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TR NEWS

Ferries in the 21st Century

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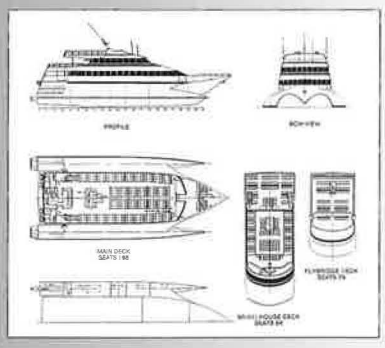

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Cover: Ferries dock in Seattle, Washington, vital parts of the city's transportation system—safely serving commuters and tourists, carrying freight, relieving roadway congestion, minimizing air pollution, and contributing to waterfront redevelopment. New technologies are adding to these benefits, as described in this issue's feature articles.

TR NEWS

features articles on innovative and timely research and development activities in all modes of transportation. Brief news items of interest to the transportation community are also included, along with profiles of transportation professionals, meeting announcements, summaries of new publications, and news of Transportation Research Board activities.

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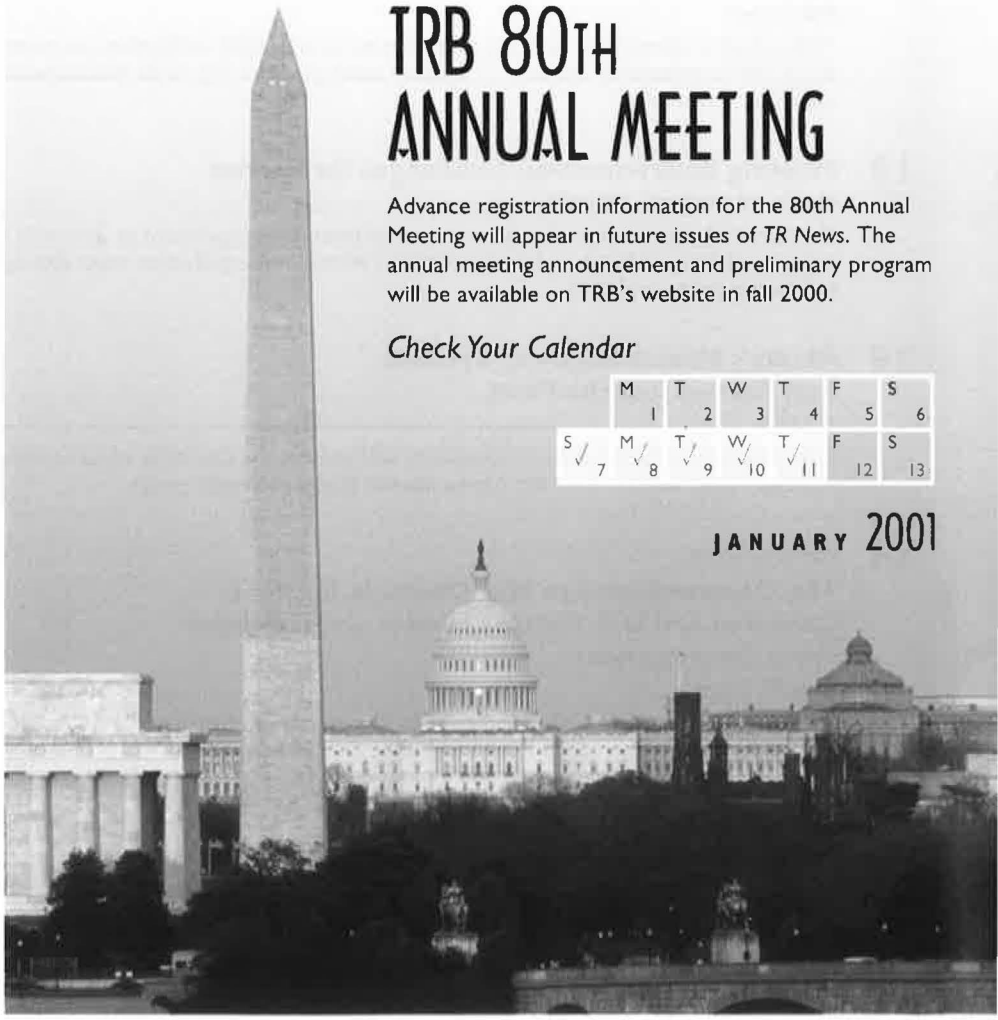


FERRIES IN THE 21ST CENTURY

INTRODUCTION

RAYMOND G. DEARDORF

The author is planning director for Washington State Ferries, Seattle, and chair of TRB Committee on Ferry Transportation.

Long a vital means of transportation in areas with major lakes, rivers, bays, and sounds, ferry travel is reemerging as a major link in the nation's transportation system. In the state of Washington, the state-operated ferry system annually transports nearly 27 million riders and 11 million vehicles on a fleet of 29 vessels. Ferry systems serve as extensions to both the highway and the transit systems.

Many earlier ferry operations were replaced by bridges in the late 1800s and throughout much of the 20th century. Recently, however, ferry travel has seen a resurgence, as populations have grown in areas traditionally served by ferries and as land-based transportation systems have become increasingly congested in areas without ferry operations. The advent of fast ferry technology has enabled a more creative deployment of vessels, introducing viable alternatives to congested landside facilities.

The articles in this issue of *TR News* present the broad spectrum of opportunities and challenges facing further development of ferry travel. Martha Bewick's article sets the stage by tracing the national and international initiatives that are shaping the operating environment for current and anticipated ferry systems. Bob Gorman next describes the context and some of the preliminary findings of the U.S. Department of Transportation's National Ferry Study; he outlines the evolution of ferry travel in the United States, identifies current and developing trends, and cites three examples of active and proposed ferry systems.

The article by Alex Farrell and James Corbett delves into the environmental issues affecting ferry transportation. The role of the ferry in reducing motor vehicle travel and pollution and the need to control emissions as well as other other impacts from ferry vessels are discussed in the context of current and proposed systems.

Capt. Bob Doll discusses the challenges facing the Alaska Marine Highway System (AMHS). He explains the circumstances in which the AMHS was built and shows how changing financial realities, societal shifts and expectations, and advances in vessel technology can lead to an entirely different approach to route structure and service.

Finally, Gregg Ward provides an operator's point of view on how the regulatory environments in the United States and Canada are hindering the development of efficient cross-border ferry operations.

Ferry transportation continues to be important for the movement of passengers, vehicles, and freight across water. It has emerged as a viable alternative in areas where landside transportation has become increasingly congested. The demand for new ferry services is growing in an operating environment that has become much more complex. Concerns about environmental impacts, congested waterways, and the financial capabilities to operate and provide necessary vessel and terminal investment will influence how ferry transportation systems evolve in the 21st century.

Editor's Note: *Appreciation is expressed to Joedy W. Cambridge, Marine Transportation Specialist, TRB, for her efforts in developing this issue of* TR News.

Rising Tide for Ferries

The World's Largest HOVs or Floating Bridges

MARTHA A. R. BEWICK

The author is principal of The Harbor Consultancy International, and works with the International Marine Transit Association.

A rising tide lifts all boats. This familiar phrase is particularly apt for ferries in the United States today. But what are the forces behind this tide—where does the push and pull come from? The tides of change for ferries are being influenced by transportation decision makers at the national level, at the state level, and by ferry entrepreneurs and associations, as well as by innovations in technology.

Two major federal initiatives—the Transportation Equity Act for the 21st Century (TEA-21) and the Marine Transportation System (MTS)—have contributed to the rising tide of public awareness of ferries. The evidence of a sea change for this mode include the large and complex San Francisco Bay Area Water Transit Initiative; statewide ferry plans and programs in Massachusetts, Rhode Island, and New Jersey; intermodal ferry-and-bus systems like the New York Waterway; and the issues and controversies arising from the advent of fast ferries on the nation's waters.

National Ferry Study

In response to a Congressional mandate in TEA-21, the Federal Highway Administration (FHWA) is coordinating an interagency National Ferry Study. Partners in the study include the Federal Transit Administration (FTA), the Maritime Administration (MARAD), the U.S. Coast Guard (USCG), and the U.S. Army Corps of Engineers, reflecting Secretary of Transportation Rodney Slater's ONE

Washington State has an active ferry system, serving commuters, sightseers, and commerce.

DOT vision of collaboration among the modal agencies.

This partnership is significant for ferries, which have not had a federal agency "home." The design, construction, classification, licensing, funding, operation, ownership, and management of ferries—as well as their intermodal links and integration into transportation strategies—have fallen to the separate domains of many agencies at the local, state, and national levels. An early analysis of the jurisdictional agency roles in Boston Harbor, for example, indicated that 161 agencies had some part in the oversight of new ferry projects.

During the past 25 years, national ferry studies have been sponsored by MARAD, by FTA, and by FHWA. Wherever ferries carry vehicles, FHWA has been the lead agency; it administers the Ferry Discretionary Grant program. Wherever ferries are primarily transit vehicles in urban centers, FTA has provided the lead. For example, the agency was the source of 80 percent of the funding for the $35 million Golden Gate Ferry System in the 1970s. Part of the Golden Gate Bridge Highway and Transportation District, the Golden Gate Ferry System continues to be a model for integrated intermodal transportation.

USCG is the key regulatory agency for vessel inspection, licensing, and rulemaking for sailing in navigable waters or transportation corridors. USCG currently is working closely with the Passenger Vessel Association of the United States on public–private partnerships to shape new rules, new roles, and new directions.

The National Ferry Study will provide valuable information for transportation planners, as well as for Congress, including a national ferry data base, reports on the opportunities for fast ferries and for alternative fuels in ferries, and summary findings from national focus groups.

The focus group participants, drawn from public agency stakeholders and private ferry operators and owners, have represented a wide range of ferry operations: small river ferries that carry only 49 passengers, a hazardous materials ferry that crosses the Detroit River, the 2,500-passenger ferries of Puget Sound and the Washington State Ferries system, the overnight ferries of the Alaska Marine Highway System, and the integrated ferry-and-bus systems of New York City. The ferry systems represented in the focus groups transport millions of passengers, automobiles, bicycles, buses, and trucks each year. Many are critical lifelines to islands, and many are privately operated.

TEA-21 also includes a provision for ferry discretionary funds, which have elicited great interest and spurred applications from many states. Several other TEA-21 funding categories are stimulating interest in ferries: congestion mitigation and air quality, national park access, intelligent transportation systems, and transportation enhancement.

Increased traffic congestion has led more people to seek alternative means of transportation. For example, New York's burgeoning ferry system includes such mainstays as Staten Island ferry (*above*), commuter ferries across the Hudson River to New Jersey, and ferry for sports spectators to Shea Stadium.

Marine Transportation System

The MTS report to Congress, published in 1999, noted that the "navigable rivers and canals were America's first 'interstate transportation system,'" and called on the myriad agencies, users, and beneficiaries of the nation's waterways to strengthen the system in the new century.

As defined by U.S. DOT, the MTS "consists of waterways, ports and their intermodal connections, vessels, vehicles, and system users." The vision statement calls for the MTS to be the world's most technologically advanced, safe, secure, efficient, effective, accessible, globally competitive, dynamic, and environmentally responsible system for moving goods and people.

The report states that the national waterways annually carry more than 100 million U.S. residents via ferries across 35 states. In addition, 78 million recreational boaters, 5 million cruise ship passengers, 110,000 fishing boats, and military deployment operations sail the waves. The principal activity on the 25,000 miles of U.S. waterways is the movement of "more than 2 billion metric tons of domestic and international commerce," as well as 3.3 billion barrels of oil. The waterways also include natural resources and wildlife habitats.

The key issues of dredging, preservation and management of the channels, and "minimizing conflicts among land uses along the waterfront and intermodal connections" apply to ferries as well as to cargo and tanker traffic. Ferries are the principal people-moving partners in any plan to transform the national waterways from a critically underserved link to an equal player in the national transportation system. For this reason, the maritime agencies responsible for waterways should participate directly in decision making about transportation funding.

In the meanwhile, the nation's ferry systems face complex issues, such as the management of waterways traffic, access to intermodal land-based terminals, development along waterfronts, competition for funds, and integration with traditional transportation.

New Understanding of Waterways

The opportunities for moving people as well as goods are important considerations for metropolitan planning organizations shaping new regional plans for waterway corridors. In the Boston area, for instance, one-third of the access routes into the city cross over water. When waterways are seen as surface corridors and therefore as opportunities for transit and intermodal links—instead of as obstacles to transportation—ferry initiatives quickly emerge. In the last 25 years, ferry routes have grown in Boston, and new routes now are feasible. The principal challenge for Boston ferries is that waterfront development for office and residential use is limiting landside–waterside interchanges.

A new level of understanding of the waterways and of the vehicles using them would approach a waterway as an opportunity for surface transportation rather than as a barrier, or as a variety of high-occupancy vehicle (HOV) lane—it would consider ferries not just as water transit vehicles, but as floating highway bridges, as partners in clean air attainment, as avenues to national parks, and as bicycle trail links.

With a capacity of 6,000 passengers, the Staten Island (N.Y.) ferry functions as the world's largest floating HOV. It has a fuel consumption rate of 214 gallons per hour, which amounts to only a few tablespoons of fuel per person per trip at capacity. Fast ferries, however, approach a per person fuel consumption rate equivalent to that of airplanes. Nonetheless, ferries hold a promise as clean air vehicles.

Agency Initiatives

A partner in both the MTS and the National Ferry Study, MARAD is scheduling a conference to brief local councils of governments about the desirability of ferries as an alternative mode of transportation; it is preparing a "soup to nuts" presentation about the role federal agencies can play in ferry initiatives. Another partner, USCG, is organizing a

The public's view of marine transportation is beginning to shift—waterways are more frequently being seen as connectors instead of obstacles and ferries are being seen as movable bridges. *Right*, bus information is posted along the ferry terminals in Seattle; *far right*, passengers disembark at Rowes Wharf Ferry Terminal in Boston after ferrying across the river with their bicycles.

Golden Gate Ferries' Larkspur Terminal in Marin County, California, offers ample accommodations for vessel berths, car parking, and bus stops.

series of meetings focusing on harbor safety committees as responsible players in managing the nation's 25,000 miles of navigable waterways.

Sea Changes

But what is the optimum capacity of the MTS waterways for moving people? A 1971 federal study suggested that potential daily ridership would total 1 million, based on the location of urban centers and journey-to-work patterns along the U.S. waterways. Today, there are approximately 250,000 daily ferry riders nationwide, fewer than the daily totals for ferry ridership in the city of Istanbul, Turkey.

Ferry systems can be valuable partners in providing mobility and accessibility, particularly in congested urban centers. Seattle, San Francisco, New York, and Boston have launched several new ferry initiatives in recent years. Other cities—such as Jacksonville, Florida; Portland, Oregon; Corpus Christi, Texas; Long Beach, California; and Providence, Rhode Island; as well as states such as Massachusetts, Rhode Island, Maine, and New Jersey—have been exploring the potential of ferries in intermodal transportation (see sidebar, page 8).

Ferries can play a role in achieving the environmental, safety, and national security goals expressed in Slater's ONE DOT strategic vision. Ferries serving a waterway corridor can provide a floating HOV lane and help to achieve congestion mitigation objectives.

Safety is a preeminent concern in ferry transportation. Fortunately, with USCG's strict and effective requirements for licensing vessels and crews, there have been no fatalities in ferry transportation in the United States since World War II—an enviable record among transportation providers.

When crises or disasters have occurred along waterways, ferries have served effectively for both transportation and evacuation. For example, the emergency use of available ferry vessels eased the effects of collapsed bridges in Washington State and in San Francisco Bay, and when a strike, tunnel flooding, and the World Trade Center bombing interrupted transit in New York City.

Shaking the Status Quo

During the last 15 years, fast ferries have created new transit markets throughout the United States. As the new vessels in the channel, fast ferries have raised concerns from other channel and waterfront users; for example, the size and force of the wakes and the vessel's speed. The advent of fast ferry technology has shaken up the status quo on the waterways. Waterways that have become havens for fishing, recreational boating, and the movement of cargo and containers now can be used instead of bridges to link sides of rivers, to avoid highway congestion by connecting points along a corridor, to cross a harbor, and to provide an alternative mode of urban transit.

Ferrying the Gulf from Studies to Initiatives

Recent significant developments in ferry transit in the United States have included such initiatives as the Savannah River Ferry system, the San Francisco Giants Pac Bell stadium ferries, and the Rhode Island ferries and terminals. These and other initiatives, however, have started with studies—the Corpus Christi Water Transportation Study, the Bay Area Water Transit System analysis, and the Cape Cod–Provincetown Ferry Study provide good current examples.

Answering the Call to Action

In 1998, U.S. Secretary of Transportation Rodney Slater called for increased use of the nation's waterways, ports, and intermodal connections as an "accessible . . . dynamic, and environmentally responsible system for moving goods and people." In December 1998, Savannah, Georgia, voted to start the first new ferry program after the secretary's call to action. Savannah's International Trade and Convention Center and Chatham Area Transit Authority have selected the River Street Riverboat Co. to operate the center's new cross-river 49-passenger-ferry service. The fleet, which soon will enter construction, is being underwritten in part with federal and state funds.

Called the "Savannah Belles" and named for prominent women in Savannah's history, the vessels will link the new convention center and its adjacent Westin Savannah Harbor Resort to downtown transportation, hotels, and historic waterfront areas. In a preliminary trial, water taxis started service in December 1999, carrying 12,000 passengers in one month. By February 2000, this had doubled to 24,000 passengers per month. In March, the Convention Center provided remote parking and water taxi connections to relieve traffic congestion during the St. Patrick's Day celebrations attended by 400,000 people. The system is designed to provide transportation for Savannah employees, visitors, and residents.

Savannah cross-river ferries will link passengers to a trolley line running the length of historic River Street "to an $11 million transit transfer facility." Eventually, the Convention Center Authority and Chatham Area Transit plan to promote these modes, encouraging visitors to use transit while in Savannah.

On the West Coast, the April 11 opening of the San Francisco Giants Pac Bell stadium, a new "old style" waterfront ballpark, also introduced new ferry connections. Seating up to 41,000 fans, the stadium is served by trains, Bay Area Rapid Transit, trolleys, buses, and ferries. More than 50 percent of the ballgame attendees are using transit, exceeding the city's goal. Public and private ferry operators carry approximately 1,400 people to the stadium pier for each game.

The Blue and Gold Fleet provides ferry connections to Tiburon, Sausalito, Oakland, and Alameda; the Red and White Fleet links the stadium to Richmond; and Golden Gate Ferries, with free parking at its 1,200-car park-and-ride lot in Larkspur, carries 700 riders, near capacity for a single vessel. Ferry passengers from Vallejo and other cross-bay destinations make transit connections from the Ferry Building or can walk to other transit about 20 minutes away.

Rhode Island recently launched a ferry link between Pawtucket and Providence, connecting Providence's Water Place and Providence River to the National Park Service's Blackstone River corridor. Rhode Island also is anticipating a demonstration ferry connection between Providence and the East Bay. Managed by the Rhode Island Public Transit Authority, the new ferry receives support through TEA-21 Congestion Mitigation and Air Quality demonstration funds.

Meanwhile, a new Newport ferry terminal facility is under construction. It will support ferries, water taxis, and cruise ship tenders, as well as provide harbormaster facilities.

New Directions from Studies

In Corpus Christi, the Regional Transit Authority (RTA), the city, and the port are assessing conditions, investigating alternatives, and developing an implementation plan to operate the successful seasonal ferry service year-round. The agencies seek to support the city's "bustling tourist and convention business season" by expanding excursion opportunities. RTA currently supports a harbor ferry from Memorial Day to Labor Day, linking recreational destinations. A downtown trolley and a beach shuttle support the ferry.

The Cape Cod Commission recently completed a Cape Cod–Provincetown ferry study, conducting an extended survey of ferry passengers and potential customers. Preliminary findings indicated a lack of awareness about the three current ferry services (from Gloucester, Boston, and Plymouth), the need for better advertising and signage for the terminals, and a desire for alternative Cape Cod destinations, as well as for increased frequency and faster service. Responding to the survey results, ferry operators have expanded

their website information and have integrated the packaging of transportation, connections, and destinations.

In the meanwhile, a new fast ferry service has started from Boston, lowering fares on the Boston ferry services. Fast-ferry times from Boston to Provincetown are 1.5 to 2 hours, half the travel time via conventional ferry. Automobile travelers to and from Cape Cod during this past Memorial Day weekend met delays of up to 3.5 hours, making the case for expanded use of the uncongested Massachusetts Bay waterways.

Also in the Boston area, the Boston Redevelopment Authority and City of Boston issued a comprehensive "Boston Inner Harbor Passenger Water Transportation Plan" in January, inventorying ferry facilities, services, and water transportation; as well as terminal facility conditions, needs, and design guidelines. It also included a passenger water transportation plan, a strategy for implementing it, and options for its funding.

Studies in Progress

Public authorities in other areas also are studying new ferry routes or upgraded services:

◆ Rochester, New York, and Toronto, Ontario, have envisioned a fast ferry across Lake Ontario for passengers, automobiles, commercial vehicles, and tour buses. The fast ferry would provide an alternative to the congested international highway routes and border crossings, cutting travel time by 2 hours. The cities will select a route operator later this year.

◆ Maryland and Virginia state transportation agencies are exploring Chesapeake Bay ferry crossings. A recent Baltimore newspaper editorial endorsed the Maryland Department of Transportation's investigation of the "feasibility of ... ferry service between Point Lookout, Maryland's southernmost point, and Crisfield, 30 miles across the Kedge's Strait."

◆ Some miles south, Virginia's Northern Neck Planning District Commission is initiating a "Mid-Chesapeake Bay Ferry Feasibility Study" to examine the technology required, the operating costs, and the market demand.

◆ The states of Maine and New Jersey, the Long Island Sound region, and Pensacola, Florida, also have ferry studies under way.

But what is the role of waterways within the framework of the MTS? If waterways are transportation corridors for the movement of goods and people—and therefore critical elements of the national transportation system—should transportation movements be protected, advocated, and enhanced? Or should transportation movements be restricted? What are the priorities for waterways that also serve millions of unlicensed pleasure boat users and that provide valuable habitats? These complex issues are under consideration today.

The regulatory history of the National Highway System demonstrates the need for licensing all users of the highway corridors; it is clear that similar conflicts of use must raise the same issues for the marine corridors.

Flexibility and Capacity

The waterways are "self-healing roadways," readily adaptable to required changes. An excellent example of the flexibility and capacity of a ferry fleet occurred several years ago during an international computer conference that was expected to draw 10,000 visitors each day to Boston's World Trade Center. Using its ferry fleet, Bay State Cruises provided frequent links among the conference site, Logan Airport, and two downtown piers adjacent to conference hotels. For the seven days of the conference, Bay State Cruises carried 9,000 people daily on its ferries, providing easy cross-harbor links and enhancing the conference's accessibility.

The ease with which ferries were introduced to San Francisco Bay after the 1989 Loma Prieta earthquake prompted a series of ferry studies and investments in new ferry routes. At one time, San Francisco's Ferry Building was the world's second most heavily used transportation terminal, with 250,000 ferry riders passing through daily. The Bay Area now has rediscovered its waterway corridor capacity. Legislation has established a new Ferry Authority for San Francisco Bay (see sidebar, page 10). A comprehensive Bay Area Water Transportation Initiative is under way, calling for the establishment of new ferry routes to many of the old destinations and to new ones as well.

International and Association Perspectives

The MTS vision projects the development of the "world's most technologically advanced"

system; however, ferry planners in the United States have much to learn from their counterparts in other countries. U.S. planners must do more in designing and integrating intermodal connections, managing navigational corridors, establishing systemwide information and fare policies, and incorporating technological advances. Hong Kong, China; Vancouver and Halifax, Canada; Dublin, Ireland; Hälsingborg and Stockholm, Sweden; and Dover, United Kingdom, offer successful models.

Yet the U.S. ferry industry has much to contribute as well. The United States is building more fast ferries today than any other country. London-based and Australia-based international fast-ferry conferences have convened in the United States for the first time during the past two years. Ferry system planners from around the world often visit new U.S. ferry-and-bus systems, such as New York Waterway in New York City, and integrated and accessible ferry-and-dock facilities, such as Harbor Express in Boston.

The Boston-based International Marine Transit Association, holding its 25th annual conference in Venice, Italy, this October, provides ferry owners and operators worldwide an opportunity to exchange information. Sixteen maritime magazines published around the world offer regular articles about new ferry technologies. Associations such as the Passenger Vessel Association of the United States and the International Navigation Association provide unique and technical industry perspectives. The Brussels-based International Union of Public Transport has initiated a new waterborne committee, which meets regularly.

The Society for Naval Architects and Marine Engineers recently published a white paper on fer-

Ferrying Back to the Future

MICHAEL CUNNINGHAM

The Bay Area Water Transit Authority debuted in January 2000, as the San Francisco area's first regionwide public transit operating agency. It was the result of an effort to address the region's chronic transportation and mobility challenges. Although the bay is one of the finest natural harbors in the world, it is underutilized for transportation. But this has not always been the case—before the widespread use of private vehicles, water transportation was the mainstay of the region's transit network.

As congestion increasingly has crippled the region's highways, the Bay Area is rediscovering water transit. A comprehensive water transit network has proved to be the missing piece in the Bay Area's transportation puzzle—a mode that can link all of the disparate transportation systems of the nine Bay Area counties, providing ready connectivity and mobility.

Established under the leadership of California State Senator Don Perata and Governor Gray Davis, the Water Transit Authority is developing a regional water transit implementation and operation plan. The Authority will build on the findings of the Bay Area Water Transit Task Force, a multistakeholder initiative led by the Bay Area Council and charged by the California Legislature to investigate the feasibility of expanding water transit on San Francisco Bay. The Water Transit Authority will submit its completed plan to the California Legislature for ratification; after approval, it will implement and operate a world-class water transit system on San Francisco Bay.

The findings and recommendations of the Water Transit Task Force have provided the starting point for the Authority's plan. After concluding that water transit offers many benefits to the Bay Area, the task force developed a conceptual design for a new system, addressing the need for a comprehensive network of terminals and routes to connect the north, south, east, and west subregions of the Bay Area. Fully built, the envisioned system would accommodate an annual ridership of 25 to 30 million passengers, using as many as 35 to 40 terminals. A fleet of approximately 120 high-speed vessels, primarily state-of-the-art catamarans, would be deployed on 30 or more routes.

However, the expansion of water transit into a world-class system will not solve all of the region's mobility challenges—it also must invest in an array of infrastructure improvements. But with the establishment of the Water Transit Authority, the Bay Area is boldly moving back to the future, reviving an idea whose time has come again.

(The action plan developed by the Bay Area Water Transit Task Force is available on the Internet at www.bayareacouncil.org/watertransit/.)

The author is Vice President for Transportation, Bay Area Council.

ries and clean air issues, and the American Association of State Highway and Transportation Officials has expanded the focus of its water transportation committee within the past three years to include the nation's ferries.

The tides of change for the ferry mode are affecting not only the United States, but also systems worldwide. As planners from traditional highway and transit agencies reach across the modal divide to welcome participation by representatives of ferries, and as waterways gain recognition as an integral part of the national transportation system, the rising tide for ferries will increase transit opportunities for all.

New York Studies Its Ferries

I. BERNARD JACOBSON

Ferry operations on New York's Long Island have become critical to planning for land use and sustainable development in five towns—including the Hamptons resorts—located at the island's east end.

A series of studies has identified ferry services as potential relief for road congestion, mitigating forces in pollution abatement, improvements for accessibility, and essential transportation links:

- The New York State Department of Transportation's (NYSDOT's) *Long Island Transportation Plan to Manage Congestion*,
- Long Island Railroad's *East End Transportation Study*,
- NYSDOT's *North Fork Recreation Travel Needs Assessment*,
- The East End Transportation Council's *Sustainable Development Strategy Study*, and
- The Long Island Sound Ferry Coalition's *Ferry Service Clearinghouse Data Base*.

These studies are educating state, regional, and local planners about the capabilities and usefulness of passenger and vehicle ferries as full partners in the transit system.

The author is General Manager, North Ferry Co., Inc., Shelter Island Heights, New York.

Fast ferries are in service worldwide, including this SEABUS vessel operating between Dar es Salaam on the mainland of Tanzania and the islands of Zanzibar and Pemba.

Clearing the FOG about Ferries

National Study to Shed New Light

BOB GORMAN

The author is a community planner with the Planning and Environment Core Business Unit (HEP), Federal Highway Administration.

One of the oldest modes of transportation in the United States is experiencing a renaissance. Before trains, buses, cars, or airplanes, the waterways provided our earliest transportation corridors. Travelers on land often had to find a way to cross rivers, lakes, and harbors. Ferries were the solution. At first, it was a simple craft, often little more than a log raft propelled by poles or pulled across a river by ropes. Later, the vessels evolved, adopting the latest technological advances.

By the end of the 19th century, at the pinnacle of ferry operations, New York City moved more than 200 million passengers a year on 50 different ferry routes; San Francisco ferries carried similar numbers. In 1880, the Brooklyn Bridge opened, followed by the construction of more and more bridges and tunnels during the next few decades. By 1964, the Verrazano Narrows Bridge linked Brooklyn and Staten Island, spanning one of the last gaps in the system of roads and bridges connecting New York City's five boroughs and New Jersey. The only commuter ferry line still operating was the Staten Island Ferry, between Staten Island and Manhattan—the distance separating the two boroughs was too great to bridge cost-effectively.

What was happening in New York was mirrored in other parts of the country that had relied on ferries. However, just as ferries were dismissed as no longer feasible except if distances were too long or traffic was too light to warrant construction of a bridge, they began a comeback. At first, the shift was too small to detect, but as the momentum increased it could no longer be overlooked.

Staging a Comeback

Why did ferries make a comeback? The three reasons likely having the greatest impact were

Oldest continuously operating ferry service in United States crosses Connecticut River between Rocky Hill and Glastonbury. Service dates back to 1769.

Redeveloped waterfronts, like Rowes Wharf in Boston, make metropolitan ferry service more attractive.

◆ Major technological advances, particularly increasing speeds;

◆ Rediscovery and redevelopment of harbors and waterfronts; and

◆ Increased traffic congestion and the difficulty and cost of constructing major bridge and tunnel projects in an urbanized environment.

First Signs of Recovery

One of the first signs of recovery surfaced in the New York metropolitan area. Ports had been shifting much of their operations away from the central cities to locations with access to interstate highways and major rail lines. The revolution in containerization also reduced the need for warehousing and other industrial activities that had clustered around seaports. As these vacated waterfront properties deteriorated, opportunities for redevelopment emerged. Efforts to improve water quality also made living on or near a waterfront attractive to many.

Adding to this renewed interest was the availability of premium amenities: scenic views, recreational boating, and jogging or bicycling along waterfront promenades. The New Jersey waterfront across the Hudson River from Manhattan offered all of these. The availability of inexpensive land close to

New York Waterway has operated ferry services across Hudson River from New Jersey points to Manhattan in New York City since the early 1980s, pioneering the renaissance of the ferry.

Fast Ferry in Action

Crossing Maine's Gulf by *Cat*

One of the highlights for vacationers in Maine or Nova Scotia, Canada, is a trip by fast ferry across the Gulf of Maine. There are three ways of getting from Bar Harbor, Maine, to Yarmouth, Nova Scotia:

- Drive up the coast of Maine, cross into New Brunswick, Canada, and continue along the coast until reaching Nova Scotia. Then drive down the coast of Nova Scotia to Yarmouth. In all, the trip covers more than 600 miles.
- Drive to Portland, Maine, and take the overnight cruise ferry to Yarmouth.
- In Bar Harbor, Maine, board *The Cat*, the high-speed ferry, and sail directly across the Gulf—this cuts the trip by about 400 miles, and the crossing takes only 2 hours 45 minutes.

The Cat is a state-of-the-art vessel built in Australia. It carries 900 passengers and 240 vehicles; its speed approaches 50 knots. It is powered by four engines capable of producing 38,000 hp. The engines are water jets, shooting out a tail 20 feet high and 50 feet long at full speed on the Bay of Fundy's open waters.

Before acquiring *The Cat*, Bay Ferries operated a conventional vessel that made the crossing in 6 hours; each vessel could make only one daily round trip. *The Cat* makes two round trips per day, and the number of passengers has doubled since it began operating. The same model of ferry is under consideration for longer coastal routes and for crossing the Great Lakes.

The Cat is North America's first high-speed catamaran, travelling up to 50 knots.

Manhattan soon fueled a real estate boom in apartment and condominium developments. A contemporary joke was that you could pay an exorbitant rent to live in Manhattan and have a view of Hoboken, or you could live in Hoboken for an affordable one-third of the rent and have a clear view of the Manhattan skyline. A developer then added a new amenity to attract customers to the New Jersey side—ferry service to midtown Manhattan.

New York Waterway began operations in the mid-1980s and with its success started to add more and more routes. Three other ferry companies now have begun service, and together all four companies transport more than 30,000 passengers daily on 15 routes serving Brooklyn, Hunters Point, La Guardia Airport, Yankee Stadium, and Shea Stadium in New York; and Weehawken, Jersey City, Hoboken, and Atlantic Highlands in New Jersey. To accommodate this resurgence in ferry operations, New York City is developing multiuser terminals at several Manhattan locations on both the Hudson and the East Rivers.

Technological Advances

Changes in technology also have played a major role. Advances in designs, materials, navigation systems, and propulsion systems have resulted in ferries that operate at high speeds with relatively small wash and wakes. Many of these advances originated in Australia, after the collapse of a bridge on the island of Tasmania necessitated the introduction of ferry services. Tasmania already had some shipbuilding industry, and the local shipyards began not only to

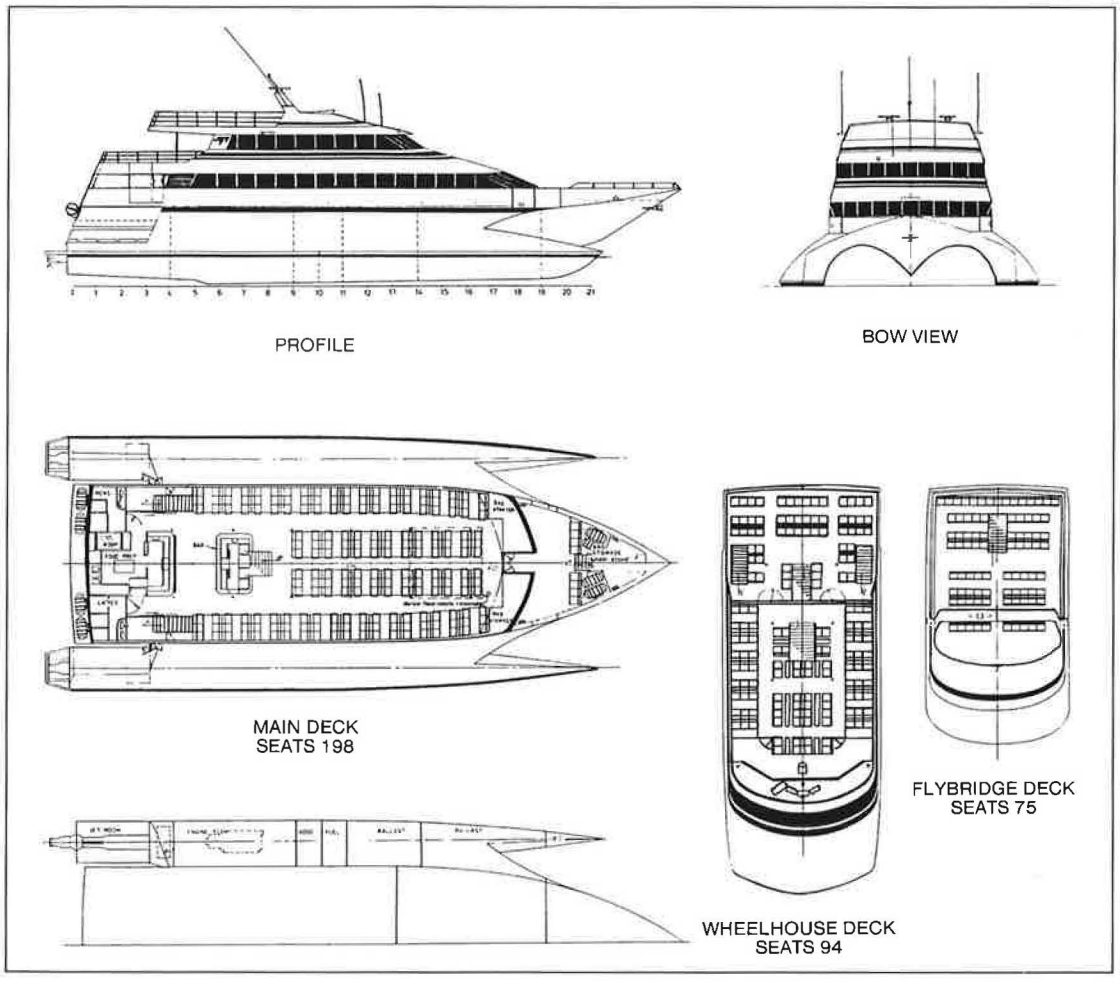
produce the ferries needed but to improve on their design. Soon companies like Incat and Austal were providing ferries for the worldwide market. Incat's 91-m-long *Tasmania* now holds the speed record for an Atlantic Ocean crossing, averaging more than 40 knots.

Coping with Growth

Finally, although traffic congestion continues to grow in many of our urban areas, opposition also grows to major new projects like bridges and tunnels. Armed with environmental challenges, citizen groups have halted or delayed large new projects with increasing regularity. In the Washington, D.C., metropolitan area, efforts to replace the Woodrow Wilson Bridge have been tied up in the courts for more than 10 years despite widespread support from Congress, the states of Virginia and Maryland, and most local officials.

The state of California is anticipating an increase in population over the next 20 years that would be the equivalent of the current population of Florida. Since most Californians already live near the coast, areas like San Francisco are going to be challenged as never

Technologically advanced fast ferries like the new TriCat model have contributed to a ferry comeback.



Sketch of the Wave Piercer Catamaran, showing the seating capacity of a high-tech, catamaran-style fast ferry, similar in design to models pioneered by Australian shipbuilders.

before to find ways to accommodate growth. The Metropolitan Transportation Commission (MTC) projects a 250 percent increase in Bay Area traffic by 2020. If new bridges or tunnels cannot be built, other solutions are needed. The Bay Area is considering massive investments in ferries as one of the solutions. Interest in the potential of ferries also has increased as a result of their role in transporting people during such recent emergencies as the earthquake and transit strikes.

The Bay Area Water Initiative, a task force created by the California legislature, has proposed a regional plan that would expand ferry service throughout the Bay Area. Phase I of the plan would introduce up to 75 more vessels and 28 new terminals, achieving capacity to move 15 million to 20 million passengers per year (four to five times current levels). In Phase II, up to 125 vessels operating from 35 to 40 terminals would move 25 million to 30 million passengers per year, or 7 to 10 times current levels.

Federal Funding

Several developments at the federal level could support these and other efforts stemming from increased interest in ferry transportation. In 1991, the Intermodal Surface Transportation Efficiency Act (ISTEA) required states to develop transportation plans and programs for all modes. At the same time, ISTEA provided funding—and the flexibility to use current program funds—for ferries. For example, the new National Highway System (NHS) provided connections to all major intermodal terminals, including 59 ferry terminals. Surface Transportation Program funds could be used for transit purposes including ferries. The Congestion Mitigation and Air Quality program (CMAQ) provides funds for projects that can have a positive impact on improving air quality. ISTEA also allocated funds directly to ferries under a new Ferryboat Discretionary Program.

During the deliberations for the major transportation act succeeding ISTEA, the Transportation Equity Act for the 21st Century (TEA-21), there were several requests for increased funding for ferry projects. But because there was so little information available about this mode of travel, it was difficult for Congress to evaluate the requests. The numbers for ferry operations and passengers were uncertain. This knowledge gap probably was due to the industry's unique structure. State or local public transportation agencies operate some ferry systems, but many others are privately owned and operated. Complicating the picture is that many operators not only provide ferry services but also dinner and sightseeing cruises as well as whale watching and other excursions.

Multimodal Terminal Model
Transportation "Big Top"

Ferries have been crossing Long Island Sound for more than 150 years. Legendary circus impresario P.T. Barnum was one of the early investors in the Bridgeport–Port Jefferson Steamship Co., which operated a ferry service between Bridgeport, Connecticut, and Port Jefferson on New York's Long Island.

During the past several years, Bridgeport has undertaken projects to improve its terminal, provide parking, and renovate its waterfront. Using a combination of Ferryboat Discretionary funds, Federal Transportation Enhancement funds, and Surface Transportation Program funds, along with a substantial amount of state and local aid, the city constructed a new terminal and parking garage, along with pedestrian facilities, other dock improvements, and a boardwalk. It also constructed a truck access road to the ferry dock. After completion, there will be a seamless link among ferries, Amtrak, and the bus transit system.

New multimodal terminal is just one of the changes undertaken by Bridgeport, Connecticut, to improve its ferry service.

National Ferry Study

To gain a better perspective, Congress included a provision (Section 1207c) for a National Ferry Study by the U.S. Department of Transportation (U.S. DOT). The study will compile a detailed inventory of all ferry operations. It also will report on the potential for new ferry operations, fast ferry operations, and alternative fuels. This last task—of particular interest to California because of its air quality problems—probably will become more important as the Environmental Protection Agency promulgates emission standards for the marine environment.

Since there are no agencies within U.S. DOT with exclusive responsibility for ferries, the Federal Highway Administration (FHWA)—whose active ferry projects have been obscured by the scope of its other initiatives—was asked to take the lead on this study. FHWA shares jurisdiction over ferries with the Federal Transit Administration (FTA), the Maritime Administration (MARAD), and the U.S. Coast Guard (USCG).

In the past, FHWA always had considered ferries a viable alternative for connecting federal roads when bridge or tunnel construction was too expensive; however, it has expanded that view, as it now administers the Ferryboat Discretionary Program and coordinates the ferry study. In brief, FHWA's study partners have the following involvement with ferries: FTA provides capital and operating funds for ferry operations, particularly in urbanized areas; MARAD helps finance the construction of vessels; and USCG is responsible for marine safety.

After reviewing the information available on ferry systems and defining the parameters of the study, the agencies began work in earnest early this year. U.S. DOT's Volpe National Transportation Systems Center in Cambridge, Massachusetts, contracted to survey the 222 ferry operators identified; completion of the survey is scheduled for July 2000, when analysis of the results will begin.

Concurrently, focus groups of ferry operators and public transportation agency representatives are evaluating the potential for new or fast ferry operations. Preliminary findings have identified a need to coordinate and integrate ferry systems with other modes of transportation. In addition, many of the impediments to new services result from local—rather than state or federal—conditions and regulations. Operators first must resolve the landside issues related to terminal location and to passenger arrivals and departures before making decisions about vessel acquisition and operation.

Fast Ferries

The potential for fast ferries is well established—they have operated throughout the world for the past 20 years. Each year, new designs emerge, power plants improve, and speeds increase. At first, the United States lagged behind other nations, but this is changing. American shipyards have obtained licensing agreements from foreign shipbuilders and now are producing state-of-the-art vessels; 14 fast ferries are now under construction in the United States.

The National Ferry Study will compile a detailed inventory of all ferry operations and report on the potential for new ferry operations, fast ferry operations, and alternative fuels.

But speed comes at a price. Fast ferries cost considerably more to operate than conventional ferries, and the time savings must be considered in the context of the entire trip. Unless passengers can embark and disembark quickly and can transfer to another mode with a minimal wait, the time savings can

Alternative Fuel Pioneer

Paddle Wheels and Natural Gas

The Virginia seaport cities of Norfolk and Portsmouth are undergoing major redevelopment of their downtown areas after years of neglect. In each case, the downtown's proximity to the waterfront has been key, and the redevelopment has been extensive—not only removing decaying docks and warehouses, but replacing them with museums, ballparks, shopping malls, condominiums, townhouses, and office buildings.

A ferry system operated by the Hampton Roads Transit Authority (HRTA) links the two cities, separated by the Elizabeth River. The ferries are conventional, but HRTA chose an old-fashioned paddle-wheel design to attract tourists. One of the three ferries operates exclusively on natural gas.

After learning about the local gas company's pilot program to explore the potential for natural gas as a transportation fuel, HRTA considered operating one of its ferries with natural gas. Until then, there were no ferries operating on natural gas exclusively—although some in British Columbia used natural gas, they also relied on diesel fuel.

To be practical as a transportation fuel, natural gas must be either compressed (CNG) or liquified (LNG); it must have large storage tanks, which raises safety concerns. CNG must be kept at high pressure, requiring high-pressure fittings and relief valves; LNG may be the more volatile of the two. Before certifying the HRTA vessel, the Coast Guard carefully reviewed all elements of the design, since industrial standards are still evolving for CNG. The CNG-fueled vessel is now in service daily and has been a success.

evaporate. The advantages of fast ferries become more apparent when the route exceeds 7 miles.

Although fast ferries have proved highly successful, they have critics. The effects of fast ferries' washes and waves on shoreline erosion as well as their impact on wildlife have become issues. Nonetheless, the waves are small, considering the ship speeds; but the waves do have unique energy characteristics, which are the subject of studies under way in the United States and Europe. Another concern is safety. Although ferries have been one of the safest modes of transportation, this could change with increased speeds. USCG is holding hearings to improve the management of marine traffic on congested waterways.

Alternative Fuels

It is difficult to assess the potential for vessels powered by alternative fuels because so few are in operation. The most likely candidates are probably compressed natural gas (CNG) or liquid natural gas (LNG), as well as hydrogen fuel cells. Fuel cells are still experimental, but there are a few vessels operating on natural gas. Moreover, the transit industry is relying more and more on natural gas. About 20 percent of new buses operate on CNG or LNG, and their performance can be instructive.

Two transit agencies in California, Sacramento Regional Transit District and the SunLine Transit Agency, now rely on natural gas; although their initial investment was considerable, engine performance has improved and less maintenance is needed. After 7 years of operation, the overall cost of the natural-gas-powered buses was less than that of conventional models.

Improved Understanding

Although ferries cannot solve all of the problems of increased traffic and congestion in large metropolitan areas adjacent to rivers, lakes, bays, and coastal areas, they can help. Ferries also can help to revitalize deteriorated waterfront properties that are in transition from port and industry activities into residential and entertainment centers. This will require improved understanding of the potential for ferries as well as improved means for integrating this mode into the transportation system. The National Ferry Study will begin this process.

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MEETING ENVIRONMENTAL CHALLENGES *for Ferries*

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Passenger ferries are ready to take on an expanded role in the U.S. transportation system. To accomplish this, however, the ferry industry must meet several challenges associated with growth, including its impact on the environment. The research community and the shipbuilding and vessel operating industries must work together to meet the environmental challenges of ferry service expansion if they want to offer the American public an option for clean marine transportation. Developing the new technologies and methods to enable this option is an important goal on the transportation research agenda.

Capacity Demands

Ferries and Congestion

The principal reason that ferries are receiving increased attention is that transportation systems in many coastal urban regions are straining at the seams. This is particularly true for water crossings—bridges and tunnels are crowded for longer periods each day, and expansion is cost-prohibitive or politically infeasible.

Congestion has real costs. In its 1998 Regional Transportation Plan, for instance, the Metropolitan Transportation Commission (MTC) estimated that more than 100,000 person-hours are lost to congestion each workday in the nine-county San Francisco Bay Area; it projected that this figure would increase by more than three times during the next 20 years (*1*). Not only are person-hours lost, but so too are the rapid, reliable deliveries within the region and to the local air-freight hubs on which many businesses rely. With roads congested, businesses are finding it increasingly difficult to meet their time-sensitive shipping and delivery schedules. Growing regional populations and increased affluence alike tend to increase the demand for mobility and exacerbate roadway congestion.

Creating a new passenger-ferry service, or expanding a service, is a relatively easy way for regional transportation systems to increase their water-crossing capacities. In addition, ferry systems are much more flexible than fixed crossings, since operators can add and shift routes according to demand and can do this incrementally. Dedicated cargo ferries can add specialized capacity to the freight transportation system—cargo ferries can operate on routes, on schedules, and with fee structures optimized for freight movement without interfering with (or being compromised by) passenger modes. In this way, passenger and cargo ferry systems (ferry vessels plus terminals) can replace the need to expand a bridge and tunnel infrastructure.

Ferries and Mass Transit

Passenger ferries not only add water-crossing capacity but also are a form of mass transit. In many communities, mass transit (especially rail) is undergoing renewal and expansion because it reduces commuter trips in single-occupant vehicles and increases the transportation system capacity. However, successfully shifting commuters from personal car and truck to mass transit requires strong incentives. Since the most congested parts of transportation systems often are the water crossings, fast ferries can provide clear advantages. Yet mass transit systems also must be able to minimize the number and inconvenience of mode shifts, and this remains a key challenge for passenger ferries, which cannot provide door-to-door service.

In addition to faster, more direct water crossings, passenger ferries offer other benefits that should increase their status and attract commuters. Ferry transportation can be more enjoyable than other modes due to scenic views, the relaxation of

riding and not driving, and amenities not available on bus or rail, such as walking space, roomy seats, and food and beverage service. However, ferries also encounter the same mass-transit challenges as other modes, such as achieving time-efficient connections for modal shifts at terminals, so that people can transfer conveniently to or from cars or buses.

Other Challenges

A primary challenge for expanded ferry service is the design of a system that balances these premium-mode service advantages with basic mass-transit objectives, such as convenient access, low cost, and frequency of service. Many of the advances in this area will come from the design and operation of ferry terminals that serve as multimodal transit nodes, requiring adequate highway access and parking, and with feeder systems that transport passengers to and from the terminal and origin or destination, as appropriate.

Safety also is an issue. Adding many high-speed ferries to an already-crowded waterway may require new technologies and practices for managing maritime traffic.

However, we must not think of the nation's waterways simply as potential highways. Increasing waterborne passenger travel also must be balanced with other significant uses, such as water recreation, aesthetics, environmental quality, and oceangoing freight transportation.

Environmental Impacts

Air Pollution

One of the biggest environmental issues facing the ferry industry is air pollution, a longstanding concern for all motorized vehicles. The typical pollutants are sulfur, nitrogen oxides (NOx), and particles (both coarse and fine). All of these affect human health adversely, particularly the health of children, elderly persons, and people with respiratory problems such as asthma. Over the past several decades, on-road vehicles have had to meet increasing controls on all of these pollutants. The toxic components of particulate matter (PM) released by diesel engines now are becoming a concern; the California Air Resources Board, for example, has declared diesel exhaust a toxic air contaminant and a potential carcinogen.

New York commuters rely on ferry service to get to work on time; expanding service may lead to increased safety management problems, especially as new technologies and practices are introduced.

Potential damage to land, property, and wildlife due to wakes is one of the environmental issues facing the ferry industry in deployment of fast vessels.

As regulatory agencies have identified and controlled the largest sources of pollution, smaller sources, such as ships, have gained attention. Marine emissions research funded by the Environmental Protection Agency (EPA) shows that after more than three decades of escaping the notice of regulators, U.S. shipping now accounts for about 1.4 percent of all U.S. NOx emissions, and 7 percent of nonroad NOx (2).

Marine engines currently produce higher emissions per power output than regulated on-road diesel engines. Estimates of average marine diesel engine emission factors are 12 to 17 g/kW-h, compared with an average of approximately 3 g/kW-h for current bus-fleet engines (3,4). Since these emissions are concentrated along navigable waterways, they can have significant local effects.

Similar research has shown that international shipping also affects coastal-area pollution and possibly contributes to global climate change (5,6). Although most maritime air pollution comes from freight traffic, passenger ferries represent an extremely visible and fast-growing presence, so that ferry emissions have become an important issue for the maritime industry.

Policy makers at both the federal and international levels are developing and implementing air pollution standards for ships. New ferries soon will have to meet emissions requirements; Table 1 compares current marine emissions standards with standards for comparable sources. All of these regulations, however, apply only to new vessels; engines already in use will continue to operate at high emissions rates. The long service lives of marine diesel engines (typically more than 20 years), coupled with growth in marine transportation, probably will increase marine emissions for the next several years despite the new regulations.

A trend of increasing emissions would cause problems for local air quality and transportation planners in major urban areas, which must reduce emissions, often by 15 percent each year. Most likely, planners will look at controlling in-use marine diesel engines as a relatively inexpensive way to meet this goal—it is easier to reduce emissions from an uncontrolled combustion source than from one that already has been controlled.

Landside Issues

Air emissions are not the only environmental issue for ferries. Also attracting attention from transportation researchers and the maritime industries are the landside impacts of ferry operations, such as the impact of increased traffic, noise, and air pollution on neighbors of proposed ferry terminals.

The dramatic increase in passenger-ferry service in some areas suggests that expanding current facilities (e.g., parking lots) will be too costly or even impossible due to space constraints and political opposition. Sustainable growth concepts applied to the transportation infrastructure may favor

expanded ferry systems, but land-use changes are rarely simple. Therefore it is necessary to consider passenger-ferry terminals as new transit system nodes, not just as berthing facilities.

Waterways Issues

In addition to these landside concerns, there are water-related environmental issues, particularly dredging, wake, and impacts on wildlife. Dredging might be necessary to provide safe channels for new ferry routes but it is always controversial, especially in older urban harbors with sediments that may be contaminated with industrial pollution from previous years. Wakes, especially from high-speed vessels, can cause or accelerate shoreline erosion, simultaneously damaging valuable property and speeding up the need for dredging. Finally, both noise and wakes from ferries can have a negative impact on wildlife, a major concern in some areas, such as Washington State.

Environmental Objectives

The U.S. ferry industry must establish two strategic objectives for meeting environmental challenges. The first is to integrate improvements in environmental performance into the modernization of ferry systems across the country. This includes reducing air emissions and mitigating other direct impacts from ferries. This will produce better ferries and ferry terminals that can provide the same level of service as today.

The second—and tougher—strategic objective is to make ferries part of integrated transportation system planning, by applying advanced technologies to increase capacity and improve environmental performance. This will require not only achieving a balance among the multiple uses of water resources but also attending to safety concerns, even while building more ferries and ferry terminals to meet demand. Teams of transportation professionals from industry, academia, and government, applying new research tools and methods, are needed to meet this second, tougher objective.

San Francisco Bay Ferries

Roadway congestion is at its most intense in fast-growing regions, such the San Francisco Bay Area, home to some of the nation's most longstanding air-quality problems and to some of its most congested traffic. The Bay Area also is the site of the highest-stake debate on ferry system expansion in

TABLE 1 Marine Emission Standards and Comparisons (g/kW-h)

Standard		Start Date	HC	NOx	HC+NOx	CO	PM
MARPOL Annex VI[a]	<130 rpm		—	17.0		—	—
	130–2000 rpm	2000	—	17.0–9.8		—	—
	>2000 rpm		—	9.8		—	—
EPA locomotive	Tier 0	2000–01	1.3	12.7		6.7	0.80
	Tier 1	2002–04	0.7	9.9		2.9	0.60
	Tier 2	2005	0.4	7.4		2.0	0.27
EPA on-road diesel engines	MD	2002			2.5		0.10
	HD	2002			2.0		0.10
EPA nonroad	Tier 1	2000	1.3	9.2		11.4	0.54
	Tier 2	2001–06			6.4–6.6	3.5	0.20
	Tier 3	2008–10			4.0	3.5	0.20
EPA marine diesel[b]	**Tier 1**	**2000**		**17.0–9.8[c]**			
	Tier 2	**2004–06**			**7.2**	**2.0–3.5**	**0.20–0.30**
	Tier 3	**2008–10**			**4.0–5.0**	**2.0–3.5**	**0.20–0.30**

Notes: HC = hydrocarbons; NOx = nitrogen oxides; CO = carbon monoxide; PM = particulate matter.
[a] MARPOL is the main international maritime treaty addressing air pollution from ships. When ratified, Annex VI will apply to all marine engines built after 2000.
[b] 40 CFR Parts 89, 92, and 94. *Federal Register*, December 11, 1998.
[c] All MARPOL requirements apply under EPA Tier 1 rules.

the country, a debate that is framing many of the most important research questions.

Bold Vision

More than a dozen ferries currently serve the Bay Area, operated by a variety of private and public entities. More than half of these are new high-speed (up to 34 knots) craft, with capacities of 250 to 400 passengers. The commuter lines carry slightly more than 11,000 passengers per day.[1] Fares cover 25 percent to 100 percent of the costs, depending on the route, and ridership on all routes has been growing over the last several years. Berthing capacity, however, is limited, with only 14 locations available, and connections to mass transit also are limited (7). As a result, the typical ferry commuter drives from home to the terminal, boards the ferry, and—after reaching the city—walks or uses other transit to the final destination.

The Bay Area's congestion spurred research by the Metropolitan Transportation Commission (MTC), which is currently responsible for administering ferry routes, and by the Bay Area Council (BAC), a group of local business leaders. Both groups called for the expansion of service but differed on specific recommendations. MTC recommended adding five new vessels to expand service on three routes but concluded that new ferry service was a lower priority than other improvements to the system (8). BAC was more visionary, calling for a "world-class system" of 125 high-speed and cargo ferries with 42 terminals, including airport and cargo facilities (7). The BAC plan would expand the number of riders vastly—to as many as 30 million riders per year.

The Bay Area is the site of the highest-stake debate on ferry system expansion in the country, a debate that is framing many of the most important research questions.

The BAC study covered many conceptual aspects of marine transportation, including route planning and terminal locations, operating cost estimates, and a plan for a new authority with public funding. However, the BAC study addressed only a few environmental issues for ferries, focusing mostly on the effects of terminal construction on wetlands and wildlife habitat, wake impacts on shorelines and wetlands, and the need for dredging. The report covered several landside issues related to the effects on surrounding properties, including potential problems for neighboring communities due to the increased traffic. Nonetheless, in its February 1999 report, BAC gave little consideration to air pollution, claiming without substantiation that there would be an "apparent" improvement in air quality when commuters opted for ferries instead of cars.

Environmentalists Sound the Alarm

The environmental community was quick to respond. In July 1999 the Bluewater Network issued a report highly critical of the environmental performance of passenger ferries (9). This study, however, relied on limited data[2] and simple calculations; it claimed that emissions from uncontrolled marine diesel engines could be 6 to 10 times greater than highway modes on a passenger-mile basis. In particular, the study showed that newer-model diesel and natural-gas transit buses could be much cleaner replacements for automobile trips than older ferries.

This conclusion should have been no surprise. The environmental performance of on-road vehicles is the result of emissions regulations, and marine engines are unregulated; no one had yet suggested low-emission ferries.

As Bluewater Network admitted in the first sentence of its study, the analysis was only a first step in understanding ferry emissions. The main point was not to declare ferries a lost cause, nor to offer potential engineering solutions, but to demonstrate the need for further study of the impacts of ferries on air and water quality before expanding service. They added momentum to ongoing research into emissions from marine transportation.

Although the government and private transportation sectors already had begun addressing concerns about marine air pollution even before the Bluewater study attracted national attention, the study proved controversial and acted as a wake-up call for ferry advocates. Throughout the summer of 1999, news reports and editorials about ferry emissions appeared in newspapers across the country, making air pollution the primary environmental issue for ferries.

Industry Response

In direct response to the Bluewater Network claims, the Maritime Administration (MARAD) and the Society of Naval Architects and Marine Engineers (SNAME) began to compare emissions from ferries and other transit modes. The Trans-

[1] Tour ferry routes (e.g., to Alcatraz) draw fewer than 2,000 passengers daily, but like tour buses, they are not considered mass transit.

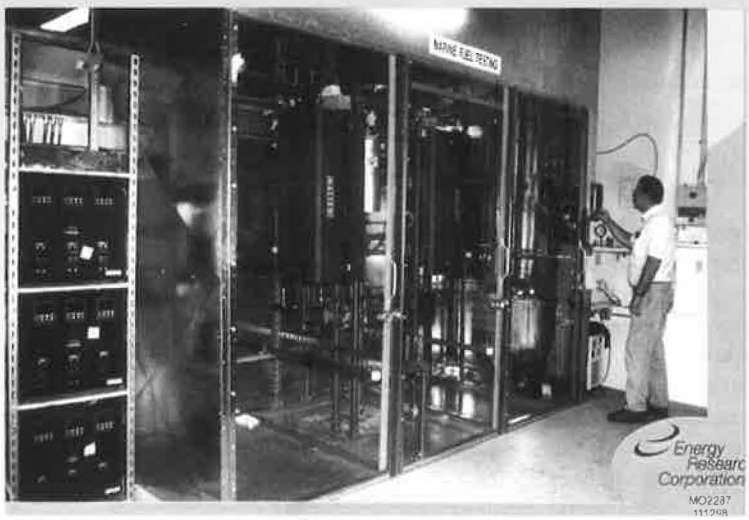
[2] The few published sources of marine emissions profiles focus on oceangoing vessels.

Marine Fuel Cell Under Development

The U.S. Navy and Coast Guard are performing research and development on a diesel-fueled 625-kW fuel cell prototype for marine use. Fuel cells offer lower fuel consumption, reduced emissions, and lower thermal and acoustic signatures compared with conventional naval power plants. As petroleum supplies become more expensive, fuel cells can run on such alternatives as natural gas, methanol, and hydrogen. However, there are technical challenges, such as developing a reliable desulfurizer and onboard fuel reformer, reducing overall plant size, and designing components that can be mass produced to reduce cost.

The services evaluated two systems, one using polymer electrolyte membrane and the other molten carbonate (MC) fuel cell technologies. They selected the MC system, from Fuel Cell Energy Corp., for further naval development; the prototype completion is scheduled for 2003. Target size and weight are <2 ft^3/kW and <40 lb/kW, respectively, and target fuel consumption is <170 g/kW-h. The prototype system will be suitable for use as a ship service generator or for powering an electric propulsion motor. With marine demands for electric power increasing, fuel cells may emerge as an important energy resource.

—Information from USCG Research and Development Center



Testing for reduced sulfur at Marine Fuel Test Facility, Groton, Connecticut.

portation Research Board's Committee on Ferry Transportation sponsored a panel session at the 79th Annual Meeting in January 2000 to discuss environmental issues for ferries; the panel included representatives of BAC and the Bluewater Network. Under the SNAME Ship's Machinery Committee, an Ad Hoc Ferry Transit Environmental Impact Panel prepared a summary of the issues raised by Bluewater. Ongoing engineering studies are reevaluating the emissions comparison between ferries and buses; these studies apply updated and detailed assumptions (including current engine and emission control designs) as well as an on-road emissions model used by the California Air Resources Board.[3]

Currently, all of these calculations agree that on a per-passenger-mile basis and under assumptions similar to those of the Bluewater study, uncontrolled emissions from marine diesels could be several times greater than heavily-regulated on-road diesels.[4] However, these studies also pointed out that ferries with emissions controls could perform as well as or better than other mass transit modes.

Each of these studies went on to consider alternative ferry systems, such as new engines that comply with EPA and international emissions limits, control technologies such as selective catalytic reduction, or alternative fuels and propulsion combinations. They showed that emissions control technologies were available, technically feasible, and more affordable than many expected. These analyses strongly suggested that the ferry industry could meet the challenge of achieving low emissions.

The most direct response to the Bluewater study was the formation of the Clean Marine Opportunities Partnership, a consortium of groups in the Bay Area. This group is planning to develop, test, and commercialize new ferry technologies that meet air quality and other environmental goals, enabling the expansion of ferry service in the Bay Area and nationally.

Another important response to the Bluewater study was the ferry legislation passed and signed into law in California last year; it provided clear instructions for an environmental assessment. Sponsored by State Assembly member Don Perata, the legislation (SB-428) allowed for the creation of a new authority along the lines suggested by BAC. However, the ferry expansion was contingent on positive findings from safety and air quality studies. In conjunction with these studies, Governor Gray Davis recently proposed a pilot project of several low-emission ferries as part of a larger transportation expansion plan.

Research for Clean Ferries

Although a lot of confusing smoke and noise has been generated about the environmental impacts of

[3] *Methodology for Estimating Emissions from On-Road Motor Vehicles, Vol. I, Introduction and Overview.* California Air Resources Board, October 1996. (Cited in MARAD draft report.)

[4] Later reports use more detailed assumptions and initial results conclude that emissions from unregulated ferries are 2 to 5 times greater than from heavily-regulated on-road diesels, not the 6 to 10 times difference cited by the Bluewater Network.

ferry service in the United States, and there is much still unknown, the key implications are clear:

1. The debate should not be about ferries versus other mass transit—but about how to integrate marine passenger and cargo service into the transportation systems of growing coastal regions.

2. Ferries and their supporting infrastructure can have significant environmental impacts, but these are not necessarily better or worse than the impacts of other modes—engineering and operational choices will determine the scope and scale of these impacts.

3. An integrated analysis of increased ferry service in a transportation system is necessary, including a comprehensive study of emissions and of all potential options, such as suburban feeder bus systems and multimodal terminals.

4. There is no single right answer for ferries—fast catamarans are not always better than traditional 25-knot monohulls. It depends on the route—the best system for the San Francisco Bay will not be the best one for New York or for Seattle.

Improved Engines and Fuels

The pressing need for reduced air emissions from ferries, combined with the long life of marine engines makes it necessary to consider methods that can reduce emissions from the engines now in use. The ferry industry must go beyond current environmental regulations to assure its future success.

The technical difficulties are not daunting; in the near term, ferries can employ traditional air-pollution controls, such as selective catalytic reduction systems, water injection (direct, through emulsions with fuel, or through air humidification designs), and advanced engine control systems. Marine engine manufacturers are offering these technologies on new construction in the international ferry market.

Cleaner marine diesel fuels also should be considered. Lower-sulfur diesel fuels not only reduce PM emissions directly but also enable the use of advanced catalysts that reduce NOx. However, technological improvements should focus on developing effective and affordable emissions control equipment for retrofits.

But the greatest difficulties will be in policy and economics; the current thinking—reflected in the current regulations—is that only new vessels need to be controlled. In some cases, there may be enough political resolve to require retrofits, but a better approach would be to offer incentives to vessel owners. This would entail emissions reduction credits or public funds to sponsor emission control programs. Moreover, economic incentives often spur technological innovation, which pays long-term dividends.

Fast ferries have introduced high-tech look. These vessels are incorporating advances to decrease air pollution and minimize wakes.

Low-Emission Ferries

Although incremental improvements to vessels will be needed in the short term, ferries will need new technologies with dramatically improved environmental performance to be competitive in the future. Expanded passenger-ferry service will be possible only if it improves—or at least does not degrade—environmental quality, and ferry expansion always will be compared with potential expansions of other transit modes, such as buses or rail, which also will continue to become cleaner. Although meeting EPA standards would reduce ferry emissions, this will not suffice—ferries will have to go well beyond current emissions standards to realize their potential.

Ferries will need to run on engines with optimized emissions controls, including some traditional marine propulsion systems such as gas turbines and diesel-electric drives. However, to drive emissions as low as possible, ferry operators must look at new core technologies that have low air pollution emissions and are reliable and cost-effective.

One promising possibility is to deploy an entirely new class of ferries that operate on gaseous

Kings Pointer Tests Conversion to Natural Gas

The U.S. Coast Guard (USCG) and the Maritime Administration (MARAD) are collaborating in a ONE DOT effort to convert the diesel–electric generators on the *Kings Pointer*, one of the U.S. Merchant Marine Academy's training vessels, to operate on a mixture of compressed natural gas (CNG) and diesel fuel. This initiative seeks to improve air quality in major port cities, anticipating stringent air quality standards from state and federal regulatory agencies.

CNG burns cleaner than diesel in an engine without emissions controls and can reduce engine maintenance costs. A successful conversion would help the federal government both reduce its dependency on petroleum from foreign sources and meet strict air quality standards. MARAD is working closely with USCG's Marine Safety Center to identify and resolve safety and regulatory issues that pertain to the storage and use of CNG as a marine fuel.

Tests of the *Kings Pointer* will establish the emissions reduction and also determine the life-cycle costs of the converted engine. The results of this study will be useful to commercial ship and ferry operators in metropolitan regions that already have an infrastructure for CNG fueling.

—Information from USCG Research and Development Center

fuels, particularly natural gas.[5] These are inherently clean fuels that do not contain hard-to-remove contaminants such as sulfur and that burn much cleaner than marine diesel fuels, especially in terms of soot. In addition, natural gas is less expensive than diesel fuel in many places and the high consumption by faster ferries can more easily cover the capital costs for both fueling infrastructure (e.g., the compressor) and onboard storage. Also, the reduced noise and vibration of natural gas engines should appeal to passengers and waterfront residents. Moreover, natural gas improves the fuel diversity of the transportation system and reduces the need to import petroleum.

Natural Gas Research

Recently, the U.S. Department of Energy's Clean Cities Program and the Gas Research Institute funded a project to look closely at natural gas as a fuel for ferries. This research showed that substantial reductions in many emissions categories were possible by switching from diesel fuel (*10*). Moreover, it showed that these reductions were cost-effective compared with emissions reductions from other sources, such as highway improvements or even power plants. But it also showed that considerable work is still needed in measuring marine diesel emissions.

Ferries are perhaps better suited for natural gas than are cars and light-duty vehicles. Because gaseous fuels are less dense than liquid fuels, storing energy-equivalent amounts on board imposes space and weight penalties in vehicle design. In automobiles, this translates into less space (typically less trunk and passenger room), slower acceleration, and a reduced range for similar-sized vehicles. But consumers value the attributes of spaciousness, speed, and range (*11*). Moreover, consumers expect and rely on a ubiquitous fuel infrastructure to support their mobility; this, too, makes the introduction of alternative fuels difficult.

Both the performance and fueling problems are smaller issues for ferries, which typically fuel at a central location (often the berth); moreover, the large volume and the regularity of the fuel demands are attractive to natural gas suppliers, encouraging investment in a refueling infrastructure. Further, research shows that the most important benefit of converting fuels is the publicity from using a "green" fuel—although this affects consumer choice only somewhat, it may be important to ferry operators seeking positive public awareness (*12*).

Responding to Climate Change

During the time that the San Francisco Bay ferry system develops (assuming it goes forward), minimizing climate change likely will become a key national policy goal. The principal challenge is to reduce emissions of fossil-derived carbon dioxide from the world's energy systems. Because of the growth in energy use worldwide, the U.S. transportation system will need to reduce drastically its carbon dioxide (CO_2) emissions on a per-mile-traveled basis by midcentury. There are two main paths: using renewable carbonaceous fuels (e.g., ethanol or biodiesel) or using an energy carrier produced without releasing CO_2 (e.g., electricity or hydrogen).

A significant recent development is the discovery of a potentially low-cost method of carbon-free hydrogen production—the capture and sequestration of CO_2 in conjunction with the standard steam reforming of natural gas. Size matters for this technology—both hydrogen production and CO_2 sequestration favor centralization. All of the advantages noted for natural gas-centralized fueling and fewer space and acceleration constraints—also apply to hydrogen as a ferry fuel. In addition, ships'

[5] Biofuels such as ethanol or biodiesel provide some of the same benefits as natural gas, but are more expensive—unless subsidized—and involve a host of production-related issues.

intense operational patterns can offset higher capital costs relatively quickly through lower operational (i.e., fuel) costs. In the long term, the development of designs and procedures to use natural gas will prove relevant to the deployment of ferries fueled by carbon-free hydrogen.

Hydrogen fuel also enables the use of fuel cell propulsion, which would eliminate air pollution and engine noise from ferries. However, it is conceivable that carbon-free hydrogen also could be used in a reciprocating engine. In either case, ferries could become the first true zero-emission vehicles.

Whole System Research

Meeting the environmental challenge for ferries is not about air emissions alone. Similarly, meeting the air pollution challenge for ferries is not about engines alone. In addition to addressing marine engines as the source of air emissions, transportation researchers need to consider the whole ferry system. Design choices in subsystems that do not directly involve the engines also can affect emissions reductions or increases. These research issues include the following:

◆ Hull form choices. Though specific to application and speed, these also determine the power and fuel requirements, which in turn are proportional to the emissions rates. In addition, naval architects should consider designs that address other important environmental issues, such as wake damage.

◆ Innovative terminal designs to improve passenger loading and unloading, including parking, and to reduce ferry turn-around-time. These terminals can be multimodal mass transit facilities connecting ferries, buses, and rail, similar to some international systems.

◆ Developing and improving a fueling infrastructure for low-emission alternative fuels (e.g., biodiesel, natural gas) for an expanding ferry system. This infrastructure may serve ferries only, or it may include other marine vessels in the region. In either case, research is needed to ensure that the fuel infrastructure responds to systemwide requirements safely.

◆ Understanding the delays associated with modal transfers and assessing the related environmental impacts (e.g., idling vehicles in parking lot queues).

◆ Comprehensive vessel safety and ferry traffic risk assessments to accommodate row boats, canoes, windsurfers, and pleasure craft on a bay with high-speed ferry crossings. Many recreational users do not listen to vessel traffic service broadcasts; maintaining safe distances while crossing the bay at high speeds may be the responsibility of the ferries or commercial vessels.

Environmentalists have raised questions about effect of increased ferry service on air and water quality and have called for further study.

◆ Improved understanding of what promotes or inhibits ridership in all mass-transit modes. The course ahead involves more than the "field of dreams" approach—building a system and hoping the passengers will come. Moving the lone commuter out of the car and into any form of mass transit remains a challenge.

Meeting the Challenges

The U.S. transportation industry can provide world-class ferry service to increase urban transit capacity and mitigate environmental damage. Ferries offer many advantages to commuters, as long as the system is accessible and meets basic transit needs. Although all projected transportation expansion costs are sizable, ferries may provide more capacity per dollar than additional highways and bridges.

However, achieving this objective requires the collaboration of the public, researchers, and industry to pursue near-term and long-term options in a context of integrated mass transit. This will require

Closely-watched ferry fleets in the San Francisco Bay Area, like Blue and Gold (*left*) and Vallejo Baylink (*above*), have an opportunity to convince opponents that ferries can increase urban transit capacity and mitigate environmental damage.

an understanding of the transportation choices facing commuters and businesses, and designing the right mix of ferries and other modes. The ferry industry has an opportunity to help meet all the transportation challenges, environmental and otherwise, in the coming decades.

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Natural Gas Vehicle Infrastructure Working Group:
www.gri.org/iwg

ALASKA'S MARINE HIGHWAY SYSTEM

Fast Ferries Join the Fleet

R. J. DOLL

Captain Doll is Director, Southeast Region, Alaska Department of Transportation and Public Facilities.

In an era when small government is the ascendant philosophy, and taxpayers are "in revolt," publicly-funded ferry systems may be challenged to sustain themselves. Several of the largest ferry systems in North America are experiencing financial difficulties. Although the public takes ferry service for granted, funding is uncertain. Typically, the search for means to continue operations occupies the attention of management and, as a result, day-to-day operations suffer, revenues decline, and the challenges magnify.

One strategy to overcome these circumstances is to go "high tech." But how does that apply to a ferry system? Will the public accept it? The Alaska Marine Highway System (AMHS) is about to find out.

Point of Departure

From the Gold Rush of 1898 until the mid-1950s, Alaska's southeast coast was its population center. The Alaska Steamship Company and other commercial carriers provided the only substantial connections with the outside world. Air travel routes were not well established and the few primitive roads did not reach many of the islands and glacier-bound communities.

When "Alaska Steam" ended its passenger service in 1954, Alaskans felt truly isolated. The closing was due, in part, to a Federal Maritime Board decision to end passenger service subsidies; however, subsidies continued for airline service. Also contributing to the company's losses was the union's refusal to adjust crew size to the decreased passenger loads in winter.

After attaining statehood in 1959, Alaska gave priority to the creation of a waterborne transportation system that would respond to public requirements rather than commercial imperatives. A June 1944 study had reached four main conclusions (*1*):

1. The route should connect Haines and Skagway, Alaska, with Prince Rupert, British Columbia.

2. A highway would require many short ferry runs to cross the bays and channels on the route.

3. This highway–ferry combination would cost an enormous sum.

4. If many short ferry runs would be necessary, why not consider one continuous ferry route from Prince Rupert to Haines and Skagway?

That is how the AMHS was built. There have been many modifications to its ships and routes over the years, but the AMHS remains a long-haul, high-capacity, 24-hour, 7-day, year-round, deep-water ferry system. Intentionally or not, it is modeled after its Alaska Steam predecessor. Passengers and vehicles can embark in Bellingham, Washington, or in Prince Rupert, and travel 3,000 miles to Dutch Harbor in the Aleutian Islands. The route also traverses some of the world's most spectacular natural scenery, which travelers can view in comfort. In 1965, the route was the subject of a 43-page photo feature in *National Geographic* (*2*).

Passenger and vehicle demand is highly seasonal (Figure 1), and earnings reflect the seasonal demand (Figure 2).

The numbers for passengers and vehicles have declined from their peak during the Persian Gulf War, when the war and international terrorism diverted many travelers to the relative security of U.S. tourism. The AMHS transports 104,000 vehicles and 350,000 passengers each year, earning an annual income of about $39 million, or 55 percent of expenditures. This gap between revenue and expenditures is increasing despite steady or slightly rising ridership (Figure 3).

For many years, the AMHS operated an eight-ship fleet. One oceangoing ship sailed in southwest Alaska, and one "lakes, bays, and sounds" ship served Prince William Sound. The remainder of the lakes, bays, and sounds ships served the southeast, two on local "feeder" routes and the remainder on the main line from Prince Rupert and Bellingham to Skagway. In 1998 AMHS added another ocean-capable ferry, allowing a link across the Gulf of

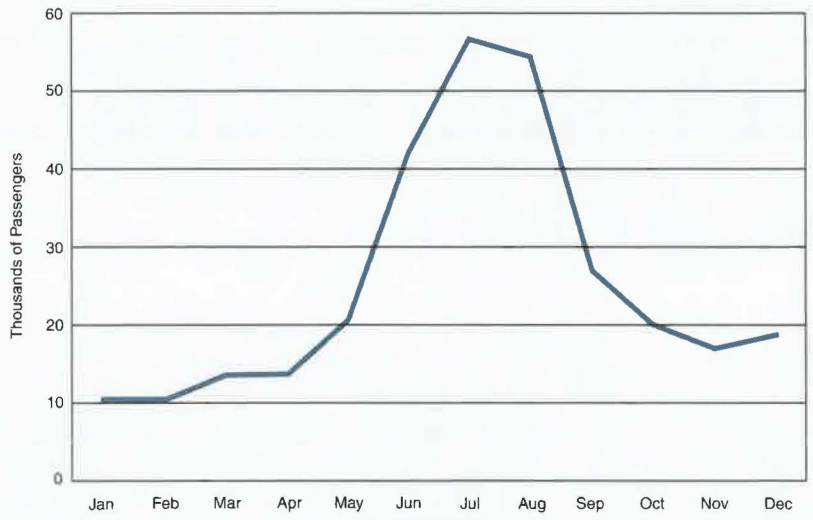

FIGURE 1 AMHS southeast passenger traffic, 1998.

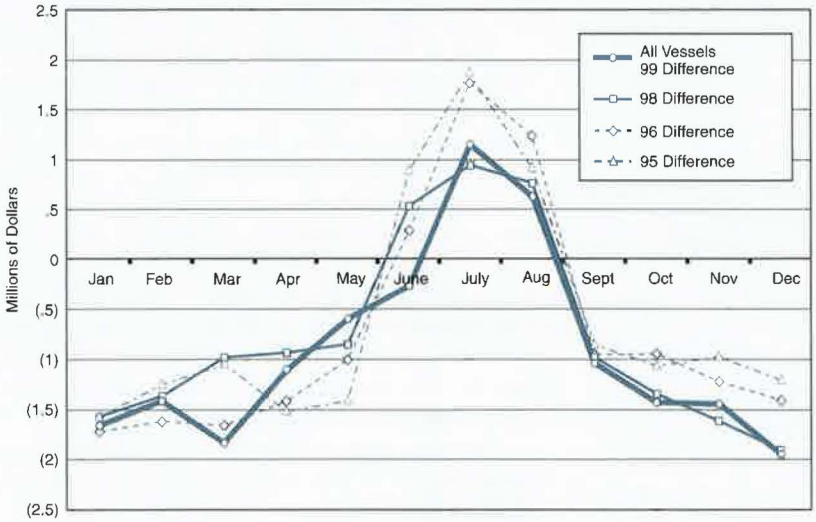

FIGURE 2 AMHS net operating earnings and losses by month.

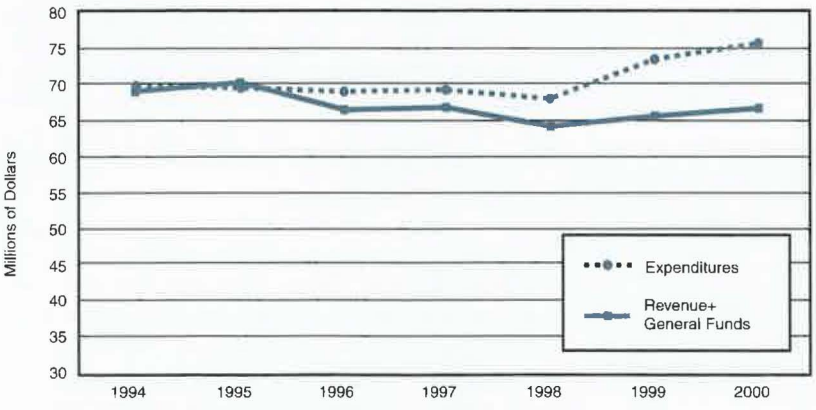

FIGURE 3 AMHS expenditures and revenues, 1994–2000.

Alaska between the southeast and southwest systems. Concurrently, one of the former mainline ferries moved to a summer-only shuttle service between Juneau and Haines-Skagway, another first.

A financial comparison of the four mainline ferries with the two feeders and the two serving the southwest demonstrates the revenue potential for each type of service (Table 1).

System Characteristics

In opting for a system to carry passengers from its southern terminus to any point along the coast of Alaska, AMHS planners avoided the costs, construction challenges, and delays involved in establishing shuttle routes. In the days before federal transportation funding had reached its present scale, and in a regulatory and labor climate which was more forgiving, this choice is not surprising. However, in the 40 years since, these original decisions have become less appropriate and less appealing.

AMHS at the New Century

A ferry system designed in the 1960s necessarily incorporates features that now are less than optimum from regulatory, social, financial, and political perspectives. Some of these problems could not have been anticipated, some were anticipated but were accepted, and some have gained significance over time. Although no one of these problems is critical, taken together they necessitate a new direction.

Long-Haul Service

Passengers riding a ferry on a through-voyage from one end of the route to the other require service provisions throughout their stay on board. They must have food and lodging as well as provisions for medical needs, recreation, and safety. In effect, the ferry must serve as a mobile hotel. This is a labor-intensive function, and costs are not easily recovered, since each passenger uses the hotel features to a different degree. Tourists and vacationers seek comfortable travel, but business and short-haul travelers or residents are less willing to pay for conveniences. This creates antagonisms among users, reflected in decreased levels of public support.

Ship and Route Design

A ferry that travels extended distances along the Alaska coast in winter as well as summer must be robust in design and construction and efficient in fuel consumption and storage capacity. AMHS ferries are dependable but are limited to a speed of 16 knots. Although an AMHS ferry can handle heavy weather, its draft may be limiting. Because a bow opening would impose other limitations, the

ferries cannot offer "through loading" over the bow and stern, like conventional ferries. As a result, loading can be tedious—stowage must account for multiple destinations over several days and for vehicles ranging from personal automobiles to 70-foot motor homes. This in turn leads to loading delays and passenger frustration.

Difficult currents and tides often require the ferry to make adjustments en route, so that the times of arrivals and departures are not only inconsistent from day to day but sometimes occur at inconvenient hours.

Service Concerns

There also are other scheduling issues—for example, a linear route means that weekend and holiday service may not be available for a given community. Critical comparisons of the service each community receives are inevitable. Additionally, with several ferries sometimes moving in both directions along a 1,000-mile route segment, conforming to random tide constraints, and experiencing loading or off-loading delays, sometimes a ferry will depart or arrive at the same port within hours of another. Optimizing schedules is a challenge.

So too is the seasonal nature of travel in Alaska. The relatively large size of the long-haul ships inhibits the system's ability to adjust capacity to seasonal demand. Reducing total fleet numbers in the off season leads to fewer port stops per week, antagonizing residents. Moreover, operating a large ship less frequently does not equate to larger loads per trip; those who must travel when ferry service is not available find alternatives.

Regulatory Regime

The transportation industry is highly regulated. It was among the first to feel the hand of the federal government in the 19th century and its constant development in capacity and speed has maintained public scrutiny. For a time, the maritime world escaped this regulatory attention. But a series of maritime disasters in the 1960s and 1970s directed attention to the transport of crude oil and then to roll-on–roll-off (RO-RO) ferries.

The sinking of the *Herald of Free Enterprise* in the English Channel and the *Estonia* in the Baltic Sea are two of the most prominent deep-sea ferry incidents that have prompted more stringent regulations. The International Maritime Organization (IMO), under the aegis of the International Convention for the Safety of Life at Sea, holds wide-ranging authority over deep-sea shipping, which is essentially an international business. RO-RO passenger ferries have received particular attention, and the U.S. Coast Guard has adopted and applied the IMO rules. Because it is an international carrier, serving Canada and crossing Canadian waters, the AMHS must adhere to the world's highest standards. Although the system probably would have adopted those same standards on its own, the net effect has been increased costs.

For example, until recently, open lifeboats and open inflatable rafts were acceptable means of escape from a ship in danger of sinking. Lifeboats can load from the embarkation deck, but passengers were expected to descend flexible ladders down the side of the ship to enter a raft, possibly at night and in adverse weather. Annual maintenance of a simple

TABLE 1 AMHS Major Cost Sectors and Revenue Sources

	Average per year, 1993–1998				FY 1999
	Expenses*	Revenues	Loss	Rev./Exp.	Rev./Exp.
SE Mainline	$33.6	$31.3	$(2.3)	93%	86%
SE Feeder	10.2	3.4	(6.8)	33%	32%
Southwest	8.5	4.3	(4.2)	51%	53%

* Expenses do not include shoreside and vessel overhead. All dollar figures are in millions.

M/V *Matanuska* traverses some of the world's most spectacular natural scenery on Alaska Marine Highway System.

In Haines, Alaska, heavy motor homes board the M/V *Malaspina*.

lifeboat or raft costs approximately $3,000. The systems required today, including escape chutes and other sophisticated devices, cost about $20,000 in annual maintenance per ship.

Societal Changes

A few more general societal changes affecting the AMHS deserve mention:

- Alaska's demographic center and political power has shifted to the northwest. The extensive land and air transportation needs of more remote, inland communities increasingly compete for federal and state funding.
- The public expectations for long-distance travel are based on airlines. Daily service, minimal travel times, and frequent departures are the standards many use to evaluate travel options. Most passengers, whose primary goal is to maximize time at their destination, tolerate virtually any inconvenience that air travel can impose. Today it is a novel idea that travel itself should be enjoyable or that it might be considered part of the destination.

Shuttle Service

In the spring of 1999 the state's Department of Transportation and Public Facilities completed the Southeast Alaska Transportation Plan (SATP), an intensive study of options for improving the area's transportation. The SATP proposed a series of ferry and road links, much like the plan discarded in 1960. But with advances in high-speed ferry technology, as well as in road construction, the planners had tools that were not available earlier.

In particular, high-speed ferries could overcome the distances between communities. In addition, the capacity would be more appropriate for winter demand, overnight accommodations would not be necessary, and daily schedules would be predictable. These features would translate into lower crew costs and an increased ability to adjust capacity to demand. A comparison of the operating costs of a conventional AMHS ship, the *Malaspina*, with those of a high-speed ferry on the same shuttle route is revealing (Table 2).

The most significant differences are crew costs and vehicle capacity. Savings in crew costs result from the fast ferry's ability to deliver passengers to their destination in less than one day without the need for extensive services and to return the crew to its home port each evening. In Alaska, speed is not a matter of passenger convenience—it is the only practical way to overcome the distances between ports and to decrease the costs involved. But the primary benefit of a combined conventional and high-speed system is the ability to adjust capacity to seasonal demand.

However, smaller ferries cannot accommodate peak-season volumes and therefore cannot earn the revenues of large-capacity vessels. They also cannot offer the opportunity to see the scenery of the southeast coast at a leisurely pace, a major attraction for visitors and residents. Again the solution is in the capacity-demand adjustments that fast ferries make possible.

TABLE 2 Cost Comparison of Fast Ferry and *Malaspina* in Shuttle Service

	Fast Ferry	*Malaspina*
Crew size	10	39
Crew hours	10	24
Vessel capacity	35	88
Wages and benefits	$4,392	$21,158
Night shore support	$1,133	—
Fuel	$2,515	$2,011
Supplies	$976	$3,118
Total cost/day	**$9,016**	**$26,287**
Cost/day/vehicle	$258	$299

Shoulder Season Adjustments

A useful model for the AMHS plan had been in place for several years. The M/V *Columbia* is assigned exclusively to the Bellingham-Skagway route, one of the most popular and most lucrative for the AMHS. The ship operates only from May to October, on the route for which she was designed, and earns $2 million above operating costs, the only ferry in the system consistently in the black (4). If the AMHS could find a way to replicate this example, it might secure its financial future. A fast-ferry shuttle system would provide that opportunity.

AMHS in 2005

With the mainliner *Columbia* as an operating model and fast ferries supplying both basic intercommunity service and seasonal flexibility, the AMHS of the future will offer the following:

- Year-round fast-ferry shuttle service between communities, 5 days per week, on predictable, daylight schedules;
- Short road connections between shuttle terminals;
- Long-haul, mainline service year-round from Bellingham to Skagway;
- Long-haul, mainline service in the summers with two ships from Bellingham and one or more from Prince Rupert; and
- Cross-gulf service regularly in the summer and less frequently in the off-season.

Conclusion

Shifting from a labor-intensive to a high-technology system entails major capital costs. With a high-speed, low-capacity vessel, operating costs depend on the speeds employed, the number of cycles per day or week, and the cost of fuel. But if ferries are operated to meet service requirements imposed without regard to traffic demand and revenue potential, the expected savings cannot be realized.

Speed is key to revitalizing AMHS operations and finances. It is the only technology that can overcome the distances between ports in Southeast Alaska. Speed will enable daily service, allowing passengers to reach their destinations in a single day; it also will reduce operating costs. The cost savings from overnight crews will more than offset the costs of increased fuel consumption.

However, if the temptation to extend the long-time operating plan cannot be resisted, costs will skyrocket. A 40-hour week with round-the-clock operations necessitates two crews at more than twice the shuttle-ferry crew costs and frustrates the concept of overnight maintenance. Nonetheless, continued operation of the mainliners is essential for generating revenue, particularly from commercial cargo. Achieving the two goals of reduced costs and improved revenues is basic Business 101. The new plan should reduce public funding of AMHS by approximately $10 million by the end of 2010—a goal that should gain wide support.

In recent years the Marine Highway Fund, established at $40 million in 1992, has compensated for shortfalls in appropriations and revenues; but the current rate of withdrawals will exhaust the fund by 2003. Time is running short for AMHS and for the communities it serves.

KAREN LEW

M/V *Columbia* travels Bellingham-Skagway route exclusively, one of the Alaska Marine Highway System's most popular and lucrative passages.

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State of Alaska:
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THE OBSTRUCTIONS ARE NOT OBSTACLE ILLUSIONS

GREGG M. WARD

Canadian and U.S. Policies Hinder Cross-Border Ferry Development

The author is vice president of Detroit-Windsor Truck Ferry.

The Great Lakes provide a tremendous opportunity for the United States and Canada to develop, promote, and deliver efficient, sustainable, and environmentally beneficial marine transportation. Using these waterways for passenger and commercial transportation has a rich history tracing back to the 1920s. The blue waters of the Great Lakes reach the shores of some of the most spectacular and vibrant cities in North America. Considering the dense, binational population, the hubs for tourism and manufacturing, the waterways, and the environmental benefits of marine transportation, why is there no thriving, binational ferry transportation network on the Great Lakes?

Regulations and restrictions on marine transportation have tempered the enthusiasm for a ferry network and other marine transportation operations on the Great Lakes. Nonetheless, there are many opportunities for expanding interlake and cross-border ferry services; these services can be both financially viable and environmentally desirable. It is not market forces that are impeding these developments but the negative consequences of government intervention and regulation. Are both the Canadian and U.S. governments biased toward highway transportation at the expense of marine transportation?

Debut of a Service

My family's experience as operators of the Detroit-Windsor Truck Ferry (DWTF) enables me to offer an operator–entrepreneur's perspective on the disincentives impeding cross-border ferry transportation on the Great Lakes. DWTF began operations on Earth Day 1990, highlighting a commitment to sustainable and environmentally friendly transportation.

The company's premise is to provide a safe, efficient, and economical marine crossing between Detroit, Michigan, and Windsor, Ontario, for hazardous materials and oversize and overweight transports restricted from using the local bridge and tunnel. Each ferry crossing removes trucks laden with hazardous material from the 165-mile detour route through Port Huron, Michigan, and Sarnia, Ontario. The only alternative for specialized transports too large for a cross-border bridge is crossing by land in Minnesota and Ontario—a detour of thousands of miles.

In nearly a decade of public service, DWTF has eliminated tens of millions of route miles for hazardous materials on trucks and on large, specialized carriers. This is a significant accomplishment for a privately-funded and operated extension to a continental highway system.

The service allows businesses to eliminate unnecessary highway miles; save time and money, and reduce risk exposure. Local and regional transportation authorities also have avoided the capital expenditure of providing either a similar publicly-funded ferry service or the physical infrastructure to accommodate these vehicles. The general public benefits from reduced contact with these vehicles, as well as from reductions in fossil-fuel consumption, in emissions, and in damage to the roadways.

Implementing similar services would yield similar benefits; however, new services are not likely without an understanding and acknowledgment of ferries' significant contribution to economic development, tourism, congestion mitigation, and the environment.

Canadian Obstacles

Cost Recovery Program

In Canada, two major obstacles confront cross-border ferry developers. The first is a cost recovery program for the services of customs and immigration personnel; applied selectively to marine operations, this program discourages new commercial and passenger-ferry routes into Canada.

For example, DWTF requires customs clearance for the commercial goods its customers transport, yet the Canadian government demands full cost recovery. This penalty for operating a marine-based border crossing—or for the privilege of using a marine route to import U.S. commercial goods into Canada—has cost DWTF more than $500,000 during the past 10 years. However, the operators of the bridge and tunnel facilities less than 1 mile upriver do not pay these charges; a new vehicular bridge

and rail tunnel between Michigan and Ontario have been exempted from cost recovery, and a new vehicular bridge planned between Detroit and Windsor also would be exempted.

Shouldn't the cost-recovery policy apply to all transportation modes? The official listing of international rail and highway border crossings subject to Canada's cost-recovery program shows only DWTF. But DWTF soon might have company—a new cross-border passenger-ferry service to the current and proposed waterfront casino developments also would face the cost-recovery burden.

The truck ferry, which serves the just-in-time requirements of the Big Three automotive companies, is limited to an 8.5-hour, 5 days-per-week operation; Canada has declined a request for an increase in hours, even though the ferry pays the cost of customs services. In contrast, increases in the customs workforce at the bridge and tunnel are provided regularly at no cost to the operators.

Icebreaking Fees

The second Canadian policy hindering cross-border ferry development is the icebreaking services fee. Instituted 2 years ago, this regulation subjects each vessel to a fee of $3,100 per transit whenever a vessel moves into or out of a Canadian ice-zone port during ice season. Although the fee is capped at eight transits per season, it is the same for any length of transit and applies whether or not icebreaking services are provided. In this way, both a vessel on a 1,000-mile journey and a DWTF ferry on a 1-mile crossing of the Detroit River pay the same $3,100 per transit fee. Moreover, in the case of the Detroit River, the U.S. Coast Guard performs a majority of the icebreaking.

A U.S.-based cross-border passenger-ferry service could operate year-round on the Detroit River; however, a service with only three small vessels would have to pay $74,400 annually in Canadian icebreaking service fees. Interestingly, several provincial ferries have refused to pay the fee.

U.S. Obstacles

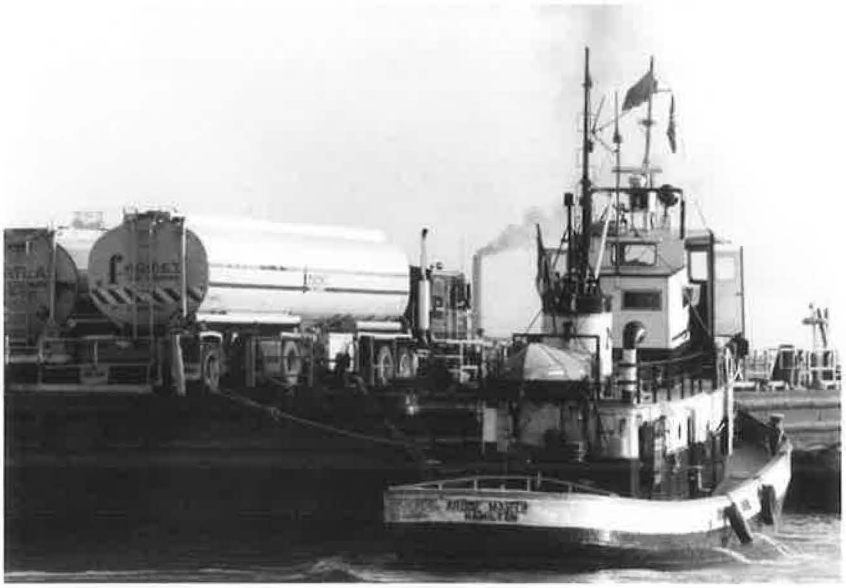
Freight ferries and barge services are viable on the Great Lakes but the opportunities remain underdeveloped. The safe and efficient movement of nonbulk freight via water between manufacturing centers would reduce traffic congestion, roadway deterioration, and the pressures of the driver shortage facing North American trucking companies. A vibrant marine-based freight transportation system also would ensure the availability of qualified mariners for military preparedness.

The most significant U.S. barrier to the development and operation of cross-border ferries is the harbor maintenance tax (HMT); this imposes a fee on the cargo of shallow-draft vessels in waterways that are not dredged. For example, DWTF uses a barge to transport commercial vehicles. With a loaded draft of less than 4 feet, the barge crosses the Detroit River, a nondredged channel. When entering the United States, the cargo on the tractor-trailer aboard the barge is subject to the HMT; however, if these same transports crossed at the local bridge or tunnel, there would be no comparable tax.

Detroit-Windsor Truck Ferry prepares to carry tanker trucks containing hazardous materials across Detroit River from Windsor, Ontario, to Detroit, Michigan.

To avoid paying the tax, vehicles laden with hazardous materials can divert to a land border crossing more than 100 miles away. Proposals to replace the HMT with a harbor services tax based on vessel tonnage and number of transits would prove even more onerous to ferry service development. Unless the replacement legislation exempts them, cross-border ferries transporting commercial goods are facing imminent financial collapse.

The Detroit-Windsor gateway is the busiest commercial border crossing in North America, with the Big Three automotive companies and their suppliers accounting for a major portion of the cross-border traffic. Much effort has gone into implementing innovative procedures to expedite customs clearance at the land border crossings; however, there is no similar automated cargo clearance for marine operators, which transport highway vehicles laden with millions of dollars of cargo each day. Instead, a separate, manual customs entry must be made on each shipment, resulting in delays and increased broker fees. With the contin-



Tugboat and barge of Detroit-Windsor Truck Ferry approaches Detroit harbor from Canada with typical load of heavy trucks and hazardous materials.

ued emphasis on open borders and technology solutions, a consistent methodology should apply to the entry of commercial goods at all border crossings, including ferry terminals.

State and Local Obstacles

It is not only the federal governments that have disregarded the value of ferries and other marine transportation—the state of Michigan and the city of Detroit also have weighed in. According to the U.S. Census Bureau, the Port of Detroit traded more than $85 billion in goods in 1998. Even though marine transportation plays an important role in the regional economy, highway and local signage for trucks to and from marine terminals is lacking. In contrast, clear signage directs local taxpayers and tourists to the privately-owned racetrack, casinos, and international bridge.

Affected most adversely by large tractor-trailer units gone astray are the residents of the economically-depressed communities adjacent to the marine terminals. The state and local governments should provide directional signage to enable trucks to take the most direct routes to and from the terminals.

With thousands of miles of coastline and with trade and traffic expanding under the North American Free Trade Agreement, the state of Michigan and the province of Ontario should do more to explore the opportunities offered by their waterways. Transportation and trade corridor planning should encompass maritime routes. Waterfront land-use policy should give full consideration to marine transportation and industrial needs, development, and planning.

Ending the Neglect

States, provinces, and communities with access to navigable waterways should give more consideration to marine transportation for alleviating mobility and congestion problems. There are countless examples worldwide of ferry services that have provided air quality improvements and congestion mitigation. Ferries use a ready resource and expand the transportation options of urban communities. They provide commercial transporters with a safe and efficient shortcut to highway driving. Among the many intrinsic values of waterborne transportation are panoramic views and an environmentally sound alternative to more cars on bigger highways.

Can the United States and Canada afford continued highway expansion without also recognizing how this policy contributes to urban sprawl, congestion, pollution, stress, and a resulting decline in quality of life? There are stark similarities between Henry Ford's famous quip that buyers could have "a Model T in any color as long as it is black" and the government's attitude that it will entertain any transportation alternative as long as it is a highway.

The U.S. Department of Transportation's strategic plan focuses on ONE DOT; however, the majority of its resources continue to flow primarily to one mode—highway transportation. The efforts of those in the government and private sectors to promote the environmental and economic benefits of marine transportation should be acknowledged. The Marine Transportation System (MTS) initiative is laudable; however, the MTS has not yet allocated the resources necessary to maintain and upgrade the system to reach its potential.

The obstacles facing the marine industry—specifically cross-border ferries—are not an illusion. However, there is optimism that today's demand for greater government accountability will lead to more responsible stewardship of our natural resources and tax dollars. Hopefully, the United States and Canadian governments will catch a new vision to gain the maximum benefits from the environmental and economic contributions of the maritime industry.

Ferries on the Web

American Association of State Highway and Transportation Officials:
www.aashto.org/a_search.html

This site is for AASHTO's Standing Committee on Water Transportation. Links to the committee's officers, charge statement, and staff liaison are presented.

Città d'Acqua:
www.iuav.unive.it/citiesonwater

The International Centre Città d'Acqua, "Cities on Water," works to promote scientific and cultural exchange through addressing issues, problems, and opportunities for cities located on the water, whether situated along the coast, around gulfs, bays, or lagoons, on lake shores or estuaries, or along important waterways. Città d'Acqua sponsors conferences and publishes proceedings, including *Cities on Water and Transport* and *Land-Water Intermodal Terminals*.

Dan Youra's Guide to Worldwide Ferry Schedules:
www.youra.com/ferry

This website provides an excellent gateway to ferry information (e.g., schedules, fees, special events, and frequently asked questions) from all over the world.

International Association of Ports and Harbors:
www.iaph.or.jp

Envisioning "World Peace through World Trade, World Trade through World Ports," this website seeks to promote the development of the international port and maritime industry.

International Association of Public Transport:
www.uitp.com

UITP's waterborne committee reports, activities, and membership information are available. Also provided are links to the online database Mobi+, UITP events, and an electronic newsletter.

International Marine Transit Association:
www.ferry.org

IMTA is the "international information exchange for ferry owners and operators worldwide." Links are provided so that research, technical data, and other experiences within the ferry industry may be shared. Information is posted about the 25th Annual Conference, to be held October 2000 in Venice. The site is undergoing expansion.

International Maritime Organization:
www.imo.org

IMO is the key United Nations agency responsible for maritime pollution rules, maritime safety, and other mandates affecting maritime practices. The website includes a directory of maritime links, maritime news, the history of IMO, and announcements for upcoming meetings and conventions.

International Navigation Association:
www.pianc-aipcn.org

PIANC is a scientific and technical organization that promotes management and sustainable development of navigational inland, coastal, and ocean waterways for the safe and efficient operation of all types of commercial and recreational vessels. Websites related to navigation, marine research and education, and ports and maritime information are provided through links.

Massachusetts Bay Transportation Authority:
www.massferryroutes.com

This website provides details about boat services in Massachusetts, including schedules, maps, passes, fares, and other news and information. Commuter rail, subway, and bus information are also available.

Passenger Vessel Association:
www.passengervessel.com

PVA's website includes interesting details on vessel specifications of member organizations, including shipbuilders and ferry operators. High-speed ferry activities, ferry grants, and information about MARAD ferry conferences can also be accessed.

Society of Naval Architects and Marine Engineers:
www.sname.org

SNAME is a professional society of members serving the maritime and offshore industries and their suppliers. More maritime websites, event listings, and membership, scholarship, and award information can be found online.

U.S. Department of Transportation:
www.dot.gov

The U.S. DOT provides links to many maritime-related agencies with policy responsibilities for ferries, ferry programs, and ferry funding mandates. A small number of these agencies and their respective website addresses include

Maritime Administration:
www.marad.dot.gov

(This website contains *An Assessment of the U.S. Marine Transportation System: A Report to Congress.*)

U.S. Army Corps of Engineers:
www.uscg.mil/welcome.html

U.S. Coast Guard:
www.uscg.mil/welcome.html

U.S. Federal Maritime Commission:
www.fmc.gov

Washington State Department of Transportation

TRAC WASHINGTON STATE

NEW RAMP METERING ALGORITHM IMPROVES SYSTEMWIDE TRAVEL TIME

AMY O'BRIEN

The author is a technical communications specialist with the Washington State Transportation Center at the University of Washington, Seattle.

In an ongoing effort to smooth traffic flow, the Washington State Department of Transportation (WSDOT) has sponsored research since 1994 to improve its ramp metering algorithm. After lengthy development, careful modeling, and online testing, a new algorithm has proved so successful that WSDOT is using it in the greater Seattle area to meter more than 100 ramps on Interstates 5, 405, and 90, and on State Route 520 (Figure 1).

Problem

Ramp metering improves operations on a freeway by restricting and evenly spacing the traffic volume entering a freeway. Although more advanced than many used around the country, WSDOT's previous ramp metering algorithms still had limitations. First, the data from loop detectors—the in-pavement sensors—were often missing or inaccurate because of communication problems, hardware failures, and poor calibration. The former algorithms calculated metering rate adjustments directly from raw loop-detector volumes and were limited therefore by the accuracy of the mainline volume data.

Second, ramp metering has the inherent difficulty of balancing two conflicting objectives: to reduce mainline congestion by decreasing entry rates and to reduce ramp queues by increasing entry rates. WSDOT's previous algorithms often oscillated between these opposing objectives. As a result, they responded to congestion rather than preventing it—and correcting the congestion was difficult.

Third, freeway systems are difficult to model accurately because traffic conditions can change abruptly or gradually, and a small event can have a large effect. WSDOT's previous algorithms depended on the accuracy of a system-flow model, and flaws in that model hampered the metering.

Finally, the previous WSDOT algorithms were difficult to calibrate. Ease of calibration is important because of variations in the desirable balance between mainline congestion and ramp queue length. In some areas, local politics may dictate shorter ramp queues, but in others, freeway flow may be paramount. Traffic patterns also can change as a result of urban growth, construction, time of year, or other conditions, requiring a new balance of performance objectives.

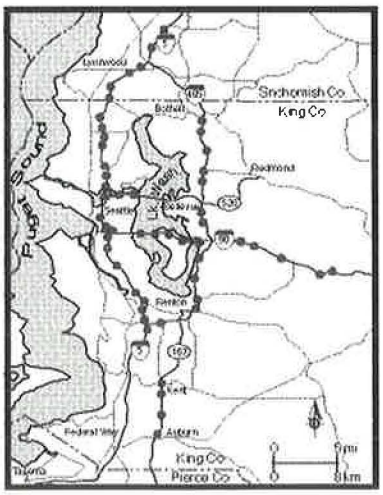


FIGURE 1 Seattle-area sites of ramps metered with fuzzy logic controls.

Solution

To address these problems, researchers at the University of Washington's Department of Electrical Engineering developed a ramp metering algorithm based on "fuzzy logic" control. Fuzzy logic emphasizes qualitative over quantitative information, and inputs and outputs are descriptive (e.g., "no congestion," "light congestion," and "medium congestion"), which is appropriate for imprecise or incomplete information. It also uses rule-based logic to incorporate human expertise; in this way, it can balance several performance objectives simultaneously and consider many types of information, such as traffic conditions downstream. These capabilities allow fuzzy logic to anticipate a problem and take temperate, corrective action before congestion occurs.

Application and Results

The fuzzy logic algorithm (FLA) was tested online within two cor-

ridors along I-405 and I-90 for a 4-month period beginning March 1999. The sites were chosen for their recurrent congestion, absence of construction, adequate loop detection, full closed-circuit television (CCTV) coverage, and metered ramps geographically isolated from corridors controlled by a different algorithm. The FLA's performance was compared with that of two previous WSDOT algorithms, dubbed "bottleneck" and "local." The evaluation balanced several objectives at the study sites: to decrease mainline congestion, increase mainline flow, and maintain acceptable ramp queues.

At the I-90 study site, the FLA produced lower mainline congestion than the local algorithm (Figures 2 and 3). The 8.2 percent change in mainline congestion was visible on CCTV. The FLA also prevented significant regular bottlenecks; the local algorithm did not. Overall, the FLA produced a 4.9 percent increase in throughput. With the combination of lower mainline congestion and higher throughput, the FLA controlled the mainline more efficiently than the local algorithm.

However, the effects of the FLA on ramp queues were mixed. Some ramp queues decreased, while others increased slightly. Nonetheless, these ramps had sufficient storage space, and given the mainline benefits, slightly longer ramp queues were acceptable.

The I-405 site, congested for hours each day, offered a more difficult challenge. Test results showed that mainline congestion was 1.2 percent worse with the FLA than with bottleneck metering. Vehicle throughput was nearly identical, with the FLA producing an increase only 0.8 percent more than the bottleneck algorithm. However, the FLA excelled at trimming the I-405 ramp queues, reducing the time each ramp was congested by an average of 26.5 minutes. These shorter ramp queues were politically preferable for I-405, since no acceptable level of metering would have reduced mainline congestion significantly.

Benefits

Limited by the accuracy of loop detectors and complicated by nonuniform traffic conditions, the online test results were mixed. Travel times, diversion to alternative routes, demand, and queue delay could not be measured directly. However, the tests showed that on I-90 the new algorithm decreased mainline congestion noticeably and increased flow. On I-405, the ramp queues decreased significantly but mainline congestion increased only marginally.

In addition to these operational advantages, the FLA was easier to use. With congestion indicators as inputs, the FLA can handle poor data, incidents, special events, and adverse weather without modifying the control parameters. It also mimics the way that operators approach ramp metering, making it easier to understand and calibrate for desired performance.

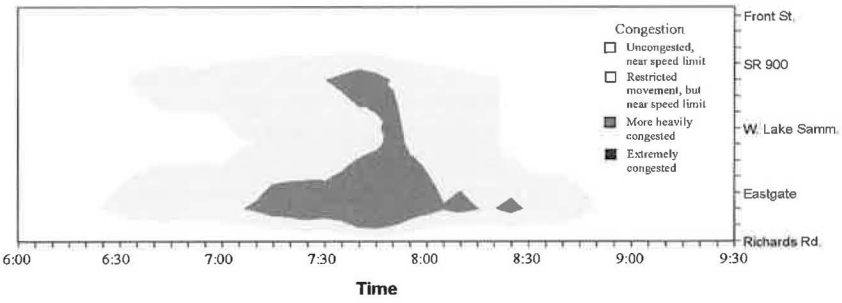


FIGURE 2 Contour map of location and duration of congestion on I-90 during morning peak period with ramps metered using the local algorithm; congestion is heavy from 7:10 to 8:10 a.m.

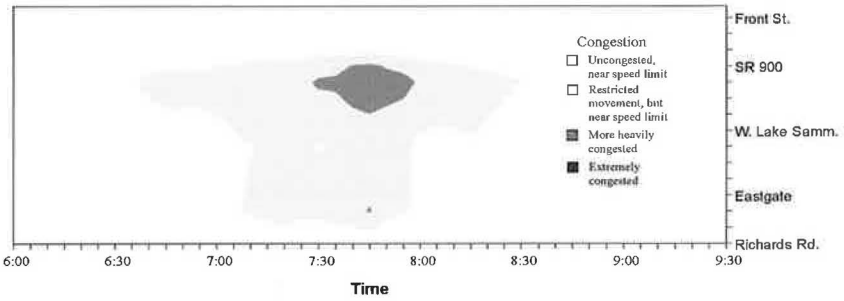


FIGURE 3 Contour map of the effects of fuzzy logic metering on I-90 during morning peak period; congestion is reduced, particularly near the Richards Road and Eastgate on-ramps.

Overall, the FLA appears to reduce total travel time systemwide, increasing flow in comparison with WSDOT's previous metering algorithms. Given these results and the other benefits of the new algorithm, WSDOT is applying the FLA to meter all of the ramps in the greater Seattle area.

For more information contact Cynthia Taylor, Research Engineer, University of Washington, Department of Electrical Engineering, Box 352500, Seattle, WA 98195 (telephone 206-616-1394, email taylorc@isdl.ee.washington.edu), or Deirdre Meldrum, Associate Professor, University of Washington, Department of Electrical Engineering, Box 352500, Seattle, WA 98195 (telephone 206-685-7639, email deedee@ee.washington.edu). At WSDOT, contact Paul Neel, Traffic Systems Management Center Flow Engineer, Washington Department of Transportation, Northwest Region, Mailstop 25, P.O. Box 330310, Seattle, WA 98133-9710 (telephone 206-440-4464).

EDITOR'S NOTE: *Appreciation is expressed to B. Ray Derr, Transportation Research Board, for his efforts in developing this article.*

Suggestions for "Research Pays Off" topics are welcome. Contact G. P. Jayaprakash, Transportation Research Board, 2101 Constitution Avenue, NW, Washington, DC 20418 (telephone 202-334-2952, e-mail gjayapra@nas.edu).

Edward P. Wasserman

Tennessee Department of Transportation

Edward P. Wasserman is Director, Division of Structures, and a 35-year veteran of the Tennessee Department of Transportation (TDOT). His expertise in management and bridge design and construction has been focused on developing and maintaining clear and thorough bridge design specifications that are both state of the art and user friendly.

"My primary focus is to encourage research that will lead to improving products, advancing design methodology, and producing increasingly informative materials publications," states Wasserman. "Each of these aids designers in the pursuit of safe, technically accurate, and economical structures that require a minimum of maintenance over their service life."

With the exception of a two-year period of active duty with the U.S. Army, Wasserman's service to TDOT has been continuous since his graduation from Vanderbilt University in 1965. He has designed precast-prestressed concrete bridges and welded plate girder bridges for grade separation and for stream and river crossings. In 1976 he was appointed head of structural design for the Division of Structures and in 1986 was promoted to Division Director. His current responsibilities include management of preliminary and final designs, detailing of structures, and approval of shop drawings during construction; inspections and repairs; and permit processing.

Wasserman's office produces designs for approximately 120 bridges each year, including concrete and steel girder bridges over roadways, railroads, and waterways. Designs for retaining walls, box culverts, noise barriers, and other miscellaneous structures also come out of his office. Some of the innovations adopted by the Division of Structures include

- Continuous bridges with a minimum of expansion joints—or none at all,
- Bridge designs to minimize damage in high-risk earthquake zones,
- Bent caps integral with steel girder superstructures,
- Prestressed concrete bridges made continuous for live loads,
- Post-tensioned bridges,
- High performance steel (HPS) bridges, and
- High performance concrete (HPC) bridges.

In his continuing efforts to advance bridge engineering, Wasserman has written many technical papers, including "Jointless Bridge Decks," "Aesthetics for Short- and Medium-Span Bridges," "Integral Post-Tensioned Concrete Bent Caps," and "High Performance Steel: An Owner and Designer Prospective." He also has lectured extensively. "We strive to exemplify the TDOT Division of Structures' traditional belief that to advance technology one must lead by doing," Wasserman says. "I have encouraged and championed innovations that include design and construction of both the longest jointless steel (525 ft) and precast-prestressed concrete (1,175 ft) bridges; the first steel bridge specifically designed to use the newly produced high performance weathering steel (HPS-70W); the first steel bridge to utilize HPS-70W steel in its most optimized, economical application, combining homogeneous and hybrid HPS sections; the first jointless high performance concrete bridge; the first steel-rolled beam bridge, designed to be a simple span for dead load and continuous for live load; and the first use of thermo-mechanically processed HPS for bridge application in the United States."

A licensed engineer, Wasserman is a member of the National Society of Professional Engineers and the American Society of Civil Engineers and serves on many industry-oriented committees. He currently chairs the NCHRP Project Panel on Load and Resistance Factor Design (LRFD) Specifications for Horizontally Curved Steel Girder Highway Bridges. Previously, he served on several other NCHRP project panels, including those on Elastomeric Bearings Design, Construction, and Materials; High-Load, Multirotational Bridge Bearings: Design, Materials, and Construction; and Improved Design Specifications for Horizontally Curved Steel Girder Highway Bridges, as well as the NCHRP Committee for Fatigue Behavior of Welded and Mechanical Splices in Reinforcing Steel. His current service to the Transportation Research Board includes membership on the Committee for Steel Bridges.

His notable contributions to the bridge design field have earned honors for Wasserman, including the James F. Lincoln Arc Welding Foundation Bronze Award, the National Steel Bridge Alliance's Special Award for Contributions to State-of-the-Art Steel Bridge Design and Construction, the American Iron and Steel Institute's Innovation in Steel Bridge Award, and the Tennessee Society of Professional Engineers' 1998 Government Engineer of the Year Award.

All of Wasserman's honors and accomplishments are a testament to his role as "an ombudsman between the practicing engineer and academic, who seeks a balance between overly complex and overly simplistic approaches to bridge design engineering."

"Everyone has a defining moment when they decide what they want to do when they grow up, or should I say get older," Rich May, pavement design engineer in the Performance Roads Group at Koch Materials Company, observes. "For me, it happened when I was 11 years old. Santa Claus brought me a figure-eight model road-racing set for Christmas. That's when I knew I wanted to work on roads." A civil engineer and enthusiastic researcher in the field of transportation for more than 27 years, May has remained true to his boyhood resolution.

His first position after graduating from Drexel University was in the Federal Highway Administration Office of Research. The experience fueled May's interest in research as he began to realize how many road-related issues needed study.

"With the completion of the Interstate Highway System, the focus of research had turned from new design to rehabilitation," May recalls. "I was using the FHWA 'Thumper' testing device to measure deflections on pavement projects and evaluate their condition. These deflection responses to plate load were used to back-calculate the individual layer properties and interpret the pavement behavior. FHWA allowed me to further my education and introduced me to many of the experts in the field, for which I am very grateful. That kind of assistance and learning was extremely important to a young student."

May continued his road rehabilitation work at FHWA, monitoring methods for eliminating reflective cracking in asphalt pavement overlays, evaluating pavement overlay design procedures and replacement sections in portland cement concrete (PCC) pavements, exploring nondestructive testing of highway sections, studying pavement management system concepts, and investigating asphalt-concrete mix additives.

Not satisfied with his primary duties of monitoring and managing contracts, and convinced of the value of short-term, focused research, May decided to get more involved in the direct use of research findings. In 1985 he joined the Asphalt Institute as principal engineer, developing and updating technical manuals on pavement design for highways and airfields. These publications included *Performance Graded Asphalt Binder Specification and Testing, Thickness Design: Asphalt Pavements for Highways and Streets, Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types,* and *Thickness Design: Asphalt Pavements for Air Carrier Airports.*

May also designed and programmed several software packages for structural pavement design, asphalt concrete mix design, and life-cycle cost analysis. The software supplemented the technical manuals, allowing engineers to perform the manual calculations more quickly. His most rewarding responsibility as principal engineer, he says, was providing technical support, computer assistance, and structural pavement design assistance to 18 field engineers in different parts of the country.

When he became director of technical services, May managed the laboratory testing support provided to the Institute's member companies. During his final two years at the Institute, he was principal investigator for the FHWA National Asphalt Training Center II Contract on Superpave Training and Field Assistance, conducting research on issues raised during the implementation of the Strategic Highway Research Program's Asphalt Research Program.

"As pavement designer, I get to apply my knowledge and experience in structural design and mixture analysis as part of a team that really stands behind its work on the road," notes May. "We're always looking for research results that we can use immediately on major highway projects."

May's professional affiliations include the American Society of Civil Engineers, the Association of Asphalt Paving Technologists, and the American Society for Testing and Materials (ASTM). He currently chairs ASTM's Committee D04 on Road and Paving Materials. Active with the Transportation Research Board since 1979, May has served on committees and task forces studying pavement rehabilitation, strength and deformation characteristics of pavement sections, nondestructive evaluation of highway pavements, and full-scale and accelerated pavement testing. He currently serves on the Committee for Flexible Pavement Design.

May received the FHWA Incentive Award for his service in conducting a National Research Conference and the Standards Development Award from ASTM's Committee D18 on Soil and Rock for his work on the *Standard Guide for Calculating In-Situ Equivalent Elastic Moduli of Pavement Materials Using Layered Elastic Theory.*

Richard W. May

Koch Materials Company

News Briefs

Nuria Fernandez, Acting FTA Administrator, unveils the Advanced Public Transportation System Mobile Showcase in Houston, Texas. Also participating in ceremony are (*from left*) Edward L. Thomas, Associate FTA Administrator; Greg Cook, Executive Director, Ann Arbor Transportation Authority; William Millar, President, American Public Transportation Association; and John Bartosiewicz, General Manager, Fort Worth Transportation Authority.

Mobile Transit Showcase Opens National Tour

The Federal Transit Administration inaugurated its Advanced Public Transportation Systems (APTS) Mobile Showcase at the American Public Transportation Association's Bus and Paratransit Conference in Houston, Texas, in May.

A 48-foot trailer with expandable sides, the APTS can serve as a research laboratory, a classroom, or a briefing facility on wheels—an environment for conducting short courses for transit staff and overview tours for decision makers. The showcase demonstrates the benefits of APTS technologies through a hands-on bus simulation and computer workstations.

"APTS technologies and systems provide transit operators with the technological tools to increase safety and improve quality of service," Acting FTA Administrator Nuria Fernandez noted.

Directed by FTA's Office of Research, Demonstration, and Innovation, the APTS Mobile Showcase Program will tour the country for two to three years, visiting transportation conferences, transit authorities, universities, and other venues.

For more information contact Raymond Keng, FTA (telephone 202-366-6667), or Matthew Rabkin, Volpe National Transportation Systems Center (telephone 617-494-2151).

Ferries Land at U.S. Airports

U.S. airports are testing the waters with links to nearby city terminals via ferry. Two ferry services and a water taxi now serve Boston's Logan Airport; arriving passengers are met by buses. At San Francisco Airport, management is exploring high-speed ferry connections to Oakland.

Celebrating a new addition to the airport ferry fleet in New York, U.S. Transportation Secretary Rodney E. Slater joined New York Waterway President Arthur E. Imperatore Jr. to christen a new high-speed ferry, the *Fiorello LaGuardia*, at the 34th Street Terminal in Manhattan. The *Fiorello LaGuardia* joins the *Yogi Berra* and the *Frank Sinatra* as the newest 149-passenger catamarans on the Delta Water Shuttle, linking Manhattan to the Delta Shuttle at LaGuardia's Marine Air Terminal.

The vessels were built under an innovative financing arrangement—the U.S. Department of Transportation's Maritime Administration guaranteed private-sector loans through its Title XI program.

For more information contact John Swank, U.S. Department of Transportation (telephone 202-366-5807).

Fuzzy Logic Makes Sense for Road Safety

Penn State engineers have developed a computer-based technique to more reliably predict crashes caused by wet pavement on a particular section of highway and to suggest safety improvements. This technique, known as "fuzzy logic," translates a verbal description of an accident framework for use in computerized decision making based on "if . . . then" statements. For example, "If the skid resistance is high and pavement wet time is short, then the risk of skidding accidents is low." Pennsylvania's approach does not exclude quantitative information, but it is the first to base "if . . . then" references on quantitative data.

Highway departments most often fix road sections with the highest accident tolls. Penn State's fuzzy logic technique identifies accident-prone locations early on, before they climb into the "most accident" category.

"With this approach, state departments of transportation may eventually have a tool to help identify which road sections to fix first in order to get the best return on safety and economic investment," says Bohdan Kulakowski, professor of mechanical engineering and director of The Pennsylvania State University's Pennsylvania Transportation Institute. "They could focus resources on eliminating problems where the risk is highest."

For more information contact Bohdan Kulakowski, Pennsylvania Transportation Institute (telephone 814-865-1891).

Computer Tool Improves Rush-Hour Air Traffic Control

The Federal Aviation Administration's Minneapolis air route traffic control center has started using

Sharon Kurywchak, FAA, works on Traffic Management Advisor, a computer tool that will help direct more aircraft during rush hours.

Traffic Management Advisor (TMA), an advanced computer tool to help direct more aircraft during rush hours. TMA helps controllers and traffic management specialists make better decisions in handling arriving aircraft; approaching airplanes from all directions can be viewed up to several hundred miles from selected airports. As the aircraft get closer, the computer helps controllers develop plans to handle the traffic according to each airport's spacing requirements.

TMA is a critical element of FAA's Free Flight Phase 1 program, a package of computer hardware and software tools to provide state-of-the-art benefits to controllers and airlines by the end of 2002. The program includes four other elements: Final Approach Spacing Tool, User Request Evaluation Tool, Surface Movement Advisor, and Collaborative Decision Making.

Charles Keegan, director of Free Flight Phase 1 remarked, "This new equipment is another important step that will help controllers funnel air traffic more smoothly into airports across the upper Midwest."

A panel of government, industry, and labor experts recommended the tools to FAA.

For more information contact Les Dorr, FAA (telephone 202-267-8521).

Preventing Child Passenger Deaths Due to Drunk Driving

Of the 5,555 child passengers under 15 years of age killed in alcohol-related crashes during 1985–1996, 64 percent (3,556) were riding in a vehicle with a drinking driver old enough to be the parent or caregiver.

Analyzing national crash data from the Fatality Analysis Reporting System of the National Highway Traffic Safety Administration, researchers at the Centers for Disease Control and Prevention (CDC) found that the fatality rates for child passengers with a drinking driver declined from 1985 through 1990, but then were unchanged from 1991 through 1996. The study also found that as the driver's blood alcohol concentration increased, the use of a child restraint decreased (Figure 1).

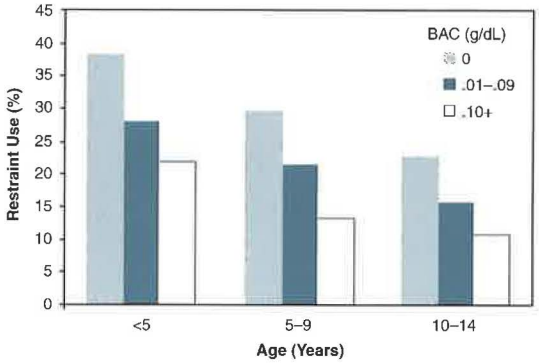


FIGURE 1 Restraint use among child passenger fatalities by child's age and blood alcohol concentration (g/dL) of driver, United States, 1985–1996 (N = 18,018).

Prevention strategies recommended in the CDC report include the following:

- Lower the legal blood alcohol limits for drivers transporting children,
- Re-evaluate special sanctions in current child endangerment laws for drivers convicted of driving under the influence with a child in the vehicle,
- Encourage families to adopt zero-alcohol-tolerance whenever transporting children,
- Train health care providers to screen adult patients for alcohol problems, recommend appropriate referrals and treatments, and provide counseling about the risks of alcohol-impaired driving, and
- Strictly enforce child safety-seat laws and pass primary seatbelt laws for all children in all seating positions.

Summarized from a CDC Research Update on the study, "Characteristics of Child Passenger Deaths and Injuries Involving Drinking Drivers," *published in the* Journal of the American Medical Association, *Volume 283, Number 17. For more information contact David Sleet, Ph.D., CDC (telephone 770-488-4652) or visit CDC's website (www.cdc.gov/ncipc/).*

Guide Touts Roundabouts

The Federal Highway Administration has published *Roundabouts: An Informational Guide*. The guide provides background information on roundabouts and the safety and operational benefits of

The Federal Highway Administration's recently published *Roundabouts: An Informational Guide* examines operational benefits of roundabouts, including increased safety and decreased traffic conflicts.

these traffic devices based on studies conducted in Europe and Australia. Research shows that well-designed roundabouts offer considerable safety benefits. They not only decrease potential traffic conflicts and reduce drivers' speed but also reduce injuries and fatal crashes by 40 to 50 percent.

The United States has about 100 roundabouts, with 150 sites under design or construction; in comparison, the United Kingdom has approximately 8,000 functional sites and France 17,000. Other countries, including Australia, Germany, and the Netherlands, also have constructed many roundabouts. Researchers reviewed European and Australian practices and publications extensively and critically to compile the best recommendations for the guide. U.S. highway planners and designers can learn from the research and can work to reduce crashes at conventional intersections, where 20 to 25 percent of fatalities and about 35 to 45 percent of injury-causing crashes occur.

Topics examined in the guide include policy considerations, planning, operation, safety, geometric design, traffic design and landscaping, and system considerations. The guide provides definitions and characteristics of safety and traffic operation and presents policies and criteria developed by the American Association of State Highway and Transportation Officials, as well as accepted international practices.

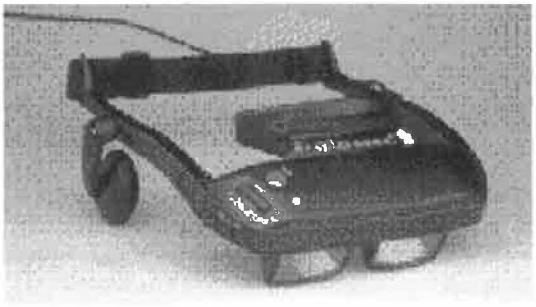
For more information contact Joe Bared, FHWA (telephone 202-493-3314). Roundabouts: An Informational Guide *(FHWA-RD-00-067) can be found on FHWA's website (www.tfhrc.gov/) and will be available in print August 2000. Order copies through FHWA's Report Center (telephone 301-577-0818, fax 301-577-1421).*

Navigators To See with Augmented-Reality Eyewear

The Coast Guard's Research and Development Center is studying a technology that could provide mariners with virtual representation to aid in navigation. The system would enable mariners to perceive virtual images of objects not visible in their physical environment.

These virtual object images would be distributed via the Internet to wireless, wearable computing devices. The augmented reality devices—perhaps glasses, monocular attachments, or binoculars—would receive and project images of the objects. Sensor fusion and software algorithms would register the images to the user's field of vision and to the target point in the environment.

Several emerging technologies could assist in this effort: satellite positioning and communications systems, wireless and mobile computing, and augmented and virtual reality hardware and software. The development of Internet information standards also will facilitate use of the new navigation technology.



Prototype of augmented-reality eyewear, which has the potential to aid in navigation, has been developed by Coast Guard's Research and Development Center.

For more information contact Marc B. Mandler, Ph.D., U.S. Coast Guard Academy Research and Development Center (telephone 860-441-2615, e-mail mmandler@rdc.uscg.mil).

Maritime Administration News

MARAD Marks Golden Anniversary

The Maritime Administration (MARAD) celebrates 50 years of service this year, marking the occasion with a series of educational and festive events. Part of the U.S. Department of Transportation since

1981, MARAD was established as an agency of the U.S. Department of Commerce on May 24, 1950, when the U.S. Maritime Commission—created by the Merchant Marine Act of 1936—was reorganized.

The agency's initial goals were the efficient administration of laws affecting the merchant marine and the prompt reduction of the backlog of work from previous years, including World War II. MARAD soon took on the additional challenge of mobilizing the American merchant marine to support the United Nations' military action in Korea.

For more history and information visit the U.S. Maritime Administration website (www.marad.gov/50th/index.asp/).

Federal Agencies To Improve Coordination of Maritime and Other Transportation Programs

U.S. Transportation Secretary Rodney E. Slater and representatives of other federal agencies have pledged to work together to improve the federal government's coordination of maritime transportation programs. In addition, Secretary Slater announced a nationwide series of dialogues focused on improving the safety, efficiency, and quality of America's Marine Transportation System (MTS).

"Our nation's ports and waterways—and how they connect with other modes of transportation such as highways and rail—make up a vital, complex system that impacts the lives and livelihoods of every American," Slater said. "We need to involve waterway users, government officials, and all members of the public with an interest in this essential segment of America's infrastructure in the effort to enhance our maritime system's ability to contribute to economic growth while protecting the environment and maintaining the highest standards of safety."

In April officials from the Departments of Defense, Commerce, Agriculture, the Treasury, and the Interior and the Environmental Protection Agency joined Secretary Slater in signing the Memorandum of Understanding to create the Interagency Committee for the MTS. This committee is charged with coordinating the federal government's MTS-related programs and ensuring that maritime policies, strategies, and goals are consistent with national needs.

The MTS consists of waterways, ports, and landside connections, which allow different modes of transportation to move people and goods to, from, and on the water. There are approximately 25,000 miles of navigable channels, 238 locks, and more than 3,700 marine terminals, marinas, and docks that support recreation and tourism. Federal officials estimate that 67 percent of consumer goods purchased by the American public are imported via the MTS.

For more information contact Dan Dewell, U.S. Department of Transportation (telephone 202-267-2304) or visit the U.S. DOT Public Affairs website (www.dot.gov/briefing.htm/).

Military Barge Deployment Is Largest Ever

The U.S. Army's Military Traffic Management Command recently completed its largest-ever deployment of the National Guard by barge, towing 64 barges of Army vehicles and equipment down the Mississippi River from Indiana to Louisiana.

Richard Lolich, program manager of the Maritime Administration's Office of Ports and Domestic Shipping, praised the barge operation: "We took hundreds and hundreds of heavy military vehicles and their crews off of the interstate highway system—that represents a big savings in fuel and driver costs." Lolich also praised water transportation for its safety and exceptional ability to move heavy cargoes relatively inexpensively.

Major Chip Whitaker, personnel officer for the 76th Infantry Brigade, noted that in addition to its economies, barge transport saves time—vehicles can be loaded for immediate deployment at their destination. Barges can transport vehicles just as they are; with rail transport, in contrast, some types of vehicles must be stripped of excess equipment to be secured and fuel tankers must be shipped empty.

Summarized from an article in The Waterways Journal Weekly, *May 1, 2000, Volume 114, Number 5. For additional information contact John Randt, Military Traffic Management Command (telephone 703-681-6242).*

Movement of more than 1,100 Army vehicles and equipment from Indiana to Louisiana is largest National Guard deployment by barge in history.

TRB Committee Reviews National Transit Database Redesign

The National Transit Database (NTD) is a system to collect, report, and disseminate financial and operating data—including safety data—on public mass transportation. Congress uses the data for transit service planning and for apportioning Federal Transit Administration (FTA) formula funds.

Each year, approximately 600 transit agencies and organizations that receive or benefit from federal transit funding must submit an NTD report. Each report contains approximately 1,000 data fields, and each agency typically fills in about 500 of these, which NTD must validate.

The NTD data have come under criticism from several federal government users. In particular, the National Transportation Safety Board (NTSB), in its *Highway Special Investigation Report* (NTSB/SIR-98/03, Novermber 17, 1998), criticized the data reported by FTA on accidents involving transit vehicles. According to NTSB, the data are "of limited value, can be used only to identify numeric trends of bus accidents, and are not usable to identify the underlying causes of, or contributing factors to, these trends." NTSB also faulted the timeliness of the data.

The Congressional *Conference Report to Accompany H.R. 2084* (appropriations for the Department of Transportation for Fiscal Year 2000) also stated that "the conferees are aware that state and local governments, transit industry personnel, and academic institutions rely heavily on operational data contained in the transit data base. The publication of this data is not timely and excludes some performance statistics that may be particularly helpful to all parties."

As a result, Congress required FTA to redesign the NTD by May 31, 2000, in consultation with the National Academy of Sciences. At FTA's request, the National Research Council, through the Transportation Research Board (TRB), established the Committee for the National Transit Database: A Review.

The committee's goal is to ensure that the redesigned database includes "the operational and

TRB Committee Members Elected to Academies

Election to membership in the National Academies, recognizing distinguished and continuing achievement in original research, is one of the highest honors accorded to a U.S. scientist or engineer. Longtime TRB participants Alan M. Voorhees and Susan E. Hanson recently were elected to membership in the National Academy of Engineering and the National Academy of Sciences, respectively.

Alan M. Voorhees

Alan M. Voorhees, responsible for planning many major metropolitan transportation systems built during the 1960s and 1970s, has been recognized by election to the National Academy of Engineering for his outstanding accomplishments in transportation, city, and environmental planning.

Voorhees

A pioneer in transportation planning, Voorhees developed techniques for projecting future traffic patterns based on land use. He made significant contributions to early applications of attitude surveys and mathematical models for commercial, recreation, and economic planning. He has been involved in the development of downtown plans for various cities; many community renewal studies; the planning of new towns such as Columbia, Maryland; and the planning of land development and transportation facilities in light of environmental factors.

In 1961 Voorhees founded the transportation planning firm of Alan M. Voorhees & Associates. Under his leadership, the firm played a key role in planning metropolitan transportation systems for Atlanta; Baltimore; Los Angeles; St. Louis; Caracas, Venezuela; Newcastle, England; and Sao Paulo, Brazil.

From 1977 to 1979 Voorhees served as dean of the College of Architecture, Art, and Urban Sciences at the University of Illinois–Chicago Circle. In 1980 he was one of the founders of Atlantic Southeast Airlines, and he has since been involved in a number of start-up corporations. He currently is president and chairman of the board of Summit Enterprises, Inc.

Voorhees has received many awards, including the Highway Research Board Award, the Institute of Traffic Engineers Past President's Award for his research into the relationships between traffic generation and land use, and the first Harland Bartholomew Award of the American Society of Civil Engineers for his accomplishments in urban planning and development. He has written many textbooks and manuals and has assisted in the preparation of such essential publications as the *Traffic Engineering Handbook*, the *Highway Capacity Man-*

performance measures and financial data necessary for FTA to fulfill its statutory responsibilities in distributing formula grants, while providing meaningful data for state and local governments, transit industry personnel, and academic institutions."

The committee members represent transit data users (government officials and researchers) and producers (transit agencies). The committee's initial meeting, April 10–11, was devoted to information-gathering from a variety of sources and resulted in a letter report to the FTA Administrator before the May 31 deadline. In fall 2000, FTA and its contractor will brief the committee on the proposed redesign for the database, tentatively scheduled for completion by October. The committee will review and comment on this proposal in a second letter report to the FTA Administrator.

Chairing the committee is Michael S. Townes, executive director of Hampton Roads Transit, Hampton, Va. The TRB contact is Stephen Godwin, director of the Division of Studies and Information Services, TRB, Washington, D.C. (telephone 202-334-3261).

NCHRP Contractor Wins Honors

For its work on the National Cooperative Highway Research Program's (NCHRP) Project 3-52, Impacts of Access Management Techniques, Urbitran Associates, Inc., has received the Honor Award for Excellence in Transportation Engineering Studies from the New York Association of Consulting Engineers (NYACE). NYACE's annual Engineering Excellence Awards, presented in April, recognize achievements that demonstrate the highest degree of engineering skill and ingenuity and that also provide significant benefits to both the public welfare and the private practice of engineering.

In its award-winning project, Urbitran Associates and its subcontractors classified access management techniques and developed methods for measuring their impact on roadway safety and operations. The product of the effort was NCHRP Report 420, *Impacts of Access Management Techniques.*

ual, and the *Highway Engineering Handbook*.

Voorhees served on the Executive Committee of the Transportation Research Board for several years. He was vice chair from 1971 to 1972 and chair from 1972 to 1973. He also was a member of TRB's Steering Committee on Urban Transportation Policy Research from 1978 to 1980.

Susan E. Hanson

Susan E. Hanson, professor of geography at Clark University, is an urban geographer with interests in urban transportation, urban labor markets, and gender issues. Her election to the National Academy of Sciences acknowledges her distinguished accomplishments in these areas. Hanson's research has explored the ways different population groups share, interact with, and use the urban environment.

"I have always seen travel as woven into the fabric of everyday life, not something you can lift out and study separately," she notes. "I have focused on the complexity of travel, looking at it in at least three different ways: the multiple-purpose trip (or trip chaining), day-to-day variability in travel patterns, and the relative importance of socioeconomic versus spatial factors in determining travel patterns."

Hanson

The Uppsala Household Travel Survey is an example of Hanson's transportation-related research. The survey consisted of a high-quality, spatially detailed data set covering urban spatial structure and household travel; it tracked the members of 300 households for 5 weeks. The data set has proved invaluable in understanding the relationship between travel behavior and urban spatial structure.

Hanson is a fellow of the American Association for the Advancement of Science, past president of the Association of American Geographers (AAG), beneficiary of a Guggenheim Fellowship, and recipient of the Van Cleef Medal of the American Geographical Society and the AAG Honors Award. Her publications include *The Geography of Urban Transportation,* "The Social Construction of Models: Recent Developments in Transportation and Land Use Models," "Off the Road? Reflections on Transportation Geography in the Information Age," and "Assessing Day-to-Day Variability in Complex Travel Patterns."

Hanson served as a member of the Transportation Research Board's Committee on Passenger Travel Demand Forecasting from 1982 to 1985 and on the Committee for a Study on Urban Transportation Congestion Pricing from 1992 to 1994.

When Is the Best Time To Apply Preventive Maintenance Treatments to Pavement?

Highway agencies employ many different preventive maintenance treatments to restore pavement condition and retard deterioration. For specific climate conditions and traffic levels, the performance of the restored pavement depends not only on the type of maintenance treatment, but also on the pavement condition when the treatments are applied. However, these relationships are not well documented, making it difficult to determine the optimal time to apply a specific treatment.

For the purpose of research to develop a guide on this subject, preventive maintenance is defined as a planned strategy of cost-effective treatments to preserve a roadway system, retard its future deterioration, and maintain and improve its functional condition without substantially increasing structural capacity. This research does not include treatments of appurtenances.

Applied Pavement Technology, Inc. of Urbana, Illinois, has been awarded a $500,000, 27-month contract (NCHRP Project 14-14, FY 2000) to develop a guide for determining the optimal timing for the application of preventive maintenance treatments to flexible and rigid pavements. This guide will help highway agencies effectively manage investments in pavement maintenance and achieve the best value for the public dollar.

For further information contact Amir N. Hanna, TRB (telephone 202-334-1892, e-mail ahanna@nas.edu).

Opening Early to Traffic—But How Long Will It Last?

With traffic increasing in urban areas, motorists are less tolerant of delays due to pavement rehabilitation. To minimize delays, state highway agencies are using "early-opening-to-traffic" rehabilitation strategies, allowing work at night or during low-traffic periods. In these applications, portland cement concrete generally is expected to be strong enough for traffic within 6 to 24 hours. Although there usually are rigorous requirements for mix design and strength development for early-opening-to-traffic concrete applications, limited consideration often is given to materials and construction aspects that influence long-term performance and durability.

Much of recent research on early-opening-to-traffic concrete has investigated mechanical properties but not durability. Without this information, the durability of the concrete cannot be predicted, the long-term performance of the rehabilitated pavement cannot be assured, and the cost-effectiveness cannot be adequately assessed. Therefore research is needed to address these durability issues and to develop guidelines for the use of portland cement concrete for early-opening-to-traffic pavement rehabilitation.

Michigan Technological University of Houghton, Michigan, has been awarded a $349,993, 24-month contract (NCHRP Project 18-4B, FY 1996) to develop guidelines for materials, mixtures, and construction techniques to achieve long-term durability of early-opening-to-traffic portland cement concrete for pavement rehabilitation. The research will examine concrete mixtures suited for traffic within (a) 6 to 8 hours and (b) 20 to 24 hours after placement; it also shall be limited to full-depth rehabilitation, such as full-depth repair and slab replacement. The guidelines will help engineers in selecting the materials, mixtures, and construction techniques to ensure long-term performance, durability, and cost-effectiveness.

For further information contact Amir N. Hanna, TRB (telephone 202-334-1892, e-mail ahanna@nas.edu).

Maximizing the Performance of Flexible and Rigid Pavements

The performance of flexible and rigid pavements in specific site conditions (e.g., traffic level, climate, and subgrade type) depend not only on pavement layer thicknesses and materials, but also on design and construction features (e.g., subdrainage, base, and shoulders).

Research is needed to identify and to determine the relative importance of site conditions and design and construction features that lead to different levels of performance by flexible and rigid pavements. The data from the Long-Term Pavement Performance (LTPP) studies are expected to provide the information for more rigorous analysis and well-supported conclusions on the importance of these features.

Arizona State University, Tempe, has been awarded a $200,000, 18-month contract [NCHRP Project 20-50(10), FY 2000] to identify, based on data from the LTPP studies for specific pavement types and site conditions, the contributions of design and construction features to different levels of pavement performance (e.g., good and poor). The research will examine only new construction

or nonrehabilitated pavements. The findings will help to identify appropriate features for different pavement types.

For further information contact Amir N. Hanna, TRB (telephone 202-334-1892, e-mail ahanna@nas.edu).

Are Pavement Markings More Effective in Yellow or in White?

The use of yellow and white pavement markings has been a subject of debate for transportation agencies since the 1920s. In 1971, the *Manual on Uniform Traffic Control Devices* first specified yellow markings to separate traffic traveling in opposite directions. However, it is uncertain whether most drivers in the United States understand or appreciate the significance of the system.

There are several concerns associated with yellow pavement markings. One is that they are 30 percent less bright (on average) than white markings. Brighter markings improve guidance during darkness and inclement weather and may enhance safety, especially for the aging population. Yellow markings also are more expensive to manufacture. Moreover, a two-color marking system increases the cost of inventory, equipment, and application. The removal of lead and other heavy metals from yellow marking materials has adversely affected nighttime color appearance.

TTI of College Station, Texas, has been awarded a $250,000, 18-month contract (NCHRP Project 4-28, FY 2000) to identify and quantify the benefits, costs, drawbacks, and implementation issues of switching from the two-color pavement marking system to an all-white one.

For further information contact Charles W. Niessner, TRB (telephone 202-334-1431, e-mail cniessne @nas.edu/).

Can the Falling-Weight Deflectometer Indicate Pavement Construction Quality?

The falling weight deflectometer (FWD) has become integral to the structural evaluation of pavements. There is a potential also for using FWD data to characterize pavement construction quality. For example, FWD data obtained shortly after each pavement layer's construction may reveal variations both in deflections and in the shape of deflection basins along a project or among projects; these can be caused by differences in the properties of pavement layers due to variations in construction.

Therefore procedures that take into account the effects of loading schemes, deflection measurement locations, deflection basin parameters, and other related factors could be used to analyze deflection data and to characterize construction quality. However, the feasibility of such procedures has not been established. Research is needed to evaluate the development of methods for characterizing pavement construction quality based on FWD data. The data available from the LTPP studies should be useful.

Consulpav International of Oak View, California, has been awarded a $174,996, 18-month contract [NCHRP Project 20-50(09), FY 2000] to use data from the LTPP studies to evaluate the feasibility of developing procedures for characterizing the quality of new and reconstructed flexible and rigid pavements based on FWD results and, if possible, to recommend procedures. The recommendations will encourage validation and implementation by highway agencies and lead to an effective characterization of construction quality and to the enforcement of pavement quality specifications.

For further information contact Amir N. Hanna, TRB (telephone 202-334-1892, e-mail ahanna@nas.edu).

CALENDAR

TRB Meetings

2000

August

20–23 National Conference on Transportation Finance
Scottsdale, Arizona
Jon Williams

27–31 2000 North American Travel Monitoring Exhibition and Conference*
Madison, Wisconsin
Thomas Palmerlee

28–30 10th International High-Occupancy Vehicle (HOV) Conference
Dallas, Texas
Richard Cunard

September

Conference on Transportation and Economic Development
Minneapolis, Minnesota
Jon Williams

1 Symposium on Landslide Countermeasures and Their Effectiveness*
Seattle, Washington
G. P. Jayaprakash

5–9 5th International Symposium on Snow Removal and Ice Control Technology
Roanoke, Virginia
Frank Lisle

14–15 Workshop on Impacts of E-Commerce on Transportation*
Washington, D.C.
Thomas Palmerlee

20–22 Traffic Safety on Three Continents*
Pretoria, South Africa
Richard Pain

28–30 Conference on Transportation Planning Needs and Requirements of Small and Medium-Sized Communities
Little Rock, Arkansas
James Scott

October

11–13 2nd International Symposium: 3-D Finite Element Modeling (FEM) for Pavement Analysis and Design
Charleston, West Virginia
Bill Dearasaugh

18–20 New Visions in Transportation: Accelerating, New Visions in Innovative Designs*
Aspen, Colorado
Peter Shaw

19–21 Conference on Native American Cross-Cultural Interaction
Albuquerque, New Mexico
Jon Williams

22–25 13th Equipment Management Workshop
Sacramento, California
Frank Lisle

29–Nov. 1 Conference on Performance Measures (by invitation)
Irvine, California
James Scott

November

11–15 8th National Light Rail Transit Conference
Dallas, Texas
Peter Shaw

12–15 Rural Mobility Solutions for the 21st Century
Lake Tahoe, Nevada
Peter Shaw

December

4–5 Remote Sensing for Transportation Conference
Washington, D.C.
Thomas Palmerlee

11–15 1st International Conference on the Applications of Geophysics to Transportation Planning, Construction, and Maintenance*
St. Louis, Missouri
G. P. Jayaprakash

2001

January

6 DAWG Forum on Pavement Performance Data Analysis
Washington, D.C.
Robert Raab

6 International Human Factors Design Guidelines for Highway Safety and Telematics Workshop
Washington, D.C.
Richard Pain

7–11 TRB 80th Annual Meeting
Washington, D.C.
Robert Spicher

7 Doctoral Student Research in Transportation Geotechnics
Washington, D.C.
G. P. Jayaprakash

7 34th Annual Human Factors in Transportation Workshop
Washington, D.C.
Richard Pain

7 Airport Ground Access Workshop
Washington, D.C.
Joseph Breen

Additional information on TRB conferences and workshops, including calls for abstracts, registration and hotel information, lists of cosponsors, and links to conference websites, is available online (www4.nationalacademies.org/trb/calendar.nsf). Registration and hotel information usually is available 2 to 3 months in advance. For information, contact the individual listed at 202-334-2934 (fax 202-334-2003; e-mail lkarson@nas.edu).

*TRB is cosponsor of the meeting.

7 **Investigative Techniques for Assessing Concrete Durability Problems: State-of-the-Practice**
Washington, D.C.
Frederick Hejl

7 **The New Disadvantaged Business Enterprise Regulations: Effects and Consequences**
Washington, D.C.
Frederick Hejl

Other Meetings

Council of Logistics Management Annual Conference

September 24–27, 2000
New Orleans, Louisiana
Sponsor Council of Logistic Management
Subjects Business issues, electronic commerce, emerging technologies, global strategies, inventory strategies, information services management, current research and surveys, transportation, and warehousing.
Contact CLM, 2805 Butterfield Road, Suite 200, Oak Brook, Illinois 60523-1170 (telephone 630-574-0985, fax 630-574-0537, e-mail clmadmin@clm1.org, website www.clm1.org/).

25th Annual Conference of the International Marine Transit Association: The Ferry Market Throughout Maritime Basins in the World

October 23–27, 2000
Venice, Italy
Sponsor IMTA
Subjects History of marine transportation; new technologies; the global market; current issues facing ferry operators of the United States, Europe, and Asia; and emergence of marine transportation in the Mediterranean, Caribbean, and South China regions.
Contact Mara Vittori or Enrica Capretti, 25th IMTA Secretariat, International Centre Città d'Acqua, San Marco 4149-30124, Venice (telephone +39-041-5230428, fax +39-041-5286103, e-mail marav@iuav.unive.it).

Steel Bridge Design and Construction for the New Millennium

November 30–December 1, 2000
Baltimore, Maryland
Sponsors Federal Highway Administration and National Bridge Research Organization, and cosponsors American Iron and Steel Institute, Maryland Department of Transportation, National Steel Bridge Alliance, Pennsylvania Department of Transportation, and Virginia Department of Transportation.
Subjects FHWA's vision for the new millennium, steel bridge design and construction around the world, integral abutments and jointless bridges, economical steel bridge details, weldability of high-performance steels, consumable development and availability of high-performance steel, latest changes in AASHTO bridge codes related to high-performance steel, and a short course, Design of Steel Bridges Using AASHTO LRFD Specifications.
Contact Stacy Umbenhower, National Bridge Research Organization, University of Nebraska–Lincoln, W351 Nebraska Hall, Lincoln, NE 68588-0528 (telephone 402-472-3462).

2001 Passenger Vessel Association's Annual Convention

February 3–6, 2001
Savannah, Georgia
Sponsors Passenger Vessel Association
Subjects Preparing crisis and emergency response plans, pollution solutions, history of East Coast passenger vessels, innovations in vessel design, how to save on dry docks, safety, employment law for passenger vessel operators.
Contact Jennifer Williams (telephone 703-807-0100, website www.passengervessel.com/).

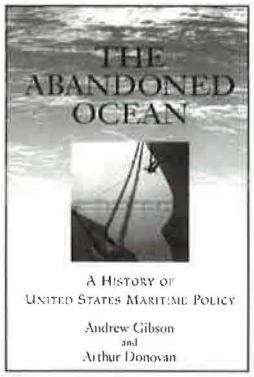
Geosynthetics Conference 2001

February 12–14, 2001
Portland, Oregon
Sponsors Industrial Fabrics Association International, North American Geosynthetics Society, and Geosynthetic Materials Association.
Subjects Economics, performance, and constructability of geosynthetics; erosion control; materials science and durability; military applications; filtration and drainage; materials testing; waste and liquid containment; seismic issues; pavement and rail systems; mining; and walls, slopes, and embankments.
Contact Janet Schneider (telephone 1-800-225-4324, fax 978-945-2654, e-mail GEO2001@ifai.com).

20th Australian Road Research Board Conference

March 19–21, 2001
Melbourne, Australia
Sponsors ARRB Transport Research, VicRoads, and Transit NZ.
Subjects Strategic issues, asset management, economic impacts, environment, structures, local roads, safety, congestion management, traffic management and planning, new technologies, pavement materials, and pavement design and construction.
Contact Margaret Husselbee (telephone +61-3-9881-1578, fax +61-3-9887-8104, e-mail 20conf@arrb.org.au, website www.arrb.org.au/).

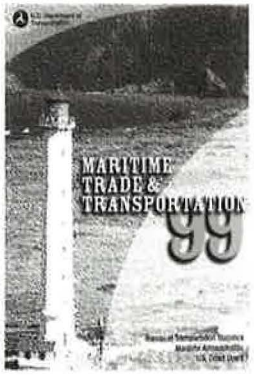
BOOKSHELF



The Abandoned Ocean: A History of United States Maritime Policy

Andrew Gibson and Arthur Donovan. University of South Carolina Press, Columbia, South Carolina: 2000; $39.95, hardcover; ISBN 1-57003-319-6; 362 pp.

This history of the U.S. merchant marine—from its establishment after the Revolutionary War through its transformations in the late 20th century—offers a comprehensive appraisal of American maritime policy. It examines the fortunes of the shipbuilding industry and the activities of the merchant and military navies. The book also analyzes federal policies that promote, regulate, protect, and subsidize American shipping in coastal and foreign trade and compares commercial and military policy goals.



Maritime Trade and Transportation 1999

Bureau of Transportation Statistics, Maritime Administration, and U.S. Coast Guard, U.S. Department of Transportation, Washington, D.C.: 1999; no charge, softcover; pub. # BTS00-02; 128 pp.

This report addresses the U.S. Department of Transportation's five strategic goals—to promote safety, improve mobility, advance economic growth, protect human and natural environments, and strengthen national security—as applied to maritime trade, transportation, and shipbuilding. It describes major trends and reviews the marine transportation industry's contribution to the U.S. economy as well as its safety record and environmental impacts. National security, advances in navigation technologies, and key information and data gaps are among the issues presented.

The Monongahela: River of Dreams, River of Sweat

Arthur Parker. The Pennsylvania State University Press, University Park, Pennsylvania: 1999; $35.00, hardcover; ISBN 0-271-01875-5; 202 pp.

The Monongahela River of western Pennsylvania served as a point of embarkation for settlers moving westward in the 18th century, was a longtime boatbuilding center, and provided an essential support for the coal and steel industries in the 19th and 20th centuries. Through anecdotes, interviews, photos, and illustrations, this volume explores the history of the river and its impact on the marine industry.

Sea Change in Liner Shipping: Regulation and Managerial Decision-Making in a Global Industry

Mary R. Brooks. Pergamon, The Netherlands: 2000; $113.00, hardcover; ISBN 0-08-043428-2; 289 pp.

Competition in the liner shipping industry, related regulatory changes, and managerial policy on cooperation and competition are the subjects of this volume. Drawing comparisons with the rail and aviation industries, the author develops principles for a common regulatory policy for liner shipping and proposes a framework for strategy formulation and implementation by shipping managers. The book presents issues in national regulation for the United States, Europe, and Canada.

America's Coast Guard: Safeguarding U.S. Maritime Safety and Security in the 21st Century

Captain Bruce Stubbs and Scott Truver. U.S. Coast Guard, Washington, D.C.: 2000. No charge, softcover; 144 pp.

This publication offers an overview of the historical, strategic, policy, and operational baselines for the Coast Guard's core humanitarian, law enforcement, diplomatic, and military capabilities. Also examined are the requirements needed to satisfy the Coast Guard's current and future modernization, especially in the deepwater operating environment. Contact Evelyn Jutte, Governmental and Public Affairs, U.S. Coast Guard, for a copy (telephone 202-267-0479).

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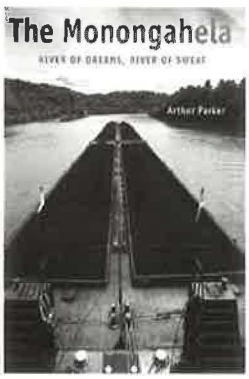

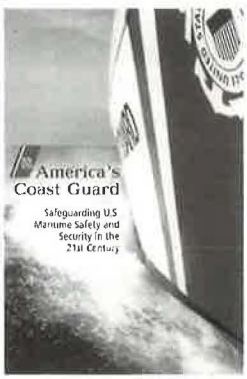

TRB PUBLICATIONS

Recommended LRFD Specifications for Plastic Pipe and Culverts
NCHRP Report 438
The capacity of thermoplastic culvert pipe in hoop compression and the resistance of profile wall pipe sections to failure caused by local buckling are presented. The research was carried out to support development of provisions for plastic pipes and culverts in the AASHTO load and resistance factor design (LRFD) specifications. At present, design methods and specifications for plastic pipes and culverts follow those for metal products. As use of plastic pipe increases, so too does the need for provisions to ensure it is both structurally safe and cost-effective.

2000; 63 pp.; TRB affiliates, $20.25; nonaffiliates, $27.00. Subscriber category: bridges, other structures, and hydraulics and hydrology (IIC).

Superelevation Distribution Methods and Transition Designs
NCHRP Report 439
The horizontal curve guidelines presented in the 1994 AASHTO publication, *A Policy on Geometric Design of Highways and Streets,* are evaluated and revisions are recommended. Although all elements of a curve are considered in the analysis, the study focuses on the use of superelevation and the transition from a tangent to a curve. The physics of negotiating a curve and the procedures for designing curves are discussed.

2000; 167 pp.; TRB affiliates, $32.25; nonaffiliates: $43.00. Subscriber category: highway and facility design (IIA).

Fleet Management and Selection Systems for Highway Maintenance Equipment
NCHRP Synthesis 283
The fleet management of highway maintenance equipment combines essential and unique functions within state departments of transportation (DOTs). The effectiveness of this management has a direct impact on an agency's efficiency. This synthesis updates information in *NCHRP Synthesis 52: Maintenance and Selection Systems for Highway Maintenance Equipment,* published in 1978, adding contemporary management, equipment, staffing, and technology considerations. The report describes equipment management, with an emphasis on hiring and retaining mechanics, how DOTs select and replace equipment, and the impact of management information systems and new technologies on fleet management.

2000, 33 pp., TRB affiliates, $16.50; nonaffiliates, $22.00; Subscriber categories: planning and administration (IA) and maintenance (IIIC).

Risk Management in the Marine Transportation System
Conference Proceedings 22
Recognizing the need to review current knowledge on the application of risk assessment and management in maritime transportation—and to formulate the next steps for the industry—the Marine Board, now part of TRB, convened a symposium in March 1999. This volume presents the themes and concerns expressed at the conference in discussion papers, expert panels, case studies, and topical workshops, including the call for a more standardized risk assessment process for the maritime industry, the inclusion of environmental considerations at the early stages of a project, and the need to establish an incident reporting system—with liability protection—to provide a data base for conducting reliable risk analysis.

2000, 128 pp., TRB affiliates, $25.25; nonaffiliates, $33.00; Subscriber categories: planning, administration (IA); energy and environment (IB); safety and human performance (IVB); public transit (VI); freight transportation (VIII); marine transportation (IX).

Preventive Maintenance and Evaluation of Pavements and Structures
Transportation Research Record 1680
Guidelines for microsurfacing, material characterization of silicone sealants, fundamental concepts of heat-strengthening repair for damaged steel bridges, and life-cycle cost analysis for zinc and other protective coatings for steel structures are examined.

1999; 76 pp.; TRB affiliates, $22.00; nonaffiliates, $29.00. Subscriber category: maintenance (IIIC).

Hot-Mix Asphalt Mixtures
Transportation Research Record 1681
Evaluated are asphalt-rubber surface mixes, aggregate size characteristics in stone matrix asphalt and Superpave mixtures, the clogging potential of porous asphalt mixtures, and an energy approach to nondestructive evaluation of complex moduli in asphalt concrete.

1999; 192 pp.; TRB affiliates, $39.75; nonaffiliates, $53.00. Subscriber category: materials and construction (IIIB).

Transportation System Management, Transportation Demand Management, and High-Occupancy Vehicle Systems
Transportation Research Record 1682
Topics include video enforcement of high-occupancy vehicle lanes, carpooling behavior, urban traffic control, and predicting change in average vehicle ridership as a result of employer trip-reduction plans.

1999; 77 pp.; TRB affiliates, $22.00; nonaffiliates, $29.00. Subscriber category: highway operations, capacity, and traffic control (IVA).

Advanced Traffic Management Systems
Transportation Research Record 1683
Incident management programs, mobile surveillance and wireless communication systems, dual loop speed traps, and roadside assistance programs are explored.

1999; 159 pp.; TRB affiliates, $31.75; nonaffiliates, $42.00. Subscriber category: highway operations, capacity, and traffic control (IVA).

Issues in the Design of New and Rehabilitated Pavements
Transportation Research Record 1684
Considerations for high-performance concrete paving, controlling early-age cracking in continuously reinforced concrete pavement, hot in-place recycling of bituminous pavement, and structural adequacy of rubblized portland cement concrete pavement are among the subjects discussed.

1999; 222 pp.; TRB affiliates, $44.00; nonaffiliates, $58.00. Subscriber category: pavement design, management, and performance (IIB).

Transportation Planning, Programming, Public Participation, and Land Use
Transportation Research Record 1685
Papers cover such topics as using commodity flow survey data to develop a truck travel-demand model, integrating statewide planning and programming, identifying intermodal connector needs, and using a transportation-improvement program database and a partnership approach to improve project delivery.

1999; 227 pp.; TRB affiliates, $44.00; nonaffiliates, $58.00. Subscriber category: planning and administration (IA).

Truck Safety Research
Transportation Research Record 1686
Examined are the effects of the mechanical condition of heavy vehicles on road safety, truck-rollover crashes on ramps, how loading and unloading cargo can influence truck driver alertness, and whether an afternoon nap can improve truckers' nighttime driving performance.

1999; 56 pp.; TRB affiliates, $19.50; nonaffiliates, $26.00. Subscriber category: safety and human performance (IVB).

Geotechnical Aspects of Pavements
Transportation Research Record 1687
Papers on resilient moduli and on micromechanics compose this two-part volume. "Part 1: Determination and Application of Resilient Modulus" covers such topics as the resilient modulus of soft soil beneath high-speed rail lines, the resilient modulus measurement of fine-grained subgrade soils, and how a stabilized aggregate base effects the durability of resilient moduli. "Part 2: Micromechanics of Asphalt Pavements and Geosynthetics in Pavements" covers micromechanical models for the temperature effects of hot-mix asphalt concrete and geogrid-reinforced flexible pavement overlays.

1999; 130 pp.; TRB affiliates, $27.75; nonaffiliates, $37.00. Subscriber category: soils, geology, and foundations (IIIA).

Various Bridge Design Issues
Transportation Research Record 1688
The long-term performance of elastomeric bridge bearings, simplified nonlinear modeling for seismic assessment of complex bridges, fatigue design of modular bridge expansion joints, and transverse cracking in concrete bridge decks are addressed in these papers.

1999; 176 pp.; TRB affiliates, $33.50; nonaffiliates, $44.00. Subscriber category: bridges, other structures, and hydraulics and hydrology (IIC).

Simulation, Instrumented Vehicles, and Human Performance in Highway Design and Research
Transportation Research Record 1689
Predicting driving performance through computerized testing, modeling motorway driving behavior, developing highway driving simulations using virtual reality modeling language, and evaluating road curves based on road view perception are discussed.

1999; 72 pp.; TRB affiliates, $22.00; nonaffiliates, $29.00. Subscriber category: safety and human performance (IVB).

Roadside Safety and Other General Design Issues
Transportation Research Record 1690
Hydrodynamic countermeasures for local pier scour, factors related to the probability of joint flooding, two-dimensional modeling for the collision dynamics of deflecting concrete barriers, and choosing an inventory data collection system are among the research presented.

1999; 192 pp.; TRB affiliates, $39.75; nonaffiliates, $53.00. Subscriber category: highway and facility design (IIA).

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FEATURES are timely articles of interest to transportation professionals, including administrators, planners, researchers, and practitioners in government, academia, and industry. Articles are encouraged on innovations and state-of-the-art practices pertaining to transportation research and development in all modes (highways and bridges, public transit, aviation, rail, and others, such as pipelines, bicycles, pedestrians, etc.) and in all subject areas (planning and administration, design, materials and construction, facility maintenance, traffic control, safety, geology, law, environmental concerns, energy, etc.). Manuscripts should be no longer than 3,000 to 4,000 words (12 to 16 double-spaced, typewritten pages), summarized briefly but thoroughly by an abstract of approximately 60 words. Authors should also provide appropriate and professionally drawn line drawings, charts, or tables, and glossy, black-and-white, high-quality photographs with corresponding captions. Prospective authors are encouraged to submit a summary or outline of a proposed article for preliminary review.

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