships used for long-range tourist lines and also a high-speed hydrofoil fleet of the Raceta and Meteor classes. The efficiency of using the large-capacity fleet is reduced by the amount of idle time these vessels spend in ports for processing and waiting for loading operations. This is explained by the insufficient development of the port and docking facilities.

The total volume of cargo handled by inland port facilities is about 400 million Mg (440 million tons). The total extent of the mechanized docking frontage is about 75 km (47 miles) of both common and client docks. As a result of the insufficient number of loaders, the mechanization of the docks remains low. On the average, for each 100 m (330 ft) of dock there is only a little more than one front loader, but study shows that the optimum number should be about two to three loaders. The amount of warehouse space, especially in the transfer ports, is also insufficient; this affects the processing times of the ships and cars and holds up the transfer of cargo between rail and river transportation. One of the most important deficiencies in the current state of the inland ports is poor development of the intraport and approach railroads, which limits the capacity of dock frontage.

Table 7. Parameters of U.S. and U.S.S.R. inland waterways fleets.

Parameter	U.S. Tow	U.S.S.R. Tow	U.S.S.R. Self-Propeller
Barge freight			
Average, Mg	1340	1100	1350
Ratio of increase (1964 to 1974)	1.2	1.4	1.7
Unit power			
Average, Mg/kW	8	5	4
Ratio of increase (1964 to 1974)	0.85	0.85	0.80
Boat power			
Average, kW	1000	373	336
Ratio of increase (1964 to 1974)	1.5	1.5	1.5
Speed			
Average, km/h	9	11	17
Ratio of increase (1964 to 1974)	1.2	1.4	1.2

Note: 1 Mg = 1.1 tons; 1 kW = 1.34 hp; and 1 km = 0.62 mile.

FUTURE DEVELOPMENT OF U.S.S.R. WATERWAYS

Basic Trends

The multipurpose use of water resources remains a basic approach to waterways improvements. However, the trend and structure of the water resources complexes will be somewhat changed. Intensive reconstruction of the rivers is proposed for purposes of reclamation and water supply rather than for hydropower. There is also the problem of redistributing the runoff between basins. Consequently, for the future, in addition to the cascades of reservoirs, navigational use of the large multipurpose canals that connect arterial rivers will be part of the development of the waterways network.

According to existing plans (1, 2), two stages can be distinguished in the future development of U.S.S.R. waterways. During the first stage (7), which may mean approximately 1985 to 1995, the waterways will develop along the following lines. The next phase of the IDWS connecting the main river basins will be completed in the European part of the country, thus providing the conditions needed for the use of large ships and tows with 4.0-m (13.3-ft) controlling depths and even as much as 4.5 m (15 ft). The waterways in Siberia will be improved on the basis of dredging and runoff regulation with controlling depths of 3.0 to 3.5 m (10 to 12 ft).

The basic lines along which the waterways will develop during the second stage (beyond the year 2000) include the formation of an integrated deep-water system for the eastern basins; the combining of the European and eastern systems; and tying the country's unified deep-water system into the water transport systems of Poland, East Germany, the countries along the Danube River, and the countries of Western Europe.

Projects Under Consideration

The following waterways projects are under consideration in the Soviet Union:

1. Partial reconstruction of the Volga-Don and Volga-Baltic waterways--Though these canals are relatively recently built, their dimensions match neither the size nor the speed of the existing fleet.

2. Pechora-Kama junction--There are a number of schemes for adding to the water resources of the Volga River. The most realistic of these is one that calls for the transfer of runoff from the northern basins. Transfer of part of the northern runoff into the Volga by way of the Kama River will have multipurpose importance because it will compensate for withdrawals of water and will increase the output of the hydroelectric stations, stabilize water level conditions in the Caspian Sea, and form new waterways that will link the Pechora River with the IDWS.

An intensive study is under way to divert a part of Siberian runoff to the arid middle-Asia region of the country. A main part of the project is a 2500-km (1560-mile) canal with an average discharge of about 100 m^3/s (36 000 ft^3/s). Navigational use of the canal would provide deep-water connection between the Siberian and Asian waterway systems. However, realization of the project is doubtful because of extremely high construction costs.

A difficult problem is that of maintaining the increased channel dimensions on the bars of the rivers of Siberia; this is essential if cargo is to be delivered to the mines and the oil and gas fields of the Far North. Intensive research is in progress, and the maintenance fleet is being increased by the addition of suction hopper dredges.

In the middle and upper flows of the eastern rivers, a number of hydropower dams with heads of 100 m (330 ft) and more have been constructed. The construction of ship lifts is the only solution here. A "sloping" ship lift is currently being completed on the Yenisey River. The lift chamber is to be mounted on a sloping, self-propelled trolley that travels on rails. The first experience has been rather negative because of limited capacity and operational difficulties and because construction and maintenance costs significantly exceed transportation benefits. Investigations are currently going on in the Soviet Union as to other, more efficient, types of lifts.

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Publication of this paper sponsored by Committee on Inland Water Transportation.

Inland Waterway Ports as Intermodal Freight Centers

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The prospect of using terminals to facilitate solutions to the urban goods movement problem has been recognized since the 1930s. The most recent promising proposal has been for a network of interlocked intermodal freight transportation facilitation centers. This has the merit of being one of the few ideas in which all parties—carriers, shippers, consumers, and urban communities—can win. But it is difficult to implement because of archaic regulations, opposition from labor unions, short-sightedness by carriers, and considerable lag in public terminal policy. The inland waterways ports form a good but not an ideal place for launching a regional network of intermodal terminals. This will require the barge lines to diversify more into general cargoes and inland stores, port cities to augment port development, and the federal government to develop a port policy and enforce equitable arrangements of intermodal interchange.

The prospect of using terminals to mitigate the urban goods movement problem has been recognized for generations. Joseph B. Eastman, coordinator of transportation in 1936, proposed that "railroads could save over $50 million a year by consolidating terminals" and that such a move would improve their competitive position and contribute to community development. In the midst of the Depression, the Interstate Commerce Commission once suggested that "all terminal properties should be thrown open to all users on fair and equal terms." In 1946, Wilfred Owen concluded in The Metropolitan Transportation Problem that "the scattered location and obsolete design of freight terminals and the absence of satisfactory physical relationships among the several methods of transportation create a heavy volume of unnecessary traffic as well as delay and high costs that penalize business, the consumer and the community." More recent studies have brought the urban goods movement problem into sharper and city-specific focus. But studies have produced relatively little progress toward a solution to the freight aspect of the urban transportation problem.

PROPOSAL

Of all the proposed solutions to the urban freight problem that came to my attention at the U.S. Department of Transportation, the concept of a network of intermodal freight transportation facilitation centers (IFTFCs) is the most useful. There have been many difficulties in implementing the IFTFC concept, but at this point it is being proposed that the inland ports, seeking diversification and growth, might constitute the ideal launching points for a regional network of such intermodal terminals. This proposal poses three basic questions:

1. What functions would a network of IFTFCs perform?
2. How well would the concept fit into the structure, functions, and objectives of inland ports?
3. What else must be done to implement intermodal freight service at the inland ports and elsewhere?

THE FACILITATION CENTER

In their final configuration, the transportation facilitation centers (TFCs) would consist of a network of freight terminals around the periphery of each major metropolitan area, tied together by a computerized management information system. Individual units would be organized in accordance with local circumstances very much as ports are today. In most instances, they would be joint ventures that combine public investment with private operations by a third party and serve all carriers on a nondiscriminatory basis.

The TFCs would perform consolidated pickup and delivery service in central business districts on behalf of highway, rail, water, and air client companies. Although designed initially to accommodate small shipments, the TFCs could be used in the collection, storage, transshipment, and distribution of all kinds of freight. They could also be used to provide a basic system of carrier pooling and container interchange. Some carriers could use TFC facilities as inland port of entry for international freight with full or part-time customs and other inspection services. Free-trade-zone and bonded storage facilities could be provided at inland ports. The computerized management information system could perform centralized billing and accounting functions, produce status reports, trace shipments, report container and equipment status, consolidate documentation, perform route and cost analysis, and prepare international shipping documents, export and import reports, and all internal accounts and records.

Benefits

All parties can win in the TFC concept. The carriers can reduce escalating terminal and pickup and delivery costs through economies of scale and improved vehicle utilization. The cities can reduce street congestion and conserve energy by having fewer partially loaded vehicles traversing streets, waiting, and loading and unloading. The shipper, the receiver, and the consumer can achieve lower inventory and distribution costs, better levels of service, and a greater variety of goods at lower prices respectively. Trade-offs will inevitably be involved in any initiative, but this is one of the unique cases in which the major parties in transportation can all win something.

Problems

What has held up such a concept? Beyond the normal inertia confronted by any major idea, however economically feasible or socially acceptable, implementation of the TFC concept is confronted by some pragmatic institutional problems, such as

1. Archaic federal, state, and local regulations that inhibit entry and adjustment of truck service;
2. Union agreements that hinder the efficient intermodal handling, pickup, and delivery of goods in urban areas;
3. Myopic carrier rivalries and practices that interfere with the provision of intermodal service, through routes, and joint rates; and
4. The lack of a positive federal port policy for ports or freight terminals of any kind.

Although the institutional obstacles may appear formidable, the benefits are sufficient to warrant a major try. The point to start may well be the ports, which have had over a century of experience with joint ventures in terminal development. The first step might well be a positive declaration of federal interest in port development backed by some plan approval authority and some funding. Federal support of research and development and demonstration projects are not enough (1).

INLAND WATERWAY PORTS

Whether the inland waterway ports are the ideal launching points for the TFC concept remains to be examined. There are several points in favor of launching TFCs or intermodal terminals. The ocean lines have been in the vanguard of offering intermodal through service. Some are already offering intermodal service arrangements that link all modes of transportation in through routes, joint rates, and single billings. It is conceivable that it may, in the near future, be easier to ship abroad than to some domestic destinations. The ocean lines have the technology to extend these intermodal service arrangements inland and ashore where most of the overseas cargoes originate and terminate. The intermodal containers, roll-on/roll-off ships, and barge-carrying ships enable the ocean lines to transship through the coastal ports and perform other port-related functions (packing, marking, documenting, financing, forwarding, and clearing) at inland points. It is noteworthy, however, that the barge-carrying LASH and Seabee ships are the only technologies that offer the inland waterway ports a distinct advantage over other inland terminal points. There is increasing incentive to perform these functions inland as the coastal ports become less efficient, more costly, and more constrained by encompassing labor agreements.

The energy argument is also favorable to the inland waterway ports. The barge and tow operations are conducted at a fraction of the energy costs for overland trucking and are less energy intensive than rail service in most instances. As energy becomes more restricted and expensive, the advantage of inland ports may increase.

That advantage, however, may be offset by fuel taxes or waterway user charges, depending on what emerges from the joint congressional committee that now has the matter under consideration. The combined impact of user charges and increased opposition to waterway expansion has placed the waterway carriers in a difficult position. The way out could entail some diversification from industrial bulk commodities to a broader base of commercial general cargoes. If this becomes the case, and the carriers are supported in their diversification efforts by local and state port agencies along the rivers, the basis could be laid for a series of intermodal port terminals.

Some federal action would still be required along two lines. The first involves assuring the inland ports of equitable access to inland traffic. This implies proportional inland rates, through routing, and equitable division of through rates. The second involves a positive federal policy on port development with some participation in port and freight terminal financing. These matters are more difficult to accomplish than it is commonly believed.

The difficulties of launching intermodal terminals at the inland ports should not be overlooked. The problems of archaic regulation, labor opposition, and carrier shortsightedness will not simply disappear. The coastal ports will resist being bypassed and having some of their conventional functions transferred to inland ports. They will be joined in this opposition by the long-haul railroads, some of the container lines that use bridge rates, and the longshoremen's unions. Barge lines will have to gear their industrial operations to commercial service and expand their marketing programs. This will be a difficult and audacious undertaking in the face of expanding user charges and a contracting waterway program. Barge-line terminals are primarily transshipment points scattered somewhat indiscriminately along the rivers. Powerful state and local support will be required to create consolidated ports capable of backing up the line's market diversification.

Characteristically, river cities and states have had little involvement in port development. In the 1970s, they have put only 0.1 percent of their transportation funds into port development compared with over 3.0 percent by coastal states. Few of the river states have port authorities or any liaison organization in their departments of transportation that is responsible for port development. Clearly, the river states and cities will have to give more priority to ports and their investment in ports. They would be assisted in such a shift in transportation priorities and investments if federal assistance were given to water ports in the same proportion as it is given to airports, highways, transit, and other modes. A positive statement of federal interest in port development would also assist in rearranging state priorities.

But such a policy declaration does not appear to be forthcoming. Moreover, the federal government appears to be so preoccupied with deregulation that it is not apt to recognize the need for coordinative types of regulation in the near future. Inland ports must be assured of equitable inland access if they are to perservere in the face of almost arbitrary bridge rates to coastal ports. Laws that require rates that are not unduly discriminatory against regional ports, make through routes and rates mandatory, and provide for equitable divisions of through rates are already on the books. Unless they are enforced, the barge lines will not enjoy equitable inland access to diversified general cargoes by rail and truck. Instead of acting as intermodal feeders, the trucks and railroads will cut parallel long-haul rates and keep short-haul rates for the river ports prohibitively high.

CONCLUSIONS

1. The IFTFC is potentially the best answer to the urban goods movement problem.

2. The IFTFC is one of the few ideas that is beneficial to carriers, shippers, consumers, and the urban public.

3. The IFTFC is difficult to implement because of archaic regulation, some union opposition, some shortsightedness by carriers, and some lag in public port and terminal policy.

4. The inland waterway ports form a good but not an ideal network for launching a regional network of IFTFCs.

5. Implementation of an intermodal terminal network at the inland ports will require (a) the barge lines to diversify and expand their penetration of the general cargo markets, (b) the river port cities and states to consolidate terminals and increase the priority accorded to ports in transportation financing, and (c) a positive federal ports policy and enforcement of coordinative regulations that require equitable interchange at the river ports.

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Publication of this paper sponsored by Committee on Inland Water Transportation.

Local and Regional Socioeconomic Impact of the Intermodal Freight Transportation Facilitation Center

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The objective of this research is to formulate a methodology that can be used to evaluate the feasibility of developing an intermodal freight transportation facilitation center (IFTFC) for a region. The purpose of this methodology is to test the feasibility of the IFTFC and to examine its regional effect.

This paper is concerned with the regional socioeconomic impact of an intermodal freight transportation facilitation center (IFTFC). Because of the importance and growing awareness of the concept of IFTFC, the following thoughts on the subject by John T. Norris of the Office of Facilitation, U.S. Department of Transportation, should be reiterated.

Traditionally, a measure of the economic impact of a coastal port on local and regional interests has been a criterion of measurement to justify (a) the existence of the port and (b) the alteration or expansion of the port or both. In more recent years, social impact has become a required consideration, primarily in the context of environmental protection. Even more recently, social impact is occurring in a few major port areas from the point of view of aesthetic and environmental beautification. In almost all cases, however, considerations of socioeconomic impact have been either shortsighted or even after-the-fact processes. The emergence of the inland waterway-Great Lakes port "system," however, provides a new opportunity. That emergence is motivated by new transport technology such as LASH, Seabee, containerization, and roll-on/roll-off (ro/ro); by new techniques of transportation facilitation such as feeder support systems that penetrate the coastal and inland waterways of the nation; and by intermodalism. Thus, the timing is right for before-the-fact, long-range considerations of socioeconomic impact with regard to U.S. inland waterway and Great Lakes ports in the context of IFTFCs.

Systematic analysis through research will ensure advance (before-the-fact) consideration of the local-regional socioeconomic impact of the IFTFC concept for waterway ports. The predicted impact should be portrayed in two distinct time frames: 1990 to 2000 and beyond the year 2000.

The first time frame is important because it relates to the period during which total national transportation demand is expected to double that of today. Without proper or adequate regard, that can be a period of irrationality and shortsightedness, particularly as to decisions of land acquisitions. That could lead to an adverse impact on society and decisions on investment and expansion that could in turn provide a false economic stimulus. That period is also potentially dangerous because of the difficulty of rationalizing what is essentially a long-term investment commitment into a short-term development situation.

In considering the time frame beyond the year 2000, we must do so in terms of projected technological advancement of the transportation industry and the effect such advancement can be expected to have on the transportation industry and the supporting infrastructure. Such projected effect will be interpreted in terms of labor requirements, qualifications, and skill; land and facility requirements including, for example, feeder highways; and supporting (service) industry requirements. The latter requirement will have a peripheral (indirect) economic impact.

Furthermore, an assessment must be made of the ability of a modern waterway port IFTFC to attract new industry and labor to the local and regional areas. A measure must be taken of the impact of such a facility on the character of business in the area, i.e., domestic commerce versus international trade. The premise is that a well-equipped port that offers efficient access to foreign and domestic markets can be expected to have an impact on the character of business in the area. Social impacts beyond the environmental aspect and including but not limited to land use must be identified and analyzed.

In carrying out the needed research, much benefit can be derived from a review of the experiences of the deepwater (coastal) ports, more to avoid than to reproduce or copy their mistakes.

MODELING METHODOLOGY

Figure 1 shows a flow chart of the modeling methodology for examining the socioeconomic aspects of the regional feasibility of IFTFCs. Each of the 14 steps of the operation is further subdivided into areas that require individual examination.

Step 1 begins with the local and regional analysis of the region and is made up of eight areas that are analyzed for past, present, and future growth patterns and trends. The specific subject areas of step 1 begin with area 1.1--an examination of the population of the region for its mix or distribution levels as to age, sex, race, religion, education, household type, and income. In area 1.2, the housing of the region is examined for its mix, value, condition, acreage, design type, and makeup. The employment of the region is determined in area 1.3: the number of employed persons working in basic industry, local service industries (retail, services, and education), and the unemployed. Area 1.4 is concerned with the amount of land area and its value for the region. The various categories of land use considered are basic industry, local serving, residential, streets and highways, open, undeveloped, and other. In area 1.5, the public facilities of the region are examined as to their type and location, and in area 1.6 the region's tax base and authority are investigated as to tax revenues generated and the associated services provided. In area 1.7, zoning patterns and current purposes of zoning throughout the region are analyzed. Finally, in area 1.8, the financial strength of the region and its ability to generate funds for public works projects are analyzed.

In step 2.0, regional modal and intermodal transportation stock is inventoried as to its condition and location. In area 2.1, the primary transportation modes--rail, pipe, water, motor, and air--are examined. In area 2.2, the primary transportation carriers (e.g., freight forwarders, parcel post, air express, and shippers' associations) are examined. Finally, area 2.3 concentrates on the intermodal capabilities and linkages of piggyback, trailer ship, LASH, ro/ro, and Seabee.

In step 3 the information form step 2 is used to review the modes and their operating characteristics concerning costs, revenues, profits, regional capabilities, energy use, environmental effects, employment, and ability to use containerization.

In step 4 the extent and type of actor groups that exist throughout the region are determined. The inventory begins with area 4.1, the examination of the political and governmental makeup of the region. In area 4.2, the political officials of the local, county, state, and federal governments that represent the region are examined. In area 4.3, the rest of the actors that have an effect on the region are studied. This group would be composed of chambers of commerce and other business, labor, and transportation-affected groups (modal actors, shippers, and manufacturers), environmentalists, and so on. In areas 4.4 through 4.8, sociopolitical pressures, environmental pressures, funding capabilities, implementation processes, and the inherent bureaucracy as well as specific problems and objectives peculiar to the region are reviewed.

In step 5, the ways in which the above groups, structures, and constraints react and interact given certain situations or stimuli are examined.

Step 6, which is made up of 10 parts, is concerned with analyzing physical and locational factors that affect IFTFC development. Area 6.1 begins with the definition of the market areas that are relevant to and affect an IFTFC project. Then, in area 6.2, the existing supply and demand capabilities for handling the various types of commodities are studied. Area 6.3 estimates the general market characteristics and their trends, and area 6.4 estimates future demand. In area 6.5, the competitive nature of the market in the transportation of goods within and through the region is evaluated, and in area 6.5 the outline of a tentative development approach begins. In area 6.7, the input-output model is used, and in area 6.8 multiplier analysis for the region is performed. The general project development plan, which uses all the data developed above, begins to take shape in area 6.9. Finally, in area 6.10, the project development life cycle is determined.

In step 7, the determination of the future states of the region is completed, and in step 8 a set of possible development options, given the possible system states, is provided. Given the above two inputs, a Markovian approach is applied to determine the level of development of IFTFC operation that would be best for the region. Given this level, the best operation and makeup of services that should be offered are determined in step 9. Tables 1 and 2 (2) give possible transportation and information services that could be offered by an IFTFC.

In step 10, site-location analysis of the IFTFC is performed; the final site location is determined in area 10.1. In step 11, the financial implications of development costs of the IFTFC are examined. Areas 11.1.1 through 11.1.3 determine the final IFTFC development costs, operating expenses, and projected operating income for the size of operation to be developed. Then, in area 11.2, the net operating income or losses attributable to the IFTFC can be determined. This task also examines the region as to any net benefits that will result from the develop-

Figure 1. Study methodology.

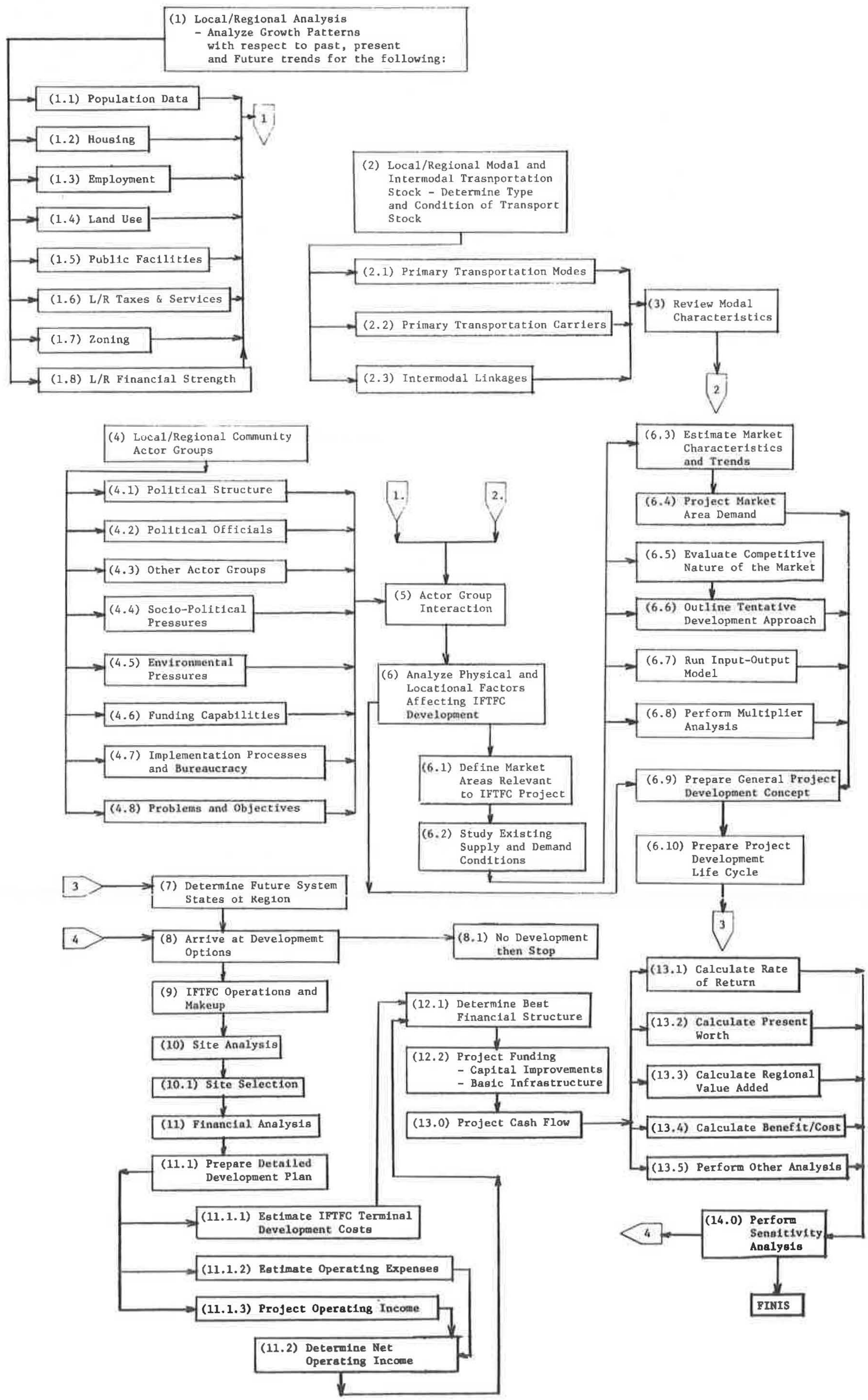

Table 1. IFTFC services.

Service	Mandatory	Desirable
City delivery	X	
City pickup	X	
Consolidation of pickups for delivery to carrier's terminal	X	
Consolidation of pickups for line-haul by carriers		X
Consolidation of pickups for carrier pooling		X
Receipt and breakdown of inbound freight for local delivery	X	
Automated billing	X	
Automated tracing	X	
Over, short, and damaged reporting	X	
In-process (short-term) storage		X
Weight and size determination	X	
COD collections	X	
Palletization		X
Containerization and unitization		X
Interline and intermodal transfers	X	
Automated documentation processing	X	
Management information and reports	X	
Pooling of equipment		X
Container exchange		X
Equipment rental and leasing		X
Equipment service and storage		X
Bonded pickup, delivery, and handling		X
Bonded storage (temporary)		X
Specialty pickup, delivery, and handling		X
Financial services		X
Transportation consulting services		X

Table 2. Services of IFTFC management information system.

Function	Service
Preparation of master bills of lading and waybills	Prepares uniform master bill of lading for consolidated shipments (computer-prepared and forwarded via communication link to carrier or destination IFTFC or terminal) and also accompanies shipments
Recording of shipment status	Maintains on-line status record of in-process shipments
Pickup-and-delivery service routing and scheduling	Optimizes routing and changes in routes and schedules to increase equipment utilization and customer service
Pickup-and-delivery truck load planning	Plans truck loading sequence to minimize time at each stop
On-line shipment tracing	Traces lost and special shipments between IFTFC, carriers, shippers, and consignees
Reporting of loss and damage	Prepares and processes reports and maintains statistical records of manner, location, incidence of occurrence, and disposition
Claim status	Prepares and processes claims and maintains records of disposition of claims
Price auditing	Conducts thorough price audit of IFTFC and others using IFTFC
Consolidated billing	Provides individual memos and generates central billing to carriers using IFTFC
Communications	Provides total integrated communications network including interface with carrier systems and other IFTFCs
Equipment and container status	Maintains on-line record of current location and status of IFTFC equipment and containers and carrier equipment operating in the IFTFC network

ment of the IFTFC (e.g., less pollution, less energy used).

In step 12, the best financial structure for IFTFC development, as well as where and how much of these funds will come from the potential services available, is determined.

In step 13, the projected IFTFC cash flow for years 0 to 25 and expected rate of return, present worth, regional value added, and regional benefits versus costs are calculated. Finally, in step 14, a sensitivity analysis is performed on the steps given above so that reasonable conclusions can be drawn concerning IFTFC development.

FUNDING

Because of the large cost investment in the IFTFC, combinations of the following methods of funding would be the best strategy for developers to follow.

Categorical Granting

One method of funding the various entities involved in the IFTFC is to use the ongoing categorical grant approach. This approach deals with programs that are administered at the level of the state department of transportation (DOT) (in some cases where state DOTs do not exist, modal agencies within the state would administer the program) and coordinated through the local A-95 clearinghouse. Basically, implementation relies on existing legislative structures subject to typical local matching requirements. In this way the individual modes rely on the existing implementation methods in order to develop the public and private intermodal transportation facilities at the IFTFC site.

Arterial Roads and Transit Needs

Arterial roads and potential site-related transit needs currently have categorical granting capabilities. Arterial roads have the federal-aid urban system and transit has the National Mass Transportation Assistance Act of 1974 for possible funding capabilities.

Rail, Air, Pipe, and Industrial Guideway System

Currently, no capital funding categorical grant capability exists for federal funding of rail or rail-yard activities. U.S. DOT-Federal Railroad Administration policy may change on this in the near future. A practical source of funds for rail capital projects that are the property of the IFTFC authority may be the Economic Development Authority capital granting as a "qualified public project."

Air, pipe, and industrial guideway systems (as automatic vehicle movement and automatic cargo-handling facilities) currently have no DOT categorical capital granting avenue open to them.

Water

The U.S. Army Corps of Engineers administers all matters that relate to construction, maintenance, and improvements of rivers, harbors, and waterways for purposes of navigation, flood control, and shore protection. The Corps can also respond (with congressional authorization) to requests for assistance from local interests concerning navigation, flood control shore protection, and other related projects within the region. Though the Corps has not as yet provided assistance for port development, it has provided channels from ocean lanes to port areas.

Site Block Grants

The site block grant method of funding groups all intermodal transportation facilities of water, rail, air, motor, pipe, terminals, and cargo handling into an intermodal "package" program (3). This group package would then be funded as a site block grant and would allow moneys to be used anywhere within the project that is most efficient.

Integrated Grant Administration

The integrated grant administration approach is proposed as a middle ground between current categorical granting and site block grants. This approach is an effort to simplify funding procedures for more than one federal assistance program. The funding process begins with the designation of one of the several federal agencies involved in the project to be implemented as the legal agency for the project. If it is approved, then the process will have required only one application for funds in conjunction with only one audit trail. This approach to multiproject, multiagency funding may ultimately prove the most valuable for IFTFC capital implementation.

Local Funding Sources

Possible local sources of funding include general obligation (GO) and revenue bonds. GO bonds require a referendum that pledges the faith and credit of the city with collateral security of all taxable property. Cities are, however, limited as to the amount of GO indebtedness they can have by state law. In addition, the IFTFC would compete with other city needs and so might be given low public priority.

Revenue bonds can also be used for financing when the issuing agency can provide assurance that income for repayment of the bonds will be in excess of the debt service requirements. Normally, interest rates for revenue bonds are higher than those for GO bonds because of their greater risk.

Other Sources

One final possibility for funding would include general and special revenue sharing for the local government. Revenue sharing, however, would most likely encounter difficulty in meeting the intent and requirements of the 1974 Community Development Act. Further, the IFTFC would be competing with ongoing uses of funds and thus would encounter enormous difficulties.

BENEFITS OF IFTFCs

The major benefits of planned IFTFCs are

1. Lower cost for equal service;
2. Better cost control in delivery of services;
3. Better services and capacity available to carriers;
4. Improved control, safety, and security;
5. Better use of land and equipment;
6. Relief of congestion in urban areas;
7. Lower sunk costs and savings in dollars to the federal, state, and local government;
8. Reduction in energy use;
9. Reduction of regional pollution; and
10. Improved regional employment, economy, and industrial development.

In conclusion, the benefit of conducting research by using the IFTFC concept involves a deeper and more orderly understanding of the processes and interactions that occur with respect to transportation modes and goods movement within a region. It is for this purpose that the methodology was formulated and, through its use, greater understanding of these interactions will result.

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Publication of this paper sponsored by Committee on Inland Water Transportation.

Risk Analysis for Marine Transportation

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Personnel, valuable commodities, and hazardous materials being transported by sea or inland waterway have been lost or released to the environment after serious ship collisions, rammings, or groundings. The quantitative determination of the risks of such events is therefore of substantial importance to marine transportation. Previous studies of ship collision probabilities have been semiempirical in nature, involving various assumptions for navigational behavior or functional dependencies. This paper derives the necessary physical relations implied by stochastic behavior through the introduction of a ship collision probability flux. The model yields analytical expressions for the probabilities of ship collisions and includes rammings and groundings as special cases. In addition, explicit expressions are given for the probabilities of a ship's being the struck versus the striking vessel. Suggestions for various applications of the stochastic flux model are presented.

It has been customary to begin any discussion of ship collision probabilities by stating that, in principle, collisions should not occur at all since the movement of ship traffic supposedly takes place under rules of the road and operating plans that are designed to prevent collisions. Collisions are, therefore, indisputable evidence that the movements of at least a small number of ships for short periods of time are not orderly. Hence, it appears reasonable to assume that the movement of ships will sometimes, though infrequently, be stochastic. Indeed, this behavior has usually been either explicitly or implicitly assumed in studies of ship collison probabilities because the specific errors or malfunctions that sometimes result in collisions are so highly variable and nonsystematic that the overall ensemble of errors or malfunctions resembles a stochastic process. However, in previous modeling attempts, further specific functional relations or navigational behavior was also assumed to obtain collision probabilities.

This study shows that these additional and more elaborate assumptions are not only unnecessary but are also not permitted by the first assumption. This paper develops a generalized model, based on the single assumption of stochastic motion, from which expressions are derived for the probability of a ship collision, the expected number of ship collisions, the probability that a ship involved in a collision is the striking or struck ship, and the frequency of ramming or grounding.

STOCHASTIC FLUX MODEL

Under the assumption of stochastic motion, the movements of ships are not correlated; the ships under consideration will not interact before a collision occurs. Thus, the analytically insoluble problem of N interacting bodies is reducible to a problem that involves only the two colliding ships. It is convenient to analyze a two-body problem in the center of a mass coordinate system so that, in effect, it is reduced to that of a single body of reduced mass moving about the other body at the relative velocity between the two bodies (1).

Accordingly, the collision problem for ships S_i and S_j of lengths l_i and l_j, widths w_i and w_j, and velocities $\vec{v}_i$ and $\vec{v}_j$ respectively, in the global reference frame shown in Figure 1, is transformed into the equivalent one-body system shown in Figure 2. In the equivalent system, the collision energy is immediately given by $E = (1/2)\mu v_R^2$ where μ is the reduced mass and v_R is the relative velocity. The collision angle is defined as θ_R rather than θ, which determines only the orientation of the striking ship.

If the speed of each ship is constant in a region of characteristic dimension D (area D^2), the probability of a collision between ships S_i and S_j in each traverse of the region by S_i is then

$$C_{ij} = T_i P_j P_{ij} \quad (1)$$

Figure 1. Collision problem: global reference frame.

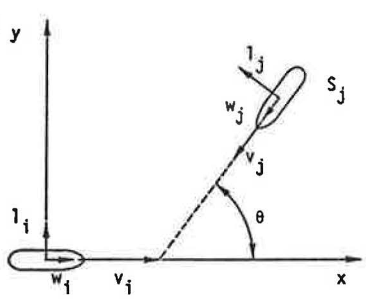
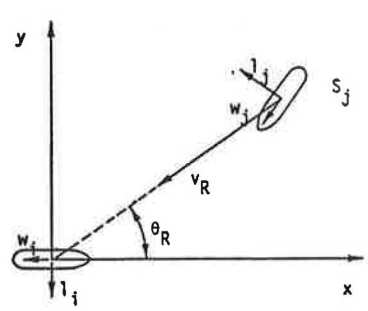


Figure 2. Collision problem: equivalent one-body system.



where

T_i = time S_i requires to traverse D,
P_j = probability of finding S_j in region D^2, and
P_{ij} = probability per unit time of a collision between S_i and S_j given that S_j is in D^2.

If the magnitude of $\vec{v}_k$ is denoted by v_k, then $T_i = D/v_i$ and $P_j = (1/\tau)(D/v_j)$ where, if velocity is specified in meters per second, τ is the number of seconds in a year. To obtain P_{ij}, consider the quantity

$$\Phi(\theta_R) = [\vec{\sigma}(\theta_R) \cdot \vec{v}_R(\theta_R)]/2\pi D^2 \quad (2)$$

where $\vec{v}_R$ is the relative velocity and $\vec{\sigma} = \vec{\sigma}_i + \vec{\sigma}_j$ is the effective collision "cross section"; $\vec{\sigma}_k = w_k\hat{n}_{wk} + l_k\hat{n}_{lk}$ where $\hat{n}_{wk}$ and $\hat{n}_{lk}$ are unit vectors normal to the width and length of the k^{th} ship in the direction that maximizes Φ. Since the quantity denoted by Φ has the dimensions of ships per unit of time, it is appropriately called the colliding ship flux. Clearly, the conditional probability of a collision per unit of time between S_i and S_j is then equal to the flux of colliding ships from all possible directions:

$$P_{ij} = \int d\theta_R \, \lambda(\theta_R)\Phi(\theta_R) \quad (3)$$

where the nonisotropic density function is expressed as follows:

$$\lambda(\theta_R) = v_R^2/(v_j^2 - v_i^2 + v_i v_R \cos\theta_R) \quad (4)$$

Thus, the probability of a collison with S_j per transit of region D^2 by S_i is

$$C_{ij} = (1/2\pi\tau)/(1/v_i v_j) \int d\theta_R \, \lambda(\theta_R)\, \vec{\sigma}(\theta_R) \quad \vec{v}_R(\theta_R) \quad (5)$$

To perform this integration, it is judicious to transform to the variable θ, where $\theta_R = \mathrm{ctn}^{-1}(\mathrm{ctn}\,\theta + \beta \csc\theta)$ in which $\beta = v_i/v_j$.

It should be apparent that the transformation is double valued if $\beta > 1$ but single valued if $\beta < 1$. Moreover, there exists a maximum angle $\theta_R^{max} = \csc^{-1}\beta$ if $\beta > 1$. Clearly, these mathematical properties yield to obvious physical interpretations.

The straightforward evaluation of the resulting integral yields, for $v_j \geq v_i > (D/\tau)$,

$$C_{ij} = \Big((1/\pi\tau)(w_i/v_j)\{2\cos^{-1}[-(v_i/v_j)] - \pi\} + (w_j/v_i)\pi + 2(w_i/v_i)\sin\cos^{-1}[-(v_i/v_j)] + 2(l_i/v_i) + 2(l_j/v_j)\Big) \quad (6)$$

By symmetry, the collision probability for $v_i \geq v_j \geq (D/\tau)$ is obtained by interchanging the i and j indexes on the right-hand side of the equation.

A ship can be expected to enter into a collision mode governed by the preceding stochastic flux equations if it or another ship in the region violates the rules of the road during a fraction α_i of its operational time. In the time interval T_i in which ship S_i is transiting region D^2, the probability of a collision involving S_i and S_j is then

$$C_{ij}^{(\alpha)} = (\alpha_i + \alpha_j - \alpha_i\alpha_j)\, C_{ij} \equiv \alpha_{ij} C_{ij} \quad (7)$$

The probability α_i reflects all factors $\alpha_i^{(k)}$ causing nonadherence to the rules of the road, i.e., human error, equipment failure, or willful negligence. In a first approximation, $\alpha_i^{(k)}$ can be regarded as statistically independent and independent of dynamic considerations so that

$$\alpha_i = \sum_k \alpha_i^{(k)} \tag{8}$$

Therefore, in the absence of statistically significant data on ship collisions, a nonempirical or first-principles estimate of the probability of collision is available through use of fundamental information on such factors as general human behavior and reliability of equipment (2). Whenever meaningful data on ship collisions do exist, of course, an empirical fit for α_i can be performed.

Thus, the probability and the expected number of collisions involving ship S_i during M transits of a region that experiences N ship transits per year are, respectively,

$$C_i^{(\alpha)} = 1 - \prod_{j=1}^{N-M} [1 - C_{ij}^{(\alpha)}]^M \tag{9}$$

and

$$K_i^{(\alpha)} = \sum_{i=1}^{M} \sum_{j=1}^{N-M} C_{ij}^{(\alpha)} \tag{10}$$

Note that the basic collision probability $[C_{ij}^{(\alpha)}]$ is independent of the size of the region. This is because the size of the region is merely the grid size selected for convenience in accordance with data specifications. However, N and M, and thus $C_i^{(\alpha)}$ and $K_i^{(\alpha)}$, vary with D.

SPECIAL CASES

An implicit result of this analysis is that the basic probability of collisions can be analytically partitioned into striking ship and struck ship incidences. If ship i is considered the struck ship when impact occurs along its length and the striking ship when impact occurs along its width (regardless of whether the other ship is also impacted along its width), it is readily apparent that the probability of i's being the struck ship during a transit is

$$C_{ij}^{(\alpha,1)} = C_{ij}^{(\alpha)} (l_j = w_i = 0) \tag{11}$$

and the probability of i's being the striking ship is

$$C_{ij}^{(\alpha,2)} = C_{ij}^{(\alpha)} - C_{ij}^{(\alpha,1)} = C_{ij}^{(\alpha)} (l_i = w_j = 0) \tag{12}$$

In cases where only side impacts can result in serious consequences to ships that are transporting hazardous cargoes, $C_{ij}^{(\alpha,1)}$ is the only important probability.

Since the dynamic variables v_i appear explicitly in this kinematic model, the analysis is adequately generalized to include, as another special case, the frequency of transiting ships ramming stationary objects such as ships at anchor, sand bars, oil platforms, and buoys. That is, if L stationary obstacles are situated in area D^2 and each occupies a rectangular area of dimension η_j and ξ_j, the number of rammings after N ship transits is

$$R^{(\alpha)} = \sum_{i=1}^{N} \sum_{j=i}^{L} C_{ij}^{(\alpha)} (w_j = \eta_j, l_j = \xi_j, v_j = \alpha_j = 0)$$

$$= (1/D) \sum_{i=1}^{N} \sum_{j=1}^{L} \alpha_i [w_i + (2/\pi)(\eta_j + \xi_j)] \tag{13}$$

APPLICATIONS

If the stochastic flux equations are used along with aggregated marine traffic and casualty statistics from seven major harbor areas of the United States during the 6-year period between 1969 to 1975, the validity of the model can be ascertained by comparing its predictions with the historical statistics. The table below gives the expected number of collisions predicted by the model and the number of collisions observed during the 6-year period at each of seven sites:

Harbor Region	Collisions: Predicted (to nearest integer)	Collisions: Observed
Boston	0	0
Galveston	1	2
Long Beach	0	0
Los Angeles	1	1
Mississippi River Delta	1	1
New York	3	3
Tampa	0	0

Details of the analysis can be found elsewhere (3).

The close agreement between expected and observed events is one indication of the validity of the model. The value of the model, however, is not in these simple results, but in its ability to provide a detailed analysis of the risks and sensitivities of specific ships in proposed or existing operations. Under the sponsorship of various public and private organizations, the stochastic flux equations have been applied to particular operations in many other regions that have very diverse characteristics including long narrow channels and wide open bodies of water. The results of the analyses have been used to evaluate, as well as manage, the risks of marine transportation.

DISCUSSION OF RESULTS

Several significant results have been obtained from this model, which is based on a single assumption. By use of Equations 9, 10, 11, 12, 13, and, for total collisions,

$$K^{(\alpha)} = \sum_{i=1}^{N} \sum_{j=i}^{L} C_{ij}^{(\alpha)} \tag{14}$$

these results can all be expressed in terms of a basic collision probability function, as follows:

$$C_{ij}^{(\alpha)} = (\alpha_{ij}/2\pi\tau v_i v_j) \int d\theta_R \, \lambda(\theta_R)\bar{\sigma}(\theta_R) \times \dot{v}_R(\theta_R) \tag{15}$$

The critical functional dependencies derived through the kinematic analysis of stochastic motion are, of course, the necessary relations between the canonical variables v_i and the probability, angle, and energy of the collision. In particular, the following results are noted:

1. The total number of collisions is inversely proportional to the speeds of ships. Thus, in the same number of transits, fewer collisions are expected at higher speeds than at lower speeds.
2. The probability of a collision per unit cross section is significantly greater at small forward angles because v_R is large.
3. Collision energy at small forward angles is considerably greater because energy increases with v_R^2.
4. Optimal velocities exist at which collision probabilities are reduced without a substantial increase in collision energies. Probable losses are minimized at these velocities.
5. The probabilities of collision, of a ship's

being the striking versus the struck vessel in a collision, and the frequencies of rammings and groundings can be intrinsically and analytically related.

Although data have often been said to indicate that course angles are isotropically distributed, it does not follow that collision angles are also isotropically distributed. What has been described as a 90° impact is not normal incidence; 90° simply describes the orientation of the striking ship. Because of the variation of relative velocity and collision energy with collision angle, a 90° impact clearly does not necessarily represent the worst case.

The usefulness of the model discussed here derives largely from the appearance of the canonical variables (v_i). These variables essentially make it possible to exchange spatial information for time-related information, which is more readily available and less variable. That is, it is not necessary to specify a ship's location or course in a region but only to specify the time it spends in the region. Thus, the size of the region D^2 can be viewed as a measure of the imprecision or uncertainty about a ship's position.

The fundamental collision probability integral developed for the analysis of stochastic motion is also suitable for other modes of motion since the density function $\lambda(\theta_R)$ can be arbitrarily perturbed or restricted to reflect nonisotropic distributions of ship orientations in the global reference frame. Thus, specific situations such as ship crossings, meetings, and overtakings can be individually analyzed. However, such efforts to quantitatively predict and restrict future accident scenarios require additional assumptions.

Because all the model results appear in analytical form, the implications of perturbations of the input parameters to reflect excursions from known or existing situations or to explore the sensitivities of the predictions can be easily determined. In particular, the model easily lends itself to the investigation of transportation scenarios projected for specific sites and operations.

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Publication of this paper sponsored by Committee on Inland Water Transportation.

Locks and Dam 26: A Dilemma in National Transportation Policy

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The issue of Locks and Dam 26 and its relation to the issue of waterway user charges represents a critical decision point in emerging national transportation policy. The history, operation, and deterioration of Locks and Dam 26 on the Mississippi River and its place as the legislative fulcrum by which to impose user charges on the waterway system are reviewed. Various types of user charges are defined, and their impacts are quantitatively explored. The relation of user charges to emerging national transportation policy and the current user charge legislation under congressional consideration are discussed. It is concluded that any user charge scheme should be initiated on a partial and monitored scale with respect to capital and operating cost recovery so that the feedback to the national multimodal transportation system can be studied and unstable patterns of use and investment do not result. The implications of rail-water rivalry with respect to modal equity are also considered.

To the casual observer, the U.S. Army Corps of Engineers' Henry T. Rainey Dam near Alton, Illinois, seems a most unlikely subject for a national controversy. This facility, commonly known as Locks and Dam 26, appears a rather ponderous and substantial expanse of iron and concrete spanning the Mississippi River, its passivity underscored by the constant activity of river traffic around it. Yet the structure is not passive but responds dynamically to a myriad of mechanical, geological, and hydrological forces that threaten its physical condition and efficiency. In turn, it is generating economic, political, and social pressures that have brought before the nation the question as to whether the public or its users shall pay for replacement and operation of the facility.

Locks and Dam 26 was authorized by the Rivers and Harbors Act of 1935 and placed in operation on May 1, 1938. The structure has two locks on the north bank of the river, a main lock 30 by 182 m (100 by 600 ft) long and an auxiliary lock 33 m (110 ft) wide by 109 m (360 ft) long. The dam consists of a gated spillway with three roller gates 24 m (80 ft) wide by 8 m (25 ft) high, and 30 tainter (adjustable flow) gates 12 m (40 ft) wide by 9 m (30 ft) high. The dam impounds a pool at a maximum elevation 127 m (419 ft) above sea level, which extends 64 km (38.5 miles) up the Mississippi River to Locks and Dam 25 and 129 km (80.1 miles) up the Illinois River to the LaGrange Lock and Dam (1).

Locks and Dam 26 is the penultimate facility of 27 locks and dams on the upper Mississippi River that create navigable, slack water pools for a total of 1079 km (669 miles), from the Upper St. Anthony Falls near Minneapolis to Locks and Dam 27 near Granite City, Illinois. Under the Rivers and Harbors Act, the Corps of Engineers was authorized to maintain a 2.7-m (9-ft) navigation channel depth between Minneapolis and the confluence of the Mississippi and Missouri rivers approximately 13 km (8 miles) downstream of

Locks and Dam 26. The Illinois River, which stretches from Lake Michigan at Chicago to its confluence with the Mississippi 24 km (15 miles) upstream from the facility, is similarly maintained at a 2.7-m channel depth.

The middle Mississippi (from the confluence of the Ohio River and the Mississippi to the mouth of the Missouri River) provides a 2.7-m-deep channel for access to and from the facility for the lower Mississippi and the Ohio River. The lower Mississippi has a channel depth authorization of 3.6 m (12 ft) but is presently maintained at that depth only from the Gulf of Mexico to Baton Rouge, Louisiana. Moreover, the strategic geographic position of Locks and Dam 26 is illustrated by the fact that it provides waterborne access and egress to over 21 states plus the Great Lakes and the Atlantic Ocean (2).

The facility at Alton enjoys an economic status commensurate with its geographic significance. In 1976, the facility handled more than 52 million Mg (57 million tons) of bulk commodities. Substantial amounts of grain, particularly corn and soybeans, move south through the facility to lower Mississippi ports for export and domestic markets. Nitrogen and phosphate fertilizers and petroleum move northward to farming areas and utilities. Thirty percent of total U.S. grain exports--over $4 billion--moved through the locks in 1976. The commodities and their 1976 amounts (3) are given below (1 Mg = 1.1 tons):

Commodity	Megagrams (000s)	Percentage of Total
Grain	27 702	53
Petroleum	6 409	12
Coal	4 700	9
Chemicals	4 751	9
Sand and gravel	674	1
Iron and steel	2 236	4
Miscellaneous	6 081	12
Total	52 553	100

Although these figures speak eloquently of the importance of the Alton dam, the same statistics illustrate its most severe shortcomings. Originally designed for a practical annual capacity of 37.7 million Mg (41.5 million tons), the barge traffic achieved that capacity in 1968 and has steadily increased since that time (4). The maximum capacity of the facility and when that capacity will be reached are open to question. Assuming an "infinite queue," use of switchboats, facility improvements, and improved traffic handling, estimates have ranged from 66 to 80 million Mg/year (73 to 88 million tons/year). According to Corps of Engineers projections, these levels may be achieved between 1980 and 1990 (5). A vivid illustration of the practical difference between effective and maximum capacity is provided by the fact that delay time per tow averaged approximately 8 h for both locks in 1976.

A second problem suffered by Locks and Dam 26 is its physical deterioration. The Corps has undertaken nine major repairs to the facility since its 1938 inception. These repairs were not attributable to navigational mishaps but to scouring, voiding, and design inadequacies (6).

A variety of solutions have been offered for the problems confronting Locks and Dam 26. Beyond maintaining the status quo, rehabilitation of the existing structure has been suggested. The rehabilitation option has not, however, been well received by Congress; both the House and the Senate have opted for replacement of the existing facility by a new locks and dam approximately 3 km (2 miles) downstream from the present facility.

Of critical importance in the economic struggle over Locks and Dam 26 is the interrelationship between two competing modes of transportation. The waterway interests maintain that the rail mode is attempting to arrogate potential future traffic to which the barge industry would rightfully fall heir. The railroads, on the other hand, maintain that such future traffic is an unjust enrichment of waterway interests because of the current, allegedly total, subsidization of the waterways by the federal government.

It is not the purpose of this paper to determine the proper successor to the riches of future traffic but to analyze the scenarios of commodity shipments through either improved or unimproved Locks and Dam 26, the magnitude and direction of traffic dimensions (if any), and the ultimate impact on both modes. Again, the existing facility has a maximum annual capacity of 66 million Mg (73 million tons). The capacity of a single 364-m (1200 ft) lock (as currently before Congress) has been estimated to be 78 million Mg (86 million tons). It should be noted, however, that such figures by themselves are of little use unless one considers the capacity of the waterway systems that serve the facility. If the constraint of the present facility is assumed to be reduced by the proposed replacement structure and existing constraint points remain constant, Locks and Dam 26 would be subject to a total traffic of almost 93 million Mg (102 million tons). By the year 2035, these capacities reach the levels of 98 and 174 million Mg (108 and 191 million tons) respectively. From these figures, it may be concluded that other constraint points will also become critically important in the future and that the question of traffic diversion caused by a new facility may in the near future become moot.

The U.S. Department of Transportation (DOT) has recently stated that a single 364-m (1200-ft) lock "will not cause significant diversion of existing rail traffic to the waterways" (7). It should be noted, however, that such a statement must be qualified by the fact that legislation now pending in Congress (H. R. 8309, Section 102C2) provides for an evaluation of the need for a second lock at the new facility. This evaluation will consider the impact of such an expansion on the railroads, but an erroneous projection could effect a diversion from rail to barge. Moreover, it could also be valid to note that the railroad industry has for the last 40 years suffered a steadily declining share of total intercity commodity megagram-kilometers--from 75 percent in 1929 to 23 percent in 1970 (8). Any adverse impact that a new Locks and Dam 26 may have on the railroads' modal share must be considered in this historical context.

Even if there is a dramatic increase in the capacity of a new Locks and Dam 26, it does not follow that such an expansion will benefit waterway operators at the expense of rail interests. In a recent study, four class I and II railroads with main-line trackage parallel to the Mississippi River and its tributaries were compared with barge lines throughout the country. In the period between 1946 and 1971, these railroads experienced a 76.2 percent increase in regulated commodities compared with an 18.6 percent increase among the other railroads. The barge lines enjoyed a 673.9 percent increase in the same period. It would appear that, whereas barge traffic shows a phenomenal increase, other market forces are at work that provide the railroads with competitive advantages (9).

USER CHARGES

The commentary above is a natural starting point from which to consider current policy and the legislative process. Current legislation proposes to tie Locks and Dam 26 to "complete recovery" of capital and operating costs on the system. Both the Senate and House bills differ dramatically in their level. The House bill calls for a return on diesel fuel of $0.02/L ($0.06/gal); Senate discussion, undecided at this point, has used numbers that range as high as $0.11/L ($0.42/gal). This indicates a need to look at user charge economics more closely. That will be accomplished by first defining the types of user charges:

1. A fuel tax per liter of tow diesel fuel consumed;
2. A megagram-kilometer fee linearly related to size and length of tow haul and possibly stratified by commodity type;
3. Segment tolls that are assessed on all individual links of the waterway structured as contiguous sections, are insensitive to traffic volumes, and are similar to a classic turnpike toll;
4. Congestion tolls levied at constraint or congestion points as a function of the level of congestion or traffic intensity at these various points; and
5. License fees, bulk fees levied annually on all towboats operating on the river (similar to a taxi medallion charge).

Although these measures have several impacts, it is best to deal initially with the quantitative impacts of some of these types of user charges by using the reach of the river that includes Locks and Dam 26 as the study area.

The river segment that runs from the confluence of the Illinois River to Locks and Dam 27 covers 53 km (32.7 miles). The current breakdown of commodity flow (1) is given below (1 Mg = 1.1 tons):

	Level of Traffic (thousands of megagrams)		
Year	Minimum	Likely	High
1977	–	52 727	–
1980	57 310	63 343	85 421
1985	63 179	77 999	112 699
1990	62 538	91 199	131 504
2000	63 090	115 010	172 020
2010	65 281	128 816	188 576
2020	68 291	144 614	207 120
2030	72 876	163 505	228 249
2035	75 575	174 300	241 568
2040	78 525	185 794	254 513

The calculation of the likely 1977 level of traffic is based on statistics available through September 1977.

The following quantitative aspects of user charges are based on annual commodity flows for 1977. The user charge levels and quantitative structures were derived from the work of Bronzini, Clark, and Strack (10):

1. For diesel fuel, costs to the operator (calculated in U.S. customary units) at $0.06, $0.12, and $0.40 are $0.06/$341 388, $0.12/$682 776, and $0.40/$2 275 920, which results in 6.6, 13.2, and 44.4 percent cost increases respectively to the towing industry. For a 100 percent recovery, a $0.05/L ($0.175/gal) tax is needed.
2. Based on length and size of haul for the segment under study, use of a tax of 0.27 and 0.55 mill/Mg·km (0.4 and 0.8 mill/ton-mile) increases the costs by 14.7 and 29.4 percent respectively and yields a recovery of $759 000 and $1.6 million respectively for system operation and maintenance.
3. Based on a segment toll concept, the upper Mississippi segment that includes this reach shows 50 percent recovery of operating and maintenance costs at 2.2 mills/Mg·km (3.2 mills/ton-mile) and 100 percent recovery at 2.5 mills/Mg·km (3.7 mills/ton-mile).

Although the impacts discussed above are monetarily the most visible readouts of the system, other very meaningful process impacts occur that are worthy of discussion and that could themselves cause real impacts on traffic and transportation systems distribution and costing throughout the entire multimodal and economic network. These include the following:

1. The fuel tax obviously yields a price increase that must be passed on to the consumer. Other literature implies that the potential for diversion to other modes is reasonably small unless the extreme of $0.11/L ($0.40/gal) is incurred. This tax, like other gasoline pump taxes, represents a direct relation to the energy status and policy of the nation and would have to be monitored carefully in light of these factors. To ensure economic stability, these taxes must not be subjected to unstable, highly time-sensitive swings in the pricing mechanism.
2. The megagram-kilometer charge is also a relatively stable charge mechanism, which implies that the increment will be passed on, at least in part, to the consumer. Again, recent simulation literature shows minimal modal-split diversion (10). The accounting and user charge mechanisms appear difficult to administer, based on origin-destination, common arrangements within tows, and other operating arrangements of tow makeup and dispersal.
3. The segment toll, although possibly sound in a microeconomic sense, is definitely a poor tool for in-place transportation systems because each segment is tolled a constant amount regardless of use to administer recovery and operation costs. This results in minimal use of the incentive and development portions of rivers and intermodal locations on the network. As a result, the capability of the waterways to sustain development of new markets and yield focal points for port, terminal, and industrial development is definitely minimized. This process of containment of waterway transportation resources and related multimodal development will only serve to retard regional economic development.
4. The congestion toll system has basic microeconomic appeal but also yields definite short-range stability to a developed transportation system. Although intended to bring about equilibrium of supply and demand, it is most certain to cause wild fluctuations in the use of modal components of the entire network. Although this may seem to serve as a modal diversion tool for the railroads, such a posture is not in the long-run interests of national transportation investment policies. Such an approach is simply too sensitive to time and facility capacity and creates seasonal regulation problems that result in potential oversupply or undersupply of capacity in terms of barges, rail cars, trucks, and so on. This system, although superficially appealing in a statistical sense, belies the true lump sum investment and capacity problems of a multiregional freight transportation system.
5. The licensing fee has properties similar to those of fuel and megagram-kilometer charges. However, its very nature requires that it be a yearly single fee charged per towboat. As such, it is not truly traffic dependent, and its inflexibility may result in overcharging or undercharging for facility operation and a potential reorientation of supply in towboat construction as waterway companies reverse their fleet investment process. It is appealing in its simplicity, but it is not the preferred charge process.

SUMMARY AND CONCLUSIONS

It is appropriate to attempt to synthesize the preceding historical, legislative, and quantitative discussion to structure the issues in a meaningful manner. In summary,

1. Is it appropriate to retard capacity development of one mode because of the financial difficulties and presumed inequities of another? The Regional Rail Reorganization Act of 1973 and the Rail Revitalization and Regulatory Reform Act of 1976 have created highly structured defense plans for bringing the railroads up to par. Obviously, this is an uphill fight, but a plan does exist and is in current implementation. If appropriate user charge conditions are met, to fail to recognize Locks and Dam 26 as the singular constraint on the system is technical ignorance, and not to improve it is to retard capacity stimulus where congestion is obvious. Locks and Dam 26 should be rebuilt in conjunction with a reasonable user charge program.

2. The preferred type of user charge is a head tax on diesel fuel. This tax is simple, is appropriately tied to other issues of national energy policy that affect the whole transportation process, and is directly related to the intensity of traffic. It should also present the most computable, stable, and accurate assessment of traffic diversion and uses of all multimodal facilities for freight. It involves a simple accounting procedure and is easily and accurately administered.

3. Much more attention should be given to appropriate and potentially harmonious intermodal cooperation at the water-surface break-bulk points. It is a known fact that ports, terminals, industrial parks, and private investors all desire to plan and engineer for both rail and water facilities. Historically, joint or through rates have been known to come into being only after the traffic demand has been well established and modal conflicts resolved at each individual break-bulk point. It is appropriate to begin to identify traffic impact points where rail and water interests could, in conjunction with dialogue with present and future shippers, develop through or joint rates that are closely integrated with the type of industrial development and, on the basis of forecasted traffic by commodity type, that improve both rail and water use as a result of present and future stability and attractiveness of price to the shipper.

This is the essence of the current legislative controversy. Although great differences exist in the House and Senate about the level of charge to be imposed, it is clear that one piece of legislation, the Domenici bill, prefers the capability of full recovery in the first round. In light of the past history of the waterways operator and an imprecise quantitative knowledge of the impacts of user charges, this appears to be initially inappropriate. We have only simulated output of the impact. Logically, it is appropriate to tie user charges to capital and operating cost recovery in a subsidy argument. Given that point, it is much more sound in an engineering and system management sense to apply some user charges, watch the system react, and respond to the experimental results with a building-blocks approach and thus develop a sound level of quantitative data than to impose full user charges at the outset, incur great multimodal instability in traffic and investment processes, and thereby create havoc in one or perhaps two modal components. Therefore, the conclusion is that we should impose user charges, coupled with facility recovery plans, but on a graduated and monitored basis.

Finally, it is appropriate to review the issues of user charges and transportation system investment in a multimodal frame of reference. This is particularly important when one views the last 7 years of emerging national transportation planning. We have lived, since 1971, through two studies of national multimodal transportation needs and capital improvement programs based on the most comprehensive requests for data ever made at the state level in our transportation history. In addition, Secretary of Transportation Coleman's administration put forth the National Policy Statement, and we currently have a 2-year commission scrambling to look at long-run needs and financing questions. The point is that to open the question of user charges in relation to rail versus water in this particular time frame is to ignore the core question of modal equity, related multimodal financing concepts, and the structure and place of the mode in current DOT organization. Future effort should be directed to intermodal or multimodal financing arrangements that assess and redistribute, through financing mechanisms, user charges and investment portions across all systems. Whether this takes the form of "one-pot funding" or separate trusts with borrowing provisions, such a detailed review should be made in conjunction with the detailed scrutiny now being given to the issue of rail-waterway facilities investment.

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Publication of this paper sponsored by Committee on Inland Water Transportation.

User Charges and Locks and Dam 26: The View of the Barge and Towing Industry

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This paper briefly reviews the growth and development of the barge and towing industry and discusses the background of the thrust for the imposition of user taxes on users and beneficiaries of the inland river system. The possible forms and levels of such taxes are discussed as well as the possible impacts on rates and modal shifts of traffic. A discussion of the equity of such taxes includes a review of federal subsidies and assistance to the rail industry. Finally, the role of various groups in attempting to define a national transportation policy is examined, and the future of the barge and towing industry is briefly surveyed in the light of recent developments.

The barge and towing industry today is locked in the heat of battle. We find ourselves having to defend our purpose and our mission with segments of the general public. Many environmentalists would prefer that one of America's greatest natural resources, its inland river system, not be used for purposes of commercial navigation. The U.S. Department of Transportation, presumably an unbiased maker of public policy, seems not to understand the barge and towing industry and the role it plays in the nation's transportation system. To understand the nature and possible ramifications of this controversy, it is necessary to step back into history and examine the role of inland waterways in the development of the United States and to see how the needs of the shipping public were met in a very special way.

BACKGROUND

We are familiar with the flatboats and keelboats of the late 18th and early 19th centuries, which brought American settlers floating down the Ohio River and made the dream of westward expansion come true. The flatboats and keelboats gave way in the early 1800s to the steamboats, which for the next 70 years were the principal means of moving people and goods within the U.S. interior. By 1840, an average of ten steamboats a day called at the Port of New Orleans, some carrying settlers upstream to the far reaches of the Missouri River and up the Yellowstone River into Montana, Wyoming, and Idaho.

By about 1880, the railroads had spread across the interior of our country. Their lines, paralleling the Ohio and Mississippi rivers and extending as far north as Minnesota, spelled disaster for river steamboats. Predatory pricing and the vast financial resources of the railroad industry rang the death knell for river commerce shortly after the Civil War.

Once competition was removed, the obvious occurred. Railroads took advantage of their monopolistic position. As a result, there was a demand from the shipping public for an alternative means of transportation.

In 1910, Congress approved a plan for a 2.7-m (9-ft) channel the entire length of the Ohio River to Cairo, Illinois, from Pittsburgh with 54 low-lift dams. In 1917, the government formed the Inland Waterways Corporation, which was directed to reestablish commercial navigation on America's inland river system. In the 1930s, the upper Mississippi River was made navigable all the way to St. Paul through a series of locks and dams north of St. Louis. During this time, the same program was put into effect on the Illinois River, providing 2.7-m navigation to Chicago. The basic infrastructure of the river was now in place and ready to accommodate a share of the nation's transportation needs.

THE CURRENT WATERWAYS SYSTEM

Today we have a waterways system that consists of thousands of kilometers of waterways running from Brownsville, Texas, on the Mexican border to the state of Florida and north to Tulsa, Omaha, St. Paul, Chicago, Pittsburgh, Chattanooga, and other cities. Additional development has created other waterways far from the heartland of America. These would include the deep-draft sea-level canal that connects the Delaware River to the Chesapeake Bay and shortens the sailing distance between Baltimore and Philadelphia by 460 km (286 miles). The Hudson River in New York, as well as the New York State Barge Canal, carries traffic on a continuous inland route from Miami to Norfolk, Virginia, and is segmented above that to the northeast. On the West Coast, navigation channels afford transportation to Sacramento as well as far inland on the Columbia River system to Washington, Oregon, and Idaho.

In the 1930s, the inland waterways system began to grow. The advent of the diesel engine and a sufficiently high power to weight ratio brought modern engines to river towboats and aided in the growth of traffic. In 1947, only about 5.2 percent of the nation's freight moved on rivers and canals. This compares with 56.1 percent (more than 10 times as much) for railroads and 29.4 percent for trucks. Pipelines, Great Lakes shipping, coastal movements by ship, and air freight constituted the balance.

By 1970, the railroad share had decreased to 31.1 percent; the truck share had increased to 36.2 percent, that of pipelines to 15.6 percent, and that of rivers and canals to only 9.3 percent. These figures indicate that modal shifts occurred primarily between rail and truck, largely because of the Interstate highway program and the inability of the railroads to provide the degree of service and reliability demanded by the shipping public. These figures clearly demonstrate that the reduction in the railroad share of traffic is not attributable to barge competition.

THE BARGE AND TOWING INDUSTRY TODAY

Some 1850 companies currently constitute the barge and towing industry. Total industry revenues, according to the Transportation Association of America, are about $950 million/year compared with rail industry revenues of over $16 billion/year.

Because of the inherent advantages of moving bulk commodities by water, barge rates today average 2.7 to 3.4 mills/Mg·km (4 to 5 mills/ton-mile) compared with more than 12 mills/Mg·km (18 mills/ton-mile) for rail. Since the 1973 Arab oil embargo, rail rates have risen substantially whereas barge rates have gone from an average of 3.4 to 3.5 mills/Mg·km (4.9 to 5.1 mills/ton-mile), according to an analysis of regulated rates by Barloon of Case Western Reserve University. In 1975, barge rates actually dropped slightly and for the first half of 1977 averaged 3.5 mills/Mg·km.

Bulk commodities constitute most traffic on the inland river system. In 1975, commodity percentages of total megagram-kilometers were as follows: petroleum and petroleum products, 40 percent; coal and lignite, 20 percent; sand, gravel, and crushed rock, 11 percent; chemicals, 6 percent; grain and grain products, 6 percent; and miscellaneous materials, 17 percent. However, on certain segments of the river these figures change dramatically. For example, in 1976, roughly 50 percent of all freight flowing through Locks and Dam 26 at Alton, Illinois, was comprised of grain and grain products.

The industry moves shippers' freight by using some 23 000 dry cargo barges and 4000 tank barges. Tank barges can be very sophisticated. For example, anhydrous ammonia is carried in pressurized and refrigerated barges at -33°C (-28°F). Other barges carry heated products, such as residual fuel and molten sulphur, at high temperatures.

North of Cairo, Illinois, on the Ohio River and north of St. Louis on the Mississippi and Illinois rivers, lock sizes limit tows to 15 barges. Below St. Louis, where there is open river to the Gulf of Mexico, it is not unusual to have an assembled tow of up to 45 loaded barges, each barge carrying approximately 1350 Mg (1500 tons). To put this in perspective, such a tow would have aboard over 22 million bushels of grain and grain products or the equivalent yield of almost 26 000 hm^2 (65 000 acres) of soybean production. This vessel would be 7.5 MW (10 000 hp) and would carry a crew of 11. Total transit time from St. Louis to New Orleans would be approximately 6 days. This illustrates the very significant efficiency of the river system in moving bulk products.

Approximately 85 000 people work directly aboard the vessels, and an equal number are employed in shoreside facilities that provide direct services to the industry.

USER CHARGES

Until the early 1970s there was very little thrust on the part of the executive branch of government, the railroads, environmentalists, and others to impose a user tax on beneficiaries of public investment in waterways. In fact, as recently as 1973, the rail and water industries cooperated in the formulation and passage of the Surface Transportation Act, which afforded significantly more benefits to the rail industry than to the water industry. It would not be untrue to say that there existed a feeling of harmony between the two modes.

However, in August 1974, a suit was filed by the 21 railroads that make up the Western Railroad Assocation and other suits were filed by the Sierra Club and the Izaak Walton League to enjoin the U.S. Army Corps of Engineers from opening construction bids on the first portion of construction to replace Locks and Dam 26 above St. Louis. Swords were drawn, and since that time railroads and water carriers have been at each other's throats. The replacement of the Alton facility has been a facade. The real issue, of course, has been user taxes.

Although the Congress appropriated several million dollars for design work on the replacement facility during the period between 1968 and 1974, because of an interpretation of the Rivers and Harbors Act of 1903, the replacement project had not been under the jurisdiction of the public works committees of the House and Senate. Congress decided to address the issue once again.

During the process of hearing and debate, it became clear to waterways interests that Senator Domenici of New Mexico was interested in the concept of a user tax. On June 22, 1977, the Senate authorized the replacement of Locks and Dam 26 and coupled with it a user tax designed to recover 100 percent of the federal navigation-related expenditures of the Corps of Engineers on the operation and maintenance of the inland waterways of the United States. The collections would be accomplished on a 5-year, phased-in basis in increments of 20 percent/year beginning on October 1, 1979. As of October 1, 1984, the government would increase these taxes to provide for the recovery of 50 percent of the capital costs of federal navigation-related expenditures on new construction and rehabilitation. These amounts would be phased in over a 5-year period in increments of 10 percent/year.

Under the provisions of S. 790, the Domenici bill, the executive branch would be empowered to establish tolls that would recover these levels of expenditures. These tolls could be in the form of tolls for each segment of the river system on a weight basis, a lockage fee, a congestion fee, a fuel tax, a gross receipts tax, or any system that combined these elements to provide for the specified levels of recovery. An inherent danger in this philosophy is the surrender of taxing responsibility by the Congress to the executive branch as well as the very real prospect that certain newly developed river systems, such as the Arkansas, Missouri, and Kentucky rivers, would be completely shut down because of the high recovery levels. The closure of these rivers would, in turn, decrease the amount of traffic that feeds into the more developed rivers and thus decrease the traffic base and require a greater tax per megagram carried than would otherwise be necessary.

Because of the constitutional question about the origination of tax bills, the leadership of the House of Representatives chose to pursue another route in dealing with the question of user taxes. As a result, on October 13, 1977, the House passed H.R. 8309, which authorizes replacement of Locks and Dam 26 and requires the imposition of a fuel tax on commercial, nonpassenger vessels on inland waterways to take effect October 1, 1979, at a level of \$0.01/L (\$0.04/gal). On October 1, 1981, the tax would increase to \$0.015/L (\$0.06/gal). In the interim a study would be undertaken to determine the impact of user charges and to determine the need, if any, to alter the levels imposed by the bill. As a compromise, the barge and towing industry, many shippers, farm groups, and labor supported the passage of H.R. 8309. This support altered a 200-year tradition of toll-free waterways and ensured that for the first time a user tax would come to pass.

It is estimated that the House version would raise some \$40 to \$50 million/year in additional tax revenues. This may not seem like a significant sum in terms of the overall federal budget, but it is estimated that this figure represents roughly 50 percent of the profits of the barge and towing industry, which would indeed have an impact.

By contrast, the Senate-passed version would impose aggregate recovery levels 10 times those of the House version and result in an increase in barge rates of anywhere between one-third and one-half at the time of full implementation.

There seems to be a wide consensus of opinion that Locks and Dam 26 should be replaced. The present structure, completed in the late 1930s, is not adequate to handle even existing traffic. The annual capacity of upstream rivers is 94.5 million Mg (105 million tons), whereas Locks and Dam 26 can only accommodate some 65.7 million Mg/year (73 million tons/year). Since annual traffic is currently more than 54 million Mg (60 million tons), even a very modest traffic growth will mean increasing delays at the existing facility until the end of the 10-year construction period for replacement facilities. Capacity of the new lock would be equal to or less than the capacity of Lock 27 just south of Alton, which is the lowermost lock in the upper Mississippi system. Below Lock 27, there is open river all the way to the Gulf of Mexico.

In spite of all the charges and countercharges, Congress has made the decision to replace the 40-

year-old Alton facility, and the only question yet to be resolved is the extent to which beneficiaries of the inland river system would be required to repay a portion of the public investment in the system.

Proponents of user taxes have contended that their imposition would have little impact on costs to shippers and, ultimately, to consumers. However, there is little factual information to prove that claim. Certainly we are all aware of the difficulties the steel industry has encountered in competing with imports. To the extent that a user charge is imposed, it will artificially increase the cost of transportation for steel out of the mill areas of Chicago and Pittsburgh to the tremendous markets in the sunbelt and the Gulf Coast areas and thus make imports even more attractive. Does anyone really know what would be the social and economic cost of additional layoffs in the steel industry?

American farmers are at this moment faced with excess supplies and are striking to get government support for at least the cost of production. Today, a quarter of all the land area of farm production goes for export, and a large portion of those export markets are served by barge transportation. The price received by the farmer is the ocean elevator world market price less the cost of transportation back to the farm. The ocean elevator price is determined by world markets over which no one has much control. Low-cost transportation is critical to the maintenance of farm income as well as the ability of the American agribusiness community to compete in world markets. These exports help to earn the dollars so desperately needed to pay for the increasing amounts of oil being imported into the United States.

To those versed in basic economics, it will come as no surpise that the barge and towing industry will in large measure pass on the cost of a user tax to shippers and therefore, ultimately, to consumers. Because the barge and towing industry carries so much of the basic raw materials of American industry, consumers can expect to pay higher prices for electricity, oil, and gasoline and products made from steel, plastics, chemicals, and other natural resources. Such taxes could effect a redistribution of income by taking additional dollars from farmers and consumers and taxing most heavily those who spend the largest percentage of their incomes on the basic necessities of life. In this sense, a user tax would be a very regressive tax.

For years barge contracts have included a provision that clearly stipulates that any user taxes imposed shall be immediately due and payable by the shipper, either as a separate item or through an adjustment in the freight rate. The barge and towing industry, with its thin margins, cannot absorb any level of user tax.

It is axiomatic that the lower the cost of transportation, the wider is the market for certain goods. Clearly, increasing the cost of transportation will impose artificial barriers to the free flow of commerce between various regions of the country.

THE RAILROAD MYTH

Railroad executives have initiated two separate public relations campaigns. The first is aimed at the investing public and the financial community. It paints a relatively glowing picture of the future. For example, the November 1977 issue of Fortune magazine carries a two-page message from the Southern Railway, which says, in part, that, in spite of the public image of U.S. railroads as a dying business, government statistics show that 9 out of 10 of the top railroads are profit-making concerns and that a major growth in the rail share of the freight market is anticipated.

In their other campaign, the railroads place much of the blame for their woes on public investment in waterways. In 1975, Stephen Ailes, then president of the American Association of Railroads, testified before a Senate subcommittee that railroads are losing between $500 and $750 million/year because of competitive barge rates. It seems clear that the principal thrust of the railroads in urging the imposition of a user tax is to inflate the cost of barge transportation artificially so that they may raise their rates proportionately to maintain the same share of the traffic. Thus, shippers and consumers will pay the user tax twice, once in the form of user taxes on the river and in the second instance in the form of higher rail rates.

The fact is that most railroads are very profitable and can look forward to increasing traffic and financial well-being in the future. Those that do not fall into this category must blame their problems on poor management, excess and unprofitable trackage, deteriorated equipment, millions of dollars of deferred maintenance, a burdensome labor situation, and other factors on which the relative prosperity of the barge and towing industry has little impact. It is clear from government reports that there is a significant amount of excess trackage, particularly in the Midwest, and that many of the railroads' problems arise from the inefficient use of a system that was built many years ago and that does not address itself to current shipper demands.

THE QUESTION OF EQUITY

Every mode of transportation in the United States, with the possible exception of pipelines, has received a substantial amount of government assistance during its history. Shallow-draft navigation has benefited from expenditures by the federal government (around $5.3 billion for the period between 1824 and 1976). Highway aid, defined as net public expenditures in excess of trust fund receipts, has been about $8.1 billion. Aviation investment (net of trust receipts) has been $14.2 billion. It is estimated that railroads have received over $21 billion, which includes an estimate of approximately $10 billion for earnings from land grants given during the 1800s. These include significant revenues from oil, minerals, timber, and real estate development during the period of westward expansion.

Railroads contend that they have repaid the federal government for the value of these land grants by charging much lower rail rates to the government than to the general shipping public. It is not difficult to figure that, if the government was getting a favorable rate, the general shipping public was paying the difference in the form of higher rail rates. Therefore, it is not the railroads but their customers who have repaid the government. It is estimated that in 1973 net earnings from land grants of the western railroads amounted to some $500 million/year. Standard and Poors notes that since 1946 the railroad industry has enjoyed over $8.5 billion in net income from nonrailroad operations alone, many of which were made possible by those land grants. For example, the Burlington Northern Railroad is the second largest owner of coal reserves in the United States.

There is a whole laundry list of public aid to railroads, including land grants, assumption of a portion of retirement benefits through the Railroad Retirement Act of 1974, grade-crossing grants, tax write-offs, loan guarantees, and other benefits. Table 1 lists these benefits and their nature. Government aid to railroads is currently at an annual level of $1.3 billion, about three times as much as current aid to navigable waterways.

A recent article in the Wall Street Journal noted

Table 1. Federal aid to the rail industry.

Source	Benefit	Amount ($)
Federal Coordinator of Transportation (1)	Various government subsidies and benefits	1 400 000 000
Lambert (2)	Earnings from land grants	10 000 000 000
Joint Economic Committee (3)	Amtrak funding	500 000 000
Federal Highway Administration (4)	Fundings of grade crossings	2 000 000 000
Federal Highway Administration (4)	Car amortization	280 000 000
Barloon (5)	Public funding of Consolidated Rail Corporation	500 000 000
Railroad Revitalization and Regulatory Reform Act of 1976	Redeemable preference shares	600 000 000
	Guarantee of load obligations	1 000 000 000
	Rail passenger service payments	200 000 000
	Debentures and preference stock	2 100 000 000
	Payment of employee benefits	250 000 000
	Northeast Corridor project	1 866 000 000
Ex 305 rate increase granted by Interstate Commerce Commission, effective 1975	Seventy percent of rate increase specifically ordered for and restricted to deferred maintenance and delayed capital improvements (1975 amounts)	
	Deferred maintenance	
	Roadway	148 000 000
	Equipment	80 844 000
	Delayed capital improvements	
	Roadway	52 250 000
	Equipment	279 185 000
Tax Reform Act of 1976	Tax savings benefiting rail industry only	
	1977	55 000 000
	1978	84 000 000
	1979	83 000 000
	1980	71 000 000
	1981	59 000 000
Historical review, government subsidy	Partial funding of Rail Retirement Act of 1974	570 000 000
	Total	22 178 279 000

that transportation officials are preparing to spend billions of dollars to put rundown railroads back in shape. The total might go well over $20 billion in the next decade by some estimates. The railroads have traditionally enjoyed benefits far beyond those enjoyed by waterway transportation and, based on programs in place as well as expected future programs, railroads will be the beneficiaries of increasing public largess.

From the point of view of public policy, the crucial question becomes one of fairness and equity with respect to public investment among the various modes. If it is in the public interest to recover all public investment, then let each mode repay the government on the same basis. It hardly seems fair to impose an arbitrary and artificial cost-recovery scheme on one mode of transportation while a competing one enjoys substantially greater public benefits.

This can only be done through the formulation of a fair and balanced national transportation policy, something which has never been formulated by the federal government. A federal commission, the National Transportation Policy Study Commission, is currently trying to formulate such a policy, but its ability to succeed to the point where such a policy could be fair and could be fully implemented is certainly open to question, given all of the special interests involved and the inability of the executive branch to take unbiased positions on the advantages and public benefits inherent in each mode of transportation.

One complicating factor is the inability of the current U.S. Department of Transportation (DOT) to view objectively the role of the inland waterways industry. Our industry has virtually no representation within DOT other than the Coast Guard, which is not our advocate but rather our policeman and regulator. Dialogue with representatives of DOT has repeatedly indicated an extreme DOT bias toward the rail industry and a complete lack of understanding of the nature and role of the barge and towing industry.

For example, at the request of Senator Magnuson, chairman of the Senate Commerce Committee, DOT was directed to conduct a 90-day study on the need for replacement of Locks and Dam 26 and the possible impact on the rail industry. In examining the need for replacement, DOT chose to ignore the fact that, for the 10 years ending in 1976, the average compounded growth rate of traffic at this facility was 4.7 percent. Instead, it selected a much lower composite growth rate of 2.9 percent by using selected years. In addition, the freight capacity of the existing facility was cited as a range of tonnage, and the high end of that range, supplied by railroad consultants, was used to project growth at the low 2.9 percent growth rate. DOT therefore concluded that there would be no real need for additional capacity until well into the 1990s. If the capacity figures derived by Peat, Marwick, Mitchell and Company in their report for the U.S. Army Corps of Engineers are used, a growth rate as low as 2 percent/year will push tonnage to capacity levels by 1984. This would be long before the 10-year construction period for a single 365-m (1200-ft) lock would come to pass.

Until this inequitable situation is rectified, there can be little hope of evolving a national transportation policy that addresses the public interest and not the special economic interest of the rail industry. We are therefore faced with a situation where artificially high costs--to be borne by shippers, farmers, and consumers--will be imposed on water carriage.

CONCLUSION

What does the future hold for the barge and towing industry? To the extent that Congress does not impose a usurious and confiscatory user charge upon the industry, the barge and towing industry will continue to play its role in meeting the needs of its shippers. The physical system is in place with the exception of a few facilities that need improvement. We are prepared to use this tremendous present capacity through the construction of additional equipment. We are positioning ourselves to train young people to assume the well-paying jobs that will increasingly become available in the industry, not only aboard vessels but in shoreside and management areas. Significant efficiencies in terms of fuel consumption, steel required for additional haulage capacity, safety, and low labor utilization will help to ensure that a fair share of new traffic finds its way to rivers and canals. Additional intermodal movements will be needed as a result of pressures from the shipping public. In several recent instances, railroads have found that their earnings are maximized by an intermodal movement rather than an all-rail proportional rate. This is encouraging in that it profits all concerned with transportation, including--and most importantly--the customer or consumer.

For 30 years after World War II, the barge and towing industry lived in an atmosphere of quiet growth and general prosperity. However, we suddenly realized during the struggle for authorization of the replacement of Locks and Dam 26 and the debate over user charges that we could no longer afford, as an industry, to sit back quietly hoping that others would understand our role, our purpose, and our problems. Our message must be taken to the public, particularly to those who are in a position to influence public policy. We need a balanced and unbiased national transportation policy that addresses the interests of all modes and, more importantly, the needs and desires of the shipping public. The barge and towing industry stands ready to play a part in the formulation of that policy.

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Publication of this paper sponsored by Committee on Inland Water Transportation.

Impacts of Inland Waterway User Charges

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The potential impacts of imposing user charges on inland waterways are estimated by using models and data of the U.S. Army Corps of Engineers inland navigation systems analysis program. Fee schedules designed to recover 50 and 100 percent of Corps of Engineers operations, maintenance, and rehabilitation expenses plus Coast Guard costs of providing navigation aids are developed. Two types of fees are considered: a uniform, systemwide fuel tax and a set of segment megagram-kilometer fees that provide for local recovery of local costs. The principal impacts examined are changes in waterway transportation costs and modal shares of interregional freight traffic. Impacts of user charges are found to vary considerably throughout the waterway network based on the type of fee, the level of cost recovery, existing (without user charges) towing industry costs, and the waterway traffic base. Segment fees generally produce greater impacts than a fuel tax.

Inland waterway user charges constitute one issue in the emerging broader policy issue of the role of inland waterways in the nation's transportation system. User charges have been proposed to increase federal revenues and to require commercial waterway users to bear directly at least some right-of-way costs. There is, however, no consensus on the best type of user charge. The study summarized in this paper developed estimates of the potential impacts of selected types of inland waterway user charges as an aid to policy makers who will be carefully scrutinizing various user charge proposals. A more detailed account of the study is available elsewhere (1).

SCOPE OF STUDY

The array of potential inland waterway user charges includes megagram-kilometer fees, lockage fees, the fuel tax, equipment registration fees, direct shipper fees, and congestion tolls. This study examines a megagram-kilometer fee and a fuel tax. These are the mechanisms that have been suggested respectively by the Office of Management and Budget (OMB) and the U.S. Department of Transportation (DOT).

A wide variety of implementation options exist for each type of potential user charge. A user charge can vary according to the types of costs recovered, the level and the timing of cost recovery, and whether costs are recovered by uniform systemwide fees or by a fee schedule designed for local recovery of local costs. This study examines potential impacts of recovering 50 and 100 percent of U.S. Army Corps of Engineers operations, maintenance, and rehabilitation (OM&R) expenses plus Coast Guard costs of providing navigation aids. Partial recovery of future construction costs is also briefly considered. Impacts are estimated for current traffic bearing the burden of current costs. Within this implementation framework, estimated potential impacts of imposing a megagram-kilometer fee or a fuel tax on U.S. inland waterway transportation are presented. Impacts of partial recovery of federal costs for the Mississippi River plus tributaries and the Gulf Intracoastal Waterway (GIWW) portions of the inland waterway system are estimated.

Inland waterway user charges could have a variety of economic impacts. This paper examines only costs in the towing industry and impacts of modal traffic shares. Further, only waterway and rail competition for movement of fixed intercity traffic is considered. Pipelines and intercity trucking are not included, and origin-destination patterns and volumes of freight traffic are held constant. Actual economic impacts require considerable time to occur. However, because of limited study time, this paper describes impacts as they might occur in a base year rather than attempting to predict an evolving economic adjustment through time. It is felt that the base-year impacts, estimated to reflect considerable market system response to user charges, can suggest the size and location of potential long-run impacts. The base year for this study is 1972, the most recent year for which detailed economic and multimodal traffic data are available.

ASSUMPTIONS

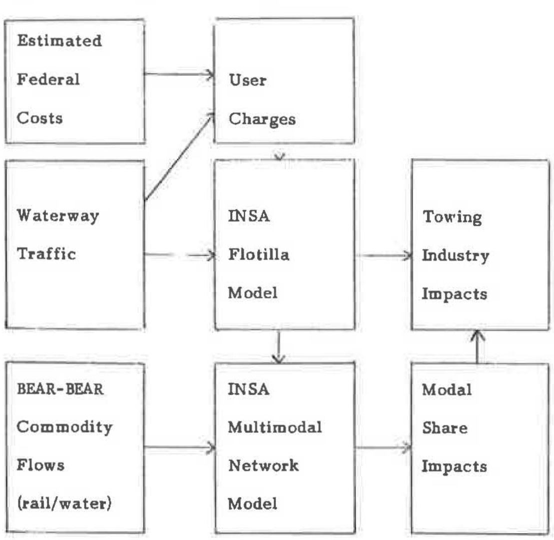
The basic premise of the study is that inland waterway transportation is one component of a multimodal transportation market and that the economic impacts of waterway user charges can be estimated by simulating market responses to the proposed user charges. Specific working assumptions included the following:

1. The towing industry is sufficiently competitive that all firms face essentially the same costs.
2. Rail and waterway technology remains unchanged in the face of waterway user charges.
3. Competition and efficient regulation allow transportation costs to adequately represent transportation market prices.
4. Each shipper is rational, fully informed, and able to shift modes freely.
5. There is no vertical integration involving the towing industry or the railroads, and market transactions are guided only by market prices.
6. Grain for export is gathered from the hinterlands of fixed inland waterway ports and travels to fixed export points.
7. Federal costs for waterway operation, maintenance, and rehabilitation and for provision of navigation aids are known precisely enough for each individual waterway to permit accurate assessment of user charges.

METHODOLOGY

A schematic of the study methodology is shown in Figure 1. Estimates of base-year federal expenditures on inland waterways were provided by the Corps of Engineers and the Coast Guard. These were used in conjunction with base-year waterway traffic to prepare fee schedules for each type of user charge and level of cost recovery. The waterway traffic data were port-to-port flows obtained by aggregating the detailed dock-to-dock flows compiled by the Waterborne Commerce Statistical Center of the Corps of Engineers.

Figure 1. Study methodology.



Estimates of user charge impacts were made by using models and data developed for the Corps of Engineers inland navigation systems analysis (INSA) program (2). Indeed, this study represents the first attempt to apply INSA to a major problem. The principal INSA models used in this study include the following:

1. Flotilla model--The flotilla model is an engineering cost simulator that combines commodity traffic patterns, waterway network characteristics, equipment performance, and seasonal variations to estimate the towing industry's waterway transportation costs and fleet requirements.
2. Multimodal network model--The multimodal network model represents intercity freight transportation and predicts transportation prices and service levels as jointly determined by traffic patterns and volumes and by network structure, costs, and capacities.

In addition to the basic INSA models, several detailed modal simulators (3, 4, 5) were also used to develop estimates of rail and waterway cost and performance characteristics for input to the network model.

The method used to estimate potential user charge impacts consisted of the following sequence:

1. Simulate base-year transportation markets to estimate equilibrium prices, traffic volumes, and modal shares in the absence of waterway user charges.
2. Estimate impacts of user charges on costs to the inland waterway towing industry.
3. By using revised towing industry costs, simulate base-year transportation markets to estimate potential impacts of user charges on equilibrium prices, traffic volumes, and modal shares.

Each of these elements contains several major tasks. Estimating transportation market equilibrium, for instance, requires estimates of transportation demand and supply, which are then combined to estimate market equilibrium. Transportation demand estimates were supplied by DOT in the form of 1972 commodity flows among the 173 Bureau of Economic Analysis regions (BEARs) defined by the U.S. Department of Commerce (6). Transportation supply curves were defined for each node and link in the national multimodal network. For this study, multimodal network elements describe only rail, waterway, local trucking, and modal interchange, but the capability exists to include pipelines and long-distance trucking in an expanded study. The total study network contains about 2000 nodes and 4000 links.

Given transportation demand and supply, the multimodal network model estimates transportation market equilibrium prices, traffic volumes, and modal shares. In essence, the direct impacts of waterway user charges are represented by their effects on the transportation costs and supply schedules of the waterway network. Market response to these changed costs then depends on the interaction of supply and demand throughout the multimodal system.

USER CHARGE ESTIMATES

Megagram-kilometer fees are estimated on both a system basis and a segment basis. Waterway traffic data used for calculating user charges are given in Table 1. For the system fee, systemwide government costs are partially or fully recovered by imposing a uniform systemwide megagram-kilometer fee. For the segment fee, government costs are partially or fully recovered by imposing a set of megagram-kilometer fees calculated so that each segment's costs are borne by that segment's traffic. A waterway fuel tax is cal-

Table 1. Estimated traffic and federal costs for major river segments.

River Segment	Megagram-Kilometers of Traffic[a] (000 000s)	Expenditures ($000) Corps OM&R[b]	Coast Guard[c]	Total
Mississippi River, Cairo to Baton Rouge	95 660	8 965.4	1 830.0	10 795.4
Upper Mississippi River	31 343	20 811.6	2 297.4	23 109.0
Arkansas River	688	12 814.5	299.9	13 114.4
White River	82	356.4	2.0	358.4
Ohio River	44 860	13 836.7	830.5	14 667.2
Monongahela River	2 207	2 543.3	42.7	2 586.0
Allegheny River	123	1 196.1	2.3	1 198.4
Tennessee River	4 789	2 437.3	93.1	2 530.4
Cumberland River	1 229	1 814.3	25.5	1 839.8
Kanawha River	1 175	1 470.3	18.6	1 488.9
Green and Barren rivers	1 959	910.2	37.1	947.3
Kentucky River	64	1 264.4	1.2	1 265.6
Illinois Waterway	11 883	6 131.1	805.8	6 936.9
GIWW West	24 700	9 194.6	1 145.0	10 339.6
GIWW East	4 213	1 405.8	1 026.1	2 431.9
Pearl River	-[d]	275.6	23.2	298.8
Alabama-Coosa rivers	184	1 187.1	-	1 187.1
Black Warrior-Tombigbee-Mobile rivers	6 502	11 421.0 (3 069.3)[e]	5 652.8 (427.1)[e]	17 073.8 (3 496.4)[e]
Missouri River	1 918	14 015.2	488.0	14 503.2
Apalachicola-Chattahoochee-Flint rivers	149	3 546.5	137.2	3 683.7
Atchafalaya River	3 585	841.2	14.9	856.1
Red River	35	14.0	21.1	35.1
Black and Ouachita rivers	181	1 861.1	3.1	1 864.2
Total	237 500	120 015.6	14 797.5	134 813.1

Notes: 1 Mg·km = 0.685 ton-mile.
All data are preliminary and subject to change.

[a] Actual port-to-port 1972 traffic on the Mississippi-GIWW network captured by the flotilla model.
[b] Estimated average annual OM&R costs for 1971 through 1975.
[c] Estimated 1974 navigation aids costs.
[d] All traffic is too localized to be captured for analysis.
[e] Revised costs for the Black Warrior-Tombigbee-Mobile rivers reflect costs when Bankhead Lock and Dam rehabilitation costs are excluded and when revised Coast Guard estimates are used. System totals use original estimates rather than parenthetical values. It should be noted that, because all federal cost estimates in this table have been derived from accounting systems neither designed nor intended for user charge impact analysis, these estimated costs may be subject to considerable revision.

culated by assuming a systemwide uniform fuel tax. The tax burden falls on the traffic of each segment according to estimated fuel consumed to move commercial traffic.

Both megagram-kilometer fees and fuel tax have been calculated for 50 and 100 percent recovery of Corps OM&R costs and Coast Guard navigation aids costs. Preliminary agency estimates of these costs are given in Table 1. These cost estimates have been derived from accounting systems neither designed nor intended for analysis of user charge impacts. As a result, these estimated costs may be subject to considerable revision. As an example, recently revised federal estimates for the Black Warrior-Tombigbee-Mobile rivers indicate a substantial change in costs. Similar revisions may occur elsewhere in the network.

Fuel Tax

Several runs of the INSA flotilla model were used to calculate uniform systemwide fuel taxes. The first model run assumed no tax and was used to estimate baseline fuel consumption. The second model run included a 50 percent cost recovery fuel tax based on without-tax fuel consumption. However, fuel consumption decreased as the model simulated the towing industry's adjustment to increased fuel price. Similar attempts at 100 percent cost recovery produced even further shortfalls. As these sample results indicate, successively higher fuel taxes lead to successively more strenuous attempts at fuel conservation. As a result, the 100 percent recovery fuel tax rate is more than twice the 50 percent recovery tax rate because of shrinkage in the fuel consumption tax base.

Data given in Table 2 show how successively higher fuel taxes might lead to more intensive fuel conservation. The first column gives possible levels of a uniform systemwide fuel tax. The second column gives estimates by the flotilla model of fuel consumed at each level of the fuel tax. The third column displays the potential fuel savings that could result from fuel conservation at each level of a uniform systemwide fuel tax.

It should be noted that these potential fuel savings do not reflect any loss in waterway traffic but

Table 2. Estimated impact of waterway fuel taxes on fuel consumption.

Fuel Tax ($/L)	Flotilla Model Estimates of Liters of Fuel Required (000 000s)	Potential Fuel Savings (%)	Estimated Total Liters of Fuel Consumed (000 000s)	Revenue Given Fuel Savings ($000 000)	Cost Recovery (%)
0	1605	0	2124	0	0
0.040	1488	7.3	1969	78	58
0.046	1477	8.0	1954	90	67
0.079	1408	12.3	1863	147	109
0.096	1393	13.2	1844	148	132

Notes: 1 L = 0.264 gal.
All data are preliminary and subject to change.

Table 3. Estimated 1972 megagram-kilometer fees and fuel taxes required for recovery of federal costs.

Type of Charge	Cost Recovery: 50 Percent, Same Traffic	50 Percent, Traffic Loss	100 Percent, Same Traffic	100 Percent, Traffic Loss	Towing Industry Cost Without User Charges[a] (mills/Mg·km)
System fuel tax, $/L	3.4	3.6	7.3	7.9	
System fee, mills/Mg·km	0.27	0.34	0.55	0.62	
Segment fee by river segment, mills/Mg·km					
Mississippi River, Cairo to Baton Rouge	0.07	0.07	0.14	0.14	1.6
Upper Mississippi River	0.34	0.41	0.75	0.75	1.8
Arkansas River	9.5	225	19.0	2246	2.3
White River	2.2	3.5	4.4	18.9	5.8
Ohio River	0.14	0.21	0.34	0.34	1.8
Monongahela River	0.62	0.62	1.2	1.2	3.4
Allegheny River	4.9	68	9.8	821	5.3
Tennessee River	0.27	0.27	0.55	0.62	1.9
Cumberland River	0.75	0.75	1.5	2.1	1.8
Kanawha River	0.62	0.68	1.3	1.4	2.5
Green and Barren rivers	0.27	0.27	0.48	0.55	5.7
Kentucky River	9.9	1095	19.7	2189	7.7
Illinois Waterway	0.27	0.34	0.62	0.68	2.1
GIWW West	0.21	0.21	0.41	0.41	2.1
GIWW East	0.27	0.34	0.55	0.62	2.3
Pearl River	-	-	-	-	-
Alabama-Coosa rivers	3.2	407	6.4	815	3.2
Black Warrior-Tombigbee-Mobile rivers	1.3	14.8	2.6	34.5	1.6
	0.27[b]	1.8[b]	0.55[b]	4.0[b]	
Missouri River	3.8	6.0	7.5	20.4	2.1
Apalachicola-Chattahoochee-Flint rivers	12.4	1262	24.7	2523	4.8
Atchafalaya River	0.14	0.14	0.21	0.27	2.1
Red River	0.48	1.2	1.0	3.0	3.3
Black and Ouachita rivers	5.1	638	10.3	1277	2.9

Notes: 1 L = 0.264 gal; 1 Mg·km = 0.685 ton-mile.
All data are preliminary and subject to change.

[a] Estimated by the flotilla model.

[b] Reduced segment megagram-kilometer fees correspond to recently revised federal estimates of OM&R and navigation aids costs. Similar revision may occur elsewhere in the system (see footnote e in Table 1).

rather arise as the flotilla model simulates the towing industry's attempts to conserve a resource that has become more expensive. In all cases, the same traffic is moving between the same ports of origin and destination. The only difference among these simulations is the price of fuel, which is modified by imposing a fuel tax.

The flotilla model tends to understate actual fuel consumption. In Table 2, the fourth column gives estimates of actual total waterway fuel consumption at each level of the fuel tax. These estimates are derived by applying the estimates of fuel savings in the third column to the estimated total 1972 consumption of 2.12 billion L (561 million gal). These estimates of total fuel consumption are then multiplied by their corresponding fuel taxes to yield the estimated federal revenues in the fifth column and the percentage of cost recovery in the sixth column of Table 2.

Results indicate that a fuel tax ranging from \$0.032 to \$0.034/L (\$0.12 to \$0.128/gal) would have recovered 50 percent of federal OM&R and navigation aids costs in the 1972 base year; the higher numbers indicate the higher tax necessary to offset reduced fuel consumption. Recovery of 100 percent of federal costs would have required a tax ranging from \$0.063 to \$0.073/L (\$0.24 to \$0.278/gal); again, the higher numbers reflect the higher tax necessary to offset reduced fuel consumption. Analysis of the modal traffic share suggests that a uniform systemwide fuel tax for 50 percent recovery would reduce system megagram-kilometers by about 5.5 percent. A similar fuel tax for 100 percent recovery would reduce system traffic by about 7.1 percent. If it is assumed that reduced traffic further proportionately reduces fuel consumption beyond the fuel savings already achieved by conservation in the towing industry, the \$0.034/L (\$0.128/gal) tax increases to \$0.036/L (\$0.135/gal) for 50 percent recovery, and the \$0.073/L (\$0.278/gal) tax increases to \$0.079/L (\$0.298/gal) for 100 percent recovery.

Megragram-Kilometer Fees

Table 3 gives estimated megagram-kilometer fees for several possible conditions. The fees are calculated for 50 and 100 percent cost recovery. For both levels of cost recovery, fees are calculated for both existing base-year traffic (Table 1) and traffic remaining after estimated losses occur. In addition, fees are calculated on both a uniform systemwide basis and a segment basis so that the fees of each segment recover the segment costs.

As Table 3 indicates, a uniform systemwide fee of 0.27 mill/Mg·km (0.4 mill/ton-mile) would provide 50 percent cost recovery assuming no traffic loss. If we take into account potential traffic loss, given this fee structure, the uniform systemwide fee increases to 0.34 mill/Mg·km (0.5 mill/ton-mile) on remaining traffic. For 100 percent cost recovery, the uniform systemwide fee is 0.55 mill/Mg·km (0.8 mill/ton-mile), which increases to 0.62 mill (0.9 mill) given potential traffic losses.

Segment fees, calculated so that the fees for each segment recover the costs for that segment, vary widely among waterway segments. For instance, the lower Mississippi segment fee is 0.07 mill/Mg·km (0.1 mill/ton-mile) for 50 percent cost recovery and 0.14 mill (0.2 mill) for 100 percent cost recovery. Under a segment fee approach, the lower Mississippi would lose so little traffic that the fees would remain unchanged. As another example, the Illinois Waterway segment fee is 0.27 mill/Mg·km (0.4 mill/ton-mile) for 50 percent cost recovery and 0.62 mill/Mg·km (0.9 mill/ton-mile) for 100 percent cost recovery assuming no traffic loss in each case. Given potential traffic loss, these fees increase to 0.34 mill (0.5 mill) for 50 percent recovery and 0.68 mill (1.0 mill) for 100 percent recovery. By contrast, segment megagram-kilometer fees increase much more rapidly on some other waterway segments. On the Missouri River, for example, the 50 percent recovery fee of 3.8 mills (5.5 mills) increases to 6.0 mills (8.8 mills) after potential traffic loss. Similarly, the 100 percent recovery fee of 7.5 mills (11.0 mills) increases to 20.4 mills (29.8 mills) after potential traffic loss.

Fees for Partial Recovery of Future Construction Costs

Parametric analysis was used to estimate megagram-kilometer fees and equivalent fuel taxes to recover various percentages of preliminary OM&R and new construction costs for fiscal years 1980 through 1984. The results (which are not included here) indicate that the $0.011 to $0.016/L ($0.04 to $0.06/gal) fuel tax proposed by the Congress is approximately equivalent to the combination of 10 percent OM&R and 5 percent construction cost recovery. It is emphasized, however, that 100 percent OM&R and 50 percent new construction cost recovery, as suggested by some, would require an estimated fuel tax of more than $0.18 ($0.70), which is twice the current cost of diesel fuel. The impact of such heavy fuel taxes on waterway carriers and industries would likely be substantial, as demonstrated in the following section.

ESTIMATED IMPACTS OF USER CHARGES

Towing Industry Cost

The last column of Table 3 gives estimated towing industry costs without user charges. These costs represent estimates by the flotilla model of fully allocated expenditures for equipment, fuel, supplies, maintenance and repairs, labor, and overhead. The flotilla model was also used to estimate towing industry costs given the user charges in Table 3. These estimates show how base-year industry costs would appear with a user charge if the industry could adjust its fleet and operating patterns to mitigate the cost burdens of user charges.

Results provided in detail elsewhere (1) indicate that individual rivers would experience a cost increase of 0.14 to 0.55 mill/Mg·km (0.2 to 0.8 mill/ton-mile) with a 50 percent recovery fuel tax assuming no traffic loss. At the 100 percent recovery level, the increase would be 0.34 to 1.2 mills (0.5 to 1.7 mills). Traffic losses caused by the fuel tax produce towing industry cost increases that are slightly greater than these figures.

The picture is substantially different in the case of segment fees. For some waterways, such as the Arkansas, Allegheny, and Kentucky rivers, segment megagram-kilometer fees shrink the traffic base so much that the remaining traffic moves at an average cost of more than $1/Mg·km ($1.46/ton-mile). For rivers such as these, the results represent a "snapshot" in an iterative analysis process. Modal-share

Table 4. Estimated system impacts of user charges on waterway-rail modal split.

Commodity	Total (000 000s)	Waterway Share With No User Charge[a] (%)	Segment Fee (100 percent recovery): Waterway Share[a] (%)	Segment Fee (100 percent recovery): Change (%)	Fuel Tax (100 percent recovery): Waterway Share[a] (%)	Fuel Tax (100 percent recovery): Change (%)
Megagrams						
Coal	398	21.5	19.0	-2.5	19.3	-2.2
Petroleum	181	39.7	36.2	-3.5	36.5	-3.2
Chemicals and fertilizer	24	66.4	62.6	-3.8	64.0	-2.4
Metals and products	37	21.1	19.3	-1.8	19.4	-1.7
Ores and scrap	90	14.4	8.1	-6.3	9.2	-5.2
Cement, stone, sand, and gravel; shells; and products	120	29.4	26.5	-2.9	26.9	-2.5
Agricultural, marine, and forestry products	124	10.7	9.2	-1.5	9.6	-1.1
Grain	83	32.2	30.9	-1.3	32.1	-0.1
Manufactured products	31	6.0	4.7	-1.3	6.0	0.0
Miscellaneous	77	10.0	9.1	-0.9	11.0	+1.0
Total	1165	23.9	21.3	-2.6	21.9	-2.0
Megagram-Kilometers						
Coal	254 000	15.9	14.4	-1.5	14.6	-1.3
Petroleum	145 000	37.7	36.1	-1.6	37.2	-0.5
Chemicals and fertilizer	26 000	77.7	72.7	-5.0	75.1	-2.6
Metals and products	47 000	22.6	20.2	-2.4	20.4	-2.2
Ores and scrap	66 000	18.7	11.3	-7.4	14.2	-4.5
Cement, stone, sand, and gravel; shells; and products	63 000	31.3	29.1	-2.2	29.1	-2.2
Agricultural, marine, and forestry products	147 000	9.2	7.8	-1.4	8.1	-1.1
Grain	99 000	40.6	39.2	-1.4	40.5	-0.1
Manufactured products	55 000	2.6	2.0	-0.6	2.6	0.0
Miscellaneous	85 000	6.7	6.9	+0.2	8.6	+1.9
Total	987 000	22.4	20.5	-1.9	21.4	-1.0

Notes: 1 Mg = 1.1 tons; 1 Mg·km = 0.685 ton-mile.
All data, which were estimated by base year (1972) simulations by using the INSA multimodal model, are preliminary and subject to change.

[a]Waterway share of total inter-BEAR waterway and railroad traffic (1972) excluding Great Lakes, Pacific Coast, and Atlantic Coast shallow-draft waterway traffic and all domestic deep-draft traffic.

analysis would undoubtedly reveal an even greater traffic loss and a resulting further increase in subsequent fees. Such waterways appear well on their way to shutdown under a megagram-kilometer segment fee at the 100 percent recovery level.

Potential Traffic Impacts

The INSA multimodal network model was used to develop preliminary estimates of the potential traffic impacts of a uniform systemwide fuel tax and a set of segment megagram-kilometer fees. In this impact analysis, the immediate effects of each user charge are represented by adjusting cost curves to reflect the user charge burden. Then, by using the adjusted cost curves to represent towing industry supply schedules for each waterway segment, the multimodal model simulates modal selection by individual shippers and aggregates these individual decisions to estimate the resulting transportation market prices, traffic volumes, and service levels.

Table 4 gives the predicted impact of 100 percent recovery user charges on the waterway-rail modal split of interregional freight traffic. On an overall basis, segment fees would cause a 2.6 percent reduction in the waterway megagram share and a 1.9 percent reduction in the megagram-kilometer share. The fuel tax impact is slightly smaller and causes a 2 percent reduction in the megagram share and a 1 percent reduction in the megagram-kilometer share. In general, larger reductions occur for most commodities in megagrams than in megagram-kilometers, which indicates that it is the shorter haul waterway traffic that is diverted to rail. This agrees with the conventional wisdom that holds that the waterway cost advantage over rail increases with the distance of the haul. This partially explains the relatively small loss of grain traffic by waterways in the face of user charges; there is a very little short-haul grain traffic to be diverted to rail, and the long-haul traffic has a large cost margin that can easily absorb the increased costs. Caution must be exercised in considering these results, however, because the ultimate origins of waterway grain traffic are not effectively captured in the commodity flow data input to the model. That is, only the proximate origin port of the traffic is known. A detailed analysis at a sub-BEAR geographical scale of waterway hinterlands for grain movements would likely show quite different user charge impacts. In addition, changing destination ports--a possibility not explored in this preliminary study--might increase waterway user charge impacts.

Table 5 gives the estimated net impact of revised modal-choice decisions on Mississippi-GIWW network traffic. In this table, estimated total megagram-kilometer traffic by waterway segment is shown for no user charge and for 50 and 100 percent cost recovery with a uniform systemwide fuel tax or a set of segment megagram-kilometer fees. The megagram-kilometer estimates in this table reflect actual base-year (1972) port-to-port flows as modified by BEAR-to-BEAR percentage traffic losses estimated by the multimodal network model.

These results suggest that, for 50 percent cost recovery, a systemwide fuel tax would reduce system megagram-kilometers by about 5.5 percent; a comparable cost recovery segment fee structure would reduce system megagram-kilometers by about 8.6 percent. The fuel tax would evidently have its greatest impact on the Black Warrior-Tombigbee-Mobile rivers. A segment megagram-kilometer fee would affect, in addition to these rivers, the Arkansas, Allegheny, Kentucky, Alabama-Coosa, Apalachicola-Chattahoochee-Flint, Missouri, Red, and Black and Ouachita rivers. By contrast, such major waterways as the lower and upper Mississippi, the Ohio, the Illinois, and the Tennes-

Table 5. Potential impacts of user charges on waterway traffic.

	Megagram-Kilometers (000 000s)				
		50 Percent Recovery		100 Percent Recovery	
River Segment	No User Charge	Fuel Tax	Segment Fee	Fuel Tax	Segment Fee
Mississippi River, Cairo to Baton Rouge	95 660	92 981	90 208	91 547	90 088
Upper Mississippi River	31 343	30 716	30 026	30 152	29 712
Arkansas River	688	607	29	523	6
White River[a]	82	72	51	63	19
Ohio River	44 860	42 706	42 436	42 213	42 168
Monongahela River	2 207	2 185	2 185	2 185	2 185
Allegheny River[a]	123	115	9	105	1
Tennessee River	4 789	4 626	4 310	4 411	4 310
Cumberland River	1 229	1 191	1 191	1 191	876
Kanawha River	1 175	1 118	1 112	1 106	1 105
Green and Barren rivers[a]	1 959	1 701	1 889	1 487	1 794
Kentucky River[a]	64	58	0	51	0
Illinois Waterway	11 883	11 456	11 005	11 324	10 647
GIWW West	24 700	24 008	23 310	23 637	23 292
GIWW East	4 213	4 094	3 975	4 032	3 972
Pearl River	-	-	-	-	-
Alabama-Coosa rivers[a]	184	161	1	137	1
Black Warrior-Tombigbee-Mobile rivers	6 502	890	578	813	495
			871[b]		800[b]
Missouri River	1 918	1 899	1 209	1 899	709
Apalachicola-Chattahoochee-Flint rivers[a]	149	131	1	115	1
Atchafalaya River	3 585	3 549	3 516	3 430	3 500
Red River	35	16	15	15	12
Black and Ouachita rivers	181	180	1	139	1
Total	237 500	224 461	217 059	220 575	214 897

Notes: 1 Mg·km = 0.685 ton-mile.
All data are preliminary and subject to change.

[a]Traffic impact estimates for these rivers with mostly local traffic are based on a preliminary parametric analysis of other rivers with similar costs and traffic. This analysis tentatively suggests that, for local traffic, moderate cost increments, and relatively high initial cost, traffic will decline at about the same rate as the increase in cost.

[b]Estimates reflect smaller segment fees resulting from revised federal cost estimates (see Table 1).

see rivers and the GIWW, which collectively account for more than 90 percent of system base-year megagram-kilometers, remain relatively untouched.

For 100 percent cost recovery, results suggest a 7.1 percent systemwide loss of megagram-kilometers with a fuel tax and 9.5 percent with a segment megagram-kilometer fee. The 100 percent recovery fuel tax would have major impacts (more than 20 percent traffic loss) for the Arkansas, White, Green and Baren, Kentucky, Alabama-Coosa, Black Warrior-Tombigbee-Mobile, Apalachicola-Chattahoochee-Flint, Red, and Black and Ouachita rivers. A comparable segment megagram-kilometer fee would effectively close the Arkansas, Allegheny, Kentucky, Alabama-Coosa, Apalachicola-Chattahoochee-Flint, and Black and Ouachita rivers to commercial traffic. The segment fee would also greatly reduce traffic on the White, Cumberland, Missouri, Red, and Black Warrior-Tombigbee-Mobile rivers.

In general, and for the network as a whole, traffic losses with 100 percent cost recovery fees are not double those with 50 percent recovery fees. This occurs because for many rivers, such as the Arkansas, Allegheny, Kentucky, and Alabama-Coosa and several others, traffic losses caused by user charges designed to recover 50 percent of federal costs are so great that there is very little traffic left to be lost with 100 percent cost recovery user charges. This also helps to explain why traffic losses tend to increase by only 1 or 2 percent on major waterways such as the Mississippi and Ohio rivers, the Illinois waterway, and the GIWW when the cost recovery level goes up from 50 to 100 percent. Much of the traffic loss on these waterways is caused by traffic losses on the tributaries that feed them, particularly in the case of segment megagram-kilometer fees. Since there is not much opportunity for further traffic losses on the tributaries as the cost recovery level increases, there is also less opportunity for traffic losses on main navigation arteries. A second reason is that user charges at 50 percent cost recovery eliminate most of the main-stem traffic that is moving at costs only slightly lower than rail costs. The remaining waterway traffic tends to be longer haul traffic with a more substantial cost advantage, and thus less of it is diverted to rail when user charges are increased to recover 100 percent of federal costs.

Impacts of a $0.011 to $0.016/L ($0.04 to $0.06/gal) fuel tax would likely be in the range of 50 to 100 percent of the impact of the 50 percent recovery fuel tax. The nonlinear nature of the relations between impacts and cost recovery level precludes making a more precise estimate without further experimentation.

ACCURACY OF THE RESULTS

Several precautions must accompany these findings.

1. Later impacts may exceed estimated base-year impacts. Estimated base-year impacts, which attempt to capture long-term market adjustments, may differ from the impacts that might occur during an actual first year of inland waterway user charges. For instance, towing industry cost impacts might exceed those reported here because the base-year analysis used here includes attempts by the towing industry to mitigate user charge impacts. Some of these industry adjustments would require a revised fleet, which would be difficult to accomplish within a year. This limited ability to adjust might cause actual cost impacts to exceed estimated base-year impacts. Conversely, estimated base-year impacts on modal shares may exceed actual modal shifts during the first year of a waterway user charge. However, cumulative impacts may exceed estimated impacts.

Exploratory simulations of base-year economic patterns (not reported in this paper) reveal that traffic origin-destination patterns might soon begin to change. Shifts in origin-destination patterns tend to reduce waterway traffic in two ways. First, a shift in the supply region may require a shift from waterway to rail. Second, preliminary results indicate that a shift in the supply region usually reduces the distance from origin to destination even when traffic stays on the waterway. The result in either case is to reduce the waterway traffic base. To maintain a given cost recovery level with reduced traffic, user charges would have to be increased in succeeding years. This additional increase in waterway transportation costs might lead to still further modal diversions and origin-destination shifts. The potential base-year origin-destination shifts are small--less than 1 percent of all rail and waterway traffic. However, simulating economic patterns through time might reveal a much larger cumulative impact after 15 or 20 years.

2. Changing grain export locations may increase base-year impacts. This study assumes constant port hinterlands for grain exports. However, imposing a waterway user charge might cause Iowa grain, for instance, to move by rail to Houston for export rather than by waterway to New Orleans. This change of export ports would further reduce the waterway share of grain traffic. Limited study time prevented us from investigating this possibility.

3. Smaller waterways are sensitive to cost estimates. Existing federal cost accounts for waterways are designed for financial control rather than analysis of user charge impacts. As a result, it is very difficult to allocate costs of navigation aids to waterway segments and to allocate OM&R costs to navigation versus other benefits. Therefore, the actual costs to be recovered may vary from those used in this study. A change in federal cost estimates would probably not appreciably affect impact estimates for major waterways but might dramatically change impacts for smaller segments. Smaller waterway segments are sensitive to cost changes because of a smaller traffic base to absorb the costs.

4. The results presented here are preliminary in nature. This study, which used the recently developed INSA models of the Corps of Engineers, represents an initial attempt to simulate transportation in great detail. Because the models and data bases are so large, the study results must contain some errors. The study supports the INSA methodology, but many of the data inputs could be improved, and revised data could lead to substantial changes in impact estimates.

5. A longer, more comprehensive study would provide more precise and accurate estimates of user charge impacts. A more comprehensive study would allow better data assimilation, more complete model calibration, and sensitivity analysis. Sensitivity analysis would allow thorough testing of the study's working assumptions, which include the competitive structure of the towing industry, constant technology and productivity, constant hinterlands for grain export, and flexible decisions on modal choice.

Before any user charge is implemented, a comprehensive impact study should examine the complete array of user charge mechanisms, implementation options, and economic impacts. Sensitivity analyses and estimates of cumulative impacts through time are especially important.

ACKNOWLEDGMENTS

This study was conducted by the U.S. Army Corps of Engineers and CACI in response to a request from the Office of Management and Budget. We gratefully acknowledge the participation in this study of numerous Corps of Engineers personnel. Additional CACI participants included C. Strack, W. Clark, A. Hochstein, R. Kistler, R. Miller, and M. Veith.

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Publication of this paper sponsored by Committee on Inland Water Transportation.