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Transportation Modes as Perceived by Shallow-Draft Water Carriers: Implications for Improved Marketing Decisions

HENRY B. BURDG and JAMES M. DALEY

ABSTRACT

Many of the most important strategic marketing decisions affect and are affected by organizational buying behavior. The ability to gain insight into the buying decision process facilitates the ability to explain and predict preferences and therefore choice. Transportation producers (carriers) are faced with the need to market their services to users (shippers). The ability of carriers to understand the perceptions of shippers and the methods used in modal and carrier choice is a marketing advantage. However, the first action in assessing shippers' perceptions is to assess carrier perceptions to serve as norms for comparison. The perception assessment methodology, application, and results for water carriers within the shallow-draft water transportation industry are described. The multidimensional scaling technique was used to depict the perceptions of water carriers in relation to the other major modes of industrial freight transportation as described by 18 modal attributes. Carriers were also queried on how they perceive shippers to make modal-choice decisions and what information sources are consulted for the decision process. A profile of the water carrier industry was produced resulting from a 1984 mail survey to the barge and towing firms.

The five major modes of industrial freight transportation offer shippers a mix of alternatives to facilitate the movement of commodities along distribution channels to the ultimate consumer. More and more frequently, shippers are making transportation decisions guided by the logistical-mission concept. The logistical mission is to develop a system for the movement, handling, and storage of materials and products that meets service requirements at the lowest possible dollar expenditure. In seeking the least-total-cost system, trade-offs are being assessed among the specific characteristics (attributes) that modes inherently offer in response to the specific service requirements of shippers.

Traditionally water carriers have considered domestic barge and railroad as the only transportation modes in contention for the long-haul movement of domestic intercity bulk commodities. Transportation statistics suggest, however, that water carriers as an industry should consider pipeline as a bold competitor. In 1982 the Interstate Commerce Commission (ICC) reported that oil pipelines moved some 558 billion ton-miles of freight, about 25 percent of the total domestic intercity freight for that year. Competition should also be considered as coming from deep-draft water vessels making coastal movements to transport domestic intercity freight. The box- (container-) on-barge concept places water carriers in competition with motor freight and the container dimension of the railroad. No one mode holds a monopoly on intercity freight movements, which indicates that shippers do indeed make modal-choice decisions.

The current understanding of modal-choice behavior focuses the decision process on the buying center member's perceptions and attitudes. These perceptions may or may not match reality. Understanding more about shippers' attitudes and perceptions is paramount to the development of a true marketing program. Steiner and Miner (1) find that little research has been done concerning the ways in which managers perceive the environment, the classification of these perceptions, or the explanation of the different perceptions that influence their decisions.

In general, there is a gap between the theory of industrial buying behavior and the practice of industrial marketing. The gap is so wide that practitioners have the common perception that researchers know little about actual industrial marketing or buying (2). Consequently, practitioners have an aversion for so-called "market research" and "theory." This feeling rests on the belief that experience, direct contact, and intuition are the only essential inputs into the development of a selling strategy. Previous study suggests that the rate of development of marketing research is directly related to how adequate one considers existing channels of communications to be between producers and consumers (3). Twedt's study on the use of marketing research suggests that about 50 percent of companies are doing some form of distribution research (4,p. 8). This would imply that communication is not as effective as producers perceive it to be.

A major reason for the theory-practice gap is the lack of specific guidelines or tools that practitioners can use in applying theoretical research to their day-to-day situations (5). Information concerning organizational buying behavior is considered valuable and relevant primarily on the basis of the ability to explain and predict buying decisions such as modal choice.

The purpose of this paper is to start bridging the gap between organizational buying behavior theory and the marketing practices of the shallow-draft water carrier industry. The results of this

analysis provide practitioners with specific information to work with for the improvement of their marketing programs. By using the framework of organizational buying behavior, a profile of the shallow-draft water carrier industry is developed in relation to the industry's perceptions regarding the major modes of industrial freight transportation and the modal-choice decision process. This research serves as the first step in understanding the marketing impacts that arise from perceptual differences between shippers and carriers within this transportation industry and serves as a reference for comparisons.

METHOD

Subjects

The subjects for this study were selected from respondents to a 1984 survey directed toward a target population of U.S. shallow-draft water carriers. This industry includes common, contract, private, and exempt carriers; firms offering towboats and barges for hire; and firms operating towboats and barges. The sampling frame was the 1983 Inland River Guide (6), which contains a listing of 628 domestic barge and/or towing companies. The survey was administered in the form of a census. A three-item multiple response questionnaire survey instrument was mailed in two waves and self-administered by respondents. The instrument generated 175 ratings per respondent for analysis. The results of the census produced a nonprobability judgment sample that reflects the general characteristics of the carrier industry.

Forty-six firms (7.32 percent) were culled from the sample because the listings were no longer in business. From the actual population (N = 582) a usable response rate of 30.93 percent (n = 180) was achieved.

Procedure

Two major dimensions of research were pursued: (a) how water carriers perceive the different modes of transportation and (b) how carriers perceive the modal selection process followed by shippers in their transportation decisions.

The importance of factors (product and service attributes, namely, freight charges, transit time, etc.) that shippers use in their evaluation of alternative modes as well as shipper perceptions of each mode for each factor influence preferences for alternatives and therefore choice. Transportation modal attributes were identified from an extensive literature review and a pretest applied to waterway users and carriers. The pretest was undertaken to recognize and reduce ambiguity resulting from the items and terminology included in the questionnaire. Preliminary questionnaires were administered to a group of local water carriers and shippers, which resulted in only minor revisions to a few questionnaire items.

Data used to measure water carriers' perceptions regarding attributes were collected by using importance ratings, which were obtained with a 5-point Likert scale on which 1 indicates that the attribute was very unimportant and 5 indicates that it was very important. Perceptions of the amount of each important factor offered by each modal alternative are a determinant of choice behavior. These perceptions were also evaluated by respondents with a 5-point Likert scale on which 1 indicates that the factor definitely was not offered and 5 indicates that it definitely was offered. Mean scores were calculated for comparison and the multidimensional scaling (MDS) technique was used to depict a spatial configuration of respondent perceptions. Data were analyzed using the MDPREF algorithm to develop the perceptual map for carriers as proposed by Carrol and Chang (7).

Carriers were asked to respond to questions concerning how they perceive that shippers make modal-choice decisions. Multiple situational scenarios were presented to which a respondent indicated a degree of agreement on a 5-point Likert scale on which 1 indicates strong disagreement and 5 indicates strong agreement.

RESULTS

Although the respondents represent a nonprobability sample, the authors view the results as representative of the population of water carriers. However, in no instance should the results of this research be implied to statistically infer sample responses to the total population.

In most business settings policy decisions that formulate and drive a marketing program originate from the upper levels of management. Approximately 96.1 percent of the respondents to this survey held the title of manager or higher. The average respondent is a vice president holding a bachelor's degree in business administration. He has worked for an average of 2.3 companies, acquiring some 19 years' experience in the transportation field. The average respondent has worked 14 years with the present company and supervises 61 employees.

Firms represented in the survey possess a broad mix of asset size and annual gross revenue receipts. The average firm generates between $5 million and $10 million in annual revenues from an average of $7.5 million in total capital assets. The commodity transport mix for respondent carriers is shown in Table 1. The typical waterway bulk commodities--chemicals, petroleum, coal, and farm products--are represented by the respondent carriers. The degree of commodity movement specialization demonstrated in

TABLE 1 Commodity Mix Transported by Shallow-Draft Water Carriers

Waterborne Commerce Commodity Classification	Percentage of Carriers Transporting Commodity
28 Chemicals and allied products	50.9
29 Petroleum and coal products	47.3
11 Coal	45.3
01 Farm products	44.1
32 Stone, clay, glass, and concrete products	34.3
13 Crude petroleum	30.0
10 Metallic ores	22.9
40 Waste and scrap materials	18.9
33 Primary metal products	13.0
34 Fabricated metal products, except ordnance, machinery, and transportation equipment	12.4
41 Special items	11.8
35 Machinery, except electrical	10.7
08 Forest products	9.4
26 Pulp, paper, and allied products	8.3
24 Lumber and wood products, except furniture	8.2
14 Nonmetallic minerals, except fuels	7.6
39 Miscellaneous products of manufacturing	7.1
37 Transportation equipment	5.9
09 Fresh fish and other marine products	2.9
20 Food and kindred products	2.4
30 Rubber and miscellaneous plastic products	2.4
36 Electrical machinery, equipment, and supplies	2.4
19 Ordnance and accessories	0.6
25 Furniture and fixtures	0.6

TABLE 2 Shallow-Draft Water Carrier Commodity Specialization Profile

Waterborne Commerce Commodity Classification	Percentage of Carriers with 50 Percent or Greater Volume
01 Farm products	17.6
29 Petroleum and coal products	11.2
32 Stone, clay, glass, and concrete products	10.7
28 Chemicals and allied products	9.5
11 Coal	9.4
13 Crude petroleum	3.5
34 Fabricated metal products, except ordnance, machinery, and transportation equipment	1.2
35 Machinery, except electrical	1.2
41 Special items	1.2
20 Food and kindred products	-[a]
26 Pulp, paper, and allied products	-[a]
33 Primary metal products	-[a]
39 Miscellaneous products of manufacturing	-[a]
40 Waste and scrap materials	-[a]

[a]Less than 1.0 percent.

the sample is shown in Table 2. In over 17.0 percent of the respondent firms, the transportation of farm products made up more than 50 percent of the firm's volume. In general, it can be concluded that there is not a high degree of commodity movement specialization within the water carrier industry. Carriers transport a wide variety of bulk commodities in a mix that serves the shippers' needs; only a limited few carriers can capture a dominant market share sizable enough to specialize in the transportation of only one commodity.

Carriers were asked to indicate the importance of transportation attributes used in the evaluation of alternative modes. The most important factors described by water carriers, shown in Table 3, include satisfaction of customers' requirements, low freight charges, loading and unloading facilities, and a low frequency of cargo loss or damage. Factors such as promotional and entertainment benefits and short transit time were not considered important in relation to the other 16 items.

To gain an understanding of modal perceptions and the amount of each important factor offered by each mode, a perceptual map was produced. The carrier's perceptual map is shown in Figure 1. In the MDS approach, each factor is represented by a vector passing through the origin of the two-dimensional space; the modal alternatives are represented as points in the same space. To determine how much of a factor a mode is perceived to offer, draw a vector for the factor through the origin, then draw a line perpendicular to this vector from the mode's position in the space. The relative position of the factor vector represents the relative perception of how much of the factor is offered by the mode. The closer the mode is to the head of the factor vector, the more the mode is perceived to offer.

For example, on the factor vector for low freight charges (see Figure 1) carriers perceive domestic barge to have significantly lower freight charges than any other mode. Pipeline is perceived to have the next lowest freight charges, followed by railroad, motor carrier, and air freight. Not only is the ranking relevant, but the distance along the vector provides a measure of similarity. Thus, carriers perceive domestic barge as a unique transportation method having distinctly lower freight charges than rail, motor carrier, and air, which are perceived as quite similar.

The value of the perceptual map is that it graphically portrays the perceptions of respondents for multiple factors and multiple alternatives in a single two-dimensional space. Analysis of the map provides the current position of each mode in relation to all the factors and modal alternatives. An ideal point was also calculated representing a hypothetical transportation mode possessing just the right combination of attributes that carriers perceive as ideal for meeting transportation needs.

Information regarding the modal-selection process suggested that carriers view the shipper's transportation manager as playing an important role in the collection of information about the features of the different transportation methods. The transportation manager would also play an important role in evaluating, negotiating terms and rates, and identifying the need for a transportation method.

The respondents indicated that the evaluation of a transportation method followed a fairly routine methodology. Carriers perceive two similar procedures: (a) a list of important factors would be developed and only those transportation methods that offered the features would be considered and (b) the transportation manager would determine an overall rating for each alternative transportation method by evaluating each alternative mode against a comprehensive list of features.

Carriers were also asked their perceptions concerning the information sources that transportation managers consult to obtain information that would help identify and evaluate transportation methods.

TABLE 3 Carriers' Perception of Importance of Factors in Selecting a Transportation Method

Factor	Mean Response Score[a]	Standard Deviation
Satisfaction of customers' requirements	4.766	0.587
Low freight charges	4.500	0.791
Loading and unloading facilities	4.485	0.983
Low frequency of cargo loss or damage	4.474	0.754
Equipment available	4.448	0.728
Consistency in service	4.419	0.733
Dependable transit time	4.378	0.873
Allowance for large shipments	4.331	0.912
Satisfaction of suppliers' requirements	4.240	0.962
Flexibility in meeting special customers' needs	4.198	0.814
On-time pick-up and delivery	4.169	0.912
Employees with positive attitudes and good manners	4.163	1.019
Information concerning shipment provided	4.000	1.037
Ability to carry large and/or odd-sized freight	3.878	1.072
Convenient pick-up and delivery times	3.854	1.088
Assistance in claims handling	3.632	1.116
Short transit time	3.506	1.152
Promotional or entertainment benefits	1.721	1.141

[a]1 = very unimportant; 5 = very important.

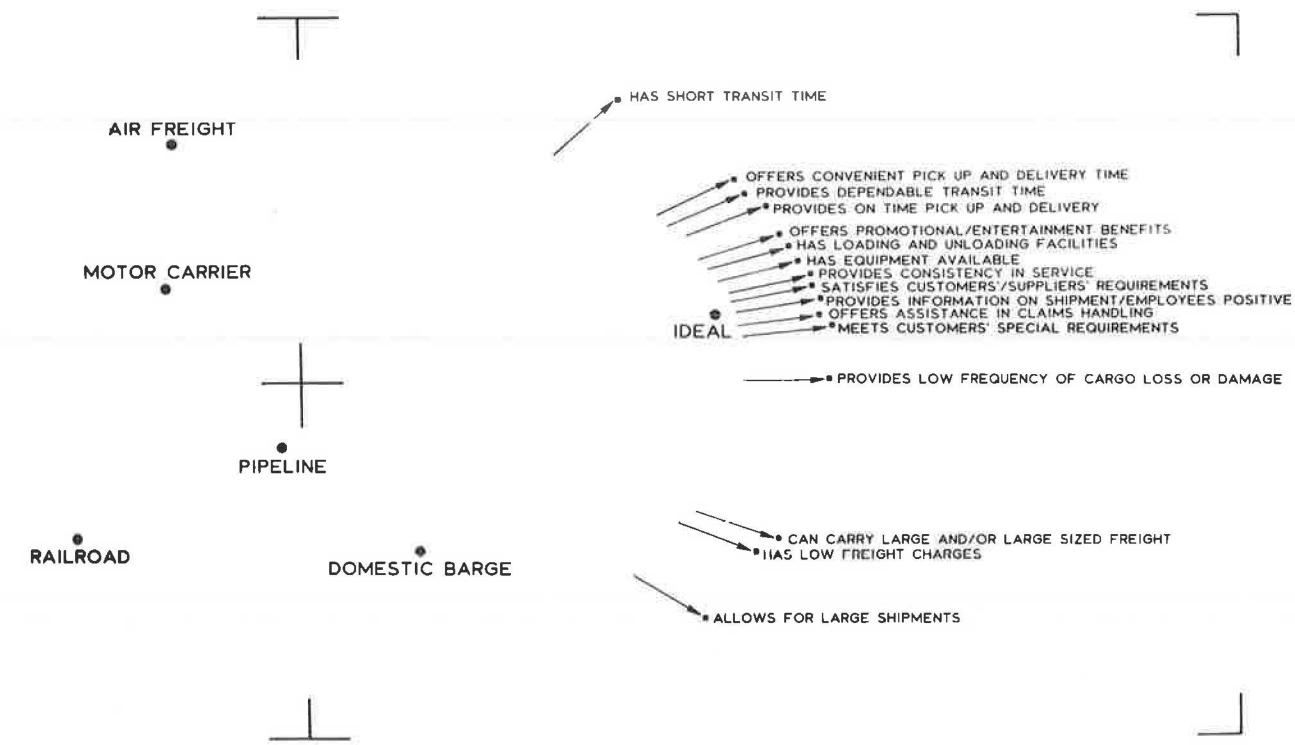

FIGURE 1 Perceptual map of shallow-draft water carriers.

The results are shown in Table 4. Carriers identified current users of the transportation method as the most frequently consulted source of shipper information.

A previous study (8) conducted by the authors in 1982 asked waterway shippers similar questions about information sources. By comparing mean response scores, it can be concluded that carriers have perceived the use and mix of information sources differently than shippers. The results of the comparisons are also shown in Table 4. Not only did the rank order of sources change, but for five of the nine sources, a significant difference was found ($p < 0.05$) between mean response scores.

DISCUSSION

What can be readily identified and empirically quantified is that water carriers are inherently biased toward their mode. Carriers perceive domestic barge as a very desirable form of transportation for the movement of industrial freight and are indifferent to the remaining four modes. This finding is also reinforced when the perceptual map (Figure 1) is reviewed and the relative position of domestic barge versus the ideal mode is compared. To the waterway carrier, the ideal transportation mode more closely resembled domestic barge and least closely resembled railroad. However, the desired characteristics of the ideal mode are far superior to any existing mode in operation today.

Respondents perceive domestic barge as a distinctive transportation mode quite dissimilar from other modes. Of particular importance is the large relative distance between barge and railroad, which indicates that very large changes in the respective attributes would be required before the respondents would consider railroad to be similar and therefore a close transportation substitute. The interpretation that must be rendered as a result of these findings is that on average, water carriers do not perceive barge and rail to be in direct competition. If this were not the case, the two modes would have been perceived as similar, occupying the same relative position on the perceptual map. This finding is so radically different from the industries' "official" position on water-rail competition that the dichotomy, at first look, appears ridiculous.

Carriers identify as the most important factor in selecting a transportation method the satisfaction of customers' requirements. This observation is consistent with today's concept of marketing, which is the anticipation of customer needs and the direction of a flow of need-satisfying goods and services from producer to customer (9). The term "customer" refers to the shipper's customer, generally recognized as the consignee. To that end, the factor of satisfaction of customers' requirements is a general one encompassing the marketing concept as goods move down the distribution channel.

The factor identified as second most important,

TABLE 4 Shipper Utilization of Information Sources as Perceived by Shippers and Carriers

Information Source	Mean Response Scores[a] Carrier (N = 168)	Shipper (N = 109)	z-Score
Technical journals	2.80	2.72	0.73
Trade journals	3.18	3.16	0.24
Carrier salespeople	3.77	3.60	1.46
Advertising brochures	2.84	2.35	4.78[b]
Current users of the transport method	3.87	3.24	6.14[b]
Trade conference or exhibits	2.69	2.43	2.27[c]
Personnel in firm	3.77	3.47	2.38[c]
Outside consultants	2.63	2.08	4.79[b]
Trade associations	2.73	2.51	1.80

[a]5.0 = consult nearly all the time; 4.0 = consult rather often; 3.0 = occasionally consult; 2.0 = seldom consult; 1.0 = never consult.
[b]Significant at $p < 0.001$ level.
[c]Significant at $p < 0.05$ level.

low freight charges, is consistent with the traditional economic approach of mode and carrier selection. When the first two factors are viewed in combination, however, the elements of the total-cost approach of physical distribution are readily perceived by carriers.

The question that arises with great marketing implications for water carriers is, Do carriers have an accurate perception of what is important to shippers in modal and carrier choice? Anderson et al. (10) conclude from their research on buyer and seller perceptions within the intramodal (carrier selection within one transportation mode) transportation choice that significant perceptual differences exist between shippers and carriers. The resulting differences have managerial implications as far as altering a carrier's marketing strategy to improve its effectiveness.

Water carriers perceive domestic barge, motor carrier, and pipeline all to have about the same transit time characteristics. Do shippers have that same perception? Is short transit time important to shippers? Will shippers tend to shift to an alternative mode if their perceptions of transit time are altered? To improve strategic marketing effectiveness it is necessary to measure the perceptions of shippers and compare the results with the perceptions of carriers. Only then will carriers truly understand whether they are attempting to meet customers' needs.

The environment in which the water carrier industry finds itself operating has changed dramatically in the last 10 years. The suggested analogy is the change in conditions from slack-water canoeing to white-water rafting. In today's turbulent, rapidly changing complex environment organizations are doing all they can to adapt to new opportunities and threats. As a result, long-range planning has little use within the water carrier industry. To cope with change the concept of strategic planning must now be firmly integrated into a carrier's management style.

Strategic planning assists management in making nonrecurring, significant decisions that affect the basic nature and direction of the organization as a result of a changing environment. The process translates into strategy formulation and program and operational planning. The foundation of strategic planning rests on marketing intelligence and marketing research.

Kotler (11,p.139) defines marketing research as "the systematic design, collection, analysis, and reporting of data and findings relevant to a specific marketing situation." Although marketing research is specifically commissioned, either internally or externally, marketing intelligence is data from external sources--overt, covert, and unsolicited in nature. Programs of intelligence and research are now needed in the water carrier industry. The industry, speaking through the National Waterways Conference (12), says:

> Gone is the old-boy network of grizzled barge operators playing Mark Twain up and down the nation's rivers. Today's bargeman better have an MBA under his belt, or at least a few in his employ, in order to deal with his competition.

To that end, the traditional mind set of carriers must be unfrozen and retraining and new practices put into being. This process should include owners, executives, and managers. Personnel at this level that do not hold current (within 10 years) education in the fields of logistics, physical distribution, marketing, or transportation now require additional training. Programs can be developed through trade associations or found at any major college or university.

In recognition of the limitations of this study, the results would suggest that transportation carriers could greatly enhance their marketing programs if they could compare their perceptions with those of shippers. The mechanism for such work is marketing research. The authors would surmise that carriers are not well attuned to the wants and needs of the shipper, which results in misdirected resources. Further research assessing shipper perceptions would render the hypothesis true or false. In addition, longitudinal analyses of transportation attribute perceptions clearly are desirable and may help to clarify and support this and previous studies.

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Some Uses of a Fuel Monitor

FENDALL MARBURY

ABSTRACT

Vessel performance-measuring equipment is coming on the market that includes various combinations of fuel flow meters, vessel speed sensors, and clock and microprocessor. The use of such equipment to control river towing operations is explored, mainly through financial performance estimates based on samples of the information from such fuel monitors. The factors on which commercial performance depends are enumerated first. Some are measured by a fuel monitor but financial and environmental factors are equally important. Commercial objectives for a towing operation are formulated next for two different conditions. Least added cost per mile is shown to be the appropriate operating objective when the company is underemployed (i.e., has idle equipment). When all assets are working, on the other hand, operating speeds should not exceed those that maximize the time rate of earning net income. Examples are given of pursuing these different objectives in the operations of a tanker and of sample river tows. Results are incidentally shown to be sensitive to current speed, acutely so when freight is being moved upstream.

The equipment to be discussed has various other names. "Vessel management system" is popular, and one sees advertisements for a "fuel log," an "integrated marine system," and others.

The system typically includes fuel meters for the main engines, a means of measuring vessel progress, a display, and supporting microprocessor with clock. Besides processing and displaying its sensors' outputs, it is usually programmed to compute and display a variety of functions that it measures, such as gallons of fuel burned per mile of progress, vessel speed, and time rate of fuel consumption.

Some of these systems measure ground speed, whereas others measure water speed. It will be shown that they would be better for the purpose suggested here if they measured both. None of them measures water depth, but reasons will be given why they all should.

THE OPPORTUNITY: CONTROLLING LINE-HAUL OPERATIONS

The question naturally arises, What does one do with this system? It looks like a reasonable way of turning the computer revolution against the energy shortage, but how can it be used for this purpose? It may be nice to know how many gallons of fuel one's tow burns per mile, but how can this knowledge be turned to advantage?

One use of a fuel monitor system is to put line-haul towing operations under better control, with the objective of improving the commercial performance of the towing company. During the underway portions of a towing operation, towboat speed and power can be chosen freely most of the time. Why not choose them so as to improve company profitability?

During a given trip, a towboat cannot, of course, deliver more than its maximum horsepower (and usually not even that much). But even this constraint can sometimes be lifted by assigning another towboat for the next trip. Why not assign towboats so as to improve company profitability?

Let us now consider how a fuel monitor system can be used to achieve these objectives.

FACTORS ON WHICH COMMERCIAL RESULTS DEPEND

As far as speed and power choice are concerned, the factors that affect commercial performance can be reduced to only a few. The first, and purely financial, factor is the costs that run at a constant time rate, in dollars per hour for instance, regardless of what the boat and barges may be doing. Crew costs are one major item that must be paid in cash, and other such cash expenses are maintenance and repair, insurance, and overhead. The other major item of this type, which may or may not include a cash component, is the cost of the capital tied up in the boat and barges, which are depreciated.

Figure 1 (1) shows how these "fixed" costs behave as towing speed changes. The cost per mile of paying $100/hr is plotted as a function of ground speed. The higher the speed, the lower becomes the cost per mile. This is why, in the halcyon days before 1973, the best way to run a towing operation was as fast as possible.

The trouble now is that going faster runs fuel consumption up to the point where its cost becomes troublesome. Figure 2, based on a trial by Dravo Corporation of a 15-barge Ohio River type tow, shows how shaft horsepower varies with speed and water depth. Horsepower is roughly proportional to the time rate at which the towboat burns money, in the form of fuel.

Both speed and water depth have strong effects on propulsion power. High speed is a well-known fuel burner, but shallow water is much more of a drag than most people believe. A tow three barges wide at 9 ft draft begins to "feel" the bottom in water about 67 ft deep; so it is in effectively shallow water most of the time. Fuel cost can be doubled by shallow water alone. A full report on this effect has been given by Schlichting (2).

This is important, because one use of fuel monitor systems is to accumulate tow performance information for future cost-estimating purposes. If water depth is not measured, recorded, and corrected for, the performance records may show so much random-looking scatter as not to be useful.

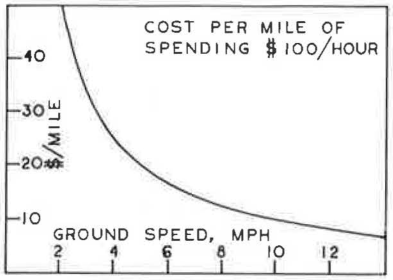

FIGURE 1 Cost per mile of spending $100/hr.

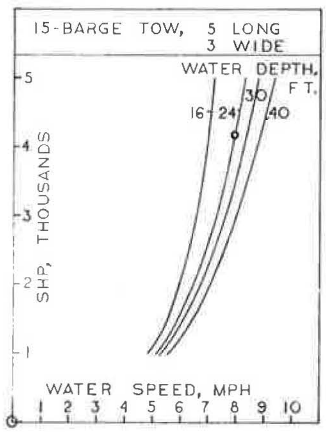

FIGURE 2 Shaft horsepower versus water speed for a 15-barge tow.

Curves like those in Figure 2 also depend on the size and makeup of the tow, a large subject to which there is not room to do justice here. It should, however, be noted in passing that the effects of tow size and arrangement are reflected in the measurements of fuel monitor systems, and learning more about them is a motive for using the systems.

Another major influence on commercial performance is the current. Curves like those of Figure 2 can be converted to cost per hour versus speed. Then, by correcting for the effect of current, they can be converted to cost per mile versus speed. In this form, a curve of fuel cost versus speed can be added directly to one of fixed cost versus speed, as in Figure 1, to produce a U-shaped curve of total cost per mile versus speed, like those in Figure 3 (1),

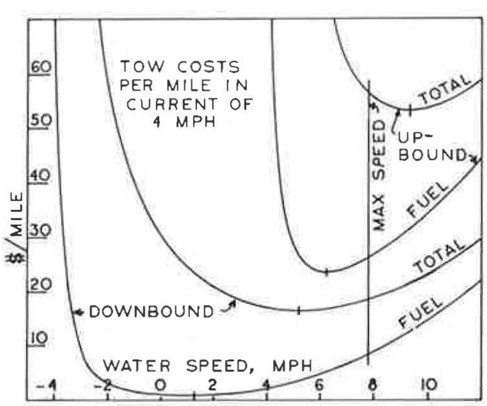

FIGURE 3 Tow cost per mile in 4-mph current.

which shows both total cost per mile and fuel cost per mile. The fuel-only curves include fuel burned while the boat is standing still as well as propulsion fuel.

The cost per ground mile is of interest, because the tow is paid for moving over ground. A lot of variation is evident in Figure 3. The effect of speed is shown directly. The effect of current can be inferred from the fact that the cost of moving the tow upstream is more than three times the cost of moving it downstream, with current at 4 mph in both cases. The effect of water depth is not shown.

Last, but certainly not least, revenues affect commercial performance of a towing operation. Now a list can be made of the factors that affect a choice of towing speed and power, with the object of improving commercial performance, as follows:

- Revenues ($ for a round trip),
- Operating or fixed costs ($/hr),
- Tow size and arrangement,
- Current (mph),
- Water depth (ft),
- Curve of fuel rate (gal/hr) versus water speed (mph) (result of tow size and arrangement, water depth, and, to a minor extent, choice of towboat),
- Price of fuel ($/gal), taxes included.

Our list contains seven items, of which three are available at company headquarters and four on the boat. In order to obtain and record the latter four for both control and planning purposes, a fuel monitor and related equipment are necessary. Older means of acquiring such data are too tedious to be practical.

THOUGHTS ON OBJECTIVES

Given the prospect of improved control of towing operations, exactly how should it be exercised? It was suggested earlier that it be with the object of improving commercial performance. This is socially acceptable but still too vague for practical use.

Two more concrete examples were also given; the least-fuel-per-mile speed of a tow was shown to be somewhat lower than the least-total-cost-per-mile speed. These objectives are clear enough for daily use, but is either of them, as a rule, desirable? The bad feature of the least-fuel alternative is shown in Figure 3; it runs total costs up substantially and unnecessarily.

Reflections on the problem have produced the following two criteria for an objective:

1. It should be computable for an individual boat, because it is at the towboat that towing operations are controlled, and
2. At the same time, it must promote the prosperity, not of the controlled boat, but of the company that owns it.

No single objective that meets these requirements has been discovered, but the combined use of two criteria appears to do so. At this writing, it appears that operations should be conducted at speeds determined by the principle of least added cost, but speeds should not exceed those that maximize profitability. [Derivations and discussions are presented elsewhere (3).]

Maximizing profitability sounds like a good thing. Why not do it all the time? The answer is that it can be done only when there is plenty of work waiting to be done, more than the company's

fleet can possibly do. That is not true all the time; it has not been true recently.

As long as a company has idle capacity, tied-up towboats for instance, the principle of least added cost will give better results. To make it easy to explain, let us consider a towing company that is all ready to operate but has no work to do. It has no income, but it still has expenses: overhead, mortgage payments on boats and barges perhaps, expenses of keeping them laid up.

Now suppose that work appears and a towboat is put into service to do it. Doing the work entails additional expenses, mainly for crews and for fuel, all cash expenses. The principle of least added cost states that the company will be as well off as possible if these added costs of doing the work are minimized. Also, the work is worth doing as long as the revenues it brings exceed the added costs of doing it. One way of minimizing the added costs is to select towing speeds so that the sum of crew, fuel, and minor cash costs is as low as possible. A suitable monitor system will facilitate this process.

The best boat to start operating with is the one whose added costs are least, presumably the newest and most efficient one suitable for the trade. As business increases to take up the first boat's time, its speed can be increased until its added costs reach the minimum possible to the next-best boat, which is the next to be reactivated, and so forth.

This process can continue until all towboats are occupied full time at their most profitable speeds, above which it does not pay to run them. To raise capacity further, more towboats must be found at reasonable rates, or higher freight rates must be obtained, to justify speed increases for all the boats.

Finding the most profitable speed is essentially a matter of mathematical programming with a pro forma calculation that responds to towing speed changes. Curves of fuel rate versus speed are necessary, such as those that can be obtained from a fuel monitor system. The calculation deducts from the revenues of a round trip the costs of capital, crew, fuel, and so on, and then divides net income by the length of time occupied by the trip to obtain net profit per hour averaged over the trip. To maximize the profit per hour, diligent search is made to find the best set of speeds, one for each leg of the trip (3).

RESULTS OF PURSUING DIFFERENT OBJECTIVES

In Table 1, the results of using these two objectives, least added cost and maximum earning rate, are compared with full-power operation. The comparison applies to a 50,000 deadweight ton tanker on a 2,000-mile round trip, but the resulting speed-power pattern is quite similar to that of a river tow, except for the omission of the effects of the current (3).

Speeds for loaded and ballast legs have been chosen so as to optimize the quantities in the boxes. Minimum cash cost per voyage is not much different from least added cost per voyage. Charging interest on cargo value to the ship is a custom of oil companies, which increases the speed on the loaded leg by nearly 2 knots in one instance.

Even the maximum-earning-rate (most profitable) speeds are below full power. The least-cash-cost speeds and powers are lower still. The lowest power called for is only 36 percent of full power, and that is in the absence of current. The effect of a current would have been to increase the optimum power for going against it and to decrease the optimum power for going with it, thus widening the already wide range of propulsion power called for by normal operations.

TABLE 1 Financial Results of Pursuing Different Objectives

Objective	Interest on Cargo Value Charged?	Speed, Knots (Fuel Rate, bbl/hr) Loaded	Ballast	Net Earnings $/hour	Cash Cost, $/voyage
Full Power (no optimizing) or Least Time	no	16 (15.20)	17.6 (15.20)	64.02	102,048
	yes	16 (15.20)	17.6 (15.20)	.74	112,636
Maximum Earning Rate (Upper Speed Limits)	no	14.8 (11.91)	16.2 (11.91)	69.12	97,633
	yes	15.5 (13.87)	15.7 (10.74)	5.82	109,212
Minimum Cash Cost per Voyage (Lower Speed Limits)	no	11.3 (5.40)	12.5 (5.40)	31.91	91,959
	yes	13.2 (8.53)	12.5 (5.40)	-16.40	105,745

Fuel rate, bbl/hr	5.40	8.53	10.74	11.91	13.87	15.20
Fuel Rate, % of full power	36	56	71	78	91	100

There being about 8,400 hr in an operating year, the speed reduction from full power to most profitable speeds would be worth not quite $443,000/year for this example.

A noteworthy feature of these results is that in the absence of current and when no charge is made for interest on the cargo's value, the best fuel rate turns out to be the same for both legs of the voyage. The ship should go faster in ballast, but should burn fuel at the same rate as when loaded.

To see the effects of currents, let us look at some river tow results. Figure 4 (4) is a plot of net profitability before taxes versus current for four different speed-power policies, three of which are practical in some sense and one of which is ideal. The left side of the figure pertains to moving loaded barges upstream and empties down, whereas the right, more profitable half is for moving loads downstream and empties up.

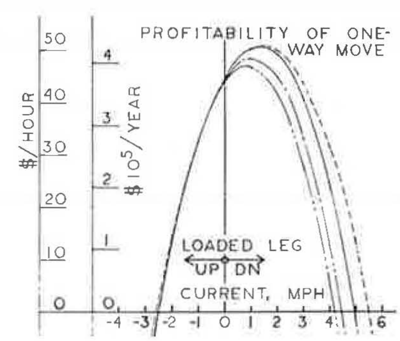

FIGURE 4 Profitability of a one-way move versus current for several speed-power policies.

Whatever the speed-control policy, profitability is seen to be quite sensitive to current. A current increase of only a few miles per hour can plunge profits from hundreds of thousands of dollars per year to below zero. The best current is not zero, but a weak current that favors the loaded leg. In the calculations that produced this figure, no credit was taken for smart piloting. Instead, cur-

rent was assumed to be just as strong when the ship was upbound as when it was going down.

As to speed policies, the lowest curve (worst performance) (marked dash-dot-dot) is for using full power all the time. Full power is assumed to be 4,000 hp with loaded tow, but only 3,000 hp with empty tow, restrained by the engine governor. On a downstream move only, this can be improved by as much as $30,000/year by using least-cash-cost powers downstream and full power upstream. (Least-cash-cost powers upbound are greater than full power.)

A greater improvement could be made (from the dash-dot to the solid curve) if the towboat were modified so as to be able to develop its full 4,000 hp with an empty tow, which is what it has upbound. The final improvement (from the solid to the dashed curve) is what could be achieved by a towboat that had all the power required, paying for fuel but not for bigger engines, and was run always at the tow's most profitable speeds.

The freight rate, net of voyage costs other than fuel, for Figure 4 is about 6.7 mils/ton-mile. To get the rate that would be paid by the average customer, one would have to add the costs of fleeting, tug services, and so on.

The fuel rates and approximate horsepower that produced Figure 4 are shown in Figure 5 (4) for a tow loaded downstream, empty up only. Note that greater power is called for when the tow is empty than when it is loaded, because when empty, it is going upstream.

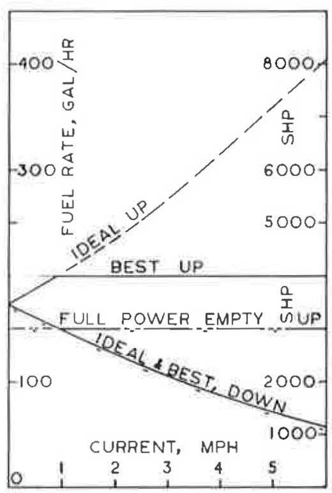

FIGURE 5 Fuel rates that produce the profitabilities shown in Figure 4 versus current when tow loaded downstream, empty upstream only.

Most towboats are set up to deliver just the opposite--full power with a heavy tow and less power with a light one. That makes them commercially suitable for moving cargo upstream and commercially unsuitable for moving it downstream, which many of them nevertheless do. Here is yet another area where there is room for improvement.

SUMMARY OF POSSIBILITIES

As the foregoing examples show,

1. It is possible to improve towing operations by better control alone, without any change in the basic equipment;
2. The fuel monitor both makes the necessary measurements and provides feedback for control of operations; and
3. Understanding and analysis of the operating company's situation indicate how to use the fuel monitor's output to the company's advantage.

As to company situations, a few examples, intended as illustrations, are all there is room for here. The number of possible operating and financial circumstances is large, and they change continuously. Full coverage is unfeasible. Everyone must therefore continually analyze his own situation. One who does so can make fuel monitors serve him very well.

The examples have treated mostly control of towing speed, the payoff for which can be estimated. There are also other applications for which the improvement is less easy to quantify, though it may be larger. It is possible to imagine a not-too-distant future in which collection and organization of towing performance data will have made great improvements in

1. Prediction of operating schedules (ETAs, etc.) and
2. Prediction of cost of operations.

The latter would appear to be especially important in these days of marginal freight rates. In one of the examples, for instance, the profitability of an upstream move fell from a rate of more than $300,000/year to less than zero as current increased from zero to only 3 mph. The current of the Ohio River does this every year. Why should the freight rates not change also? It might be safe to offer cheaper transportation if costs were under better control and operations were more thoroughly understood.

The possibility of better control is offered by fuel monitors. Better control leads in turn, and by many paths, to better performance. Fuel monitors can enable those who control towing operations to see what they are doing and thereby to improve.

ACKNOWLEDGMENT

The information in Figure 2 was supplied by the river boat building division of Dravo Corporation. Until it went out of business recently, this company was a rare source of dependable towing performance information.

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Managing Barge Operations for Improved Productivity

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ABSTRACT

Today the inland waterways industry confronts an environment that is vastly different from that faced by managers even a few years ago. Losses from ongoing operations, common even among the strongest carriers, result from recent precipitous declines in transportation demand and massive overbuilding of most segments of the barge fleet. In this depressed and uncertain setting, traditional rules of thumb concerning productivity-maximizing operating strategies may no longer be appropriate. Some largely theoretical work has been done on determining the principles that will allow operators to maximize productivity and profitability. However, there is little authoritative practical guidance on how to operate based on those principles. Tow operations are completely under the control of vessel pilots, who receive instructions from operations managers but respond primarily to riverine and weather conditions. In this research methods are being devised to bridge the gap between strategic plans and tow operations, the objective being to develop an operations planning system that combines vessel performance data and strategic objectives. The vessel performance data are supplied by an onboard measurement and reporting system. The strategic objectives are based on data from the barge company's management information system. The operations planning system combines these two information sources and uses an onboard microprocessor to develop vessel control parameters that reflect the priorities set by company management.

Today, the inland waterways industry confronts an environment that is vastly different from that faced by managers even a few years ago. Losses from ongoing operations, common even among the strongest carriers, result from a precipitous decline in transportation demand and massive overbuilding of most segments of the barge fleet. Some recent research sponsored by the Maritime Administration (1) charts the history and dimensions of this problem.

It is this depressed and uncertain strategic environment that motivates this research. Traditional rules of thumb concerning profit and productivity-maximizing operating strategies may no longer apply. Yet, even when new strategies can be derived, no effective mechanisms exist to evaluate these strategies and to turn them into guidelines for towboat operations.

The objective of this research is to develop an operations planning and control system that can modify real-time vessel performance to reflect changing strategic objectives. The intent of the system is to promote the operation of tows on the inland waterways so as to maximize corporate productivity and profitability.

IMPROVING PRODUCTIVITY ON THE TOWBOAT

Tow operations are completely under the control of the towboat captain or pilot, and there has been little in the way of guidance to the pilot as to how he should operate in response to the changing circumstances of the towing company. For the most part, the pilot responds to riverine and weather conditions and controls the tow to maintain safety and to achieve whatever speed seems to be appropriate at the moment.

The primary use of the operations planning and control system (OPCS) will be to monitor and control vessel performance based on the testing and evaluation of various operating and strategic options. Selecting the right set of options is critical today. Some examples of options needing analysis are as follows:

- Current wisdom in the inland waterways industry states, "When business is good you can't go fast enough, and when business is bad you can't go slow enough." Although this operating rule may have wide application, it is highly likely that there are operating speeds between these two extremes that are appropriate for given company circumstances. The OPCS will enable testing of proposed operating speeds and transmittal of appropriate instructions to the towboat pilot.
- There is also some debate within the industry at present as to whether towing companies should make up tows for maximum tonnage or should attempt to improve customer service by adhering to planned and publicized schedules. The OPCS will enable the towing company to analyze the trade-offs involved and then influence towboat operational decisions to enhance company performance.
- Choosing the right match between size of tows and size of towboat for particular river segments and classes of traffic has become problematic as more towing companies find themselves with sufficient towboat capacity to have alternatives readily available. The detailed vessel performance data that will be collected by the OPCS are essential to making the proper choices.

INTEGRATING SHIPBOARD AND SHORE-BASED SYSTEMS

Until recently, there was a decided lack of timely information that could be provided to the pilot for the purpose of improving towing operations. Now, however, Ingram Barge Company and several others are using fuel- and speed-monitoring equipment and other types of vessel performance measurement systems to provide instantaneous feedback to the pilot with

respect to tow operations. Typically these systems provide information on fuel consumption, engine performance, and tow speed. Many barge companies, including Ingram, have also installed a management information system (MIS) so that they have available current information on barges in tow, vessel position, future shipments, and so on. The OPCS will integrate vessel performance and existing management information data to develop towing operations plans. This system will given Ingram the ability to control river operations to conform much more closely to well-defined company objectives and to test and evaluate alternative operating strategies.

The OPCS will also include components that trace the cost and revenue impacts of various operating decisions. Thus, it may be used for cost research, market research, and corporate planning and budgeting.

In the next section the decision-making structure within a barge company is described in overview fashion, focusing on the flow of control from top management all the way through to the company's towboats. This is followed by a description of the data collection system and performance models being developed to implement the OPCS. Preliminary data and prototype analyses with the models are included in this presentation.

BARGE COMPANY DECISION MAKING

Each person within a barge company's decision-making structure is able to exert some control on the company's day-to-day operations. Likewise, each decision maker relies on limited data on vessel and company performance to determine exactly what he should do. Thus, an important first step in this research was to articulate the barge company's decision-making structure. In an earlier paper (2) this topic was discussed in greater depth than can be presented here.

An overview of the typical decision structure is given in Figure 1, which shows the information flows involving the marketing manager, the operations manager, and the vessel pilot. Each of these decision makers responds to a variety of company and external factors. The decisions he makes, in turn, become some of the controls influencing the next decision maker. The performance achieved by the company's tows should be a prime source of feedback influencing future decisions.

The objectives of the barge company for the current period (say, the next quarter) are set with reference to a number of external business factors, such as the state of the economy, world petroleum supply and demand, agricultural production, interest rates, as well as internal factors such as the current budget, profit objectives, capital spending plans, cash flow, and so forth. Developing business to achieve these objectives is the responsibility of the marketing manager. His job involves assessing the markets that the company currently serves or might want to serve in the future and gauging the company's ability to compete effectively. He must then develop price and service packages designed to penetrate those markets to the desired degree.

The service strategies developed and sold by marketing are passed on to the operations department as the service parameters within which they are expected to work. The operations manager is concerned with questions such as which vessels to assign to particular services, how tows should be made up, what schedules should be followed, and all the other details of tow operations. The operations manager must also pay attention to how each individual towing operation fits into the operating pattern of the entire fleet of towboats and barges under his control.

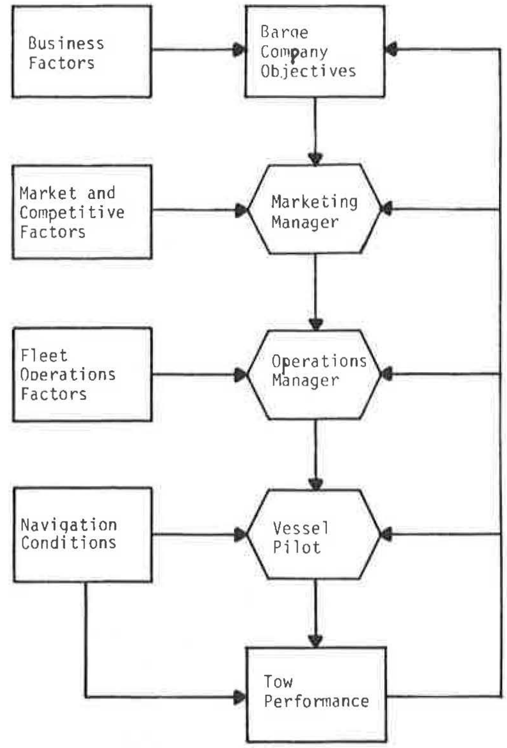

FIGURE 1 Barge company operations management structure.

The towboat captain receives instructions from the operations manager as to which work assignments his tow is to accomplish. Within these instructions, he is generally free to respond to navigation conditions and the performance capabilities of his tow. This research is developing additional information for the vessel pilot so that he can make his operating decisions within the context of the strategic objectives put forth by company management.

The decisions made by the pilot have the most direct impact on the performance of the tow. This performance might be expressed in terms of speed, fuel consumption, the positioning of barges and towboats, and so on. Each of these performance measures has meaning, but perhaps in different ways, to the various decision makers. An onboard system developed to measure certain aspects of tow performance is described in the next section.

MEASURING TOW PERFORMANCE

Ingram has installed a microprocessor-based fuel system, the Pandel FMS-3, on several of its line-haul boats. Figure 2 is a schematic diagram of the system. Its components are located on the main engines, at the head of the tow, and in the pilot house. The system measures fuel flow, engine speed, and tow speed. The central processor makes several simple calculations, the results of which are displayed on a CRT terminal device. The FMS-3 uses an off-the-shelf terminal and printer. The system is software based and most changes are relatively easy to make through the installation of a new program.

System Components

Fuel to and from each engine passes through in-line turbine meters. Fuel temperature is measured at each

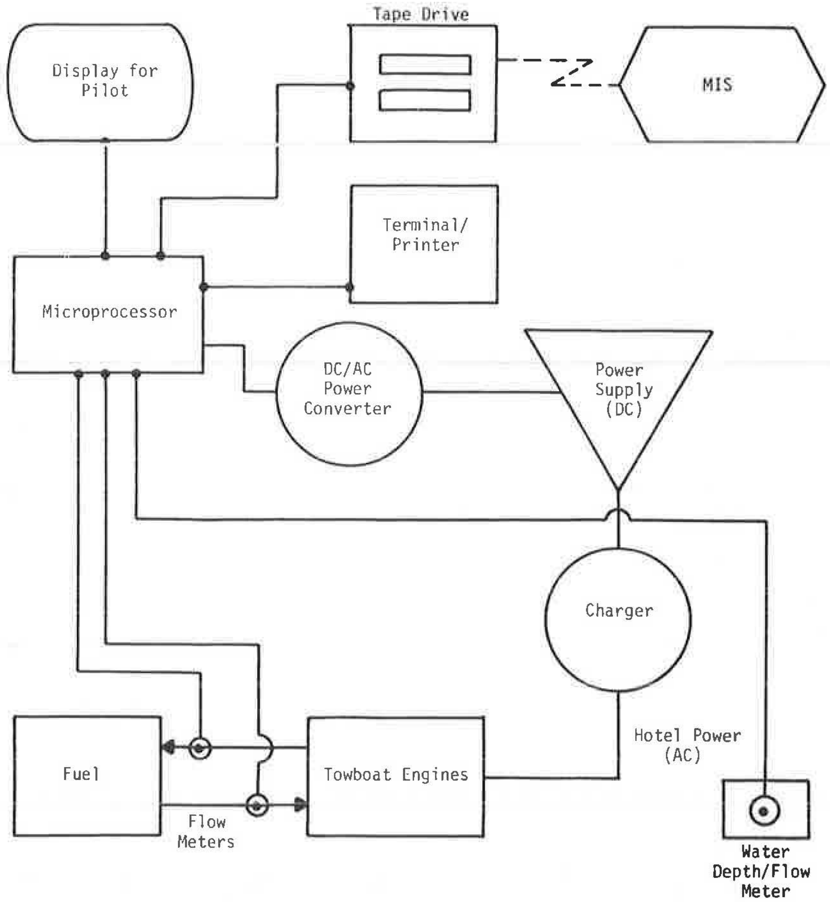

FIGURE 2 Onboard data collection system.

meter. The signals from the meters are conditioned and passed through a junction box and up to the central processor.

Water speed is measured by a paddle wheel mounted on the depth sounder pole at the head of the tow. The signal from the paddle wheel passes to a small radio transmitter. The radio signal is received in the pilot house and passed by cable to the central processor.

Engine speed is measured with electromagnetic tachometers mounted adjacent to the engine flywheels. The tach signal passes through the same junction box and up to the central processor.

The microprocessor uses AC power, which is taken from the boat's hotel power and passed through a DC power supply. This step is taken to insulate the electronics from fluctuations and transients in the hotel power.

The central processor displays fuel flow and fuel temperature into and out of each engine, engine speed, and tow speed through the water. It calculates net fuel flow for each engine and for the boat. It also calculates fuel efficiency for the boat and keeps track of the aggregate fuel consumed by each engine.

Ingram's MIS is housed in a Hewlett Packard (HP) 3000 Model 68 computer and provides compatibility with HP 150 microcomputers available to the management team. Communication between the FMS-3 and the Ingram MIS is handled with microcassette tapes and a high-speed (9,600-baud) tape recorder and player. The recorder attains its high speed via a buffer. The data are transmitted in binary form, utilizing neither stop bits nor control codes.

The data are collected by the FMS-3 and recorded on a cassette tape. The tape is sent to Nashville and read by a second high-speed recorder-player, which puts the data onto a flexible microdisk for the HP 150. A BASIC program will read and sort the data and create a master file that will be transferred to the HP 3000 for safe storage. As each file is needed for analysis it will be called back to the HP 150. Results will be filed, transferred, and stored in the HP 3000.

Use of the System

The pilot can input his own estimates of ground speed, water speed, or current. He can also compute ground speed over a measured course and automatically enter that into the processor. The system will automatically utilize the most recently input speed information regardless of the source. If the water speed device is working properly and if the pilot makes frequent ground speed measurements, the speed and fuel efficiency data displayed by the system should be accurate.

The FMS-3 provides the pilot with a real-time measurement of fuel flow and speed. With it he can instantly see the effects of any changes in the way that the boat is operated. If something such as water depth, current, engine speed, or a host of other factors changes, the efficiency of the boat will also change. The direction and extent of the change are automatically displayed on the screen.

The FMS-3 is installed on Ingram boats to function primarily as a tool for the conscientious pilot. It is understood that he already navigates the tow along the path of least resistance. He would

do this with or without a fuel measurement computer on board. His training and experience have taught him how to maneuver the tow. With the engines set to run at full power, the path of least resistance is also the path of maximum speed. The pilot knows and seeks out this path whether or not he is running at full speed. Without the computer, however, he does not know what the effect of engine speed is on fuel efficiency. The FMS-3 provides information on efficiency. Its intended use is to help the pilot to find the best speed at which to run his boat's engines.

Illustrative Measurements

Operating data were gathered under controlled conditions from an Ingram towboat. Water speed, ground speed, and fuel flow were measured with the FMS-3 and recorded manually. Data were collected for four different tow configurations: light boat, 2 empties (2 wide x 1 long), 5 empties (2 wide x 3 and 2 long), and 15 empties (3 wide x 5 long). The boat ran up-river from Baton Rouge while the data were collected. The data relating fuel consumption and engine speed are presented in Figure 3. The data support the common assumption that the relationship between fuel use (gallons per mile through the water) and engine speed is convex with respect to the origin. Heavier tows consumed more fuel. Also, the data points for two empties and five empties were nearly identical, leading to the conclusion that the cross-sectional area of the tow front is a very significant operating variable.

In the OPCS, data from the FMS-3 will be used to calibrate and implement various tow performance models. These are taken up in the next section.

TOW PERFORMANCE MODELS

Strategic control of vessel operations requires analysis of the relationships between performance measures and control parameters. The relationships will appear in the OPCS as a set of control process models, including a tow performance model, average and marginal tow cost models, and a revenue-profit model.

Generic Relationships

One output of the system will be guidelines for the towboat pilot concerning what speed he should try to attain in given circumstances. Thus much of the modeling interest centers on the relationships between various measures of tow performance and speed. Figure 4 presents a generalized analytical framework for dealing with these relationships.

The precipitous rise in fuel prices a few years ago engendered considerable interest in towboat fuel consumption characteristics. The lowermost curve in Figure 4 illustrates the general relationship between fuel consumption (and hence fuel cost) and tow speed, which was verified by the data presented earlier. At very low speeds fuel efficiency is relatively poor. The tow then moves into a more favorable operating regime, and the point of minimum fuel cost (S_f) is reached. As speed increases beyond this point fuel consumption increases rapidly, because tow resistance tends to increase with the square of tow speed.

The point of minimum fuel cost may not be the point of minimum average total cost, because there are other cost elements to consider. Average fixed cost per hour declines as tow speed increases, be-

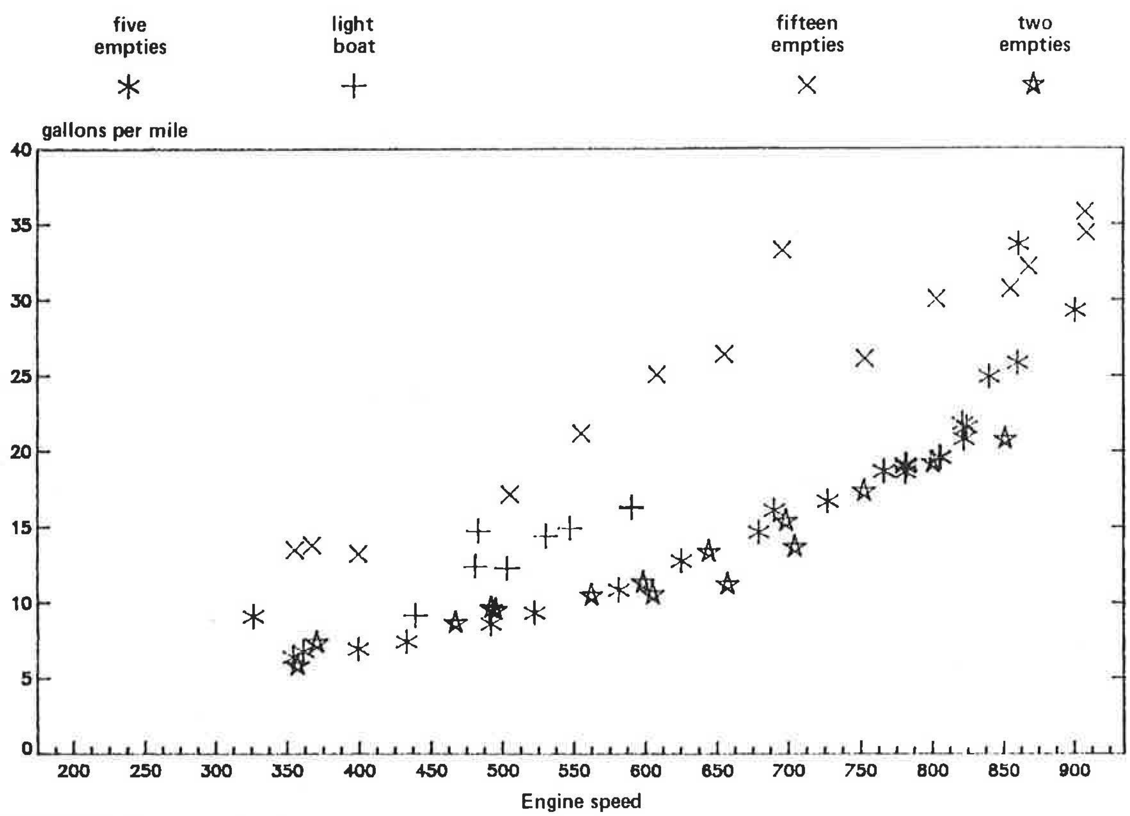

FIGURE 3 Tow operating data.

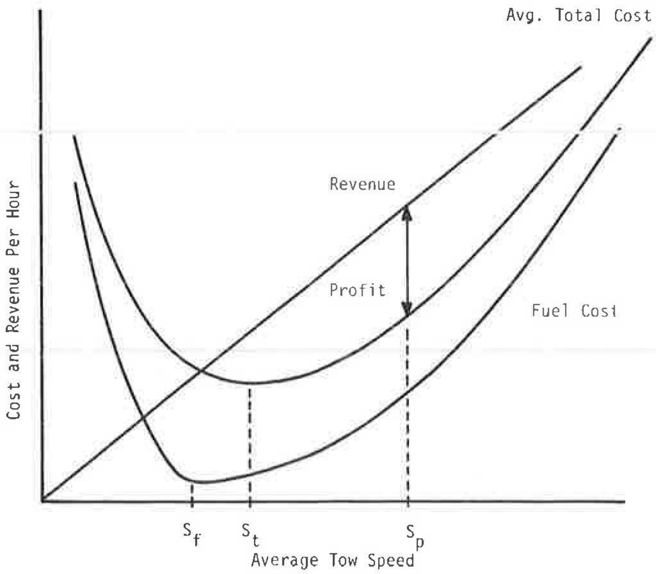

FIGURE 4 Generalized towing profitability model.

cause the fixed elements of cost are spread over a greater number of hours. Average variable cost starts at zero when tow speed is zero, because by definition there is no cost when no output is being produced. As tow speed increases, output increases and variable cost becomes positive. At the higher speeds, labor, material, and equipment all incur added stress and wear, so average variable cost tends to increase. Thus the sum of the two, the average total cost curve, tends to be U-shaped as shown in Figure 4. The low point on it occurs at speed S_t, which tends to be higher than S_f.

A third curve, the revenue curve, must be introduced to find the speed that will yield maximum profit. One possible revenue curve is shown in Figure 4. No revenue can be earned if the tow is not moving at all, so this curve passes through the origin. As higher speeds are attained, the revenue accrued per time unit increases. The speed that yields maximum profit (S_p) is found at the point at which the distance between the revenue curve and the average total cost curve is at its maximum. For the case shown in Figure 4, this speed is higher than both the minimum cost and minimum fuel cost speeds.

The cost and revenue curves can shift while the boat is under way because of changes in crew size, fuel price, barge fleeting and positioning requirements, weather, river stage, outside charter requirements or opportunities, and a host of other factors. The optimum tow operating speed will change as these other factors change.

Tow Speed Equations

A number of tow speed equations developed by previous researchers were reviewed, and four were selected for possible use in the OPCS. The Howe model (3,pp.23-33) and the Toutant model (4) are basically the same equations, the latter being a simplification of the former. Both equations require tow and river dimensions in order to determine speed developed at a given horsepower applied. The Toutant model also provides speed determination for both open-wheel and Kort nozzle boats, and utilizes a factor to adjust for the differences in tow resistance produced by various tow configurations (integrated, mixed, etc.).

The tow speed equation developed for the Inland Navigation Systems Analysis (INSA) program (5) was also considered. This equation requires the use of various hard-to-obtain parameters: user-specified coefficients relating to direction, a fastening coefficient relating to barge configuration, and the barge specific resistance.

The fourth model considered was a speed equation developed at Pennsylvania State University (6) using regression analysis. This equation determines tow speed as a function of horsepower, river current speed, direction of travel, and number of loaded and empty barges. Sample calculations were made using 15 loaded and 15 empty barges with 0 and 4 mph river current. The difference between loaded and empty tows was about 3 mph. The difference between upstream and downstream travel was about 3 to 4 mph depending on river current.

All of the equations considered are given elsewhere (7). The Howe and Toutant models were rejected for the initial OPCS tow performance model because of their reliance on river parameters, which would vary over time and distance and thus be difficult to use for operational purposes. The INSA model was rejected because of the need to compute fastening coefficients and specific barge resistance for each tow.

The final selection was the regression equation, displayed in the following as Equation 4, which was chosen for its simplicity. For this use, however, it will have to be recalibrated. The coefficient of the river speed term (0.1475C) appears to be too small in light of the actual data presented. It also appears that a variable related to the tow cross section will have to be added. If calibration of a revised regression equation produces unsatisfactory results, a revised Toutant equation (without river param- eters) will be experimented with.

Comparison with Measured Tow Speeds

Tow speeds estimated with the Penn State and Toutant equations were compared with data collected on board two instrumented vessels during break-in and initial use of the system. The data used were those tow runs where sufficient information was available and believable. Data were not used if the run contained delays. Only through runs were considered. Two basic assumptions were made: (a) that time and mile marker data input by the pilot were accurate, and (b) that speed and fuel consumption from one observation to the next were constant.

Three calculations were made with the trip data. Average ground speed was determined by subtracting beginning and ending mile points and dividing by total elapsed time. Fuel consumption for the trip was the sum of the consumption for each leg. Dividing by the total trip time gives average fuel consumption for the whole trip in gallons per hour. A gallon-per-mile figure was obtained by dividing gallons per hour by miles per hour. The regression equation for speed was used to estimate tow speed with river current (C) assumed to be zero.

Data for 10 trips with two different towboats are summarized in Table 1. The range of rpm values is listed for reference. The data in Table 1 show that actual average ground speeds are about 3 to 5 mph different from the calculated speed. If the factor 0.1475C is used, the required river current speed to make the equation work would be 20 to 30 mph in some cases. Obviously, the coefficient 0.1475 is too low, or other model parameters are incorrect. In fact, the regression equation was estimated with data for smaller tows operating on locking rivers, so new parameters are needed for Lower Mississippi River conditions.

TABLE 1 Tow Performance Data from Onboard System

Parameter	Trip No. 1	2	3	4	5	6	7	8	9	10
Direction	Up	Up	Up	Up	Down	Down	Down	Down	Up	Up
Loaded barges (no.)	3	0	5	5	29	35	30	30	4	4
Empty barges (no.)	37	49	44	44	0	0	0	0	25	31
Mileage	380	436	227	121	91	178	147	192	107	252
Speed (mph)	4.36	4.54	4.41	3.84	9.25	9.75	11.31	11.46	5.35	4.78
Fuel consumption										
Gal/hr	441.81	450.68	464.92	576.82	147.97	136.38	242.54	365.40	398.62	359.75
Gal/mile	101.33	99.27	105.42	150.21	15.99	13.99	21.44	31.88	74.51	75.31
S(calc) (mph)	9.77	9.99	8.98	8.98	8.87	7.38	7.37	7.37	8.79	8.53
S (Toutant)	8.7	6.7	6.7	6.7	10.3	8.9	7.9	7.9	8.9	7.7
Power range (rpm)	855-906	879-908	842-906	832-906	600-630	625-646	722-892	843-886	882-910	846-906

Note: S(calc) = speed calculated from Equation 4, with river current assumed to be zero. S (Toutant) = speed calculated with Toutant equation (channel width = 400 ft, depth = 30 ft, current speed = 0).

The calculations made using the Toutant equation assumed generous channel dimensions (width = 400 ft, depth = 30 ft). In general, these tow speeds were lower than the regression equation speeds for upstream tows and slightly higher for downstream tows. These figures are shown in Table 1. Note that the implicit current speeds are quite reasonable for most cases.

Tow Performance Model

The basic equation used in this model is Equation 1, given as follows: profit equals revenue minus cost. In towing operations, all costs for a given trip are considered to be fixed except fuel costs, so the equations show fuel and fixed costs separately.

$$P = R - E - F \quad (1)$$

$$R = (\sum_i r_i C_i)/T \quad (2)$$

$$E = e(60 \sum_j q_j t_j)/T \quad (3)$$

$$S = 7.348 - 3.93 (A) + 0.0915 (H)^{1/2} - 0.04288 (5.67 B_l + B_e) \pm 0.1475C \quad (4)$$

$$q_j = 3.54 \exp[(0.00427)(\text{rpm})] \quad (5)$$

where

- P = profit ($/hr);
- R = revenue ($/hr);
- E = fuel costs ($/hr);
- F = fixed costs ($/hr), to be obtained from the MIS;
- r_i = revenue rate ($/ton) for barge i;
- C_i = capacity of barge i (tons);
- T = total trip time (hr);
- e = cost of fuel ($/gal);
- q_j = fuel consumption rate for operation j (gal/min);
- t_j = time of operation j (hr);
- S = calculated ground speed (mph);
- A = direction of travel (1 upstream, 0 downstream);
- H = horsepower of towboat (hp);
- B_l = number of loaded barges;
- B_e = number of empty barges;
- C = river current speed (mph); and
- rpm = engine speed.

Revenue for a given tow movement is the sum of the freight rate (r_i) times the capacity (C_i) for each barge in the tow. Dividing by total trip time (T) gives trip revenue in dollars per hour.

The cost of fuel (e) and the fixed costs relating to each tow movement will be available from accounting data. Provision should also be made for onboard input of any additional costs incurred while en route.

For an accurate tally of fuel consumption, the pilot should be encouraged to take a reading of time, mile point, and fuel consumption each time the tow speed is changed and each time any major activity change occurs, for example, waiting at idle, making or dropping tow, locking. The total fuel cost then would be the sum of consumption at each activity times fuel price per gallon.

Example

As an example of use of the model, take the case of a tow moving 29 loaded barges 91 miles downstream (trip 5 in Table 1). The actual speed was 9.25 mph. From the regression equation, speed was calculated to be 8.87 mph, indicating a river current of 2.58 mph. Fuel consumption was 147.97 gal/hr or 15.99 gal/mile. Now six loaded barges are added and two conditions are considered.

Condition 1

Maintain the same engine power (rpm) as in the original case. From the regression equation the new speed for the added load is 7.38 mph. Using the same river current, the actual speed would be 7.76 mph (approximately 1.5 mph slower). The 91-mile trip at this speed would take 11.72 hr or 1.89 hr longer (1 hr 53 min). Because engines are running at the same speed, the fuel consumption rate will be as before, 147.97 gal/hr, but for the additional time period. Total fuel consumption for the trip will be increased by 279.17 gal. The revenue will increase according to the rate and capacity of the added barges ($\Sigma\, r_i\, C_i$); fuel costs will increase by $279.17 (at $1/gal). Total fixed costs would also increase because of the extra 2 hr afloat.

Condition 2

Maintain the original tow speed of 9.25 mph. To do this, engines must be run at a higher power. In the original case, the engines were run at 600 to 630 rpm. The equation for fuel consumption in terms of power yields 617 rpm for the consumption rate of 147.97 of the original case. Although we have no relationship at this time between speed and power,

assume that a new engine speed of 650 rpm is used to maintain the 9.25 mph. Fuel consumption rate then would be 170.42 gal/hr or 18.42 gal/mile. This is an increase of 2.43 gal/mile and a total increase in fuel of 220.68 gal. Again, revenue would be increased and fuel costs will increase, but total fixed costs would remain the same as in the original case.

SUMMARY

The objective of this project is to make the MIS and the onboard microprocessor work together to improve operations planning and control. The system implements through hardware, software, and training the conceptual and organizational structures previously presented. Corporate information sources, planning and operational control decisions, and tow performance results are integrated in real time to achieve improved towing operations.

Measurement of project benefits is an important and integral part of this entire research effort. A principal research hypothesis underlying this project is that the absence of towboat performance measures prevents cost-effective vessel control. Providing such measurement is a first step in this research effort. The measured changes in capital, labor, and fuel productivity will be used to judge the impact of the project on corporate profitability.

The authors believe that the potential economic benefits of the project are substantial, but one of the objectives of this research is to make this determination. For example, use of the OPCS should result in a more cost-effective trade-off between fuel and other operating expenses. Ingram alone spends nearly $15 million each year on fuel, so even modest percentage reductions in fuel consumption are highly leveraged.

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San Francisco Bay Area Seaport Plan: A Study of Its Development and Implementation

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ABSTRACT

The purpose of this paper is to describe the process by which the San Francisco Bay Area Seaport Plan was developed, to compare it with other regional port planning efforts, and to evaluate recent and impending implementation actions. The plan was prepared to serve the needs of the Metropolitan Transportation Commission; the Bay Conservation and Development Commission (BCDC), which is responsible for managing the development of the bay and its shoreline; and the Bay Area ports. The basic goal of the plan is to help resolve the inherent conflict between port development and maintenance of environmental quality. Policies were developed to achieve this goal and are the means by which the plan is implemented. Development of the plan required both a technical studies phase and a policy formulation phase, which collectively spanned an 8-year period. The policies are the result of extensive deliberation by a divergent group of opposing interests. This plan has several elements common to other regional port plans, including federal participation, which proved to be important and the first instance of cooperation in facilities planning among traditional adversaries. Unlike other regional port plans, however, it has a reasonable chance of being implemented, because BCDC uses the plan policies as its detailed criteria for judging permit applications. Since the plan was completed in 1982, several port development proposals have been or are about to be considered. These proposals demonstrate that the basic plan precepts can be implemented.

The purpose of this paper is to describe the process by which the San Francisco Bay Area Seaport Plan was developed, to compare it with other regional port planning efforts, and to evaluate recent and impending implementation actions. The plan was prepared to serve the needs of the Metropolitan Transportation Commission (MTC); the Bay Conservation and Development Commission (BCDC), which is responsible for managing the development of the bay and its shoreline; and the Bay Area ports. The basic goal of the plan is to help resolve the inherent conflict between port development and maintenance of environmental quality. Policies were developed to achieve this goal and are the means by which the plan is implemented.

Development of the plan required both a technical studies phase and a policy formulation phase, which collectively spanned an 8-year period. The policies are the result of extensive deliberation by a divergent group of opposing interests. This plan has several elements common to other regional port plans, including federal participation, which proved to be important and the first instance of cooperation in facilities planning among traditional adversaries. Unlike other regional port plans, however, it has a reasonable chance of being implemented, because BCDC uses the plan policies as its detailed criteria for judging permit applications.

Since the plan was completed in 1982, several port development proposals have been or are about to be considered. These proposals demonstrate that the basic plan precepts can be implemented.

SETTING AND BACKGROUND

The bay region's nine counties include some 7,000 $miles^2$ (18 000 km^2) of land inhabited by 5.2 million people. The major topographical features of the region are San Francisco Bay and the hills and valleys surrounding the bay. Because a majority of the land is occupied by hills, transportation facilities have been concentrated in the narrow plain around the bay and in the adjacent valleys. The largest and most important single feature of the region is San Francisco Bay, covering almost 435 $miles^2$ (1130 km^2) and affecting climate, land use, and transportation.

The San Francisco Bay port system is composed of marine terminals--both publicly and privately operated, natural and dredged deepwater channels, and ground transportation facilities serving the ports. There are six port operators in the bay region: the ports of Oakland, San Francisco, Richmond, Redwood City, and Benicia, and Encinal Terminals in Alameda. The port of Benicia and Encinal Terminals are privately owned but offer marine terminal services to a variety of users. The other ports are arms of their respective local governments. The ports of Oakland and San Francisco are the two major ports handling containerized and other general cargoes. Marine terminal facilities exist elsewhere in the region for specialized cargoes (e.g., crude oil), but these facilities were not the focus of the plan. Figures 1 and 2 show the location of the six ports (including the Bay Area highway network) and the deepwater channels, respectively.

The development of the San Francisco Bay Area Seaport Plan (1) was sponsored by both MTC and BCDC. MTC is the regional transportation planning agency for the nine-county San Francisco Bay Area and is responsible for setting transportation funding priorities. California state law requires MTC to maintain a regional transportation plan that is to include, among other things, a maritime element. The Seaport Plan is intended to satisfy this require-

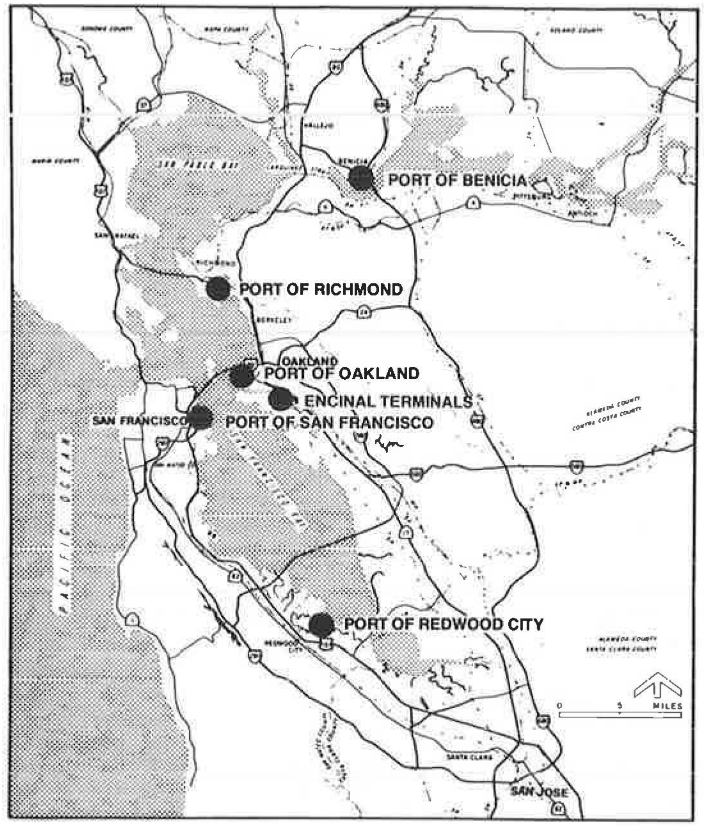

FIGURE 1 San Francisco Bay Area ports *(1)*.

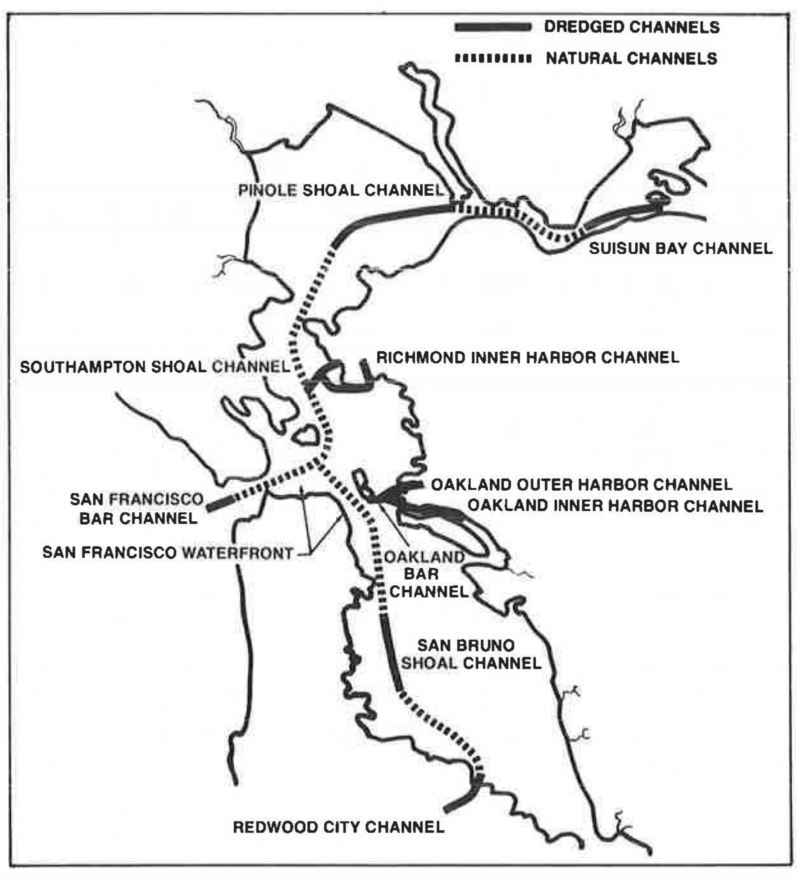

FIGURE 2 San Francisco Bay deepwater channels *(1)*.

ment. MTC will use this plan to review port-related transportation funding requests and environmental documents for port-related projects. BCDC is the state agency designated by the California legislature to regulate filling and dredging in San Francisco Bay and to manage the development of its shoreline. The San Francisco Bay Plan, BCDC's comprehensive plan for the bay, identifies ports as one of the important water-oriented uses in the region and calls for a regional port development plan. BCDC's concern with the bay and the development of its shoreline is largely one of environmental protection and can best be expressed by the following statement from the Bay Plan (2,p.1):

> The Bay must be protected from needless and gradual destruction. The Bay should no longer be treated as ordinary real estate, available to be filled with sand or dirt to create new land. Rather, the Bay should be regarded as the most valuable natural asset of the entire Bay region, a body of water that benefits not only the residents of the Bay Area but of all California and indeed the nation.

BCDC will use the Seaport Plan to review permit applications from port developers, to review federal actions affecting the bay, and to review environmental documents.

To assist with the development and implementation of the Seaport Plan, MTC and BCDC formed the Seaport Planning Advisory Committee, composed of 17 members representing government, the ports, and development and environmental interest groups. Many of the committee members are policymakers for their respective organizations. In fact, the work of the committee is of such great importance to BCDC that its chairman serves on the committee. In addition, each port has generally appointed either its port director or a port commissioner. The committee met over a period of 8 years and completed the plan in May 1982. The Seaport Plan, with some revisions, was adopted by the MTC and BCDC in the fall of 1982.

PLAN DEVELOPMENT

The plan development process took approximately 8 years, in part because of the level of funding available for technical studies, in part because of the need to achieve a consensus among diverse interest groups, and in part because there was no previous plan to start from. At the beginning of the planning project, the ports were resistant to the idea of a regional port plan and of regional agencies "interfering" in their affairs. By the end of the project, the port community as a group had endorsed the Seaport Plan and all but one of the six Bay Area ports had voted in favor of the plan. Even the one port that voted against the plan concurred with 99 percent of the document, but voted no because of one provision affecting its lands. Of the 15 members of the committee present and voting on plan adoption, there was only this one negative vote and some dissent on individual provisions. When the plan came to a vote before MTC and BCDC, it was unanimously adopted by both commissions.

Many factors influenced this outcome of virtual unanimity on the plan:

- Technical studies that sought to answer the questions brought to the process by the various participants;
- A strong commitment at both MTC and BCDC to the development of a regional port development plan;
- A mechanism to enforce the plan through BCDC's permit authority;
- The ports' desire to protect themselves through the planning process;
- The involvement of the environmental community; and
- The influence of time, including the changes that it brings.

The technical studies consumed a majority of the 8-year period of plan development (3). These studies were intended to answer the followed key questions:

- What is the projected growth in waterborne cargo for the San Francisco Bay Area?
- How many new marine terminals will be required to serve the projected cargo?
- Where can the new marine terminals be located?
- What improvements are necessary to the channels, roads, and rails?
- What are the impacts and costs of the required new facilities?
- What methods exist to mitigate the adverse impacts of marine terminal development?

Beyond these questions, other concerns arose as the process proceeded. One such question was voiced by the ports: Why do our statistics show a greater growth rate of containerized cargo than those derived from U.S. Army Corps of Engineers' data? This question was answered during the development of the waterborne cargo forecasts (4). The answer lay in the units used to compile the statistics--revenue tons by the ports and short tons by the Corps. This may appear to be a minor matter, but it did uncover an important factor that needed to be accounted for in developing estimates of demand for new container terminals. This factor was quantified and included in the computations. Although it is only speculation, it seems probable that the result was to increase the ports' acceptance of the demand estimates used in the plan. In fact, the process of developing the forecasts on which these estimates are based is a good example of the approach to the technical studies. The stated goal of the forecasting effort was to strive for a consensus among the affected parties.

The commitment at MTC and BCDC to the development of the plan was also a significant factor affecting the outcome. This commitment took the form of financial support, persistence, a desire to develop a plan that was acceptable to the participants of the process, and a clear focus on the goal of the plan. During the first several years of the study these factors were particularly important. Initially, the Bay Area ports clung to the idea that MTC and BCDC would abandon the study effort if they gave limited support and proceeded with their own studies. As explained later in this paper, the ports conducted studies in the late 1970s, but these studies did not alter the direction or level of effort of the MTC-BCDC studies, primarily because the port studies did not deal with the issue of the trade-off between port development and environmental protection. The persistent focus on this primary goal continued to drive the MTC-BCDC studies. Gradually, the ports began to realize that MTC and BCDC fully intended to develop a port plan. At the moment when this realization was ripe, the U.S. Maritime Administration agreed to participate in the funding of the MTC-BCDC project, after years of funding studies by the Bay Area ports. This was one of three significant turning points in the development of the plan. The ports began taking the planning process much more seriously following this event.

No plan has much meaning if it cannot be implemented. BCDC's permit authority over shoreline development gives the Seaport Plan this ingredient and provided an important incentive for the participants to take the planning process seriously. The importance of this incentive was particularly evident when the Seaport Planning Advisory Committee spent several months midway through the process preparing a short paper that would define the nature of the upcoming plan and its uses. The critical importance of the permit process was clear in the detailed questions posed during the development of this paper. Considerable discussion centered on how BCDC would exercise its permit authority and how this would affect future port development. Although MTC has a significant authority over transportation funding, this authority does not directly affect terminal development as does BCDC's authority. The completion of this paper was the second significant turning point in the planning project. The ports came to fully understand exactly what assurances BCDC expected from the Seaport Plan. Many concerns only vaguely referred to previously were now on the table. The ports did not agree with all the proposals, but the paper passed a vote of the committee and became the general policy format for the plan. The ports began to focus their attention on the parts of the technical studies they now knew would affect them most. This early introduction of the general plan policies also allowed the ports an extended period of time to fully understand them and to see the advantage of certain policies as well as the initially perceived disadvantages.

The desire of the Bay Area ports to protect themselves through the planning process also aided in attaining a successful outcome. The ports, of course, had the incentive of BCDC's permit authority, but they could have opted to seek a legislative remedy. At the beginning, they were naturally suspicious of the two regional agencies' intentions, but these suspicions appear to have faded with time. Their continued involvement was important and, whatever their motives, is to the port community's credit.

An essential purpose of the Seaport Plan is to strike a balance between port development and environmental protection. One of the most critical factors affecting San Francisco Bay is fill, and ports require fill for virtually all types of marine terminal development. The environmental activist group, Save San Francisco Bay Association, has among its concerns bay filling, retention of water surface area and volume, and the overall effects of channel dredging. This association was represented on the Seaport Planning Advisory Committee, and provided an important balance in the deliberations.

Time brought several beneficial changes to the process. The committee's ability to work together improved as the years progressed. Time also introduced several new port managers who were more sympathetic to regional cooperation. In this context, it seems probable that a higher level of funding, permitting a speedier process, might actually have resulted in an inferior outcome. The third significant turning point began with a change of management at the port of Oakland. In the late 1970s the then executive director of BCDC resigned and was quickly offered the position of chief engineer at the port of Oakland. He deliberately distanced himself from the regional port planning process for several years, although he firmly believed in regional cooperation and had, as executive director of BCDC, been the first to call for a regional port plan. When the serious negotiations on the plan began in early 1982, he once again became active in the process and helped to a very considerable degree in bringing the negotiations to a successful completion.

KEY PROVISIONS OF THE PLAN

The Seaport Plan focuses on marine terminals but also contains findings and policies covering both deepwater channels and ground access. The various provisions of the plan are intended

- To encourage cooperation among the Bay Area ports with regard to their development,
- To foster cooperation between the ports and their parent cities,
- To provide increased predictability to the ports with regard to BCDC permits,
- To steer port development to those sites with the least potential for adverse environmental impacts while still providing reasonable terminal development,
- To decrease the pressures for bay fill resulting from actions by the ports and their parent cities,
- To provide a regional context for evaluating the environmental impacts of individual port projects, and
- To provide a clear statement of the actions that will be taken by BCDC and MTC in implementing the plan.

Although there are policies covering a range of issues, the Seaport Plan has two key provisions: (a) only needed development should proceed, and (b) terminals should be located at the sites considered to be the best by the plan and these sites should be protected for marine terminal use.

The first of these key provisions is in direct response to the concerns of the environmental community, BCDC, and others that terminals were being built and then left idle or underused for long periods of time. Such idle terminals represent unnecessary environmental damage and wasted public investment in facilities. These concerns, however, represent only part of the complex equation. The plan also recognizes that increased waterborne trade is an important economic benefit to the Bay Area. Although this point might be argued by some, the Seaport Planning Advisory Committee found ample backup in BCDC's Bay Plan and the history of Bay Area development to support this contention. To balance these two concerns, the committee agreed to measure the need for new terminals by using mutually acceptable forecasts, and the concerned parties agreed to abide by the decisions made using them with regard to BCDC permits.

The need criterion, however, provides only part of the assurance desired by BCDC and the environmental community. The ports of the Bay Area still compete with each other and with other West Coast ports for cargo and the ocean carriers that transport this cargo. This competition is generally in the public interest because it helps keep shipping costs down, may generate new shipping business, and keeps the Bay Area ports sensitive to changes in shipping technology and the needs of the shipper. Nevertheless, such competition may have undesirable side effects. Terminals may still be permitted and constructed and go unused or be underused, which in turn may result in unnecessary expenditure of public funds and unnecessary bay fill. Recognizing this problem, the Seaport Plan

- Encourages the Bay Area ports to cooperate among themselves to avoid duplicating facilities;
- Provides that BCDC permits include a schedule for financing and construction of a project in order to avoid, to the extent possible, partly completed projects; and

• Provides that if existing terminals remain unused or little used for a significant period of time, no new terminal development of the same type be considered until a reevaluation of the plan is completed.

The second key provision has two parts. The first is to steer port development to the best sites. The result of the extensive site-screening process was a list of sites that are considered the best. The plan calls for these sites to first be used before any other sites, including the second-rated sites, are considered. It does, however, provide for reconsideration of other sites if it can be shown that development at some other location can occur with impacts equal to or less than those of the selected sites. The plan also requires a thorough review of the alternatives once all the best sites are used. This provision is important because it implies that development does not automatically move to the second-rated sites whenever all the best ones are used; other alternatives may be preferable for accommodating future demand.

The plan also provides that the sites chosen for marine terminal development be protected for that use (Figure 3). To this end, the Seaport Plan recognizes that these sites cannot be fully protected without the cooperation of the ports and local government, and calls on local government and the ports to protect the sites. This is particularly important because there are many competing uses for the bay shoreline and because the alternatives are vastly increased amounts of bay fill at other sites or potential loss of Bay Area cargo to other Pacific Coast ports. With the increasing need of local government to find revenue sources, the temptation to seek the quickest, highest tax revenue from valuable waterfront lands will increase. This will increase the pressure to put port property to other uses than marine terminals, which provide a longer-term benefit to the local and regional economy. Protecting port lands will probably be one of the most important and troublesome issues in implementing the plan.

COMPARISON WITH OTHER REGIONAL PORT PLANNING STUDIES

There have been 16 regional port planning studies (Table 1) throughout the United States in the last 10 years (5). These studies vary with regard to geographic area, sponsor, funding, study scope and process, and implementation. From a process and policy perspective, the most interesting comparisons with the San Francisco Bay Area Seaport Plan center on federal involvement, study process, and implementation.

A common element to all regional port studies, including the San Francisco Bay Area Seaport Plan, has been funding and management involvement by the U.S. Maritime Administration (MARAD). MARAD involvement has been an ingredient of these studies, not because federal regulations require such studies but because ports and local governments have requested federal financial support. This federal involvement has helped develop consistency in planning techniques, such as forecasting and capacity estimating, and has provided MARAD with inventory data that it can use to fulfill its national defense preparedness responsibilities. Consistency in forecasting is particularly important. Regions often compete for the same cargoes, and regional waterborne cargo forecasts typically make liberal assumptions about the capture rates for a region. Thus, these individual regional forecasts, if summed, would add to cargo flows much greater than U.S. trade as a whole could justify. MARAD involvement helps to bring this consideration to the attention of the planners and to some extent reduce the chances that unrealizable forecasts will be prepared. Inflated forecasts can result in wasted investment of public funds in marine terminals and infrastructure, and unnecessary environmental damage. Unfortunately, cutbacks in MARAD research and development funds have eliminated federal funding participation in regional port planning studies. Important local and national benefits are derived from federal involvement in these studies, and it is hoped that federal interest will be renewed. In fact, no regional port planning studies have been initiated recently. It is not clear whether the lack of federal participation is a factor or not.

Although the details of the planning process vary from study to study, there is a common aspect to the process in many cases. These regional planning endeavors have been "the first time that normally adversary groups have communicated for a common goal" (5,p.339). Taken as a broad statement about all port activities, this is not precisely accurate. Ports have actively cooperated with regard to setting tariffs and promoting navigation projects. Nevertheless, before the regional planning studies, ports had never cooperated with regard to planning their terminal facilities because they compete with one another.

In the San Francisco Bay Area, the ports began working together when MTC and BCDC initiated port planning in the early 1970s. Even though the Bay Area ports were all represented on the committee formed to provide guidance to MTC and BCDC, they revived a dormant port organization and started cooperative planning in defense against the regional agencies interfering in their affairs. In fact, they completed a study in 1976 (see Table 1). This study, however, did not satisfy the requirements of the laws and policies under which MTC and BCDC were pursuing regional port planning. The regional agencies continued to move forward with their planning, and after several further attempts to do planning in the late 1970s, the ports finally accepted the fact that MTC and BCDC would ultimately produce a plan and that they should begin to seriously work with the regional agencies to structure the plan to their best possible advantage. The pivotal action that coalesced this change in the port's approach was MARAD's agreement to participate in the funding of the MTC-BCDC port planning project.

During the planning process, the ports learned to work not only with one another but with the members of the MTC-BCDC Seaport Planning Advisory Committee, which included representatives from government agencies, from an environmental interest group, and from development interests. The working relationship was not always comfortable for all parties, and divisions among the ports and among committee members existed. Nevertheless, the Bay Area ports did begin talking to each other and have continued to cooperate on limited areas of common interest, such as marketing materials.

With regard to implementation, more will be said in the next section, but it is worth noting two important differences in the San Francisco Bay Area Seaport Plan from other regional port plans. First, through the policies in the plan and BCDC's permit authority, this plan can be enforced to an extent not available to other regional port plans. Any shoreline development will require a BCDC permit and will be reviewed for conformity with the Seaport Plan. This review helps assure that port development will be consistent with the plan and helps assure that other shoreline uses will not preempt future port development at the sites reserved for port use. Second, BCDC and MTC have agreed to continue to use the Seaport Planning Advisory Committee to provide

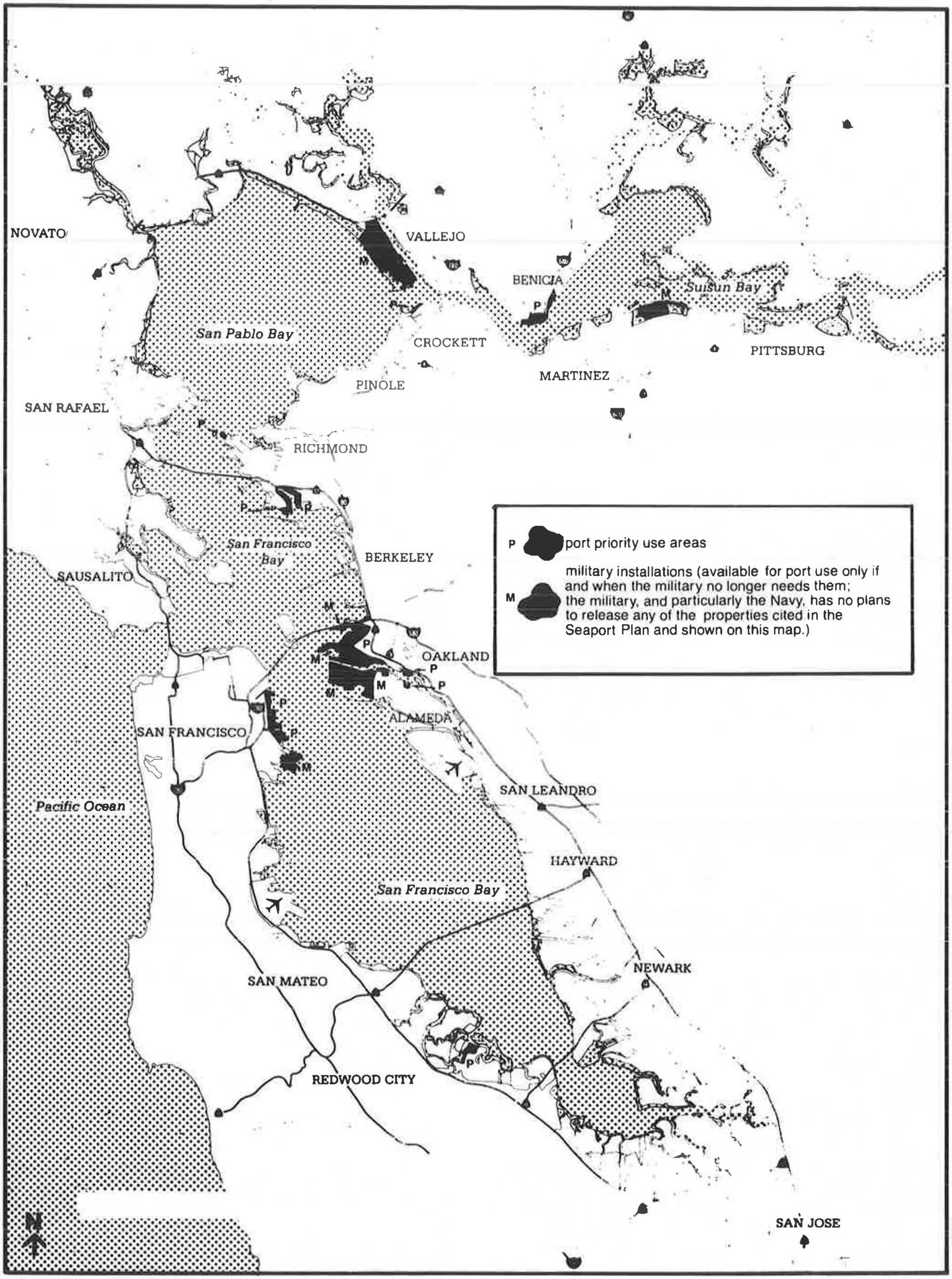

FIGURE 3 Port areas to be protected *(1)*.

TABLE 1 Regional Port Planning Studies *(5)*

Region	Local Sponsor	Year
Pacific Northwest	Washington Public Ports Association and Portland, Oregon	1975
San Francisco Bay	Northern California Ports Association	1976
Metropolitan St. Louis	East-West Gateway Council	1976
Mid-America	Seventeen states along Mississippi River from Illinois to Louisiana	1978
Florida	State department of transportation (DOT)	1978
Virginia	Virginia Study Commission	1979
Maryland	State DOT	1980
Alaska	State DOT	1980
Oregon	State Economic Development Department	1980
Great Lakes	Eight Great Lakes states	1981
New England	New England River Basins Commission	1981
Hawaii	State DOT	1981
State of Washington	Washington Public Ports Association	1981
San Francisco Bay	MTC and BCDC	1982
Delaware River	Delaware River Port Authority and area city and port authorities	1982
New York-New Jersey	NY-NJ municipalities	1983

advice on proposed port projects. Typically, the groups formed to prepare regional port plans disband following completion of the plan, either because the sponsoring agencies terminate the group or because of friction among the members, such as fear that the large port will dominate. This will not be the case in the Bay Area and has not been the case in Washington State, where the planning committee continues to provide peer review of proposed projects.

RECENT AND IMPENDING IMPLEMENTATION ACTIONS

Since completion of the Seaport Plan in 1982, three marine terminal developments have been authorized, three projects are being or will shortly be considered, and one unconstructed project will require an extension of its BCDC permit. Of these, three provide good examples of the policy and process issues discussed earlier. They are the port master plan for Encinal Terminals, Alameda; the Alameda Gateway Project; and the Pier 50 ship repair facility, port of San Francisco.

The Encinal Terminals port master plan was approved by BCDC in late 1983 and was the first permit to be issued under the Seaport Plan. The plan consists of expansion of an existing container terminal, redevelopment of an old marine terminal facility into a container terminal, and various other improvements, including a marina expansion and commercial development. This project was first reviewed by MTC and BCDC during the public comment period on the draft environmental impact report and then underwent extensive review during the deliberations that led to issuance of a development permit by BCDC. During the permit proceedings, two issues surfaced.

The first issue pertains to scope and schedule for the project and can be best expressed with the following question: Is it reasonable to issue a permit for the entire master plan when construction on some parts of the plan will not start for many years? This is important because there are a limited number of terminals that may be permitted according to the forecasts of need in the Seaport Plan. If one port receives permits for several terminals, no other port may be able to receive a permit for a considerable time, until the demand forecasts show that more new terminals are needed. To avoid a monopoly on permits for new terminals by a single port, the Seaport Plan requires a development schedule that contains milestones that must be met. These milestones must be consistent with the guidelines provided by the Seaport Plan. If the applicant is unable to meet that schedule, the permit is to be revoked and the terminal capacity represented by that permit can then be made available to other ports.

Encinal Terminals prepared a schedule in which construction would not begin for 4 years. This was excessive, based on the Seaport Plan's guidelines. In addition, the other ports in the Bay Area objected to the proposed schedule. After much discussion and testimony at the public hearing on the project, BCDC made the following finding (6,p.13):

> To allow four years to the commencement of construction would allow the applicant to control the capacity represented by this authorization for that entire period of time without any firm indication being demonstrated that the terminals would actually be built. The Commission finds this period to be excessive.

A compromise was then reached with the applicant that involved a 2-year period till commencement of construction and milestones with regard to financing, both of which are consistent with Seaport Plan policies. It is significant that the outcome of this debate over the first permit to be issued under the Seaport Plan was to reaffirm the basic precepts and findings of the plan.

The second issue relates to the adversary role the ports have with one another. As stated in the foregoing, the other ports objected to the schedule originally proposed by Encinal Terminals. This was only a part of their concern with the master plan, and their testimony before BCDC came very close to a recommendation to deny the permit, but stopped short of this. Clearly, as competitors, their own self-interest must prevail, and they could only be expected to cooperate to a point where that self-interest was not threatened.

The Alameda Gateway Project and the port of San Francisco ship repair proposal had significant policy implications--primarily that of protecting marine terminal sites. These proposals were the first example in which the Seaport Planning Advisory Committee functioned as an aid to implementing the plan.

The Alameda Gateway Project is a commercial and water-related industry project proposed for shoreline lands designated for marine terminal use in the city of Alameda. When the Seaport Plan was developed, certain military lands were designated for marine terminal use, should the military ever release the property. Although city and regional land use plans showed the site as having military ownership, it does not, although it is surrounded by military lands. Thus, there was an oversight in the plan, but this oversight has raised an issue of protecting lands designated for marine terminal use: Would loss of this shoreline land compromise potential marine terminal use of backland areas and adjacent shoreline areas? MTC and BCDC staff reviewed the project and concluded that it would not diminish the potential for marine terminal development on adjacent military lands, should the military release them. The Seaport Committee discussed this project at its meeting in August 1984; thoroughly debated the staff recommendations; took testimony from the project proponent, the Mayor of Alameda, the port of Oakland, and an Alameda citizen opposed to the project; and voted to recommend to MTC and BCDC that the marine terminal designation be deleted. Again, the basic precepts of the plan were affirmed.

The dynamics of the committee are important with regard to this project and the San Francisco project. Of the nine committee members present at the August meeting, five were new, including the chair. Therefore, a review of the plan's policies was necessary before project proposals were discussed. More important, though, the new members deferred to the members who had seen the plan through its development. In fact, several of the new members abstained during the voting.

The port of San Francisco ship repair proposal involved a questionable interim use at an existing pier designated for marine terminal development. The port planned to lease a major portion of the pier for ship repair and installation of a drydock. The lease was to be for 5 years with 5-year options thereafter. Substantial investment was to be required by the lessee to make the pier suitable for its uses and to anchor the floating drydock. This project was also discussed at the August 1984 meeting, and the Seaport committee was faced with the following question: Is this truly an interim use or is it likely that the ship repair facility will become permanent, foreclosing future marine terminal use and development? This was an extensively debated question. Those speaking for the ship repair project were the port of San Francisco (a member of the committee) and the prospective lessee. Those speaking against included a member of the committee, a former port of San Francisco commissioner who is also a former committee member, and another ship repair firm in San Francisco. Interestingly, the committee member speaking against the project is the Mayor of San Franciso's appointee to MTC, who had participated in the development of the plan. Despite the Mayor's support of this project, this committee member believed that it was not in keeping with the Seaport Plan. Again, the views of those committee members who participated in the plan development dominated, and a motion to recommend that BCDC deny the permit was passed. This project is not dead, however. The port of San Francisco has requested that the chair of the committee call a meeting to reconsider this vote, claiming that they have new information. The meeting will be December 5, 1984.

CONCLUSIONS

The following can be concluded with regard to the process of developing and implementing the Seaport Plan:

- Implementation authority is essential. Developing a plan without such authority will be frustrating and the plan will collect dust, once completed. This authority must be tempered, however, with a desire to resolve disagreements so that a near consensus can be reached. The legitimate interests of all parties must be recognized.
- The sponsoring agencies must be persistent and focused on the primary goal of the plan. Persistence keeps the process moving when there are forces opposing its direction, and focus permits compromise while preserving the essential goal.
- Fortuitous changes occurred in port management that facilitated the process of plan development.
- The participation of MARAD was beneficial and provides important benefits to all regional port planning projects. MARAD funding of such studies should be reinstituted.
- The Seaport Plan can be implemented and the basic precepts of the plan have been reaffirmed in recent actions.

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