U.S. Department of Transportation
Federal Highway Administration

CHALLENGES AND OPPORTUNITIES FOR AN ITS INTERMODAL FREIGHT PROGRAM

FINAL REPORT

FEBRUARY, 1999

Intelligent Transportation Systems
Joint Program Office

final report

Challenges and Opportunities for an ITS/Intermodal Freight Program

prepared for

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Office of the Secretary – Office of Intermodalism
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16. Abstract
This final report was developed as part of the project, "ITS/Intermodal Freight Design for Operational Tests." The objective of the proj-ect was to develop a plan for conducting field operational tests to facilitate movement of intermodal freight in the U.S.

Information technology is transforming the intermodal freight industry by enabling it to integrate operations across the supply chain. Advanced communications and information systems and intelligent transportation systems (ITS) provide real-time information on intermodal freight operations and congestion on highways and rail lines. Enough of these systems are in operation today to be linked in a demonstration of information flow for end-to-end monitoring of the intermodal movement. Sharing information about congestion and operations across the intermodal freight system is key to addressing the problems of port and terminal capacity and the reliability of highway and rail access to the ports and terminals.

This report describes how a national ITS program for intermodal freight can promote the application of ITS technology to intermodal freight transportation. It defines eight possible operational tests that could link public and private information and management systems, enabling terminal operators, freight carriers, and state and metropolitan traffic operations managers to share information to optimize flows and better utilize equipment and facilities. These tests would provide benefits to the intermodal industry, its clients, and the general public that shares the use of the transportation system.

This report identifies three major steps in building a program that will serve industry, local, and national needs. The U.S. DOT should: 1) solicit and fund proposals for operational tests that will demonstrate the productivity and safety benefits of exchanging information between private sector shipment information and asset management systems and public sector traffic and safety management systems; 2) support ITS/intermodal forums, studies, and programs to advance private and public sector opportunities for accelerated application of ITS technology to the intermodal freight system; and 3) support the evolution of data interchange standards where they benefit industry and government.

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Executive Summary

Industry and government are concerned about the capacity of ports and terminals – and the highways, rail lines, and waterways that serve them – to handle steadily increasing volumes of intermodal traffic, especially containerized freight. The volume of intermodal freight traffic is growing significantly. The number of intermodal containers moving through ports worldwide doubled over the last decade, and intermodal air freight, intermodal traffic on U.S. railroads, and the volume of intermodal freight moved by truck grew apace. Volumes are expected to double again over the next decade.

For the most part, this growth will be handled through existing ports and terminals; however, the weakest link in the chain will not be the ports and terminals, but the reliability of highway and rail access to the ports and terminals. Both motor carriers and intermodal rail operators are caught in – and contributing to – a spiral of congestion. Congestion will not shut down ports and terminals, but it can have devastating and disproportionate impacts by degrading the reliability and predictability of intermodal service for shippers and receivers. Reliability and predictability are the most important characteristics of freight transportation in an era of tightly integrated operations and just-in-time inventories. Unless this problem is addressed, the safety, reliability, and responsiveness of the intermodal freight system will deteriorate and its contribution to the nation's economic growth and national security will be diminished.

Information technology is transforming the intermodal freight industry by enabling it to integrate operations across the supply chain. Advanced communications and information systems and intelligent transportation systems (ITS) provide real-time information on intermodal freight operations and congestion on the physical transportation system. Enough of these tracking and communications systems are in operation today to be linked in a demonstration of information flow for end-to-end monitoring of the intermodal movement. Sharing information about congestion and operations across the intermodal freight system is critical to regaining capacity and reliability.

This report describes how a national ITS program for intermodal freight can promote the application of ITS technology to intermodal freight transportation. It outlines eight possible operational tests that could link public and private systems so that terminal operators, freight carriers, and state and metropolitan traffic operations managers can share information to optimize flows and better utilize equipment and facilities. These tests would benefit the intermodal industry, the businesses they serve, and the general public with whom they share the use of our transportation system.

The U.S. Department of Transportation (U.S. DOT) has an opportunity to act as a convener and catalyst to focus, coordinate, and accelerate the application of ITS technology by the intermodal industry and state and local transportation agencies. The intermodal industry is driven by the private sector. The public sector cannot design and deliver new intermodal services, nor should it force information systems upon the marketplace.

However, the U.S. DOT can bring parties together; focus attention on issues and opportunities; provide seed money to leverage private investment and test applications; and underwrite standards development to determine industry and user consensus.

The report identifies three major steps in building a program that will serve industry, local, and national needs. The U.S. DOT should: 1) solicit and fund proposals for operational tests that will show the productivity and safety benefits of exchanging information between private sector intermodal shipment information and asset management systems and public sector traffic and safety management systems; 2) support ITS/intermodal forums, studies, and programs to advance private and public sector opportunities for accelerated application of ITS technology to the intermodal freight system; and 3) support the evolution of data interchange standards where they benefit industry and government.

1.0 Introduction

Industry and government are concerned about the capacity of ports and terminals – and the highways, rail lines, and waterways that serve them – to handle steadily increasing volumes of intermodal traffic, especially containerized freight. They are concerned that landside access to ports and terminals is emerging as the weak link in the intermodal freight system. In particular, they are concerned that congestion on the highways and rail lines serving intermodal ports and terminals is undermining the capacity and reliability of intermodal freight service.

Sharing information about congestion and operations across the intermodal freight system is critical to regaining capacity and reliability. Successful intermodal freight movement requires that all of the transportation components function as part of a larger system rather than as discrete, independent modes, and as a process rather than a series of interfaces and events. Advanced communications and information systems and intelligent transportation systems (ITS) provide real-time information on intermodal freight operations and congestion on the physical transportation system. Enough of these tracking and communications systems are in operation today to be linked in a demonstration of information flow for end-to-end monitoring of the intermodal movement that can be used to minimize congestion and harmonize operations. This will benefit the intermodal industry, the businesses they serve, and the general public with whom they share the use of our transportation system.

This report describes how a national ITS program for intermodal freight can promote the application of ITS technology to intermodal freight transportation. The goals of the program are to enhance the safety, reliability, and responsiveness of the intermodal freight system and the national transportation system. These enhancements will contribute to the nation's economic growth and national security. The program goals and the actions recommended by this report are consistent with the U.S. Department of Transportation's (U.S. DOT's) strategic plan and its strong emphasis on integrating the capabilities of its operating administrations.

The report identifies three major steps in building a program that will serve industry, local, and national needs. The steps are: first, solicit and fund proposals for operational tests that will show the productivity and safety benefits of exchanging information between private sector intermodal shipment information and asset management systems and public sector traffic and safety management systems; second, support ITS/intermodal forums, studies, and programs to advance private and public sector opportunities for accelerated application of ITS technology to the intermodal freight system; and third, support the evolution of data interchange standards where they benefit industry and government.

The next section of the report, Section 2.0, provides background information on trends and issues in the intermodal freight industry. Section 3.0 analyzes the challenges to solving them. Section 4.0 defines the federal government's role as a convener and catalyst to focus, coordinate, and accelerate the application of ITS technology by the intermodal industry and state and local transportation agencies. Section 5.0 states the recommendations for initiating a national ITS/intermodal freight program. Section 6.0 provides examples of operational tests that could accelerate the application of ITS technology and define the benefits to industry and government. Section 7.0 discusses the organization and management of operational tests. Section 8.0, the final section, describes the next steps for the U.S. DOT in developing an ITS/intermodal program.

2.0 Intermodal Freight Trends and Issues

Intermodal freight transportation is the movement of freight by the coordinated and sequential use of two or more modes of transportation. Intermodal freight moves from a shipper to a receiver by multiple modes through transfer points within a system.

The elements of the intermodal freight system are:

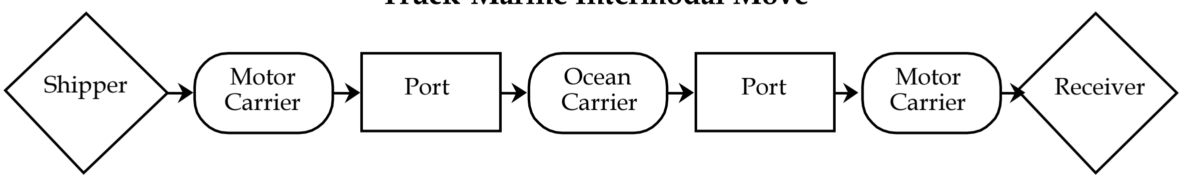
	Air	**Rail**	**Water**	**Road**
Carriers	Air cargo carriers	Railroads	Shipping lines	Motor carriers
Conveyance	Airplanes	Trains	Ships and barges	Trucks
Terminal	Airports	Rail terminals	Ports	Truck terminals
Infrastructure	Airways	Railways	Sea and inland waterways	Roadways

Figure 2.1, on the next page, illustrates three typical intermodal freight movements: truck-marine, truck-rail, and truck-air. The illustrations do not portray all possible intermodal movements.

Figure 2.1 Illustrative Intermodal Freight Movements

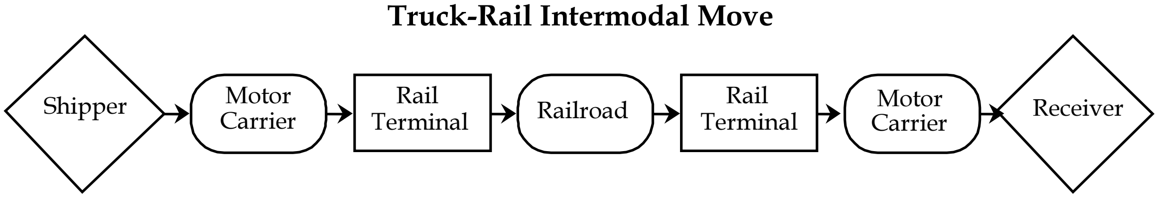
Truck-Marine – This example of a typical truck-marine intermodal freight movement begins with the shipper or consignor, who loads the cargo into a container. A motor carrier picks up the container from the shipper and transports it to a seaport where the container is transferred to an ocean carrier. The ocean carrier transports the container to an overseas port, where the container is transferred to a second motor carrier, who delivers it to the receiver or consignee.

Truck-Marine Intermodal Move



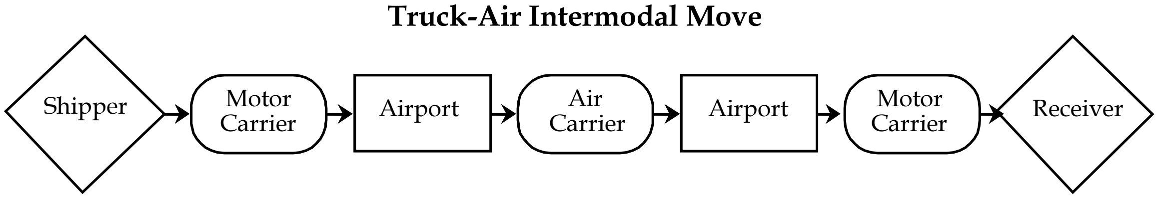
Truck-Rail – In a truck-rail intermodal movement, a motor carrier picks up the cargo, which may be in a container or an intermodal trailer, from the shipper and transports it to a rail terminal where it is transferred to a railcar. The railroad transports the container or trailer to another intermodal rail terminal where a second motor carrier picks it up and delivers it to the receiver or consignee.

Truck-Rail Intermodal Move



T**ruck-Air –** The third example is a truck-air intermodal movement**.** In this movement, a motor carrier picks up the cargo from the shipper, packages it with other air freight on a shipping pallet, and transports it to an airport freight terminal where it is transferred to an airplane. The air carrier transports the pallet to another airport where a second motor carrier picks it up and delivers it to the receiver or consignee.

Truck-Air Intermodal Move



■ 2.1 Growth

The volume of intermodal freight traffic is growing significantly. The pattern can be seen clearly in the growth of marine, rail, air, and truck intermodal operations.

The number of intermodal containers moving through ports worldwide doubled over the last decade.[1] Worldwide maritime containerized trade grew at a rate of 9.5 percent annually; the volume through U.S. ports grew at 6.0 percent annually. The total volume of marine trade is expected to triple over the next two decades, much of it moving in containers.[2] Today, 55 percent of all general cargo in international liner trade is carried in containers; by 2010, experts predict that 90 percent of liner freight will be shipped in containers. The economic recession in Asia may depress near-term growth rates; however, the combination of increasing trade and increasing containerization is expected to double or triple the number of containers moving through major container ports within the next two decades.

Intermodal traffic on U.S. railroads tripled over the last two decades. The volume of international containers, domestic containers, intermodal truck trailers, and roadrailers handled by the railroads grew from 3.0 million to 8.7 million over the period.[3] The annual growth rate over the last decade was about 8.0 percent. In 1997, revenues from intermodal service accounted for about 18 percent of total railroad revenues.[4] Intermodal traffic and revenues are expected to increase by more than 50 percent in the next decade.[5]

The volume of intermodal air freight also doubled over the last decade. The volume of cargo carried by all-cargo airlines grew 10 percent annually between 1991 and 1996; and the volume of freight carried as belly cargo in passenger planes increased at about 9.0 percent. The volume of intermodal air freight is expected to double again in the next decade as more high-value commodities, including electrical equipment, food products, and textiles, travel by air. At major air cargo hubs such as Los Angeles, Chicago, and New York, some analysts estimate that air cargo volumes could triple over the next decade.

Trucks begin and end almost all intermodal moves by rail, ship, or plane. The volume of intermodal freight moved by truck has grown apace with the increase in marine, rail, and air intermodal freight volumes, approximately doubling over the last decade. Data on intermodal truck moves is incomplete, but one proxy for the rate of growth is the rate at which railroads and motor carriers are adding intermodal equipment. By that measure,

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[1] *The Impacts of Changes in Ship Design on Transportation Infrastructure and Operations*, U.S. Department of Transportation, Office of Intermodalism, February 1998, page 1.

[2] Admiral James M. Loy, commandant of the Coast Guard, quoted in "Maritime Traffic Jam?," *Journal of Commerce*, August 10, 1998.

[3] Association of American Railroads website, www.aar.org, October 2, 1998.

[4] Association of American Railroads, telephone conversation on November 18, 1998.

[5] Eugene Pentimonti, American Trucking Associations, at the I-95 Intermodal Leadership Summit, Princeton, New Jersey, October 1998.

growth has been rapid: the domestic intermodal fleet of containers, trailers, and road-railers grew by nearly 30 percent between 1992 and 1996.[6]

The growth of intermodal freight carried by trucks is expected to accelerate through the next decade, with intermodal operations likely to outperform the industry as a whole. The trucking industry, which today captures 80 percent of all revenue spent on domestic freight transportation, is expected to see a 30 percent growth in revenue over the next decade and a 25 percent growth in tonnage carried. These forecasts predict that the trucking industry could lose long-haul traffic (i.e., trips over 1,000 miles) to intermodal rail, but gain short-haul and regional drayage moves (i.e., local trips and trips up to 500 miles) because of the overall increase in demand for intermodal freight service.

2.2 Performance

Along with this growth have come other changes and new pressures on the intermodal freight industry, including competition, customer demands for better service and information, the emergence of integrated supply chain management systems, and a need for more coordination of military and commercial systems.

The trucking industry and the railroads were deregulated in 1980. Deregulation triggered massive restructuring and reorganization of these industries, increased competition and innovation, and lowered prices and profits. In the railroad industry, the changes are still playing out. CSX and the Norfolk Southern have bought Conrail. The merger negotiations, which took two years, became final in August 1998. It will be another three years before all the impacts on rail service, including intermodal rail service, are fully realized. (These may be significant; some experts predict that the two competing railroads could double or triple the volume of intermodal containers moving through the Ports of New York and New Jersey over the next two decades.) The steamship industry will be deregulated in May 1999. This is likely to trigger another round of restructuring and reorganization as well as sharp pressures to streamline marine intermodal operations and reprice intermodal services.

Businesses and consumers are ordering goods with less lead time and requiring more predictable delivery within ever-narrower windows of time. They also want intermodal carriers and terminal operators to provide them with better and more timely information on the movement of their freight as well as greater flexibility in rerouting freight en route. These demands are driven by businesses' need to reduce costs to compete in the global market. Businesses have taken advantage of the low transportation prices brought about by deregulation by substituting more frequent deliveries for high-cost inventories and outsourcing manufacturing to reach cheaper, overseas labor. According to some estimates, as much as 50 percent of all firms will be operating under just-in-time manufacturing or retailing systems by the year 2000. For the intermodal industry, this trend means

[6] *The Intermodal Network*, Intermodal Association of North America, ca. 1998.

tremendous pressure to keep prices low while also seeking better and more reliable services. Significant financial penalties are incurred for poor performance.

Information technology is transforming the intermodal freight industry by enabling it to integrate operations across the supply chain. The first wave of change, which is well underway, has been a shift from paper-based systems to electronic systems for transaction management and information exchange. The driving technologies have been low-cost computers; bar codes and readers; automated equipment identification (AEI) tags; sophisticated database management software; and electronic data interchange standards (e.g., EDI, EDIFACT). The industry has adopted these technologies to meet basic customer demands for timely information and transactions. With the introduction of more accessible and affordable electronic commerce services over the Internet, all parties to the intermodal system – not just the largest corporations – will be expected to exchange information and conduct business electronically.

The second wave of change, just now underway, is the integration of real-time operations. The driving technologies are satellite location and communications systems (including low earth orbit (LEO) satellites that make it possible to track containers, and perhaps packages, either directly or through the truck, ship, or train that carries them); smart cards; global telecommunications networks; and expert systems software. These technologies are making possible the exchange of real-time performance and asset utilization information among shippers, carriers, and receivers. This information will feed manufacturing, distribution, and sales operations models and optimization tools. What will emerge is an integrated supply chain management system that is highly dependent upon cost-effective and reliable intermodal freight service.

The U.S. Department of Defense (DoD) relies heavily upon the use of commercial transportation services, especially intermodal freight services. The DoD maintains its own electronic systems – as does any large global shipper – to trace and manage its freight shipments. However, there is a growing consensus within the DoD that it must operate in a more integrated environment. It must ensure the compatibility of its shipment identification and information systems with those of commercial carriers. This will leverage the capabilities of existing, private sector systems; ensure the efficient coordination of defense and commercial systems during national emergencies; and reduce duplicative research and development efforts. For the DoD, this means relying upon services, including information services, in the complex, market-driven, private sector environment; and for the intermodal industry, this means additional pressure to deliver effective services.

■ 2.3 Capacity

The growth of intermodal freight traffic and the pressure for improved performance have triggered major concerns about the capacity of ports and terminals, especially the highways and rail lines that serve them, to handle the steadily increasing volumes of intermodal traffic.

Of particular concern is the impact of megacontainerships. Ocean carriers are investing in megaships to meet demand and drive down costs. These megaships are capable of carrying

4,500 to 6,500 20-foot equivalent container units (TEUs), compared to today's large containerships, which carry between 2,000 and 4,000 TEUs. Megaships are one percent of the world containership fleet, but they are eight percent of new containership orders.[7] It is expected that megaships will dominate the trade between major container ports within the next decade. At those ports that have the waterside capacity to handle them (i.e., channels 50 or more feet deep, berths 1,250 feet long, high-capacity cranes, and adequate container storage areas), the megaships will generate huge volumes of landside truck and rail traffic.

Few ports are equipped to handle a doubling of intermodal container traffic or the surges that would be created by megaships. Most ports and rail terminals are located in densely developed urban areas. Additional space for piers, container storage, railroad tracks, and truck roads can and is being purchased and developed, but slowly and usually at a very high cost. There are opportunities to develop new, greenfield rail-truck terminals outside metropolitan areas, but these too are costly and have significant environmental impacts. For the most part, the growth in intermodal freight traffic will be handled through existing ports and terminals.

Techniques for increasing throughput at ports and terminals exist; some have been implemented in U.S. ports, and many more have been adopted by European and Asian ports. The techniques include transshipment (i.e., direct transfer of containers from megaships to smaller feeder ships and coastwise barges); use of on-dock intermodal rail service (i.e., direct transfer of containers from ships to railcars) to minimize the dwell time of containers in terminals; stacking of containers to reduce the need for additional land area; deployment of advanced technologies to locate containers and optimize the positioning and movement of equipment and operators; and around-the-clock operations.[8] The throughput capacity of ports and terminals is being improved by applying these techniques; however, equivalent improvements are not being applied outside the gate.

Congestion and generally poor landside access are emerging as a critical problem for ports and intermodal rail terminals. Both motor carriers and intermodal rail operators are caught in and contributing to a spiral of congestion that is undermining the overall reliability of the intermodal system and its capacity to accommodate growth.

Most drayage operators – motor carriers that specialize in hauling intermodal containers – operate during the day because shippers and receivers, as well as many ports, schedule pickups and deliveries during normal businesses hours. The carriers also operate during the day because labor costs are lower; in a highly price-competitive business, they cannot afford to pay drivers premium wages for night work. The drayage carriers pay a price for this. They must compete with automobiles and other trucks for space on highways and port access roads where congestion slows them down, increasing cost and reducing productivity.

The cost of this congestion to the intermodal industry is moderate today, but if the volume of intermodal freight traffic doubles over the next decade, the cost will rise significantly.

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[7] *The Impacts of Changes in Ship Design on Transportation Infrastructure and Operations*, U.S. Department of Transportation, Office of Intermodalism, February 1998, pages 3-4.

[8] *The Impacts of Changes in Ship Design on Transportation Infrastructure and Operations*, U.S. Department of Transportation, Office of Intermodalism, February 1998, page 45.

Large trucks are a small percentage of the vehicles on urban highways – typically, less than five percent of total vehicles during congested peak periods – but a doubling of intermodal truck volumes on already saturated access roads will add appreciably to congestion.

When highways are saturated, traffic flows are unstable; the frequency of incidents – minor accidents, overheated engines, etc. – increases; the time required for traffic flow to recover increases exponentially; and reliability vanishes. Whether the cause of delay is an accident, bad weather, or simple highway repairs, the effect is the same. A one- or two-hour delay in a drayage movement can mean a missed train and a delay of a day in a domestic shipment. A missed connection on an international move can mean a delay of a week. For an intermodal system trying to serve just-in-time manufacturing and retailing businesses, reliability is critical. Poor reliability means lost business.

The problem is not restricted to truck movements to and from ports and terminals. Although less visible, rail congestion also is a problem. In metropolitan areas, freight trains compete with passenger trains for space and time on rail lines. Intermodal rail service could relieve truck pressure on congested highways, but only if the rail system has the capacity to accommodate increased rail freight and rail passenger service. Moreover, in some intercity rail corridors, intermodal rail must compete for space and time with other rail freight service. The increase in intermodal traffic also can bring intermodal rail and drayage operators into conflict. In a number of cities, longer and more frequent intermodal trains block the highway at-grade rail crossings used by drayage operators to move containers from ports to rail terminals.

Congestion will not shut down ports and terminals, but it can have devastating and disproportionate impacts by degrading the predictability and reliability of intermodal service for shippers and receivers. Reliability and predictability are the most important characteristics of freight transportation in an era of tightly integrated operations and just-in-time inventories. The volume of intermodal freight traffic is growing significantly. The weakest link in the chain will not be the ports and terminals, but the reliability of highway and rail access to the ports and terminals. Unless this problem is addressed, the safety, reliability, and responsiveness of the intermodal freight system will deteriorate and its contribution to the nation's economic growth and national security will be diminished.

3.0 Applications and Challenges

3.1 ITS Applications

Industry, transportation agencies, and planning authorities are aware that they must provide new capacity and improve the performance of the intermodal freight system. A consensus is building, albeit slowly, to address the problems.

New capital investments are planned, and some are underway, to expand or refurbish ports, rationalize terminals, provide on-dock rail service, and improve intermodal connectors. But all of these projects are constrained by space, cost, and environmental impacts. Most will take considerable time, and the largest of the projects may take decades. Debate over the Alameda Corridor project in Los Angeles took over 10 years; design and financing required another five years; and construction will not be complete for another two years. It is unlikely that the intermodal industry will build its way out of its capacity problems in the near future.

Some intermodal traffic will be reallocated or redirected to less congested ports and terminals. This will reduce pressure at congested ports and terminals. However, most intermodal freight is bound for distribution centers in major urban areas. Diversion of this freight to outlying ports and terminals means a more circuitous delivery route and additional truck and rail miles of travel. In many areas of the country, this will only shift the problem to other corridors, most of which also are congested. It is unlikely that the intermodal industry will be able to move around its capacity problems.

Growth and capacity constraints are forcing the intermodal industry to look at redesigning operations and reengineering business practices to optimize the use of existing facilities in addition to making capital improvements.

The private sector has applied advanced information technology to optimize shipment and asset management. This has included the following systems:

- **Shipment tracing and information systems** that manage the flow of materials and products from source to user. The systems are used to optimize the end-to-end visibility, security, and control of goods through a logistics system. They focus on the total freight trip and serve shipper's and receiver's needs. Integrated supply chain management systems may link suppliers, manufacturers, carriers, distributors, retailers, and customers.

- **Inventory and stowage management systems** that track and manage the movement of containers and trailers within port, rail, and truck terminals and their placement aboard ships. These node-based asset management systems are used to optimize the use of space in terminals; manage the stacking of containers of different lengths; make efficient use of labor and equipment; and schedule equipment repair and maintenance. They focus on the terminal and serve the needs of terminal managers. These systems use optimization or expert systems software and AEI tags. The systems typically are linked to booking and gate clearance systems.

- **Asset location and management systems** that dispatch, locate, and track a vehicle or container. Link-based route and fleet management systems are used to estimate time of arrival, minimize out-of-route travel, optimize equipment use, and improve safety and reliability. Satellite systems use Global Positioning System (GPS) technology; ground systems use loran, cellular telephone, wireless radio transceivers, and AEI tags. Some systems are coupled with onboard computers and sensors that monitor vehicle and cargo condition. These systems focus on the vehicle and serve the needs of fleet managers.

There has been parallel development of intelligent transportation systems by the public sector for traffic and highway management. This has included the following systems:

- **Traveler information systems** that provide real-time information on highway congestion, incidents, construction, and road closures. Advanced traveler information systems deploy dynamic message signs, closed-circuit television video sharing, probe systems, highway advisory radio, and Internet sites. These systems focus on the trip and serve the needs of drivers making decisions about their route and time of travel. These systems often are linked to onboard location and management systems and traffic management systems.

- **Toll collection systems** that enable the electronic payment of highway, bridge, and tunnel tolls. These systems are used to expedite throughput, minimize queuing and delay, improve travel time and fuel consumption, and reduce congestion and the risk of accidents at toll barriers. The systems use radio frequency identification transponders. Similar systems are in place at weigh stations and international borders for automated screening of trucks for safety and regulatory compliance. These systems often couple transponders with weigh-in-motion devices. These systems focus on control points and serve the needs of regulators.

- **Traffic management systems** that improve the management, operation, and safety of traffic on roadways and at railroad grade crossings. Advanced traffic management systems and traffic operations centers are used to improve the flow of traffic, reduce congestion, and improve the safety of the road operations. The systems use flow monitoring sensors (e.g., vehicle detection loops, closed-circuit television cameras); traffic control devices (e.g., traffic-responsive and traffic-adaptive traffic signal systems, ramp meters); and transportation network models. They focus on the highway network and serve the needs of traffic managers. The systems typically are linked to traveler information systems.

Figure 3.1 describes these and additional private sector and public sector information systems and ITS applications.

Figure 3.1 Existing Private Sector and Public Sector Information Systems and ITS Applications

Shipment Information Systems	
Function:	Manage the flow of materials and products from source to user.
Purpose:	The systems are used to optimize the visibility and control of goods (and their conveyances – containers, trucks, ships, etc.) through a logistics system. Integrated or extended supply chain systems may link suppliers, manufacturers, carriers, distributors, retailers/customers, and consumers/end users.
Technology:	The systems use information management and communications technologies.
Examples:	Ryder Integrated/Logistics i2 Technologies; Federal Express interNetShip; UPS on-line tracking system; Tie Logistics COMMAND®; ALK Associates E-tracker™; DHL Worldwide Package Tracking; Manna Freight's Freight Tracker.

Security Systems	
Function:	Monitor the condition of vehicles, containers, and goods during shipment or in storage at terminals.
Purpose:	The systems are used to prevent theft and vandalism of trucks, chassis, containers, and freight.
Technology:	Most systems use sensors coupled to radio frequency transponders, onboard vehicle communication systems, or video surveillance systems. Systems typically are linked to vehicle location and management systems or terminal inventory management systems.
Examples:	Qualcomm TrailerTRACS®; Savi InsideTRAK™; Maher Terminals Logistics System, Inc. (MTLS) Electronic Security Processing System.

Customs Clearance Systems	
Function:	Automate the filing, processing, review, and issuance of documents for import and export of goods.
Purpose:	The systems are used to automate transactions, improve customs control, and minimize delays for shippers and receivers.
Technology:	The systems use transaction processing software and communications technology.
Examples:	U.S. Customs Automated Commercial System, Automated Manifest System, Automated Export Reporting System, Automated Export System, and International Trade Data System; Syntra Global Logistics System.

Figure 3.1 Existing Private Sector and Public Sector Information Systems and ITS Applications (continued)

Ship Stowage Management Systems

Function: Plan and track the location of containers aboard ships.

Purpose: The systems are used to maximize stability, minimize handling during loading and off-loading, position refrigerated containers, and isolate hazardous cargo.

Technology: The systems use computer models and optimization or expert systems software. Systems typically are linked to booking and terminal inventory management systems.

Examples: NAVIS; MTLS Vessel Planning System; Realtime Business Solutions TopX (Terminal Operation Package – Xwindow); August Design GRAIL robotic container-handling facility for Sea-Land Service, Inc.

Railcar Planning Systems

Function: Provide for the efficient configuration of loads and railcars at railyards for train service.

Purpose: The systems are used to enhance rail terminal operations by optimizing the use of space, managing containers and equipment, and improving scheduling of loads and deliveries for rail operations

Technology: The systems use computer models and optimization or expert systems software, radio frequency identification (RFID) devices, Global Positioning System (GPS) receivers for position identification, and mobile inventory vehicles for integrated inventory and equipment location identification. Systems may be linked to booking and gate clearance systems.

Examples: MTLS Rail Planning System; ALK Associates PC-Rail and locomotive management system; OASIS.

Motor Carrier Routing and Dispatching Systems

Function: Automate the routing and dispatching of trucks.

Purpose: The systems are used to match drivers, equipment, and loads to pickup and delivery windows; minimize travel time and cost; and schedule maintenance.

Technology: The systems use scheduling algorithms, Geographic Information System (GIS), and linear optimization software. The systems often are linked to vehicle location and management systems.

Examples: ALK Associates PC-Miler (truckload carriers); Rand McNally MileMaker (Household Goods Carriers Bureau mileage guide); SABER (general trucking); Descart (local pickup/delivery operations); Emery computer-aided dispatch system; Prophesy LoadExpress Plus.

Figure 3.1 Existing Private Sector and Public Sector Information Systems and ITS Applications (continued)

Terminal Inventory Management Systems	
Function:	Track and manage the movement of containers and trailers within port, rail, and truck terminals.
Purpose:	The systems are used to optimize the use of space in terminals, manage the stacking of containers of different lengths, make efficient use of labor and equipment, and schedule equipment repair and maintenance.
Technology:	The systems use computer models and optimization or expert systems software, RFID devices, GPS receivers for position identification, and mobile inventory vehicles for integrated inventory and equipment location identification. Systems typically are linked to booking and gate clearance systems.
Examples:	NAVIS; OASIS; APL Seattle Terminal System; Matson Hawaii Terminal System; August Design GRAIL robotic container-handling facility for Sea-Land Service, Inc.; MTLS Container Terminal Management System; Maher Terminals Marine Terminal Automated Management System; APL integrated Port Management and Vessel Planning System at the Port of Los Angeles.

Gate Clearance Systems	
Function:	Automate the verification and inspection of drivers, truck tractors, trailers, containers, and chassis moving into and out of marine, rail, air, and truck terminals.
Purpose:	The systems are used to verify bookings, maintain security, and establish liability for damage.
Technology:	The systems use automatic vehicle identification (AVI) technology, e.g., GPS, RFID transponders, optical character recognition (OCR) linked to computerized databases. Systems typically are linked to booking and terminal management systems.
Examples:	Maher Terminals OCR Gate System; Southern Pacific/Santa Fe Los Angeles Terminal OCR System; Port Authority of New York and New Jersey (PANYNJ) Sea-Link card system; APL automated gate clearance system in Los Angeles; Port of Portland electronic shipyard planning system; LA King gate systems.

Figure 3.1 Existing Private Sector and Public Sector Information Systems and ITS Applications (continued)

Asset Location and Management Systems (LMS)	
Function:	Locate and track a vehicle or container.
Purpose:	The systems are used to estimate time of arrival, minimize out-of-route travel, optimize equipment use, and improve safety and security.
Technology:	Satellite LMS utilize the GPS, geostationary satellites, or low earth orbit (LEO) satellites. Ground-based LMS utilize loran and wireless radio transmitters, dead-reckoning/map-matching computers, or automated equipment identification (AEI) transponders. Some systems are coupled with onboard computers and sensors that monitor vehicle or cargo condition.
Examples:	**Ship LMS:** GPS; U.S. Coast Guard Vessel Traffic System (VTS); Electronic Chart Display and Information System (ECDIS); Portable Communication, Navigation, and Surveillance System (PCNS) **Railcar LMS:** Locomotive Automatic Train Control System (ATCS), Amtech railcar AEI tags **Truck LMS:** Qualcomm OmniTracs, HighwayMaster **Container/Trailer LMS:** Orbcomm (untethered trailer system), Qualcomm TrailerTRANS®, Savi WideTRAK™ **Chassis LMS:** Amtech, Hughes, Mark IV, etc., AEI tags

Traveler Information Systems (Advanced Traveler Information Systems, ATIS)	
Function:	Provide real-time information on highway congestion, incidents, construction, and road closures.
Purpose:	The systems are used to provide drivers with information to make trip, time, and route choices.
Technology:	The systems use variable/changeable message signs, closed-circuit television (CCTV) video sharing, radio frequency probes, highway advisory radio (HAR), and Internet web sites. Systems often are linked to onboard location and management systems and motor carrier routing and dispatch systems. Systems typically are linked to traffic management systems.
Examples:	SmartRoutes SmarTraveler (Boston); I-95 Corridor Coalition FleetForward; TRANSCOM travel advisory for New York-New Jersey metropolitan region; Minneapolis-St. Paul Orion Project.

Figure 3.1 Existing Private Sector and Public Sector Information Systems and ITS Applications (continued)

Traffic Management Systems (Advanced Traffic Management Systems, ATMS; Freeway Traffic Management Systems, FTMS) and Traffic Operations Centers (TOCs)	
Function:	Improve the management and operations of traffic on freeways, arterial roadways, and local streets.
Purpose:	The systems are used to improve the flow of traffic, reduce congestion, and improve the safety of the road operations.
Technology:	The systems use flow-monitoring devices (e.g., vehicle detection loops, CCTV cameras), traffic control devices (e.g., traffic-responsive and traffic-adaptive traffic signal systems, ramp meters), and transportation network models. Systems typically are linked to traveler information systems.
Examples:	Montgomery County, MD ATMS; Houston TranStar; Detroit ATMS/ATIS – Michigan ITS Center (MITSC); Oakland County, MI FAST-TRAC; Milwaukee MONITOR FTMS; Minnesota DOT Minneapolis-St. Paul Traffic Management Center; Metropolitan Model Deployment Initiative (MMDI) integrated traffic operations and freeway management systems.

Railroad Grade Crossing Management Systems	
Function:	Manage gates and warning systems at highway at-grade rail crossings to improve safety and reduce delays.
Purpose:	The systems are used to provide notice to drivers when a train is approaching and early warning to locomotive engineers when vehicles are blocking a crossing.
Technology:	The systems integrate information from radar, sound detectors, traffic detector loops, dynamic message signs, and railroad signal control systems. The systems typically are linked to rail and highway traffic operations centers, and can be linked to onboard navigation systems.
Examples:	Connecticut DOT/Amtrak four-quadrant gate system; San Antonio AWARD; Long Island Railroad, NY; Minnesota DOT; Illinois DOT.

Figure 3.1 Existing Private Sector and Public Sector Information Systems and ITS Applications (continued)

Incident Management Systems	
Function:	Enable transportation and safety officials to quickly and accurately identify a variety of incidents and implement a set of actions to reduce the impact of incidents on traffic flows.
Purpose:	The systems are used to improve incident detection, response, and clearance and to spread information about an incident to encourage drivers to seek alternate routes and reduce the traffic building in the queue.
Technology:	The systems vary in sophistication and may employ automatic detectors, CCTV, HAR, variable message signs, computer-aided emergency dispatching, as well as special service patrols and cellular phones and roadside callboxes. The New York City and Houston systems use vehicles equipped with RFID transponders (for electronic toll collection) as probes to measure the flow of traffic and identify congestion caused by incidents.
Examples:	Earliest incident management programs were in major cities such as Los Angeles and Chicago. Today, at least 15 states and 30 metropolitan areas have incident management programs. These systems often are linked to ATMS/ATIS.

Hazardous Materials (Hazmat) Response Systems	
Function:	Provide information to emergency response personnel at the scene of an accident about the contents of a hazmat load.
Purpose:	The systems are used to improve incident response for hazardous materials and reduce the impact of incidents involving hazardous materials on traffic flow and safe operating conditions.
Technology:	The systems include information systems and communications linkages, AEI, automatic vehicle location, automated route guidance, and mayday signaling.
Examples:	Operation Respond; Tranzit Xpress; ALK Associates PC-HazRoute.

Figure 3.1 Existing Private Sector and Public Sector Information Systems and ITS Applications (continued)

Electronic Toll Collection Systems	
Function:	Enable the electronic payment of highway, bridge, and tunnel tolls.
Purpose:	The systems are used to expedite throughput, minimize queuing and delays, improve travel time and fuel consumption, and reduce congestion and the risk of accidents at toll barriers.
Technology:	The systems use RFID transponders and transaction processing software.
Examples:	Metropolitan New York, New Jersey, and Pennsylvania EZ-Pass; Oklahoma PikePass; Massachusetts Turnpike FAST LANE; Florida Turnpike SunPass; Illinois Tri-State Tollway; Dallas North Tollway; New Orleans Crescent City Connection and Lake Pontchartrain Causeway; private toll roads in Orange County, California.

Weigh Station Clearance Systems	
Function:	Enable commercial vehicles to avoid stops at weigh stations.
Purpose:	The systems are used to increase throughput, minimize queuing and delays, focus enforcement resources on noncompliant motor carriers, and reduce safety hazards associated with queuing and trucks entering and exiting weigh stations.
Technology:	The systems use weigh-in-motion (WIM) systems, dedicated short-range communications (DSRC), onboard or roadside electronic displays and/or OCR, and locally maintained or networked information databases. WIM systems may weigh vehicles traveling at high speeds (installation on the mainline of the highway) or low speeds (installation on the approach ramp to the facility).
Examples:	Advantage CVO (formerly, Advantage I-75); HELP, Inc. PrePass; Oregon Green Light; Multi-jurisdictional Automated Preclearance System (MAPS); AVION System, Ontario, Canada.

Figure 3.1 Existing Private Sector and Public Sector Information Systems and ITS Applications (continued)

Oversize/Overweight Permitting Systems	
Function:	Automate the filing, review, payment, and issuance of state and local government permits to motor carriers to haul oversize or overweight (OS/OW) loads on highways.
Purpose:	The systems are used to facilitate and expedite the processing of OS/OW permits issued by state officials to motor carriers.
Technology:	The systems use electronic data interchange (EDI) and/or Internet communications, transaction processing software, and sometimes GIS and automated routing capabilities. The systems often are linked to bridge load-rating systems.
Examples:	Cambridge Systematics, Inc.; Geopak; American Management Systems; and KPMG.

Safety Assurance Systems	
Function:	Provide information on the safety history and performance of motor carriers and drivers.
Purpose:	The systems are used to select vehicles and drivers for inspections with the result that resources are focused on high-risk carriers and drivers, and to enhance enforcement's ability to monitor the en route safety status of the vehicle and driver.
Technology:	The systems use information management and communications technologies. The systems may be linked to weigh station clearance systems.
Examples:	U.S. DOT information systems SAFER (Safety and Fitness Electronic Records), MCMIS (Motor Carrier Management Information System), and CDLIS (Commercial Driver License Information System); and ASPEN software program for automated safety inspections.

A solution to managing increasing intermodal freight volumes through congested ports, rail terminals, and transportation corridors lies in linking these systems so that public and private operators can share information to optimize flows and better utilize equipment and facilities. The flow of accurate and timely information through the intermodal system is just as important today as the movement of freight. It provides the thread that binds individual operations into an intermodal system.

Access to and from ports and terminals could be improved by linking different public and private systems, as illustrated in the following examples:

- **Terminal outbound flow management –** Traffic signals on terminal egress roads can cause congestion, queuing, and delays for trucks moving from terminals. Terminal gate clearance systems could be linked with the computer-controlled traffic signal systems that are part of regional and corridor traffic management systems. Information about the number of trucks being dispatched by the terminal would be relayed to the traffic management system. With this information, traffic operators could synchronize traffic signals to anticipate or respond to changes in the flow of intermodal truck traffic.

- **Terminal inbound flow management –** Heavy inbound truck traffic at terminals can exceed the processing capacity of terminal gates, resulting in queues and costly delays. Information from electronic toll collection and weigh station clearance systems, which identify and locate trucks, could be linked to terminal gate clearance systems to provide terminal operators with a real-time snapshot of inbound traffic flows. With the information, terminal operators could work with motor carrier dispatchers to spread out arrivals and minimize peaking. Rescheduling as little as 10 to 15 percent of arriving trucks can significantly reduce the total time lost in gate queues.

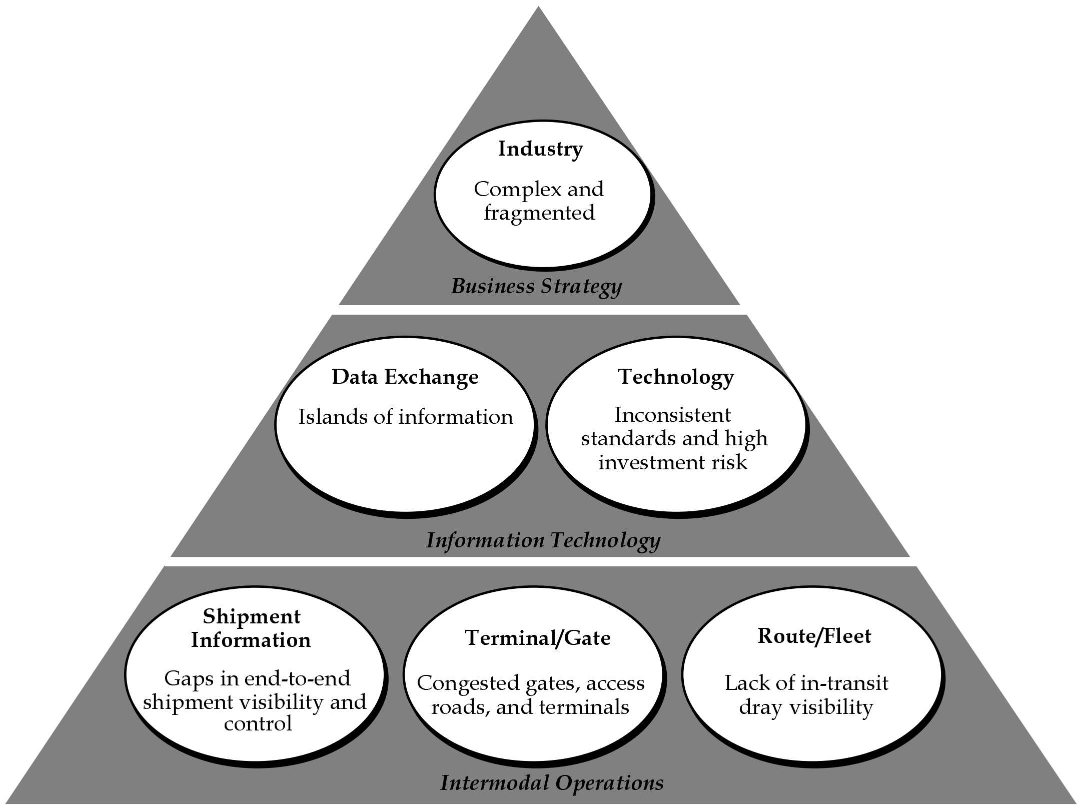
- **Truck safety and weight screening –** Weigh station checks and roadside inspections, especially when there is congestion, create a burden for compliant motor carriers by creating additional delays. Terminal gate clearance systems could be linked to state motor carrier safety systems to provide drivers and terminal operators with a pre-travel check of the regulatory status of the driver, vehicle, and motor carrier firm. With this information, problems with credentials and equipment could be addressed before a driver leaves, reducing the likelihood of delays from inspection en route.

Section 6.0 outlines these and five additional concepts for linking private sector systems with public sector systems. Each concept would give operators greater control and flexibility in managing their operations and help integrate operations across the intermodal freight system. Safety and productivity benefits also would accrue across the board.

3.2 Challenges

The application of these types of solutions across the intermodal industry, especially between the public and private sectors, has been uneven and inconsistent to date. There are challenges at three levels – business strategy, information technology, and intermodal operations – as illustrated in Figure 3.2.

Figure 3.2 Intermodal Impediments



Business Strategy Challenges

There are few forums in which to develop a consensus for solutions and catalyze action. The intermodal industry is by its nature fragmented, complex, and highly competitive. It depends upon the cooperation of a large number of widely diverse stakeholders working in different modes, different regions, and different countries. Each group has its own unique business philosophy, culture, and historic basis of operation. The relationships among them are shifting constantly, as are their roles and responsibilities.

The risk in this environment is that the intermodal industry, which has been slow to link systems across private sector operations, will be equally slow to make the business case for linking systems between the public and private sectors. If this happens, the intermodal industry will have no consensus and little momentum for addressing congestion problems. More important, it will have little influence on federal, state, and local investment decisions addressing congestion and freight movement. The price of intermodal service will spiral, reliability will drop, and the nation will be slow to realize the economic and security benefits of a more cost-effective and efficient intermodal freight system.

Information Technology Challenges

Second, the intermodal industry lacks a high-level information system architecture for the intermodal freight system. Development of an architecture and data interchange standards that define how and with whom information is shared is held back by competitive pressures, uncertainty about technology, and the sheer complexity of the industry. A few of the largest intermodal carriers have integrated shipment information and asset management systems across modes, but most private and public sector intermodal operations have implemented systems only within a single mode or firm. Moreover, the industry as a whole has been slow to evolve and adopt information exchange standards that meet its needs. The industry has relied on a patchwork of standards imposed (often ad hoc) by shippers, brokers, individual carriers, Customs, etc. The result is islands of information.

The risk for the intermodal industry is that this patchwork of standards will slow the adoption of the shipment information and asset management systems that are needed to address capacity and congestion problems. Information technology will transform the intermodal industry as it has other sectors of the economy, but the intermodal industry is at risk of lagging behind the rest of the economy. Standards (with the flexibility to evolve over time) can reduce the risk of investing in new technology and speed the development of integrated supply chain management systems.

The intermodal industry, which is dependent on small as well as large operators, needs a minimum level of interoperability and harmonization of business practices across the industry to improve reliability and overall performance. Without standards, interoperability, and harmonization, adoption and implementation of information technology and intelligent transportation systems will be uneven across port, terminal, carrier, and metropolitan traffic management systems.

Intermodal Operations Challenges

Finally, there is little systematic cooperation among the public and private sectors to leverage their complementary investments in freight and traffic management systems. Both have similar needs: to reduce congestion at transportation nodes; to smooth the flows along transportation links; and to ensure safe, secure, and cost-effective trips. However, the public and private sectors have different mandates, different work styles, and different investment timeframes. Well-defined customer needs and stockholder pressure to show returns on investment drive the private sector. Broadly-defined public needs and political pressure for accountability drive the public sector.

There is a high risk in dealing with capacity and congestion issues of miscommunication of needs, duplication of effort, and unproductive investment. These challenges must be addressed to realize national and industry goals. The costs of just muddling through are high. The challenge is to bring the diverse industry and government parties together.

4.0 The Opportunity

The U.S. DOT has an opportunity to act as a convener and catalyst to focus, coordinate, and accelerate the application of ITS technology by the intermodal industry and state and local transportation agencies. The intermodal industry is driven by the private sector. The public sector cannot design and deliver new intermodal services, nor should it force information systems upon the marketplace. However, the U.S. DOT can bring parties together; focus attention on issues and opportunities; provide seed money to leverage private investment and test applications; and underwrite standards development to determine industry and user consensus.

The federal government has a compelling interest in the safety, reliability, and responsiveness of the intermodal freight system and its ability to contribute to the nation's economic growth and national security. It also has a compelling interest in working with states, metropolitan planning organizations (MPOs), and port authorities to reduce congestion and air pollution.

The case for U.S. DOT action has been made clear through legislation and the U.S. DOT's outreach efforts, studies, and program initiatives. These activities, summarized in Figure 4.1, have identified intermodal freight needs and explored the application of advanced information technology and ITS to these needs.

At the policy and business strategy level, the U.S. DOT's interest in intermodal freight was spelled out in the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). ISTEA mandated consideration of freight needs and stronger linkage between transportation investment and economic development. It focused attention on intermodal freight infrastructure, impediments, and actions; established the Office of Intermodalism in the Office of the Secretary at the U.S. DOT; and called for the establishment of ITS America. The National Commission on Intermodal Freight Transportation, created by ISTEA, recommended making efficient intermodal transportation a major goal of federal transportation policy; increasing investment in intermodal transportation; and restructuring government institutions to support intermodal transportation. In the reauthorization of ISTEA through the Transportation Equity Act for the 21st Century (TEA 21), enacted in 1998, Congress forcefully restated the need for public transportation policy and investment decisions to consider freight transportation needs. This theme has been echoed in the U.S. DOT's outreach meetings, including its most recent conference on the Marine Transportation System (MTS).

At the information technology level, the U.S. DOT's interest in intermodal freight was most clearly enunciated at the DOT's June 1998 workshop in Reston, Virginia on the future of intermodal freight identification technology. Participants in the workshop made clear that there was strong interest on the part of both the private and the public sectors in moving toward an intermodal freight information system architecture and developing data interchange standards for the intermodal industry. The DoD, which participated in the workshop, made clear that it intended to push the industry toward greater interoperability through its automatic identification technology (AIT) program and its demands as a major intermodal shipper. The opportunities and the potential benefits to apply information technology to manage capacity and congestion have been pointed out in a half-dozen studies commissioned by the U.S. DOT, including a report for the National Science and Technology Council.[1]

At the intermodal operations level, there has been a consistent message about the need for federal leadership to convene stakeholders and catalyze action. Carriers, port authorities, state transportation directors, researchers, MPO officials, brokers, consultants, and Customs officials have repeatedly pointed out the need for immediate and practical attention to the capacity and congestion problems facing the intermodal freight system. This message has been voiced at hearings on the National Highway System and intermodal connectors; at the Office of the Secretary's public forums on ISTEA legislation and reauthorization, megaships meetings, and the MTS conference; and during the six recent ITS/intermodal freight program listening sessions.

This report identifies U.S. DOT actions to act on this opportunity and begin the process to convene stakeholders and catalyze actions to meet the needs of the 21st century.

[1] *Initiative to Promote Enhanced Freight Movement at Ports and Intermodal Terminals, A Strategic Plan*. U.S. Department of Transportation, Research and Special Programs Administration, Volpe National Transportation Systems Center, December 1998.

Figure 4.1 Previous U.S. DOT Initiatives to Address Intermodal Freight Challenges

Outreach

National Conference on Intermodalism

In December 1994, five U.S. DOT operating administrations and the Secretary's Office of Intermodalism worked with the Transportation Research Board (TRB) to convene national transportation leaders at a three-day conference addressing intermodal issues. In a conference session on new technologies, partnerships, and procedures, participants emphasized that many innovations and improvements to freight transportation could be achieved through enhanced EDI system applications and links to improved data on traffic flows. The session also focused on the need to understand the impacts and opportunities of technological innovation on the entire logistics chain.

ITS/CVO Program Briefing

In November 1995, the Federal Highway Administration (FHWA) met with private industry intermodal leaders in Baltimore, Maryland to brief them on the ITS/Commercial Vehicle Operations (CVO) program and information systems architecture. At this meeting, the industry leaders communicated to the FHWA the need to take into account private sector needs and priorities regarding ITS/CVO technologies when designing a systems architecture and setting standards and protocols. The private sector message was strong and clear: ITS architecture must be "open," and the industry must be involved in discussions of standards setting.

Conference on Setting an Intermodal Research Agenda

In March 1996, the U.S. DOT joined with the DoD's Defense Advanced Research Projects Agency (DARPA) and the TRB to sponsor a conference intended to define a long-term commitment to research and deployment of technologies that facilitate intermodal transport. An important case was made for federal involvement through financial investment in high-risk, long-term research and programmatic endeavors – ones in which the private sector or smaller governmental entities would otherwise not participate. Throughout the conference, it was emphasized that partnerships and coordination were at the foundation of any attempts to achieve improved intermodal transportation through information sharing.

Figure 4.1 Previous U.S. DOT Initiatives to Address Intermodal Freight Challenges (continued)

Outreach (continued)

National Freight Partnership
From 1995 through 1997, the U.S. DOT sponsored an outreach initiative with the intermodal freight industry called the "National Freight Partnership." This effort convened transportation decision-makers representing different levels of government and many segments of the intermodal freight industry to better understand the service requirements of the freight community; identify emerging freight and trade developments; and create public-private teams to define problems and devise solutions. Activities included the creation of freight advisory committees for metropolitan planning organizations in four cities; identification of critical connections to intermodal terminals; examination of more cost-effective means of fulfilling freight-related regulatory mandates; and examination of critical international trade issues. One of the most frequently discussed topics during this initiative involved information that would be useful to both public and private sector transportation managers in pursuing more effective system operations.

Megaships Meetings and Report
In response to the introduction of large containerships or "megaships" handling international cargo at domestic ports, the U.S. DOT sponsored four regional meetings during 1997 to solicit views and perspectives from regional private and public stakeholders about the current conditions and future needs of their marine transportation systems. The findings were summarized in the February 1998 report, *The Impacts of Changes in Ship Design on Transportation Infrastructure and Operations*. Comments were made at every regional meeting that ITS technologies could help achieve greater port terminal efficiencies. Many participants from the private sector predicted that there would be rapid deployment of ITS technologies to intermodal freight transportation once compatibility issues with private sector systems were resolved.

Intermodal Freight Identification Technology Workshop
The Intermodal Freight Identification Technology Workshop, held in Reston, Virginia in June 1998, brought together leaders from the public and private sectors to outline a planning framework that would address intermodal freight identification and tracking technologies. Participants produced a plan of activities and projects that included creating intermodal standards for freight identification and location; evaluating the feasibility of an "universal reader" that could accommodate different modes and container types; and developing readable security tags for containers. An Intermodal Freight Technology Working Group was formed and co-chaired by the U.S. DOT and the private sector to implement the workshop recommendations. The goal of the working group is to identify and support technologies that promote interoperability, asset and cargo visibility, and system harmonization.

Figure 4.1 Previous U.S. DOT Initiatives to Address Intermodal Freight Challenges (continued)

Outreach (continued)

National Conference on the Marine Transportation System

In a three-day conference hosted by the U.S. DOT in November 1998, senior management from several federal agencies met with transportation industry executives and state and local government officials to address Marine Transportation System (MTS) initiatives. The conference focused on topics relating to safety, security, infrastructure, environment, and economic competitiveness, and recommended a framework for collaborative planning both nationally and locally. Among the recommendations addressing ITS issues were: 1) increase the use of ITS technologies to better utilize existing MTS infrastructure; 2) improve awareness of the importance of seamless, end-to-end transportation in meeting the public's demand for goods; and 3) promote and expand cooperative research and technology programs between government and industry.

Listening Sessions on ITS/Intermodal Freight Pilot Tests

In November and December 1998, the U.S. DOT's ITS Joint Program Office, Office of Intermodalism, and Maritime Administration (MARAD) conducted six listening sessions in six U.S. cities to solicit ideas on facilitating intermodal freight transportation through deployment of ITS technologies. Ideas for linking communication and information systems in the public and private sectors emphasized the need for cooperation among system stakeholders and concentration on shared information that would be of greatest benefit to all pilot test participants. The concept of an ITS/intermodal freight program was validated through the listening sessions, and input from participants will be used by the U.S. DOT as a framework for future ITS operational tests.

Figure 4.1 Previous U.S. DOT Initiatives to Address Intermodal Freight Challenges (continued)

Studies

Intermodal Freight: An Industry Overview

In March 1994, the Volpe National Transportation Systems Center completed a study for the FHWA's Office of Policy Development that provided an overview of the intermodal freight industry's operating practices. The report noted that improved information systems, along with fully integrated service delivery systems, are pivotal to a successfully operating intermodal freight service. The report cited predictions that the use of neutral, non-carrier-specific EDI systems was expected to be one of the major developments of the 1990s.

Toward a National Intermodal Transportation System

The National Commission on Intermodal Transportation, created by ISTEA, made several observations relating to intermodal information in its report, *Towards a National Intermodal Transportation System*, published in September 1994. For example, the Commission recognized that information systems provide critical support for transportation. Telecommuting, video-audio conferencing, and electronic interchange were cited as technologies that can alter both passenger and freight transportation patterns. The committee emphasized that planners must recognize the importance of information systems development and ensure that the potential benefits of such systems are fully exploited.

Intermodal Freight Transportation

Recognizing that the new priorities established by the Congress with the passage of ISTEA included understanding the intermodal freight transportation system, the FHWA sponsored a study of the impediments to intermodal freight transportation. The final report, *Intermodal Freight Transportation*, published in December 1995, focused almost exclusively on impediments to intermodal freight posed by the transportation system's physical infrastructure. It noted that congestion and overcrowding was becoming especially problematical at terminals. It also noted, however, a comparable need for new equipment, new EDI systems for tracking freight, improved operating systems, and better integration of modal systems.

Figure 4.1 Previous U.S. DOT Initiatives to Address Intermodal Freight Challenges (continued)

Studies (continued)

Implications of Intermodal Freight Movement for Infrastructure Access, Capacity, and Productivity
In March 1996, the Volpe National Transportation Systems Center completed a report for the FHWA's Office of Policy Development that evaluated the status of intermodal freight in the U.S. with reference to problems of physical infrastructure access and capacity. The report identified opportunities to improve system operations and expand capacity by applying ITS/CVO technologies to expedite freight processing, streamline gate procedures, preclear vehicles requiring documentation, and track freight while en route to its destination.

Intelligent Transportation Systems and Intermodal Freight
In December 1996, the Volpe National Transportation Systems Center produced a paper for the U.S. DOT's ITS Joint Program Office entitled *Intelligent Transportation Systems and Intermodal Freight Transportation*. The paper described EDI technologies already in use by the intermodal freight industry and suggested how federal actions could enhance the interface between the ITS program and industry initiatives. The paper concluded that individual private sector companies have invested significantly in advanced technologies specific to their own operations, but that there were very few examples of applications being used by more than one mode. The paper did suggest opportunities for ITS technology applications to the freight transportation system that could enhance the capacity of the system as a whole.

Initiative to Promote Enhanced Freight Movement at Ports and Intermodal Terminals
In December 1998, the Volpe National Transportation Systems Center delivered a strategic plan to the U.S. DOT's Research and Special Programs Administration that addressed the National Science and Technology Council initiative to promote "Enhanced Goods and Freight Movement at Domestic and International Gateways." The plan suggested ways that federal research and development addressing freight movement could be coordinated, targeted, and leveraged to ensure the best investments and most valuable products. To support its objective to "promote advanced intermodal terminals and communications systems," the plan noted that information systems must be deployed to optimize fleet management and load dispatching, reduce transit times, and improve equipment utilization.

Figure 4.1 Previous U.S. DOT Initiatives to Address Intermodal Freight Challenges (continued)

Program Initiatives

ITS/Intermodal Freight Program

The FHWA is developing a national ITS/intermodal freight program to promote the application of ITS technology to intermodal freight transportation. The program goals are to enhance the safety, reliability, and responsiveness of the intermodal freight transportation system and contribute to enhanced transportation efficiency and safety. The program posits that sharing information across the intermodal freight system is key to regaining capacity and reliability in intermodal freight movement.

Assessments for an Intermodal Operations Planning and Coordination System

The Metropolitan Planning group of the new (1999) Planning, Environment, and Real Estate organizational unit within the FHWA is implementing phase two of a research and deployment testing project that is assessing state-of-the-art ITS technologies that facilitate landside access to ports. The deployment test incorporates a paperless gate entry system that uses an Internet interface to improve motor carrier scheduling and coordination of pickups, drop-offs, and backhauls.

International Border Clearance Program

Through the International Border Clearance (IBC) Program, the FHWA has sponsored a number of field operational tests of border crossing technologies and processes, including standardized data elements, electronic credentials, electronic clearance, and onboard systems, to facilitate international trade and transportation efficiency and safety. A strategic plan, a comprehensive IBC system design and information systems architecture, a concept of operations, and an IBC business operations and processes document also have been prepared.

Strategic Partnership Initiative

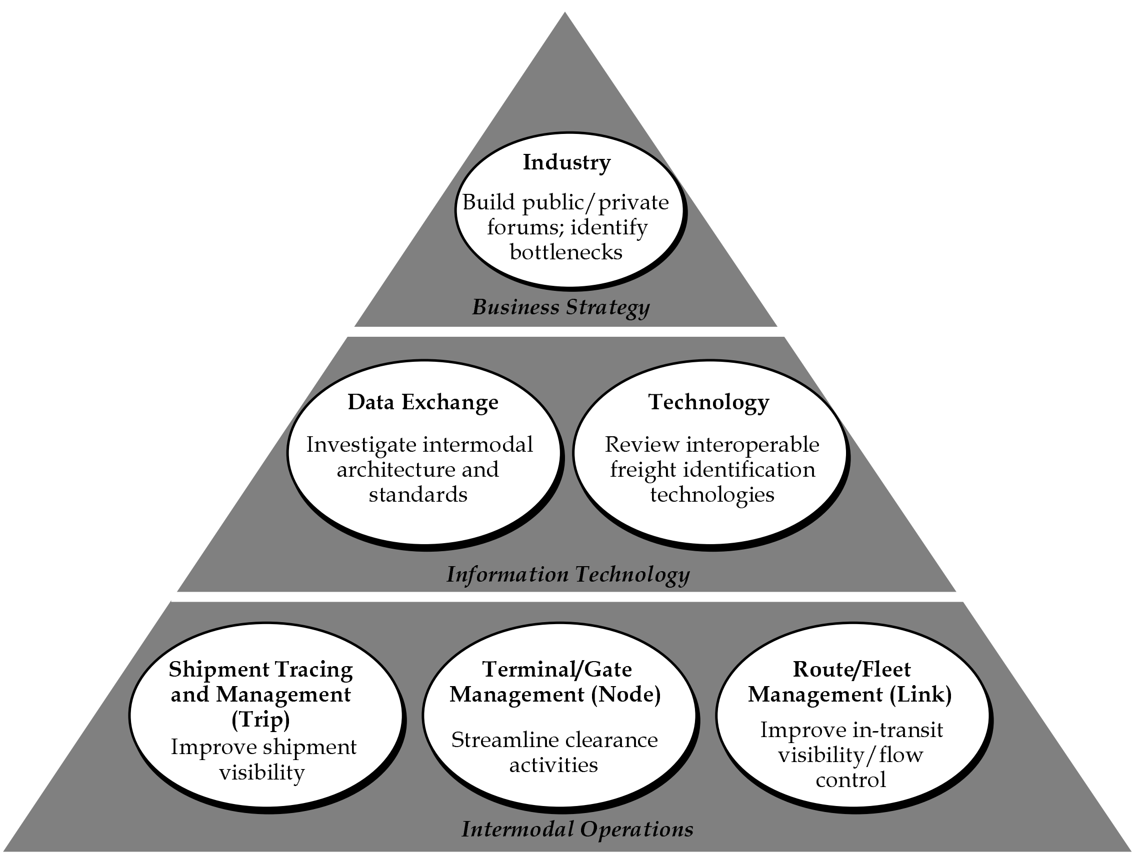
The National Science and Technology Council has developed a Strategic Partnership Initiative focused on identifying technology-based partnerships among government, industry, and academia to speed the introduction of new technologies into transportation systems and operations. One initiative area includes the improvement of intermodal information infrastructure to enhance goods and freight movement at domestic and international gateways. The focus includes advanced ocean terminal design and operating systems, advanced high-speed rail freight networks, and advanced truck-container transport and handling systems.

5.0 Recommendations

This report recommends that the U.S. DOT develop an ITS/intermodal program that will promote the application of ITS technology to intermodal freight transportation. The program will address concerns about landside access to ports and terminals; leverage complementary public and private investments; and ensure the safety, reliability, and responsiveness of the intermodal freight system.

The program is built upon U.S. DOT action at three levels – business strategy, information technology, and intermodal operations – as illustrated in Figure 5.1 and detailed below.

Figure 5.1 Opportunities for ITS Intermodal Initiatives



Recommendation 1. The U.S. DOT should solicit and fund proposals for ITS/intermodal freight operational tests.

The operational tests should link existing private sector shipment information and asset management systems with public sector traffic and safety management systems so that information can be shared. The tests should be conducted at major intermodal centers that can demonstrate significant capacity and congestion problems. The tests could involve truck-rail, truck-port, rail-port, or truck-air operations at marine or inland (i.e., dry) ports and terminals. The tests should be designed, staged, and evaluated in 24 months or less.

The tests should be designed to show improvements in the productivity and safety of intermodal freight operations; explore new partnerships; and identify the baseline need for an intermodal information systems architecture and data interchange standards.

In addition to the usual recipients of ITS program funds such as state and local agencies, proposals should be solicited from consortia of private and public groups with demonstrated interest and capability to improve the operation of the intermodal freight system. Test funds could be distributed through state DOTs, MPOs, or by partnership agreement to private or not-for-profit entities.

A budget of $500,000 has been established to fund the tests in federal fiscal year (FY) 1999; and a budget of $1,000,000 is anticipated for FY 2000. Individual tests could be funded at amounts up to $500,000.

In evaluating and awarding the operational tests, the U.S. DOT should consider the following key criteria:

- **Appropriateness/transferability –** Operational test proposals should address significant productivity, congestion, or safety problems that are common to the industry. The proposed solutions should be transferable to other intermodal operations. Preference should be given to projects that can show tangible results within a 24-month period.

- **Institutional capacity –** Proposals should demonstrate the ability of the sponsoring group to organize, manage, and sustain a consortium of intermodal freight stakeholders. Preference should be given to groups that can demonstrate successful completion of prior work in communications and information systems and alliances with the intermodal industry.

- **Technical capability –** Proposals should demonstrate the appropriate technical knowledge, skills, and experience to link ITS systems. The technical approach should employ an open systems architecture that is compatible with ITS and industry system elements, and show the ability to form the foundation for an ITS systems architecture and industry standards. Preference should be given to projects that utilize and leverage public and private systems that are in operation.

- **Resources –** Proposals should demonstrate the capability to marshal staff with appropriate skills. Preference should be given to projects that will match and leverage public funds with private funds, equipment, and services.

Recommendation 2. The U.S. DOT should support the emerging ITS/intermodal forums and continue identification of intermodal freight issues and promising ITS applications.

The U.S. DOT should further empower the U.S. DOT's Intermodal Freight Steering Committee by giving it responsibility for identification and refinement of intermodal issues, review of technology, and delineation of possible frameworks for an intermodal freight information systems architecture. These responsibilities should be carried out through oversight of in-house and contract studies; coordination of public sector participation in the operational tests; and assessment of the operational tests. The knowledge and experience gained by the committee should be used to help shape federal intermodal freight policies and program initiatives.

The U.S. DOT should continue to utilize the ITS America Intermodal Freight Technology Working Group. The U.S. DOT should solicit the working group's advice on the conduct and evaluation of the operational tests, private sector outreach, and potential frameworks for an intermodal information systems architecture and data interchange standards. The U.S. DOT should encourage the evolution of the working group as a broad-based policy and program resource that can provide input on promising ITS intermodal applications.

Recommendation 3. The U.S. DOT should build upon the operational tests to establish the need for and scope of an intermodal information systems architecture and data interchange standards.

The operational tests will provide information on the need and market for an intermodal information systems architecture and data interchange standards. The U.S. DOT should build on this information and other information gathered through its outreach efforts, research studies, and programs. The U.S. DOT should continue to pursue opportunities to develop an open intermodal information systems architecture and standards through program coordination with other federal agencies (e.g., DoD, U.S. Treasury, the Justice Department, etc.) and domestic and international standards organizations. The discussions should involve representatives from the ITS Joint Program Office, the Office of Intermodalism, the U.S. DOT operating administrations, ITS America, industry, vendors, and state and local transportation agencies. If the operational tests demonstrate a need and a market for an intermodal information systems architecture and standards, and the ITS America intermodal working group coalesces industry support, the U.S. DOT should initiate a formal definition of the architecture and drafting of standards.

6.0 ITS/Intermodal Freight Operational Test Concepts

This section outlines eight intermodal freight operational concepts that combine existing systems and ITS applications for pilot tests. The pilot, or operational, tests would be conducted to facilitate movements of intermodal freight. Tests would link existing private sector shipment information systems and asset management systems with public sector traffic, regulatory, and safety management systems as listed in Section 3.0, Figure 3.1.

The operational tests are based on recommendations from previous studies and conferences sponsored by the U.S. DOT, as well as input from the six recent listening sessions on potential applications of ITS technologies. The eight concepts represent some but not all of the ideas advanced in the listening sessions and the studies and conferences. They were defined on the basis of problems and needs that were identified by stakeholders, and they are consistent with the operations of private and public sector stakeholders and the systems and technologies that they use.

The overviews provide the following information about the test concepts:

- Objective of demonstrating the concept;
- Problem that is addressed;
- Approach in terms of the systems that will be linked and the kinds of information that will be exchanged;
- Outcomes and benefits that are anticipated from deploying the concept;
- Performance measures that are suggested for measuring the benefits; and
- Participants that are suggested for the operational test.

Performance measures are suggested for each of the operational concepts. Performance measures are used to measure and evaluate the effectiveness of the operational concept demonstrated in the test. Measures can be quantitative, consisting of counts and measurements, or qualitative, consisting of attitudes and perceptions. Performance measures will determine the data to be collected as part of the test. In order to accurately evaluate a test, "before and after" data for measures are needed. This will enable the stakeholders to assess the impact of a change.

Key performance measures that are suggested include transit time, labor costs, accident rate, queue time, and satisfaction of motor carriers, drivers, government personnel, and other parties.

Some measures, such as reliability and predictability of transportation service, may be difficult to quantify, but the measures may be extremely important for assessing benefits. Surrogate measures may be used for measures that are hard to quantify. For example, on-time performance, which is a common requirement in freight delivery contracts, can be used as a measure of reliability. Other measures that are not readily quantified include customer satisfaction and user satisfaction. These measures frequently are assessed qualitatively through interviews or surveys.

More than one performance measure can be used to measure the performance of a system, application, or service. To measure the effectiveness of providing motor carriers with traffic information from linked public and private systems to avoid incidents and reduce delays, measures that are applicable include transit time, loads transported per vehicle per day, labor costs, and number of times a penalty is incurred because of non-on-time performance. Which measures are used for the test would be determined by the evaluator, with the approval of the project steering committee, on the basis of appropriateness and availability of data in terms of historical records and ease of collection.

Performance measures have to be used carefully for assessing benefits. To ensure that the measures are meaningful, they must be verified with stakeholders, including participants in the test. The test evaluation would clearly indicate the parties that will benefit from each performance measure. For example, the motor carrier, the driver of the truck, and the carrier's customer stand to benefit from reduced transit time.

Motor carriers are suggested participants in many of the tests. Clearly the "motor carrier industry" is extremely diverse with a range of operating characteristics, fleet size, and automation and technological capabilities. The tests should include motor carriers that provide drayage operations.

6.1 Operational Test Concept – Intermodal Outbound Flow Management

Objective

Improve the mobility of trucks exiting terminal gates by adjusting street traffic signals based on real-time traffic conditions or optimized signal timing plans.

Problem

Traffic signals on terminal egress roads and corridors can cause congestion, queuing, and delays for trucks exiting the terminal gate.

Approach

Link the terminal's gate clearance system with the traffic-responsive and -adaptive traffic signal systems that are part of a regional or corridor traffic management system. The key systems are:

- Gate clearance system that automates the verification and inspection of drivers, trucks, and containers; and
- Traffic management system that regulates traffic signal timing and coordination in a corridor.

Gate clearance systems could provide information on the volumes of trucks exiting the terminal to the regional or corridor traffic management system. The traffic management system would use the information to adjust the timing of street traffic signals and freeway ramp meters to ensure efficient traffic flow and minimize queuing. Timing could be based on day and time of day patterns or real-time traffic conditions.

Anticipated Outcomes/Benefits

- Reduced congestion on egress roads;
- Fewer delays on primary routes;
- Improved corridor traffic management;
- Reduced fuel consumption;
- Reduced vehicle emissions; and
- Increased safety on egress roads.

Suggested Performance Measures

Quantitative Measures

- Transit time;
- Loads per vehicle per day;
- Labor costs;
- Time waiting at traffic signals;
- Time waiting at freeway ramp signals;
- Average corridor speeds; and
- Accident rate on egress roads.

Qualitative Measures

- Assessment of driver/motor carrier satisfaction; and
- Traffic management system operator's assessment of effectiveness.

Suggested Participants

- Operators of traffic management systems or traffic operations centers (e.g., state DOT, regional transportation commission);
- Motor carriers;
- Terminal operators; and
- Local police or other agency for accident data.

6.2 Operational Test Concept – Terminal Inbound Flow Management

Objective

Improve the management of inbound truck and container traffic at terminals by using information on anticipated inbound volumes and arrival times to spread out total arrivals.

Problem

Heavy inbound traffic at terminals can exceed processing capacity, resulting in queues that may extend onto access roads, delays, and high peak-period operating costs for the terminal.

Approach

Link electronic toll collection and weigh station clearance systems with the terminal's gate clearance system and the motor carrier routing and dispatching system. The key systems are:

- Electronic toll collection system that enables the electronic payment of highway, bridge, and tunnel tolls;
- Weigh station clearance system that enables commercial vehicles to avoid stops at weigh stations;
- Gate clearance system that automates the verification and inspection of drivers, trucks, and containers; and
- Motor carrier routing and dispatching system that automates the routing and dispatching of trucks.

Regional electronic toll collection and weigh station clearance systems identify passing trucks and mark the location and time. The observation could be forwarded to terminal operators which would use the information to anticipate truck arrivals, preplan gate activities, and communicate with motor carrier dispatchers to schedule arrival times. A third-party facilitator could manage the location data for the terminal operators.

Anticipated Outcomes/Benefits

- Reduced queuing at terminal gates;
- Reduced delays waiting for gate processing;
- Reduced terminal peak labor costs;
- Improved corridor traffic management;
- Reduced fuel consumption;
- Reduced vehicle emissions; and
- Increased safety on access roads.

Suggested Performance Measures

Quantitative Measures

- Gate processing time;
- Queue length;
- Time queued up at terminal gate;
- Transit time;
- Loads per vehicle per day;
- Labor costs;
- Cost to terminal per unit handled;
- Units handled per terminal employee per work shift; and
- Accident rate on access roads.

Qualitative Measures

- Assessment of driver/motor carrier satisfaction; and
- Assessment of terminal operator satisfaction.

Suggested Participants

- Operators of electronic toll collection systems;
- Operators of weigh station clearance systems (e.g., state DOT, or state police or highway patrol);
- Terminal operators;
- Motor carriers;
- Third-party facilitators;
- Local police or other agency for accident data; and
- MPOs.

6.3 Operational Test Concept – Incident Avoidance

Objective

Provide motor carriers with real-time information on incidents, congestion, construction, and other traffic conditions to enable them to optimize their routing and dispatching by avoiding incidents and other delays.

Problem

Motor carriers incur substantial costs as a result of delays due to incidents, congestion, and other traffic conditions.

Approach

Link the corridor incident management system and/or traffic management system and the corridor traveler information system with the motor carrier routing and dispatching system. The key systems are:

- Incident management system that detects an incident and implements incident response and clearance;
- Traffic management system that detects and monitors traffic conditions;

- Traveler information system that provides real-time information on traffic conditions; and
- Motor carrier routing and dispatching system that automates the routing and dispatching of trucks.

Regional or corridor incident management system and/or traffic management system have information on incidents, congestion, and other traffic conditions that the traveler information system could pass to the motor carrier routing and dispatching system. The routing and dispatching system would use the information to select alternate routes or adjust dispatching to avoid incidents and other delays. Designated truck routes, weight limits, and other restrictions would be kept up-to-date in the carrier system.

Anticipated Outcomes/Benefits

- Reduced delays due to incidents and congestion;
- Increased fleet operating efficiency;
- Improved corridor traffic management;
- Reduced fuel consumption;
- Reduced duplicate shipments sent to avoid just-in-time penalties; and
- Improved motor carrier and highway safety.

Suggested Performance Measures

Quantitative Measures

- Transit time;
- Loads per vehicle per day;
- Labor costs;
- Times penalized for non-on-time performance;
- Costs of penalties for non-on-time performance; and
- Accident rate on corridor.

Qualitative Measures

- Assessment of impact on business lost due to unacceptable on-time performance; and
- Assessment of motor carrier customer satisfaction.

Suggested Participants

- Operators of incident management or traffic management systems (e.g., state DOT, regional emergency management agency);
- Operators of traveler information systems (e.g., state DOT, private provider, public-private organization);
- Motor carriers;
- State DOT and local police or other agency for accident data; and
- MPOs.

6.4 Operational Test Concept – Pre-Trip Safety and Weight Screening

Objective

Reduce the frequency and duration of stops at weigh stations and other inspection sites for safe and legal motor carriers.

Problem

Weigh station stops, especially when there is congestion, and roadside inspections create a burden for the compliant motor carrier because delays directly impact a carrier's ability to meet schedules thereby increasing cost and reducing profitability.

Approach

Link the terminal's gate clearance system with the regulatory safety assurance or weigh station clearance system. The key systems are:

- Gate clearance system that automates the verification and inspection of drivers, trucks, and containers;
- Safety assurance system that provides information on the safety history and performance of motor carriers and drivers; and
- Weigh station clearance system that provides links to databases containing carrier and driver credentials and safety information and enables commercial vehicles to avoid stops at weigh stations.

Drivers at the terminal gate could verify their credentials and safety status by querying the regulatory safety assurance or weigh station clearance system. The truck would be weighed at the terminal (the state would conduct weighings or arrange for weighings by terminal personnel), and this information along with the status of credentials and safety performance transmitted to the weigh station. The information also would be available to road patrol officers. If the truck is in compliance with weight, credentials, and safety requirements, the weigh station clearance system would clear the truck for bypass as it approaches the facility.

Anticipated Outcomes/Benefits

- Reduced delays for compliant carriers;
- Increased highway safety from reduced queuing at weigh stations; and
- More efficient utilization of public resources.

Suggested Performance Measures

Quantitative Measures

- Weigh station or roadside inspection stops;
- Time queued up and processed through weigh stations;
- Transit time;
- Loads per vehicle per day;
- Labor costs; and
- Accident rate at highway mainline to weigh station approach ramp.

Qualitative Measures

- Assessment of utility to weigh station or road patrol personnel; and
- Assessment of motor carrier satisfaction.

Suggested Participants

- Terminal operators;
- Operators of safety assurance or weigh station clearance systems (e.g., state DOT, or state police or highway patrol);
- Motor carriers;
- State DOT for accident data; and
- Federal Highway Administration.

6.5 Operational Test Concept – Motor Carrier Credentials at Terminals

Objective

Enable a motor carrier to obtain a permit at the terminal to transport an oversize or overweight load.

Problem

Movement of a load may be delayed for hours or days because the motor carrier must obtain a permit from a public agency to transport the oversize or overweight load.

Approach

Link the terminal's gate clearance system with the automated oversize/overweight (OS/OW) permitting system. The key systems are:

- Gate clearance system that automates the verification and inspection of drivers, trucks, and containers; and
- OS/OW permitting system that automates the issuance of permits.

Typically, arranging for a permit to transport an OS/OW (also called high, wide, or heavy) load is done before a driver arrives at a terminal to pick up a load. However, when the driver does not have a permit, the driver could apply for and receive a permit at the terminal. Potentially, regional permits would be obtainable from regional permitting systems. In addition, the state could conduct weight inspections at the terminal and certify vehicle weight (or the terminal could do it in arrangement with the state), potentially enabling the truck to bypass static weighing at the weigh station.

Anticipated Outcomes/Benefits

- Reduced delays waiting for permit processing; and
- Streamlined regulatory processes.

Suggested Performance Measures

Quantitative Measures

- Turnaround time for processing;
- Transit time;
- Loads per vehicle per day; and
- Labor costs.

Qualitative Measures

- Assessment of motor carrier satisfaction.

Suggested Participants

- Terminal operators;
- Operators of oversize/overweight permitting systems (e.g., state DOT);
- Motor carriers; and
- State agency for conducting weight inspections.

6.6 Operational Test Concept – At-Grade Rail Crossing Advance Notification

Objective

Enable vehicles to avoid delays at at-grade highway/railroad crossings by providing advance notification of train arrivals.

Problem

Trucks as well as passenger vehicles experience significant delays at at-grade railroad crossings.

Approach

Link the railroad grade crossing management system, the corridor traveler information system, and the motor carrier routing and dispatching system. The key systems are:

- Railroad grade crossing management system that detects an approaching train;
- Traveler information system that provides real-time information on traffic conditions; and
- Motor carrier routing and dispatching system that automates the routing and dispatching of trucks.

Railroad grade crossing management system could provide information on an approaching train to the corridor traveler information system. The traveler information system would pass the notification to the motor carrier routing and dispatching system for use in diverting trucks to alternate routes and avoiding delays. If possible, trucks would be diverted to routes with grade-separated railroad crossings.

Anticipated Outcomes/Benefits

- Reduced delays waiting for trains to pass;
- Reduced fuel consumption;
- Reduced vehicle emissions; and
- Increased safety near railroad grade crossings.

Suggested Performance Measures

Quantitative Measures

- Transit time;
- Loads per vehicle per day;
- Labor costs; and
- Accident rate on roadways intersected by railroad grade crossings.

Qualitative Measures

- Assessment of driver satisfaction.

Suggested Participants

- Railroads;
- Operators of traveler information systems (e.g., state DOT, private provider, public-private organization);
- Motor carriers;
- Local police or other agency for accident data; and
- Federal Railroad Administration.

6.7 Operational Test Concept – Intermodal Hazmat Incident Response

Objective

Facilitate the response to incidents involving intermodal hazardous materials shipments.

Problem

Timely and effective hazmat incident response is jeopardized because responders cannot identify potentially hazardous materials involved in a crash or spill.

Approach

Link the ship stowage management system, the port/rail/truck terminal inventory management systems, and the location and management system with the hazardous materials response and incident management systems. The key systems are:

- Ship stowage management system that plans and tracks the location of hazmat containers aboard ships;
- Terminal inventory management systems that track and manage the movement of hazmat containers within the terminal;
- Location and management system that locates and tracks a vehicle or hazmat container;
- Hazardous materials response system that provides identifying information on hazmat loads; and
- Incident management system that detects an incident and implements incident response and clearance.

Hazardous materials containers could be identified and tracked end-to-end. Container identity, response instructions, contact phone numbers, and location information would be supplied to hazardous materials response and incident management systems to facilitate hazmat incident response and clearance. A system has been demonstrated that posts hazmat information on an electronic network for access by emergency responders.

Anticipated Outcomes/Benefits

- Improved incident response capability;
- Increased safety of response personnel;
- Increased public safety;
- Faster clearance of the incident site; and
- Faster restoration of normal traffic conditions.

Suggested Performance Measures

Quantitative Measures

- Response time;
- Clearance time;
- Injuries to response personnel;
- Secondary crashes; and
- Performance rate for matching hazardous materials to containers.

Qualitative Measures

- Assessment of proper dispatching of emergency equipment; and
- Assessment of impact on restoration of normal traffic conditions.

Suggested Participants

- Hazardous materials transporters – waterborne carriers, railroads, motor carriers;
- State DOT and local transportation agencies;
- State and local police;
- Emergency medical services;
- Fire departments;
- Environmental protection agencies; and
- Federal oversight agencies (e.g., Federal Highway Administration, Federal Railroad Administration, Research and Special Programs Administration).

6.8 Operational Test Concept – Security of Intermodal Shipments and Assets

Objective

Improve the security of goods in-transit.

Problem

Theft and vandalism of vehicles, containers, and goods have reached crisis proportions.

Approach

Link onboard trailer and container security systems with the terminal inventory management system, the location and management system, and the customs clearance system. The key systems are:

- Onboard trailer and container security systems that monitor the condition of vehicles and containers;
- Terminal inventory management system that tracks and manages the movement of containers within the terminal;

- Location and management system that locates and tracks a vehicle or container; and
- Customs clearance system that automates the filing, processing, review, and issuance of documents for import and export of goods.

Sensors on containers would monitor their condition. The security measures are taken when goods are high in value. If a container is disturbed or vandalized in the terminal yard, the sensor system would alert the terminal operator. If a container is in-transit, the sensor would send a signal to the motor carrier location and management system which would notify the customs clearance system that the integrity of the cargo has been violated.

Anticipated Outcomes/Benefits

- Reduced theft and vandalism of vehicles, containers, and goods; and
- Increased safety of terminal personnel and motor carriers.

Suggested Performance Measures

Quantitative Measures

- Losses from theft and vandalism;
- Insurance claims; and
- Cost of surveillance.

Qualitative Measures

- Assessment of effectiveness.

Suggested Participants

- Terminal operators;
- Motor carriers;
- Insurance companies; and
- Law enforcement agencies (e.g., state police or highway patrol).

Suggestions for the organization and management of the operational tests are presented in the following section.

7.0 Organization and Management of Operational Tests

This section describes potential environments for operational tests and the roles and responsibilities of public and private sector stakeholders in the tests.

7.1 Test Environments

Institutional and Technical Characteristics

The local institutional and technical environments have considerable impact on the potential to improve operations of the intermodal freight system. At a high level, important institutional characteristics include existing public-private collaborations and broad-based stakeholder support from both government and industry. Technical characteristics include existing advanced information technologies and ITS deployments and clearly articulated plans for utilizing and leveraging these existing systems and capabilities.

Historically, little interaction has occurred between the public and private sectors regarding intermodal freight movements, and bringing the parties together is a major challenge. Existing public-private collaborations, especially public-private partnerships that have completed projects, demonstrate the type of cooperation that is needed to support operational tests and serve as a nucleus of project sponsors. One example of collaborations and consortia is working groups and steering committees that serve a variety of policy, planning, and operations-related needs and projects. Another example is coalitions and partnerships that act as "holding companies" to finance services or improvements through funds and resources contributed by all parties.

In some cases, public-private collaborations are able to effectively marshal support for projects and initiatives from a broad base of transportation stakeholders, including those with intermodal freight interests. For ITS/intermodal freight operational tests, broad-based support is necessary to maximize transferability of the products of the tests and help ensure sustainability in the long term.

Many information systems and ITS technologies already are deployed by both the private and public sectors. One way to optimize the utility of these deployments, and minimize new information technology investments, is to disseminate information that is of value to many transportation users, but which is being redundantly collected or being captured and used by one operator, one carrier, or one government agency. It is anticipated that multiple parties can exchange information by linking existing systems and help manage the increasing intermodal freight volumes at ports and terminals and on transportation corridors. Linking in-place systems simply leverages existing capabilities.

Because of the advantages of leveraging existing technical capabilities and existing institutional characteristics such as public-private working groups and partnerships, these are primary considerations in designing operational tests. Collaborative public-private ITS applications for improving intermodal freight movement also are arguably best demonstrated at major intermodal centers that have significant capacity and congestion problems.

■ 7.2 Public and Private Sector Stakeholders

The increasing use by the private sector of information processing, advanced communications, and electronics to manage the movement of goods and assets has been mirrored by the public sector's increased use of the same technologies to manage traffic, improve safety for the traveling public, and ensure regulatory compliance in trade and goods transport. There has been, however, little systematic cooperation to leverage essentially complementary technology investments. As a result, information is not shared within the private sector nor between the private and public sectors.

The types of operational tests suggested by this report present the opportunity – and the challenge – for private and public parties to share information to realize economic and safety benefits. Linking systems so that operators can share information requires cooperation through consortia of public and private parties. Participation in a test by a public-private consortium can increase the base of financial and operational support; enhance the transferability of successful results; and promote standards development through a broad base of users, interfaces, and linkages.

A broad range of public and private stakeholders could collaborate in a consortium proposing an operational test. These stakeholders include the myriad parties involved in door-to-door intermodal freight movements from shipper to consignee; the interfaces of these parties with representatives of public agencies responsible for transportation infrastructure, regulation, and enforcement; agency representatives responsible for public safety and the oversight of commercial carriers, or that otherwise take actions that impact goods movement; and other parties that directly or indirectly are impacted by the project.

Stakeholders in intermodal freight transportation include port, rail, truck, and air cargo terminal operators; shippers; freight forwarders and brokers; rail, waterborne, air, and motor carriers; third-party facilitators; and receivers of cargo. Stakeholders also include municipal and regional planning organizations; state and metropolitan agencies responsible for operating traffic management systems, traffic operations centers, and traveler information systems; state commercial vehicle regulatory and enforcement agencies; federal agencies which rely upon, oversee, or regulate intermodal freight transportation; U.S., Canadian, and Mexican Customs; port authorities; and local and regional emergency response agencies.

In some tests, federal agencies are de facto participants in "project work" requiring activities related to changes in business practices or processes, or system changes. This is especially true of U.S. Customs, which has a role in projects involving international trade data and international border crossings. In these kinds of tests, the federal agency also could serve on an operational test steering committee, as described later in this section.

Stakeholders would have the following responsibilities in implementing an operational test:

- Contribute to the development and demonstration of the project (this will vary among the stakeholders but essentially is considered project work as opposed to oversight work);
- Form and serve on a steering committee;
- Contribute resources and services necessary for developing and demonstrating the project – perform required modifications or upgrades to existing systems and technologies, supply equipment or the use of facilities, provide in-kind contributions of staff time, and contribute funds;
- Participate in the evaluation of the operational test; and
- Participate in outreach and education activities.

Steering Committee

A steering committee comprising the parties in the consortium typically is formed to make project decisions and direct the development of the project. The chairperson of the committee, selected by the members, also would be the primary contact for the project. Members of the committee could be determined by the key stakeholders in the consortium, and all of the parties in the project may or may not be represented on the committee. The main responsibilities of the steering committee might include the following:

- Contribute to, review, and approve the project work plan;
- Establish priorities and make policy and funding decisions;
- Provide staff to carry out project tasks;
- Provide reports, documents, data and other materials as deemed necessary and appropriate by the steering committee;
- Review and approve the products of work tasks;
- Keep management and staff informed of project progress; and
- Design and review the evaluation of the pilot test.

8.0 Next Steps

This section describes the next steps for the U.S. DOT in developing an ITS/intermodal program that will promote the application of ITS to intermodal freight transportation. The steps emphasize: 1) coordination of the national ITS/intermodal program operational tests with other ITS/intermodal projects and activities, and 2) examination and refinement of the border crossing operational tests.

■ 8.1 Coordination with Parallel Efforts

The U.S. DOT should support the emerging ITS/intermodal forums and continue identification of intermodal freight issues and promising ITS applications. Immediate next steps would include: 1) empowering the U.S. DOT's Intermodal Freight Steering Committee to identify and refine intermodal issues and delineate possible frameworks for an intermodal freight information systems architecture; and 2) continuing to utilize the ITS America Intermodal Freight Technology Working Group (IMFTWG) for advice and input on operational tests, private sector outreach, and frameworks for an intermodal information architecture and data interchange standards. The U.S. DOT also must continue to pursue opportunities to develop an open intermodal architecture and standards through coordination with various agencies and organizations.

Closer coordination is needed between the U.S. DOT Steering Committee and the IMFTWG to refine the national ITS/intermodal freight program. The U.S. DOT and the IMFTWG are initiating separate but parallel pilot projects. Coordination between the Steering Committee and the IMFTWG in delineating their respective operational tests will ensure that these initiatives are mutually supportive and avoid duplication.

The IMFTWG has identified three pilot projects that it intends to initiate that will be designed and implemented largely by the private sector. The projects are: 1) an operational test of intermodal chassis identification and location ("chassis tagging"); 2) an operational test of intermodal freight container identification and location ("container tagging"); and 3) initial development of intermodal freight information systems architecture. The chassis tagging project is expected to track the movement of the trailer chassis to and from an intermodal terminal. The container tagging project would follow implementation of the chassis tagging project and track containers across modes and theatres. The third pilot project would develop an information technology template to describe operational events for the end-to-end movement of freight. This project would lay the groundwork for the development of an intermodal information systems architecture.

The IMFTWG projects and the operational tests described in Section 6.0 of this report are directed toward a common goal of applying technology to improve the transportation of intermodal freight and the management of intermodal assets. Information – on operations, locations, and congestion – is the essential element of these projects. It is imperative that the U.S. DOT and the IMFTWG continue their dialogue and coordination both before and during their tests. Milestones, technical findings, "lessons learned," evaluation activities, outreach activities, and applicability of results to the development of an intermodal information systems architecture should be shared. Early communication and coordination will benefit the tests and will bring into sharper focus their impacts on the efficiency and productivity of intermodal freight transportation.

8.2 Examination and Refinement of the Border Crossing Operational Tests

Electronic clearance for commercial vehicles has been demonstrated at six locations on the U.S.-Canada and U.S.-Mexico borders, under the North American Trade Automation Prototype (NATAP) tests in 1996-1998. The tests involved equipping a truck tractor with a radio transmitter/receiver that stored a unique identification as well as a trip/load number, and cleared the truck as data was passed electronically to a customs inspector. The U.S. DOT should build on the foundation established under the tests but should reengineer further deployments based upon the test experiences and lessons learned. The evaluation of one of the sites between Baja California and the State of California at Otay Mesa showed a variety of lessons learned, two of which are discussed in this section.

Business Model

In the future, processes such as drayage and near-border storage may be modified to fit a more economic-efficient model for moving goods across the border. An example of such change might be an in-country hub in San Antonio where processing would occur inland instead of on the border at Laredo, where it is currently carried out. There is a need to investigate potential impacts that these revised border systems will have on business operations and what impacts that such changes would have on the border community. Texas and Michigan currently do not have border inspection stations like the ones at Otay Mesa or Calexico in California. This prompts questions about how safety and credentials compliance will be ensured if processing is moved inland.

Processes

With border clearance processes so heavily institutionalized within the border crossing business practices, some process change will be required to improve efficiency and integrate technology into the business operations. There is a continuing need to explore ways for businesses to file required paperwork to provide the information necessary for border clearance as efficiently as possible. Even with the introduction of technology solutions, businesses are still operating as before. Until duplicative/parallel processing is removed, the real benefits of integrating technology into either current or future business practices and border clearance procedures cannot be determined. Public and private systems need to be sufficiently integrated to remove the need for parallel processing and add real value to the expedited border crossing process.

The U.S. DOT should consider additional ITS operational tests at the border crossings that incorporate lessons learned and utilize the capabilities of NATAP, the International Trade Data System (ITDS), the U.S. Customs's electronic in-bond transit filing system, and other appropriate automated systems that will ensure safety and security while expediting cross-border traffic. The objective would be to define an "evolutionary" ITS/intermodal project that builds upon the experiences of the previous tests and is sensitive to the economics of trade and the efficient movement of freight.

■ 8.3 Conclusion

The U.S. DOT has taken a user-oriented approach in establishing a national ITS/intermodal freight program and developing frameworks for ITS/intermodal operational tests. Listening sessions conducted at six intermodal locations identified current communications and information technology and ITS systems in the private and public sectors, impediments to intermodal freight movement, opportunities for information sharing that could improve local and regional intermodal operations, and anticipated benefits of ITS applications. These ideas were used to shape the operational test concepts in Section 6.0. The sessions also provided information that the U.S. DOT is using to define the scope of potential operational tests. Finally, the sessions validated the concept of a national ITS/intermodal program.

The U.S. DOT's approach emphasized the involvement of both private and public sector stakeholders in defining the operational tests. It focused heavily on the needs of, and the benefits to, stakeholders. This approach, as has been shown in many operational tests, is critical for ensuring the transferability of the products of the tests and sustainability of deployed systems and services.

Appendix A

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Appendix B

Bibliography

Bibliography

American Shipper, "In-Bond Filings Go Paperless," January 1999.

American Shipper, "U.S. Readies Internet Link for Cargo Data," January 1999.

Association of American Railroads website, www.aar.org, October 2, 1998.

Cambridge Systematics, Inc., with Apogee Research, Inc., Jack Faucett Associates, and Sydec, Inc., for the U.S. Department of Transportation, Federal Highway Administration, *Intermodal Freight Transportation,* December 1995.

Cambridge Systematics, Inc., with Sydec, Inc. and Science Applications International Corporation, for the U.S. Department of Transportation, Federal Highway Administration, *Systems Planning for Automated Commercial Vehicle Licensing and Permitting Systems: National ITS/CVO Program Requirements*, July 1997.

Intermodal Association of North America, *The Intermodal Network*, ca. 1998.

ITS America, *Intermodal Freight Identification Technology Workshop Proceedings* (Reston, Virginia, June 9-10, 1998), August 1998.

Journal of Commerce, "Maritime Traffic Jam?," August 10, 1998.

National Commission on Intermodal Transportation, *Towards a National Intermodal Transportation System,* September 1994.

National Science and Technology Council, Committee on Transportation Research and Development, Intermodal Transportation Science and Technology Strategy Team, *Transportation Science and Technology Strategy,* September 1997.

Traffic Technology International, "Tagged for Trade," December 1998/January 1999.

U.S. Department of Transportation, ITS Joint Program Office, *National ITS Program Plan, Volumes I and II,* March 1995.

U.S. Department of Transportation, Office of Intermodalism, *The Impacts of Changes in Ship Design on Transportation Infrastructure and Operations*, February 1998.

U.S. Department of Transportation, Research and Special Programs Administration, Volpe National Transportation Systems Center, *Initiative to Promote Enhanced Freight Movement at Ports and Intermodal Terminals, A Strategic Plan,* December 1998.

U.S. Department of Transportation, Research and Special Programs Administration, Volpe National Transportation Systems Center, *Intelligent Transportation Systems and Intermodal Freight Transportation,* December 1996.

U.S. Department of Transportation, Volpe National Transportation Systems Center, *Intermodal Freight: An Industry Overview,* March 1994.

U.S. Department of Transportation, Volpe National Transportation Systems Center, *Implications of Intermodal Freight Movement for Infrastructure Access, Capacity, and Productivity,* March 1996.

Appendix C

List of Acronyms

List of Acronyms

AEI	Automated Equipment Identification
AIT	Automatic Identification Technology
ATCS	Automatic Train Control System
ATIS	Advanced Traveler Information System
ATMS	Advanced Traffic Management System
AVI	Automatic Vehicle Identification
AVION	Automated Vehicle Identification Ontario
CCTV	Closed-Circuit Television
CDLIS	Commercial Driver License Information System
CVO	Commercial Vehicle Operations
CVISN	Commercial Vehicle Information Systems and Networks
DARPA	Defense Advanced Research Projects Agency
DoD	Department of Defense
DOT	Department of Transportation
DSRC	Dedicated Short-Range Communications
ECDIS	Electronic Chart Display and Information System
EDI	Electronic Data Interchange
EDIFACT	EDI for Administration, Commerce, and Transport
FHWA	Federal Highway Administration
FTMS	Freeway Traffic Management System
FY	Fiscal Year

GIS	Geographic Information System
GPS	Global Positioning System
HAR	Highway Advisory Radio
HAZMAT	Hazardous Materials
HELP	Heavy-Vehicle Electronic License Plate
IBC	International Border Clearance
IMFTWG	Intermodal Freight Technology Working Group
ISTEA	Intermodal Surface Transportation Efficiency Act
ITDS	International Trade Data System
ITS	Intelligent Transportation Systems
ITS America	Intelligent Transportation Society of America
LEO	Low Earth Orbit
LMS	Location and Management System
MAPS	Multi-jurisdictional Automated Preclearance System
MARAD	Maritime Administration
MCMIS	Motor Carrier Management Information System
MMDI	Metropolitan Model Deployment Initiative
MPO	Metropolitan Planning Organization
MTS	Marine Transportation System
NATAP	North American Trade Automation Prototype
OCR	Optical Character Recognition
OS/OW	Oversize/Overweight
PCNS	Portable Communication, Navigation, and Surveillance System
RFID	Radio Frequency Identification
SAFER	Safety and Fitness Electronic Records

TEA 21	Transportation Equity Act for the 21st Century
TEU	Twenty-Foot Equivalent Unit
TOC	Traffic Operations Center
TRB	Transportation Research Board
VTS	Vessel Traffic System
WIM	Weigh-in-Motion

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