conventional technology in SEABUS stands as a tremendous example of the mode's potential in this regard.

Clearly, there is renewed interest in ferries as a viable transportation alternative in many areas. Just as clearly, there exists a potential for a growth of ferry services in many areas, both in terms of new service potentials and of ridership increases on existing services. The Staten Island Ferry, B.C. ferry, SEABUS, and others have experienced strong upward trends in ridership in recent years.

The logic for increased consideration of the waterborne mode is clear: The shortest distance between two points is a straight line. That line often goes over water. The technology has developed rapidly over the past several decades, and many nations have already put it to extensive use. As the resources available for massive land-based transportation systems decline, the water alternative becomes attractive, when available. After all, it is not necessary to construct the right-of-way.

The waterborne mode is not a solution to all our urban transportation problems. It is, however, a most flexible mode that can fulfill a variety of functions and roles. At the very least, it should be a more prominent option considered in situations in which it is available. Over the next two years of the current work, it is hoped that tools will be provided to aid the planner in this consideration.

The potential for waterborne transportation as a viable modal alternative has only been very lightly tapped. It is indeed ironic, but in the years to come, man may return to his original form of transportation to help alleviate the urban congestion being experienced in the more modern modes.

ACKNOWLEDGMENT

I would like to acknowledge meetings and interviews with Carl Berkowitz, executive director, New York City Bureau of Ferries; Stanley Kowleski, general manager, San Francisco Ferry Transit Division; Richard Berg, general manager, Washington State Ferries; and Charles Gallagher, general manager, British Columbia Ferry Corporation.

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Waterborne Access to Gateway National Recreation Area and Other Waterfront Recreation Areas by Passenger Barge-Tugboat Combinations

S. DAVID PHRANER

Examples of barge-tug operations are common on the waterways of America. Few (probably less than 20) exist in passenger-carrying forms. None exist that use a range of new technologies in barge-tug integrator systems for passengers. Approximately eight to ten of these barge-tug integrator systems now exist and are providing efficient movement of bulk goods. The basic feasibility of applying this technology to a unique passenger-transport need is addressed here—that of connecting large centers of population by using regional-scale waterfront recreation complexes. Gateway National Recreation Area, located in the New Jersey-New York region, is the second most visited National Park facility. Its access problems are unique and require innovative approaches. Barge-tug integrator systems exhibit characteristics that qualify them for consideration. It is estimated that modest but significant savings in capital and operating costs can be achieved by barge-tug integrator systems over conventional excursion vessels. In addition, the barge-tug combination provides some unique advantages in labor and vessel use, safety, joint use, and adaptability to purposes of recreational travel. Although barge-tug systems do have potential for application to recreation access, these advantages do not extend to use for the journey to work or for premium recreation.

The Tri-State Regional Planning Commission's involvement in water transit commenced with staff analysis of existing and past waterborne operations in the region. An analysis of the state of the art in waterborne modal technology was completed and used in an analysis of a ferry across Long Island Sound performed by Tri-State for Connecticut and New York. This study has recently been renewed. Most recent involvement is a demonstration of waterborne technology in several regional transportation applications. In addition, waterborne transportation is being considered for access by large numbers of seasonal vacationers to the Gateway National Recreation Area.

Regional, local, and federal agencies and other interested parties have cooperatively been treating the dilemma of providing efficient, enjoyable access to Gateway and other major recreation areas of the Tri-State Region. Access by waterborne transit has

been particularly difficult to implement because of the following five obstacles:

1. Lack of marine operators to provide boats and service,
2. Legislative restriction on the National Park Service (NPS) to undertake transit access improvements outside the parks,
3. Diminished construction of excursion boats,
4. Lack of acceptable or available docking facilities, and
5. Lack of year-round investment due to seasonal nature of demand (vessel and personnel inactive nine months of the year).

In spite of these formidable obstacles, the notion persists that access to Gateway by water is an appealing, attractive transportation alternative for the following reasons:

1. All six of the Gateway geographic units are located on navigable water channels but are otherwise isolated from high-capacity mass transit;
2. Five of the units are or had once been served by high-capacity water transportation from urban locations such as Harlem, lower Manhattan, Jersey City, Brooklyn, and Newark;
3. A demonstration was conducted during the summer of 1976 that confirmed the popularity of waterborne access to recreation;
4. All units of Gateway are based on waterfront themes;
5. Gateway attracts the second highest number of visitors to a national recreation area and thereby requires unique applications of transportation technology; and
6. Proposals for access to Gateway by land routes have proved unpopular with the communities through which access is furnished (this problem is becoming more apparent as Gateway transportation planning advances, but water access can be designed to provide direct access by passing these potential trouble spots on land).

BARGE-TUG CONCEPT--NEW TECHNOLOGY?

This paper recognizes the waterside characteristics of Gateway and addresses all five major obstacles to waterborne access. This is not intended to be the ultimate or completely detailed analysis of the barge concept but rather to initiate further technical analysis by naval architects or experienced marine operators.

The barge-tug concept is not new. The region's harbors and waterways have had tugboats towing or pushing lighters, stickboats, carfloats, and other barges for more than a century. With few exceptions, these activities have been directed at movement of goods rather than people. The best land-based analogies to the barge and tug are the tractor-trailer or locomotive-hauled rail cars. Special benefits occur when the power or propulsion unit is separable from the cartage unit. These benefits change with time and technology, but some always remain.

Early steamboats on the Hudson River did pull passenger barges in a variation of the barge-tug concept. The reason for this arrangement was to avoid casualties from the all-too-frequent steamboat boiler explosions and fires. Immigrants were transported to and from Ellis Island by passenger barge. In both of these applications the powered and nonpowered vessels were in convoy with one another. In the event of mishap with one, the other could rescue survivors. This benefit remains today for barge-tug combinations but on a diminished scale and for somewhat different reasons. The danger of fire has decreased considerably because of steel hulls and superstructure, and the danger of boiler explosion has disappeared because of the marine diesel engine. The constant presence of another vessel or vessels is an important criterion in determining regulations to be followed in vessel design, even to this day. The barge-tug concept shares this advantage with its earlier counterparts.

In its simplest form, the concept is a conventional tugboat that pushes a conventional barge by using a notch or other device built into the stern of the barge (Figure 1). This system has been found to be more efficient for medium to long distances than towing from alongside or from the bow of the barge.

A new technology has emerged in waterborne freight movement, which in its present state of the art includes several variations of the basic barge-tug combination:

System	Name	Originator
Rigid barge-tug integrator	Catug	J.B. Hargrove/ Seabulk
	Breit/Ingram	Breit and Garcia
Flexible barge-tug coupling	Seebeck	A.G. Weser
	Sea-Link	L.R. Glosten and Associates
	Artubar	Transway International
	Barge Train	Barge Train, Inc.
Barge on vessel	Barge Integrator (the Floater)	Mitsui Zosen (four Japanese shipping companies)
	Lash (lighter aboard ship)	

The major differences in these technologies are in the barge-tug coupling systems and the degree to which the barge and tug are integrated into a single unit. In the most-sophisticated systems, the tug is a specially designed vessel that acts in effect like a detachable power unit. In combination under way, the barge-tug resembles a large conventional bulk carrier. These variations in technology are illustrated conceptually in Figure 2. All these systems are operational except the Floater. All are applied to ocean as well as coastal or lighter-duty service. Most systems are relatively new and have been implemented in the past decade. However, the earliest concept, by George Sharp, has been in service for 27 years.

Barge-tug integrated vessels vary in size. Most barges are from 300 to 500 ft long, but the largest are more than 950 ft long and travel 12-15 knots when loaded. Several have operated through hurricanes in the loaded state or in ballast. They are estimated to save more than 20 percent in operating costs and approximately 15 percent or better in capital costs compared with a conventional vessel.

APPLYING BARGE-TUG CONCEPT TO PASSENGER TRAVEL

Which of the systems in the array of technology are most adaptable to Gateway and other passenger-recreation purposes? Catug and the Floater can be screened out as difficult or undesirable to adapt to the dual or passenger-carrying function. Among the other alternatives, the best choice may depend on ownership and intensity of service. Two ownership strategies are possible for study to optimize the utility of the concept:

1. Agency owns barges and leases general-purpose

Figure 1. Barge-tug concept, conventional form.

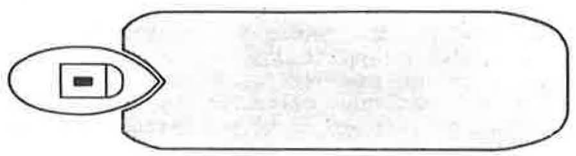
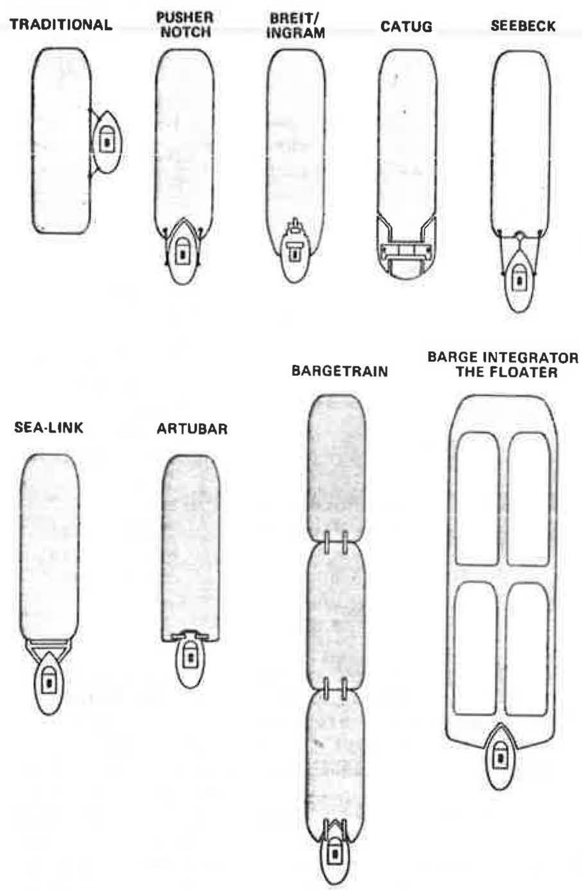


Figure 2. Variations of barge-tug new technology.



tug(s) for hours, days, weeks, months, or season; and

2. Agency owns full system of barges and tugs specially equipped by using one of the advanced technologies.

The full-ownership strategy recognizes that private tugboat operators would likely be reluctant to undertake purchasing new vessels or to retrofit their tugs by using the specialized hydraulic rams, flexors, yokes, or unique bow configurations to accommodate the alternatives that are more radical in concept. Besides the additional cost, the design refinements might render this vessel less flexible in its assignment to more conventional tugboat duties, which is a key to the success of this concept. Some of the alternatives, such as Sea-Link, which has detachable push knees, can be implemented with little additional hardware cost on the tug. The full-ownership strategy assumes, however, that the tug can be leased to an operator to perform conventional duties during the off season.

Regardless of the specific technology alternative used, two modes of operating control are possible. A profile of the resulting passenger barge-tug combination might appear as shown in Figures 3 and 4. The two operating modes differ mainly in the presence or absence of a barge pilothouse for remote control of the tug. The barge equipped with a pilothouse may be only slightly more costly but has the advantage of being mated with a conventional tug. The barge that has no control requires a tug equipped with an elevating pilothouse. The nature and extent of remote control can vary from telephonic or radio messages to direct electronic control by marine telegraph on the bridge of the barge that controls a similar unit in the tug pilothouse and engine room.

Based on these and other considerations, the use of tug-propelled barges for passengers is possible. However, is it feasible? Clearly, the concept has some serious limitations. Below a certain capacity (500-1000) it becomes impractical to use the barge-tug concept. It is most economical in its largest applications, whether it carries passengers or freight. It will be a relatively slow-speed mode that ranges around 10 knots. This is a slightly slower speed than that of the current Circle Line Liberty Island boats. For this reason alone, the use of passenger barges will be limited to recreational travel, for which the leisurely pace is consistent with the sightseeing and excursion nature of the trip. Cost, safety, and other factors should and will be addressed, but a short review of the rationale behind the employment of these technologies is required first.

RATIONALE FOR BARGE-TUG SYSTEM IN EXCURSION SERVICE

The following list gives the rationale behind this paper and forms a summary on which to build additional technical work:

1. Precedent exists for the barge-tug concept in most rigorous ocean-going cargo transportation. Twelve barge-tugs are currently being constructed under Title 2.
2. Regional precedent exists in the St. John's Guild Lila A. Wallace and four previous Guild-operated passenger barges in service since 1870. These barges have been carrying children, the handicapped, and the elderly on marine excursions. A passenger barge was built recently for California's Mare Island Ferry. Other, small-scale examples of barge-tug combinations of passengers and vehicles exist.
3. Barge-tug systems use existing proved technology, equipment, and carriers.
4. There is contract flexibility; numerous towing services and vessels exist to compete for service contracts.
5. Capital cost savings have been estimated to be at least 12 percent more than those of comparable powered vessels. In addition, fewer revenue vessels are required (four powered passenger vessels versus three passenger barges).
6. The potential exists for optimal use of personnel resources during 12 months rather than 3 months of the year.
7. More effective use of capital can be realized (seasonal use of barge, 12-month use of tug's propulsion).
8. Operational potential is created on all navigable waterways of the Tri-State region; the vessel has moderate draft and is accessible to most Gateway sites.
9. Tugs are freed for other commercial work during long layovers at the recreation site or other recreation nonpeak periods.
10. Long layovers at park sites enable use of the barge as a portable substitute for land-based

Figure 3. Conventional tug, pilothouse on barge (radio or remote control from tugboat).

Figure 4. Elevated pilothouse on tug, no pilothouse on barge (direct control on tug).

facilities at the park. Such functions might include bathhouse, snack bar, auditorium, or kitchen.

11. Extra safety and life-saving services are provided, since the independent vessel (the tug) will always accompany the primary vessel.

12. The barge can be converted (although not without redesign) to a self-propelled vessel by installing Harbormaster or other add-on propulsion unit packages. Confirmation of this point should be made during a detailed study.

13. The excursion vessel, whether powered or not, is extremely adaptable for use by the elderly and the handicapped. In fact, systemwide this mode is more adaptable than bus or rail in providing access to recreation for these groups.

14. Little or no fuel is carried on board the passenger barge, which diminishes fire hazards and attendant regulatory requirements.

15. Since it is a seasonal vessel, no heat or air conditioning is required on the barge. Power requirements for lights, etc., may be furnished by the tug auxiliaries or by on-board diesel generators.

16. Control while the vessel is under way is optional; it may be on the tug or remote from the barge. Dual control is possible and desirable.

17. Speeds achieved by barge-tug combinations are appropriate to the excursion and recreation-access function.

CHARACTERISTICS OF TUG AND BARGE IN RECREATION SERVICE

Like the transit system of the Tri-State Region, tugboat operations present many contrasts. The smallest operations have one or two small craft, whereas the largest operates a fleet of nearly 25 tugs in New York Harbor and 90 or so along the Eastern Seaboard. The Tri-State Region has more than 35 marine towing operators based in and around the metropolitan area.

Capital Cost

Capital cost is a consideration if an agency is to undertake ownership rather than lease tugs. Cost varies with the vessel size, horsepower, and design. Unit costs are lower for purchase of a "class" tug (three or more units), and the vessel price diminishes in proportion to the increase in class size. This is based on a custom design. "Stock tugs" based on standard off-the-shelf specifications and designs generally are lower in unit cost than the custom designs whether the latter are purchased in classes or not. A typical custom-built class tug in the 2000- to 3000-hp range that is 90-100 ft long will cost an estimated $2.5 to $3.0 million (1980 dollars). A well-maintained tug in intensive service will have a life expectancy in the 30-year range.

The cost of a passenger barge is difficult to estimate. The only accurate index of cost is the Lila A. Wallace of St. John's Guild. This barge is a reasonable prototype for a Gateway access vessel, although a passenger capacity of at least 2000 per barge is more desirable. Lila A. Wallace carries 1200 passengers and is 181 ft long. The cost was $2.0 million in 1974 ($11 050/ft). For comparison purposes, the 280-ft Dayliner of the Hudson River Day Line cost $3.5 million at about the same time ($12 500/ft). There is a capital cost savings of at least 12 percent if a nonpowered excursion vessel is used rather than a powered one. This saving is very conservative in view of the specialized equipment found on the Lila A. Wallace (for example, that barge has a fully equipped dental clinic). Additional savings are estimated if four powered excursion vessels operate on the same schedule as three barges.

If the barge owner elects to purchase tugs, a new barge-tug combination is estimated to cost in the neighborhood of $5 million. Six bulk Catugs are on the ways now; the total cost is $54 million, or about $9 million each. They are more than 660 ft long, however. This substantial additional cost of the tug may be recovered by the owner through leasing out the tug during nine months of the year. The cost is diminished further when it is considered that good scheduling should require fewer tugs than barges (see Figures 5 and 6, discussed later in this paper).

The agency that owns or operates the barge may choose to lease rather than to purchase tugs. Indeed, this may be wiser, at least during the initiation of the service. The purchase rather than lease of tugs means, in effect, that the barge operator is entering the tug business. This is not the type of business to undertake parttime. It is highly competitive, capital- and labor-intensive, and is fraught with complex labor and regulatory requirements. Of the experts interviewed for the preparation of this report, none regarded the purchase of tugs as preferable to leasing, particularly when the lease would cover only three months of the year.

Operating Costs

The operating costs of a tug vary. Tug operators have different cost schedules for harbor and for coastal services. Tugs are available with or without crews and by the hour, day, week, month, or season. Again, the nature and amount of use are reflected in the cost. A typical harbor schedule reflects an hourly rate for weekdays of $180. For weekends the rate rises to nearly $230/h. There is little difference between summer and winter rates. Good weather in the summer encourages shippers to schedule more traffic. Winter oil-movement peaks compensate for the good-weather traffic. One is left with the impression, however, that tugboats are available as much or more during the summer peak recreation months as during the winter months. This is an extremely important factor in a transit business, in which traditionally the excursion operator must recover the investment during the three summer months, and therefore service is priced accordingly. Again, for comparison purposes, based on the harbor fee schedule, an 8-h weekday excursion would cost $1440/day. This assumes a total commitment of the vessel and crew for that day. In fact, the tug could be free for four or more hours during midday for other duties as assigned by the operator's dispatcher. In any case, the fee for an 8-h day for a 500-passenger Circle Line vessel is $1800 or $225/h. Although the comparison is somewhat obscured by other considerations, such as the larger

barge capacity and crew costs, the magnitude of savings is estimated to be around 20 percent for a leased barge-tug over the lease of an excursion vessel.

Unfortunately, the St. John's Guild passenger barge cannot be used as an indication of barge operational cost. Its annual operating budget is around $400 000, or about $4500/day. However, its season is restricted. Also, it has an expensive professional staff not connected with the operation of the vessel, such as therapists, physicians, and dentists. In addition, the vessel is used year-round as a clinic and for other nontransportation purposes. It makes only one relatively short trip daily and as a charity gets a favorable rate from the tugboat operator.

Unit costs for operating the tug in contrast to leasing it were unavailable. Based on estimates of crew, fuel, overhead, and other costs, harbor tug operation appears to fall within the range of $120-$150/h.

Crew requirements are established commensurate with the service. The current harbor-tug operations crew consists of five or six men, as follows: either captain, mate, two deckhands, and an oiler, or the first four plus a cook and an engineer. Crews for tugs in coastal or ocean service are larger by two or three members.

The crew size for the barge is difficult to estimate. Again, the one precedent in the Tri-State Region, and perhaps the nation, is the Lila A. Wallace. This vessel is manned by the following operations crew of nine: captain, mate (who may be unlicensed), chief engineer, assistant engineer, and five to eight deckhands.

The combination of tug and barge crews results in a total crewing requirement of from 15 to 17. A new technology connection between barge and tug might reduce this number somewhat. Personnel requirements for optional food service, entertainment, medical service, or other programming would be in addition to the operations crew. These nonoperating personnel do have an important lifesaving function, however. That these personnel have basic emergency training is recognized by the U.S. Coast Guard in determining vessel safety requirements.

Speed, Draft, and Seaworthiness

Speed, draft, and seaworthiness are important considerations in applying the barge-tug to recreation access in the Tri-State Region. Speed is probably the least important of these considerations, at least to the passengers, because of the recreational nature of the trip. [Certain recreational boat trips (those of the Circle Line, for example) require strict adherence to a demanding schedule, or vessel use would be impaired. This is a consideration for the operator rather than the user, however.] The largest barge-tug combinations operate in ocean service routinely in the average range of 12-15 knots. In harbor service that used a modestly powered tug, the range would likely drop to the 10-knot average. By way of comparison, the following powered excursion vessels are operating currently at the speeds indicated:

Name	Power (hp)	Speed (knots)	Capacity	Length (ft)
Miss Circle Line (1964)	940	12	750	139
Miss Liberty (1954)	800	12	1037	121
Dayliner (1972)	3500	16	3232	280
Good Time II (1976)	700	12	500	86
Island Queen (1974)	550	13		120
Provincetown (1973)	1800	16		135

In the case of barges, the speed depends on the characteristics of the tug in combination with the dynamics of the barge. Consistent speeds are therefore impossible to estimate. It appears from comparative data furnished above that a 12-knot maximum speed is a reasonable estimate. The Lila A. Wallace, in an unwieldy towing arrangement with a tug alongside, manages a maximum of 11 knots.

Draft is an important consideration in planning applications for barge-tug technology. Again, as with speed, the tug rather than the barge imposes the limitation. The Lila A. Wallace, for example, draws only 6.5 ft. The barge can be designed to provide a relatively shallow draft, certainly no more than 10 ft in the loaded state, without loss of stability. However, all tugs, in order to fulfill their primary functions well, must "dig deep" with their propellers and steering gear. This deep hull configuration is a characteristic of the tugboat so that it can exert maximum directional forces on the object to be moved. Ocean-going tugs characteristically have an 18-ft draft. Harbor tugs have somewhat less but range from a 12- to a 15-ft draft. This characteristic of tugs represents a serious drawback in applying the barge-tug technology concepts to recreational purposes in the Tri-State Region. An examination of the region's navigation charts reveals that there are several potential recreation areas that have water-depth limitations. These depth limitations fall generally into two categories: channel depths to recreation sites that prohibit direct access by tugs and the location of deep channels that reduce routing flexibility and require route circuity. Specifically, the following regional recreation sites are limited by the following minimum channel and docking depths:

		Depth (ft)	
Chart	Location	Channel	At Dock
282	Bear Mountain	90+	30+
222	Rye Beach	20	17
369	Sandy Hook (Fort Hancock)	21	23
369	Sandy Hook (Horseshoe Cove)	19	12
542	Floyd Bennett Field		
542	Breezy Point (Fort Tilden)	19	26
542	Breezy Point (Coast Guard dock)	19	26
542	Jamaica Bay-Canarsie Pier	27	22
286	Great Kills	10	12
369	Ellis Island (southeast entrance)	19	13
369	Liberty Park	21	20
369	Liberty Island	34	13
369	Fort Wadsworth	51	71

At the origin end, all urban docks are on deep channels, except possibly Newark. The Passaic Pier at Newark (chart 287) and intervening points reach 15 ft at high water. Inner Jamaica Bay and Great Kills units of Gateway represent the areas inaccessible by tugboat because of insufficient depth. Fortunately, none of these sites, except possibly Great Kills, represents a major excursion-vessel destination. The Jamaica Bay unit is more adaptable

to the small-scale nature tour such as that provided by the 250-passenger Rockaway Boat Line craft currently being operated.

Seaworthiness is an issue that is strongly related to the next topic discussed here, safety and regulation. It is the state of a vessel and the combination of its design and condition that result in fitness for service. Because of the predominance of children on board excursion vessels, special care should be exercised in the design and stability of the barge. In particular, in Gateway service it must be able to sustain the conditions of semiopen water in Raritan Bay and off the Rockaways.

BARGE-TUG REGULATION AND SAFETY

Like self-propelled vessels, barge-tug excursion service is subject to two forms of regulation: vessel service and inspection and certification of vessel and crew.

Interstate services are regulated by the Interstate Commerce Commission except when they fall entirely within a single harbor. It then becomes a local matter. The state, counties, and to some extent the municipalities are interested in varying degrees in "local" marine services. In the case of local marine services in New York, the state has enabled counties and/or municipalities to regulate routes and fares. Marine services to federal lands are usually governed by the appropriate federal agency and regulation is usually achieved by the bid-contract arrangement. The National Park Service's Sunken Forest on Fire Island and Liberty Island Park furnish regional examples of this type of regulation, which presumably would apply to Gateway.

Inspection and certification of vessels and crews are performed by the U.S. Coast Guard exclusively. Vessels and crews are certificated by functional type of license and geographical scope. The inspection and certification decision making is routinely decentralized to the district level and, in some cases, below that. The motivation behind this type of regulation activity is primarily safety. In summary, several interrelating factors of safety apply to vessels, whether barge or self-propelled:

1. Lifesaving equipment;
2. Fireproofing and fire-fighting equipment;
3. Stability;
4. Structure strength (hull and superstructure);
5. Miscellaneous (sanitation, control systems, and auxilaries); and
6. Propulsion-boiler-fuel systems (not applicable to barges).

Lifesaving equipment serves as an example of regulations that apply to barges. The special considerations (vessel capacity, distance from land, water depth, operating season, etc.) that govern the amount and location of lifesaving equipment carried on board are stated in Title 46, Code of Federal Regulations, Subchapter H, Sections 75.10-20(a)-20(c), May 1, 1969. Other considerations that mitigate a more relaxed regulatory attitude toward Gateway barges are the presence of an auxiliary vessel, little or no fuel carried on board, and proximity of grounding depths. These characteristics are taken into consideration when the vessel is certified by the U.S. Coast Guard. The barge specifications and equipment should be reviewed by the U.S. Coast Guard and concurred on before construction begins for all five major items of inspection and certification.

Fireproofing, fire-fighting, and structural and stability requirements are related. They, with little exception, are integral characteristics of the vessel. They are not easily added on or changed. Therefore, care in ensuring that barge specifications meet U.S. Coast Guard requirements is critical. These "permanent" vessel refinements reduce the likelihood that the barge may be used for other than excursion travel to recreation. Stability can be simulated on paper by using an appropriate formula. Requirements for structural design, fire-retardant materials, fire zoning and location, and number and dimensions of points of egress are matters for early discussion among naval architects, engineers, shipbuilders, and the U.S. Coast Guard. In a sense, each vessel class is a unique case that requires special consideration.

A listing of the specific requirements that would be placed on a barge is impossible now because vessels used exclusively in a local area may be subject to some discretionary treatment by local certifiers. There are few examples of passenger barges. During the preparation of this report, none became known that employed new technology linkages between the barge and the tug. Faced with this lack of precedent, the U.S. Coast Guard at a maximum could impose on a passenger barge the same requirements as those imposed on a self-propelled excursion boat. However, it is more likely that passenger-barge requirements for local service would be less stringent.

BARGE AMENITIES AND MULTIPLE FUNCTIONS

The Lila A. Wallace represents probably the ultimate in a passenger-carrying barge. Its use during 12 months of the year for health services requires high-quality amenities for the climate control, food preparation, sanitary treatment, and health-oriented programs presented on board. St. John's Guild's former vessel Loyd Seaman (now the Robert Fulton) represents a more suitable prototype for excursion or recreation-access service. The Loyd Seaman was the last of the guild's passenger barges used exclusively during the summer. It required no heating or air conditioning. The same would be true of an excursion barge unless it was used for some stationary purpose during the winter.

As a seasonal excursion vessel, a barge is a relatively austere utility vehicle. However, secondary functions in support of activities of the NPS program may dictate features that depart from the conventional excursion-vessel design. These secondary functions could include a bathhouse; an auditorium for NPS interpretive and other presentations and group activities; a cafeteria or other food service, preparation, or distribution facility; a contingency shelter in the event of inclement weather; a medical facility; a winter storage facility; and off-season conveyance for construction and other park-related material.

Since most functions are relatively compatible and the vessel is sizable, the barge could be designed to perform all these functions by easily implemented conversion of space. Because the propulsion system and crews need not accompany the barge through its entire operational day, a land-based NPS crew can man the vessel while it is performing nontransportation park functions. This is a particularly appealing feature of an excursion barge. As Gateway grows, permanent park facilities may not be ready for use or may be of insufficient size to handle unusually heavy crowds. After it performs its primary transportation function, the barge, in effect, becomes a part of the park facilities. Its location among the units of Gateway can be scheduled according to the changing needs of park operation, month to month or year to year.

Again, as pointed out in the previous section,

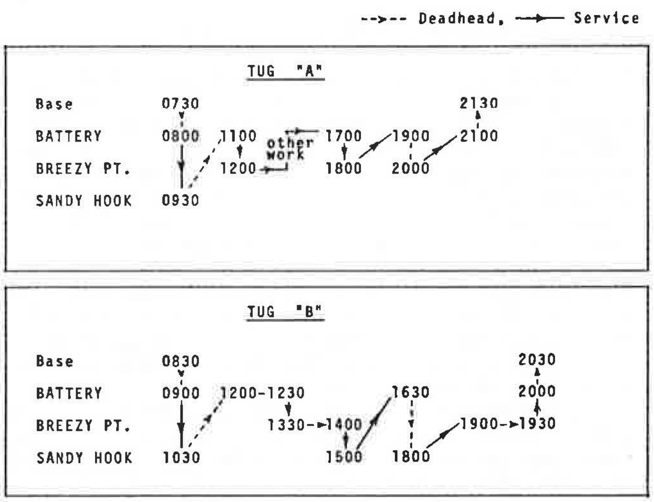
care must characterize the design of the vessel to enable it to fulfill all its functions efficiently and to meet regulatory requirements. For example, it would be difficult for an auditorium in the vessel to exceed approximately 130 ft in length because of a regulation on the maximum size permitted for fire zones. A schedule is also critical to the multifunctional role of the barge. Arrival and departure times must allow sufficient time to enable completion of programmed activities.

BARGE AND TUG SCHEDULES DURING PEAK SUMMER DAY

A sample schedule has been compiled as an attempt to optimize use of barges, tugs, and crews while a large number of people are being conveyed efficiently to and from the units of Gateway. Two scenarios, one for barges and one for tugs, have been drawn up (Figures 5 and 6); they assume the following elements:

1. Two tugs;
2. Three barges;
3. Running times from Battery to Sandy Hook of 1.5 h, Battery to Breezy Point of 1 h, and Breezy Point to Sandy Hook of 1 h; and
4. Dwell time of 0.5 h to load and unload.

Figure 5. Detailed tug scenarios for Gateway service.



The resulting scheduled departure times appear as shown in Table 1.

One barge lays over at Sandy Hook from 1030 to 1500 and another from 1500 to 1800 (Figure 6). At Breezy Point, layovers are from 1200 to 1800 and from 1800 to 2000. In both cases, the layover enables use of the barge for a food-service function and other activities. The tugs would be in continuous service (0800 to 2130 for tug A and 0900 to 2030 for tug B). Tug A would be available to the tug dispatcher between 1200 and 1700 for conventional, nonrecreation assignments. The tug and barge transportation utilization rates are different, which reflects greater use of tugs for transportation than barges or, for that matter, greater than is possible for self-propelled excursion boats. Tug utilization rates in terms of hours daily and percentage of time for two tugs are as follows:

Item	Daily Hours	Time (%)
Revenue service	13.5	52
Deadhead (light)	6	23
Dwell time (loading, etc.)	1.5	6
Layover	0	-
Other revenue service	5	19
Total	26	

For three barges, the rates are as follows:

Item	Daily Hours	Time (%)
Revenue transportation service	14	41
Deadhead (light)	-	-
Dwell time (loading, etc.)	9.5	30
Layover (land-based service)	10.0	29
Other duties	0	-
Total	34.5	

It was estimated that four or five conventional excursion vessels that had a reduced utilization rate would be required to run a similar schedule. Additional refinements in the schedule to optimize crew costs were not performed.

This schedule, which uses barges of 2000-passen-

Figure 6. Detailed barge scenarios for Gateway service.

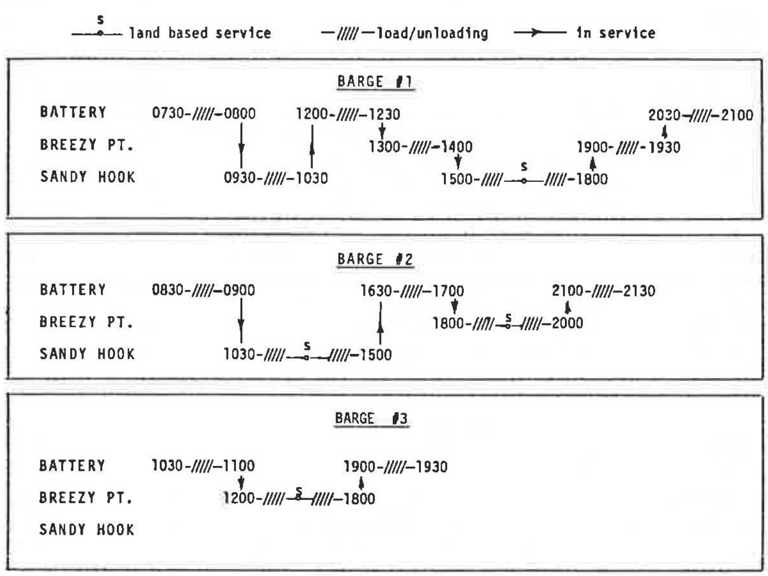


Table 1. Barge-tug departure times: sample schedule.

Direction	Destination: Battery-Sandy Hook	Destination: Battery-Breezy Point	Destination: Breezy Point-Sandy Hook
Going	0800	1100	1400
	0900	1230	
	1230[a]	1700	
Returning	1030	1800	1800
	1500	1930	
	1800[a]	2000	

[a]Intermediate stop.

ger capacity, could conservatively deliver 10 000 persons to two Gateway units, perform an intrapark round trip, and furnish food service during lunch and dinner periods at both units. By way of comparison, this is the rough equivalent of about an 85-bus fleet (50 buses that make 3.5 round trips to Sandy Hook and 35 that make 5.5 round trips to Breezy Point) working at capacity. At an average occupancy rate of four persons per automobile, the equivalency is 2500 automobiles. Manning requirements between buses and barges indicate that the barges save about 30 person-days every operating day. For all the 55-day summer seasons during a 30-year life of the barge, this labor cost savings would nearly amortize the vessels. This assumes that the capital cost of the buses is borne elsewhere and is not included in the cost comparison. Of course, the tugs and buses could be used all year, whereas the utility of the barges during the winter season is limited.

RECOMMENDATIONS

Although much of the work here assumes that a three-barge, two-tug system would be implemented, much needs to be resolved about the practicality of the concept and which barge-tug linkage technology is most suitable. Therefore, rather than making detailed proposals, I feel that the barge-tug concept as presented in this report should be passed along to the various appropriate planning, operating, and regulatory agencies for review. From this review, a lead agency should be selected to sponsor and draw up a request for proposal for a response by a naval engineer or an architectural firm. The specific action to be taken in establishing a passenger barge-tug fleet for service to Gateway would be based on the findings of that investigation.

The integrated barge-tug is a recreation-dedicated system. It is unacceptable for conventional journey-to-work transit. This system competes with the concept of joint use of transit buses and trains during off-peak periods. In spite of this, it is a multiuse system in that there is year-round deployment of the tugs and stationary uses of barges. The funding source implications of the multiuse aspects require further study as well.

ACKNOWLEDGMENT

I would like to acknowledge interviews with personnel from St. John's Guild, the Maritime Administration, various tugboat operators, and U.S. Coast Guard vessel inspection officers.