Prepared for

U.S. Department of Transportation
Federal Highway Administration

Final Report

U.S. Intermodal Freight Transportation;

Opportunities and Obstacles

Prepared by

Mousa F. Abbasi
Department of Civil and Environmental Engineering
Michigan State University
A349 Engineering Building
East Lansing, Michigan 48824-1226
Phone: (5 17)353-7803
Fax: (5 17)423-l 827
E-mail: abbasimo@egr.msu.edu

August 1996

PREFACE

The expected benefits from this study include a better understanding of the needs and priorities of the various stakeholders, identification of opportunities and obstacles in the implementation of intermodal policies to the freight transportation sector, and determination of U.S. Department of Transportation's role in intermodal freight transportation as it relates to the ITS/CVO technologies.

The study offers a background information on, definition and system architecture of, and stakeholders and impediments of inter-modal freight transportation. The research also provides a brief information on the current and future freight movement, domestically and globally, and necessary actions to facilitate this movement. Current and emerging technologies for enabling intermodal freight transportation, potential costs and benefits of ITS/CVO inter-modal freight transportation, the government's role in intermodal freight transportation, future research issues and challenges in the inter-modal freight transportation, and concluding remarks and recommendations are also presented in this study.

This study was conducted under the Federal Highway Administration Eisenhower Grants for Research Fellowships Program (FY 1995) and as part of the author's fellowship grant award.

TABLE OF CONTENTS

LIST OF FIGURES

ACKNOWLEDGMENTS

The author wishes to thank the U.S. Department of Transportatlon/Federal Highway Administration (USDOT/FHWA) for awarding him the Eisenhower Research Fellowship Grant; without it, this study could not be accomplished.

The author also would like to thank the USDOT/FHWA Office of Motor Carriers (OMC), as an organization and employees, for their guidance, assistance, and support. Working for the OMC Intelligent Transportation Systems/Commercial Vehicle Operation (ITS/CVO) Division is a challenge and honor. Thanks to all members of the Division, especially, Mr. Douglas McKelvey/OMC-ITS-CVO Division Chief, Mr. Michael Onder/FHWA Office of Intelligent Transportation Systems, and Dr. Virginia Sisiopiku/Michigan State University for their encouragement, assistance, support, comments, reviews, and friendship. It is hard to express the author's appreciation to them through this short statement.

Finally, the author would like to express his appreciation to everyone who contributed to making the study exist.

EXECUTIVE SUMMARY

The Intermodal Surface Transportation Efficiency Act of 199 1 (ISTEA) presents a new vision of the transportation system. It replaces the traditional individual mode approach with the concept of a seamless national intermodal transportation system that is efficient, safe and environmentally sound. This is described in ISTEA as follows: *"It is the policy of the United States to develop a National Intermodal Transportation System that is economically efficient and environmentally sound, provides the foundation for the Nation to compete in the global economy and will move people and goods in an energy efficient manner.* "(1)

Recent developments in the area of Intelligent Transportation Systems offer new opportunities and challenges toward the implementation of an intermodal transportation framework in the United States. Within this framework, this paper addresses issues related to the implementation of an intermodal framework to the freight transportation sector.

The objectives of this research are to define the context for intermodalism in the freight transportation industry, discuss current practices and future needs, and identify benefits and impediments to intermodal freight transportation.

Expected · benefits from this work include a better understanding of the needs and priorities of various stakeholders involved in the freight transportation movement, identification of opportunities and challenges in implementing advanced technologies and policies for interrnodal freight transportation, and definition of the role of government, in particular the U.S. Department of Transportation, in the implementation process.

It is concluded that the technology is mature to assist in intermodal freight operations, the government has the responsibility to facilitate implementation of an intermodal framework for freight movement, but the direct responsibility for intermodal freight transportation should remain in the hands of the private sector.

The study is organized as follows. Sections 1 offers a brief background information on, definition and system architecture of, stakeholders of, and impediments to intermodal freight transportation. Information on current and future freight movement, domestically and globally, and necessary actions to facilitate this movement is provided in Section 2 and the current and

emerging technologies for enabling intermodal freight transportation are presented in Sections 3 and 4, respectively Section 5 provides Potential costs and benefits of ITS/CVO intermodal freight transportation. Public sector's role in intermodal freight transportation and future research issues and challenges in the intermodal freight transportation are presented in Sections 6 and 7, respectively. Concluding remarks and recommendations are outlined in Section 8.

1. INTRODUCTION

1.1. Background

Transportation policy has been traditionally focused on individual modes: automobiles, trains, trucks, ships, airplanes, or transit systems. A need exists to interconnect such systems in a seamless intermodal transportation system that is efficient, safe, flexible, and environmentally sound, and meets the needs of the Nation's travelers and shippers. This is described in ISTEA as *follows: "It is the policy of the United States to develop a National Intermodal Transportation System that is economically efficient and environmentally sound, provides the foundation for the Nation to compete in the global economy and will move people and goods in an energy efficient manner. "*(1)

The era of intermodal freight transportation began in earnest in the mid-l980s when ocean carriers and railroads teamed up to provide doublestack rail container service(‘). This approach stacks two shipping containers on specialized rail cars for greater efficiency. Since this type of service was introduced, dramatic changes in land and ocean shipping have occurred.

Intelligent. Transportation Systems (ITS) are transportation systems which utilize information, communication, sensor, and control technologies to achieve improved levels of performance. The benefits from the implementation of a national Intelligent Transportation System (ITS) include increased productivity and efficiency, reduction of delays, congestion and environmental impacts, increased revenues from lowering overall transport costs, and enjoying higher returns from public and private infrastructure investment"‘.

The US Department of Transportation (USDOT) has developed a national ITS Program Plan in June 1992(2). Freight and Fleet Management, an Intelligent Transportation Systems/Commercial Vehicle Operations (ITS-CVO) subsystem, provides real-time communications for vehicle location, dispatching, and tracking between commercial vehicle drivers, dispatchers, and intermodal transportation providers(3). The scope of this research is limited to the intermodal freight transportation. Within this framework, providing communication links among operators of motor vehicle, rail, air, and marine, and ensuring that the systems used are compatible across modes is intermodal freight transportation.

The objective of this study is to determine USDOT's role in inter-modal freight transportation as it relates to ITS-CVO technologies. Expected benefits from this study also include a better understanding of the needs and priorities of the various stakeholders, identification of opportunities and obstacles in the implementation of intermodal policies to the freight transportation sector.

The study is organized as follows. Sections 1 offers a brief background information on, definition and system architecture of, stakeholders of, and impediments to intermodal freight transportation. Information on current and future freight movement, domestically and globally, and necessary actions to facilitate this movement is provided in Section 2 and the current and emerging technologies for enabling intermodal freight transportation are presented in Sections 3 and 4, respectively. Section 5 provides Potential costs and benefits of ITS-CVO intermodal freight transportation. Public sector's role in intermodal freight transportation and future research issues and challenges in the intermodal freight transportation are presented in Sections 6 and 7, respectively. Concluding remarks and recommendations are outlined in Section 8.

1.2. Definition of Intermodai Freight Transportation

Intermodal freight transportation is the concept of transporting freight using more than one mode of travel in such a way that all parts of the transportation process are effectively connected and coordinated, safe, environmentally sound, and offering flexibility(4). An intermodal system should be defined to include both the points of connections (e.g. ports, warehouses, etc.) and the links between them (e.g. roads, rails, etc.)(5).

Interrnodal and multimodal processes are not the same. A multimodal transportation process uses two or more modes of transportation but is not necessarily an efficient, cost-effective, and flexible process.

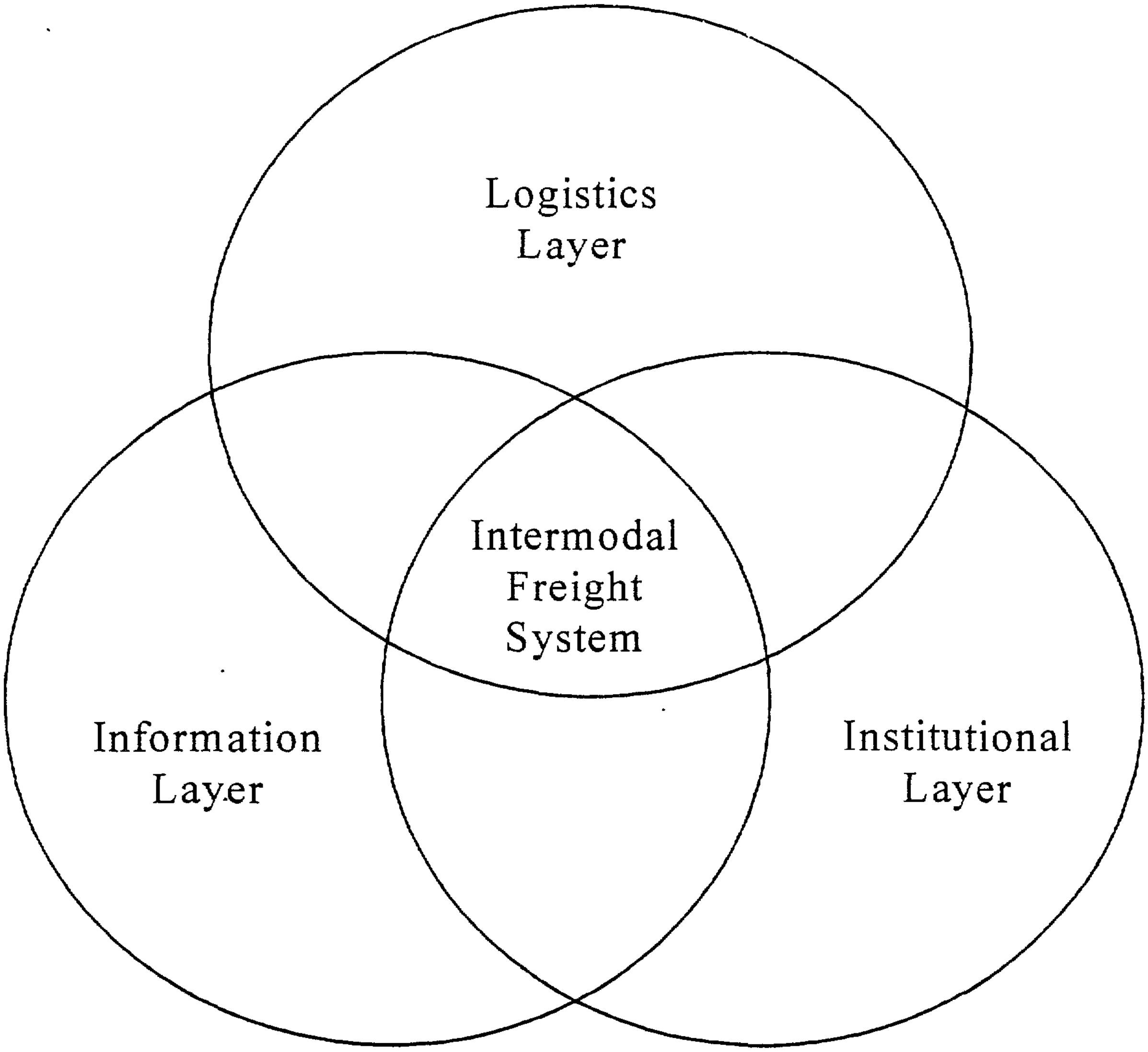
Improvement of intermodal transportation plays an important role in achieving "seamless" transportation(6). In other words, the transportation of goods by different modes is done so efficiently that the changes in mode are hardly noticeable. A better understanding on the various components of an ictermodal freight transportation systems can be obtained through a review of the system architecture structure, that follows.

1.3. System Architecture of Intermodal Freight Transportation

The system architecture of intermodal freight transportation is composed of three interconnected layers, namely logistics, institutional/organizational, and information”‘:

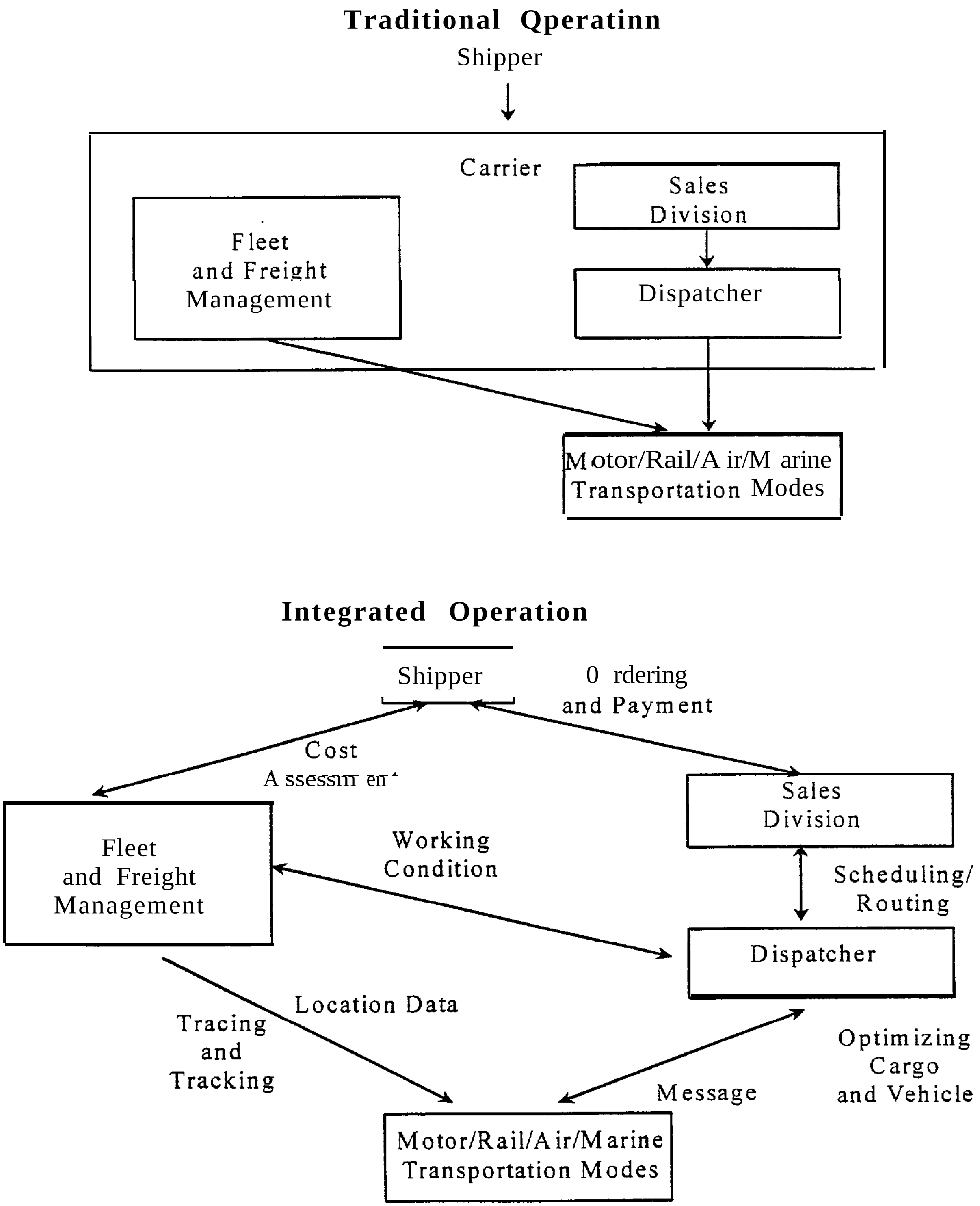
- *Logistics* layer refers to various approaches that are available to describe the complicated structures of logistics systems in terms of flow of freight, operations, intermodal facilities, flow of messages. and data required to operate the system.
- *Institutional/organizational* layer is a framework to explain or illustrate how actors and stakeholders proceed in developing and improving information infrastructure and how these actions influence the design of information systems.
- *Information* layer refers to intercomputer communications technology and procedures that facilitate dialogues between machines and enable them to cooperate. Recent advancements favor the transformation of highly hierarchized information systems into more horizontal architectures of local networks, connected to each other by gateways or bridges and possessing client/server machines.

Success of an inter-modal freight transportation system depends on the degree of interaction between the three system’s architecture layers as illustrated, schematically, in Figure 1. Interrndal and traditional freight transportation operations are different as the first one allows for the whole system to respond flexibly to the occurrence of unpredicted situations while the other does not as illustrated, schematically, in Figure 2. The integrated logistics operation transportation components and modes are communicating among each other through an interactive communication link.



Source: Organization for Cooperation and Economic Development, 1995.

Figure 1. System Architecture of Intermodal Freight Transportation.



Source: Organization for Cooperation and Economic Development, 1995.

Figure 2. Intermodal and Traditional Freight Transportation Operations.

1.1. Entermodal Freight Transportation Sector's Stakeholders

The complexity of intermodal freight transportation systems exists in the fact that there are various forms of organizations which actually operate the transport of goods. The role and stakeholder model of intermodal freight transportation system is illustrated in Figure 3(7). Flow of goods and information are treated equally. The flow of information in this model indicates that the transmission of data and messages is only conducted by structured communication. Usual communication by a telephone, cellular phone, facsimile or internet are examples of conducting unstructured communication.

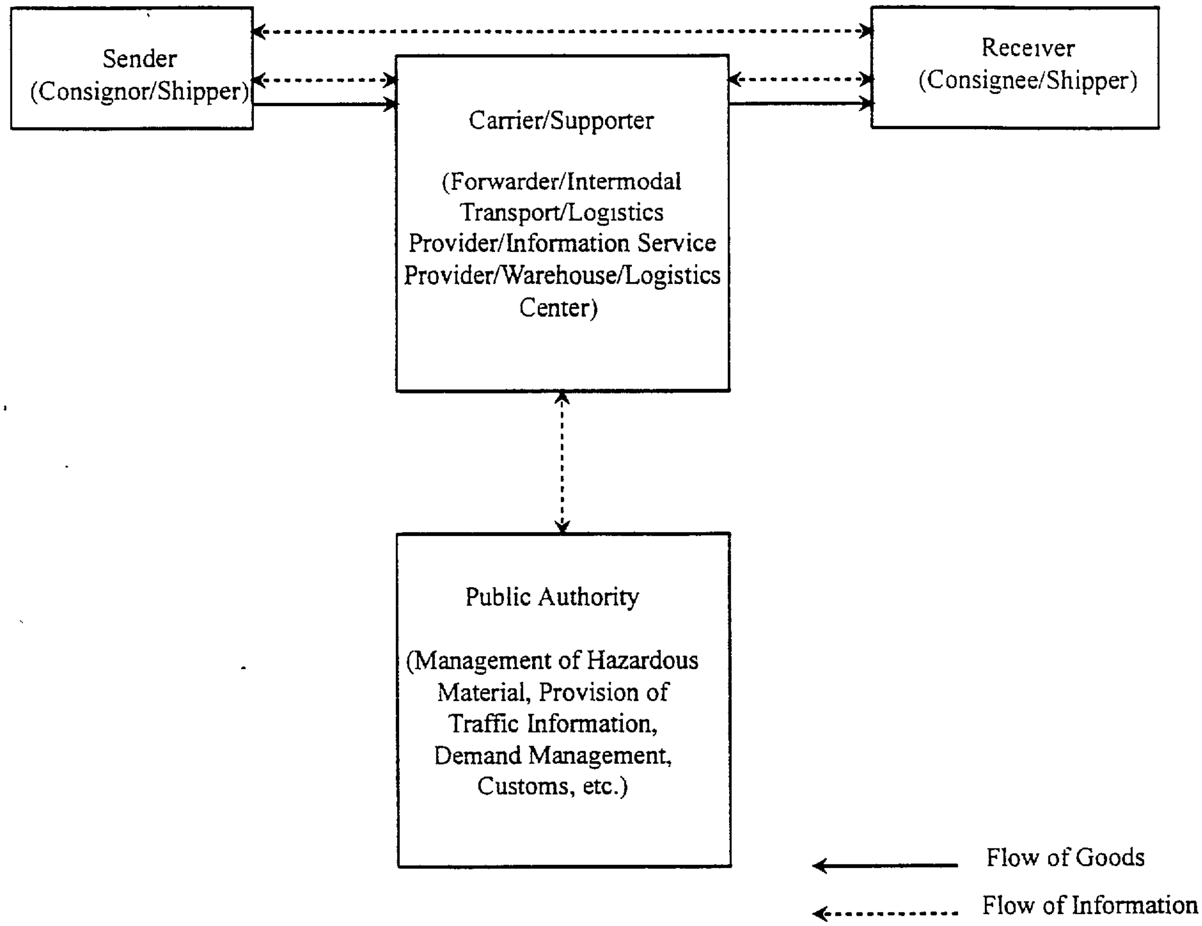
The actual responsibilities for intermodal freight transportation services lie in the hands of the providers, transport carriers, warehousing and terminal operators, integrated service providers such as freight forwarders, and others. The actual responsibilities for managing intermodal freight transportation systems belongs to the shippers and the consignees, whether manufacturers, merchandisers or others. Typically, both providers and shippers are private firms, fully capable of managing their own businesses and perspectives.

1.5. Competition and Impediments to Domestic Intermodal Freight Transportation

1.5.1. *Competition to Domestic Intermodal Freight Transportation*

Although substantial improvements have been made, domestic intermodal freight transportation still faces strong competition from over-the-road trucking for perceived and actual reasons such as the following?

- *Multiple handling of goods.* Intermodal rail involves trucking to a terminal, rail delivery, and draying to the customer. The extra handling can lead to more damage to fragile goods, less control to heat and/or cold, and less monitoring of goods. On the other hand, trucking can offer point-to-point service.
- *Longer time requiredfor short-hauls.* Container or trailer must be drayed to rail terminal to make " cut-off" times which allow for loading and train make-up. At the other end of the journey, time is required to unload the train, pick up and dray the container or trailer to the receiver. A truck can run right through from the shipper to the receiver.



Source: Organization for Cooperation and Economic Development, 1995.

Figure 3. Role Player Model of Logistics Operations.

- *Less flexible scheduling of intermodal shipments.* Trains are scheduled at specific times of day (or days of the week) and containers or trailers must be put on certain trains or wait on the next one. Trucks can leave when the load is ready.
- *Costs of intermodal shipping generally are not lower than truck for short- and medium-haul.* Although the line-haul transportation cost by rail may be lower, costs of draying containers and lifting them onto and off of rail cars must be added. Terminals costs add significantly to the cost of intermodal transportation. Generally intermodal container shipments must be over 500 miles to be competitive with the cost of trucking.

1.5.2 Impediments to Domestic Intermodal Freight Transportation

Some of the current impediments to achieving "seamless" domestic intermodal freight transportation service are categorized and briefly discussed in this section. Among the types of impediments are(6):

- *Lack of adequate infrastructure,* such as the need for new. large, well-located intennodal terminals; shortage of new loading and unloading equipment; poor landside access, including larger capacity and better designed access roads, bridge improvements to assure adequate clearances and weight capacities for truck and double-stack rail; and water depths at intermodal ports that will handle the largest container ships that will serve these ports.
- *Congestion,* such as on access routes, bridges, and tunnels serving intermodal rail and port terminals located in large urban areas. Delay on access and major trucking routes increases costs and adversely affects the ability to provide reliable just-in-time service.
- *Operational inefficiencies,* caused by the need for better located rail freight routes, and extension of double-stack rail service; the need for new ED1 facilities for managing and tracking shipments, pre-clearance, scheduling equipment usage, and managing fast and efficient flows of full and empty containers; and the need for better management of inter-modal operations and improved coordination among modes.
- *Regulations that delay and/or raise the cost of developing new facilities,* such as long lead time for obtaining environmental permits for dredging and other improvements; inconsistent

State regulations that adversely affect interstate shipments (such as differing truck size and weight limits); and increased in taxes and fees, including State franchise taxes on railroads. that raise the cost of intermodal freight transportation.

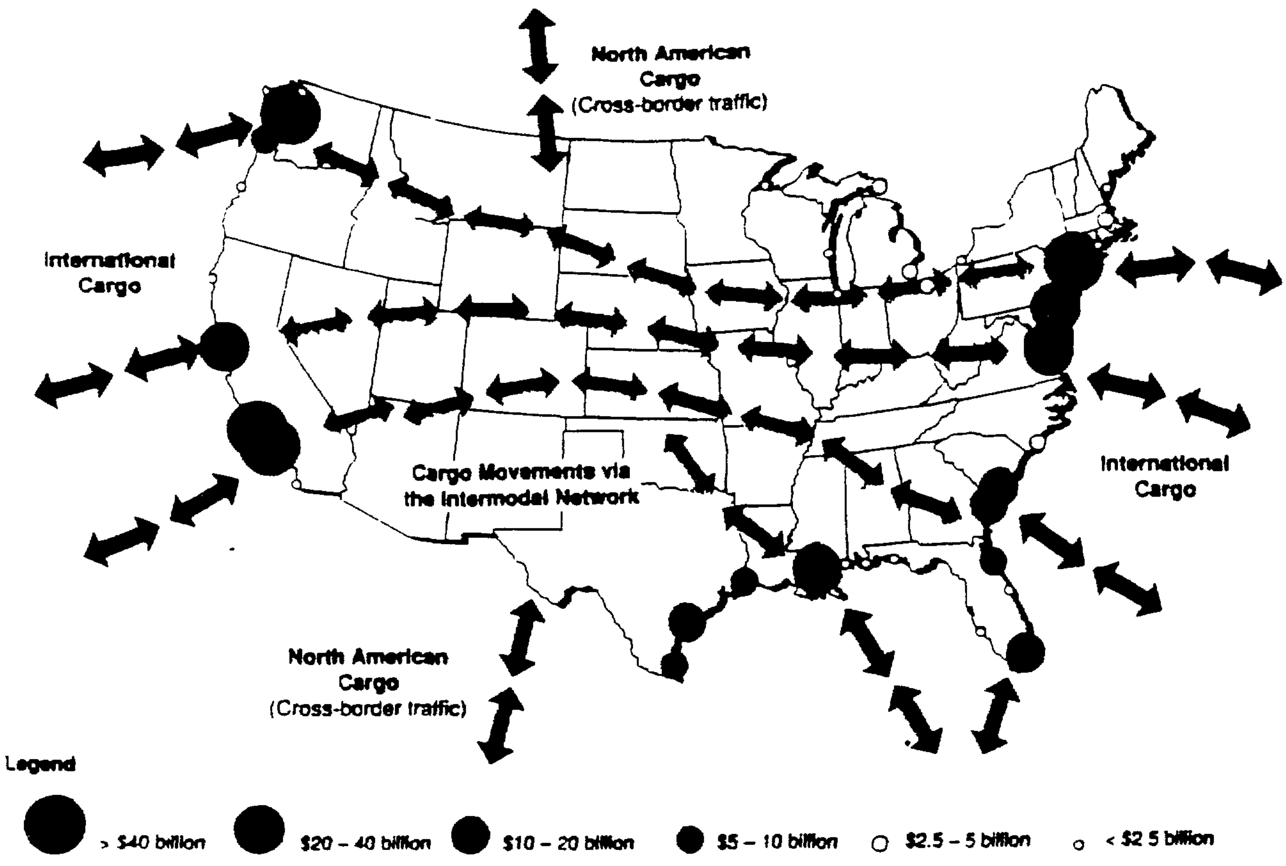
- *Institutional relationships,* that impede the efficient interconnection of modal freight transportation. especially of eastern and western freight railroads; lack of good private and public sector relationships in terminal planning and operations to allow for publicly-funded projects to complement private sector initiatives; lack of a mechanism to ensure good management-labor relationships as new equipment and operating procedures are implemented: and improve public relations. so that the benefits of good intermodal freight transportation become more widely appreciated.

Alleviating some specific impediments to intermodal freight transportation will help to reduce some of the deficiencies listed earlier and provide faster, more reliable. and more competitive intermodal freight transportation. This will help intermodal freight transportation to increase its share of the market in long-haul corridors and its penetration in the short-haul market (less than 500 miles) which includes about 70% of all intercity freight traffic(6).

2. CURRENT AND FUTURE FREIGHT MOVEMENT AND NECESSARY ACTIONS

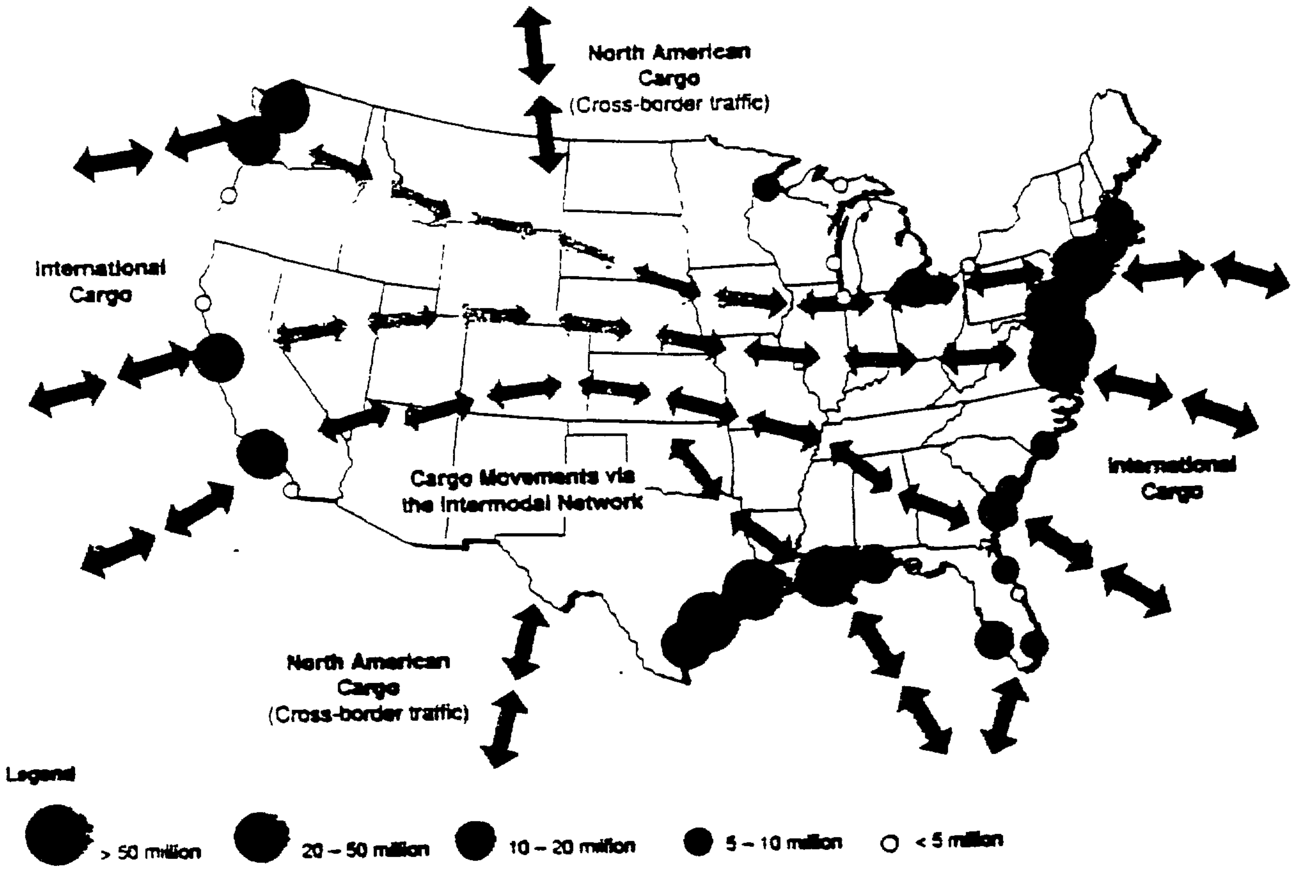
The American economy depends more and more on producers and customers all over the world. Over the past 20 years imports and exports have increased so that they equal one-fifth of the U.S. gross national product(8). U.S. ports handled $512 billion (893 million tons) in international cargo in 1993(9). These ports have become critical transfer points in the intermodal network that moves the nation’s international cargo (Figures 4 and 5).

Overall, tonnage moved through U.S. ports is expected to triple over the next 30 years(10). Increasingly, world economies are becoming interdependent; and countries are actively pursuing international trade alliances. Explosive growth of production capacity in Southeast Asia, the anticipated opening of markets in China and Eastern Europe, stabilization and expansion of trade



Source: American Association of Port Authorities, 1990.

Figure 4. Oceanborne Foreign Trade by Port Region, in 1990. in Dollars.



Source: American Association of Port Authorities, 1990.

Figure 5. Oceanborne Foreign Trade by Port Region, in 1990, in Long Tons.

with Mexico and Central and South America. and politics of international cooperation will contribute to this growth.

Another effect that appears to be emerging is increasing specialization of ports with respect to cargo-handling capabilities. Ports that are well suited to handle containers by virtue of local market size, intermodal connections, water depth, infrastructure, and other factors want to maximize their container throughput. Because container terminal are land-intensive, this involves acquiring new land and/or redeveloping existing land. In some cases. non-container terminal are eliminated, and these must relocate to other ports. The non-container ports, in turn, see the chance to fill a market void and pursue these opportunities aggressively. This effect is seen in different degrees at different ports and tends to impact commodities that do not require extensive capital investment in their facilities (such as automobile, steel, or lumber terminals). The shift from bulk to container ports is less frequent not only because the capital investment requirements are different but also because bulk terminal (particularly fuel terminals) are typically privately owned and have no commercial relationships to container operations.

If the largest U.S. ports can expect dramatically increased freight volumes both from overall growth in trade and increased specialization and if smaller ports can expect to share in this growth, the result will be a dramatically increased demand for access. Large established ports urbanized areas, with aging infrastructure and constraint dimensions, find their systems overburdened. Smaller or emerging ports discovering the downsides - impacted neighborhoods, block grade-crossings, and clogged two-lane roads - of gaining their "fair share" of the market.

Ports are attempting to deal with this in a number of way:

- One trend has been an increased aggressiveness on the part of ports in seeking transportation improvements.
- A second and equally important trend has been to attempt to move rail terminals on-dock, eliminating the local dry from the ocean terminal to the near-dock rail terminal.
- A third trend is an increased willingness to look to future-oriented concepts, such as automated container trains or overhead conveyors that would allow storage yards to be

located far inland, where truck impacts would be less significant, and long-distance slurries that would replace over-the-road hauling of bulk products.

- Finally, improvement of ports efficiency and productivity to reach the level of the best international terminals (Singapore and Hong Kong). In 1993, the Ports of Singapore and Hong Kong each handled over 9 million Twenty-foot Equivalent Units (TEUs). By the year 20 1 1, Hong Kong will handle 32 million TEUs(10).

3. CURRENT TECH-NOLOGIES FOR INTERMODAL FREIGHT TRANSPORTATION

Available technologies for improved efficiency of intermodal freight transportation include sensors, along with information and communications systems for identification. location, and surveillance.

3.1. Vehicle and Cargo Tracking Technologies

There are several available Automated Equipment Identification (AEI) technologies"": bar codes with laser readout, radio-frequency (RF) transponders with interrogators/readers, or contact technologies like magnetic card stripes and readers. Some have read-only and others read-and-write capabilities. All require Electronic Data Interchange (EDI) protocols and a dynamic logistics system to link data to decision making and flow control for efficient distribution.

A related family of technology and services comes under the label Automated Vehicle Location (AVL) that has active navigation and communication capabilities. AVL systems for surface vehicle fleets use some of the following technologies:

- *RF Technology.* RF technology for AEI relies on radio signals between passive tags and active interrogators. While this technique has been used widely for warehousing and manufacturing applications, it is now gaining acceptance at marine cargo terminals to manage and speed traffic flow through terminal gates and to track yard equipment for improved cycle time and productivity.

- *INTRANSIT VISIBILITY ('International TRANSportation Information Tracking) The* INTRANSIT system for worldwide tracking of vehicles, containers. or personnel has been demonstrated by the U.S. Department of Transportation (DOT)/Volpe Center for special Department of Defense (DOD) and United Nations (UN) purposes related to military deployments and trade embargo enforcement functions. INTRANSIT uses data received through Global Positioning Satellites (GPS) or other satellite-based positioning and satellite communications services to automatically report the locations, speed, and ID of tracked objects. This information sent can include, in addition to GPS position, data from onboard sensors. INTRANSIT. when coupled with any AEI technology, can be used successfully to track international shipments in an efficient, paperless supply and distribution system(11).
- *GPS Radio-location Systems.* The GPS are a DOD-owned constellation of 24 satellites, which enable position determination for location and navigation, with global coverage and unprecedented accuracy. The U.S. DOT is coordinating all civil uses of GPS, including international aviation applications. GPS technology can be especially useful to the freight industry when used with voice and data links in conjunction with AEI technology. GPS can be integrated into a turnkey service with commercial communications linking the vehicle with a distributed network or a central dispatch and control facility (e.g. voice radio, cellular phone, or satellite-supported mobile communication).

3.2. Better Intermodal Fleet Management Through Tracking and Logistics

Logistics information systems are perceived as the catalyst for both government and industry change, both in technology base, and in globalization of operations and institutional change. Successful logistics systems must mate transportation equipment to infrastructure and terminal upgrades. These connections are made via information and communication links between customers, carriers, and third parties. The DOD has developed transferable and applicable tracking and logistics systems for material transport, which could be broadly utilized by the freight industry. The DOD's U.S. TRANSCOM is implementing a Global Transportation

Network (GTN), designed to provide Total Asset Visibility (TAV), using automated cargo tracking and logistics planning.

Commercial Vehicle Location and Logistics Systems and Services are also available for intermodal freight transportation implementation. A number of sophisticated, turnkey radiolocation and navigational commercial services have emerged and proliferated in urban and other areas with well developed cellular phone or radio communication infrastructure. The services combine Automated Vehicle Location (AVL) with paging, voice, and data communication to a national or regional dispatch and logistics node. These technologies have first been used for emergency dispatch of priority vehicles. but increasingly used by trucks fleets for guaranteed 1 - or 2-day delivery.

3.3. Electronic Data Interchange (EDI)

The Electronic Data Interchange (EDI) family of computer and communication services is a promising technology for more efficient intermodal freight operations. EDI uses information and communication flow to reduce delays in shipment and manifesting. Although EDI is a mature technology with many competing application products and services in the market available to carriers, less than 50% of all transactions at rail terminal presently use ED1 (11). The impediments to EDI widespread adoption are(11):

- Hardware and communication protocols lack interoperability and compatibility due to the lack of industry-wide standards.
- Relatively high investment and organizational cost for hardware and software are needed.
- Small carriers cannot afford the fees and the capital investment in EDI.
- Labor unions' believe that EDI-enabled productivity savings will be achieved through labor force cuts.

3.3.1 The U.S. Customs Automated Manifest System (AMS)

A significant boost to intermodal freight interchanges has come from the automated billing and cargo manifesting ED1 system introduced since 1985 by the U.S. Customs Service. The U.S.

Customs Service has instituted and supported an EDI interface system for ocean cargo called Sea Automated Manifest System (SEA-AMS)(11). It can report electronically: the cargo manifest and bill of landing, vessel arrival times, "in-bound" movement for cargo arrival at in-land ports of entry, electronic permit to transfer, electronic status notifications (12-minute updates), and information access for system participants, while protecting the security of sensitivity data (e.g. shipment contents). The demonstrated benefits of AMS on-line data access to industry are:

- Quicker release of cargo, fewer fines, and smoother operation and resource planning. The AMS has increases participating carrier productivity through reduced processing time at major terminals by 3-4 days. reduced warehouse and transfer *costs* through advance notice to land purveyors, and saved money on Customs fines for in-bound shipments.
- Several port authorities (such as NY/NJ) have established a regional competitive advantage by implementing an Automated Cargo Expediting System (ACES) that greatly reduces cargo customs clearance and processing time.
- Most of the top 100 ocean carriers are linked with SEA-AMS, enabling filing from around the world around the clock. Small carriers with PC-based commercial interfaces or through fee-based gateway services can also participate. A growing number of rail line (CSX through Sea-Land and Canadian railroads) are linked through the Raillinc electronic information switchboard. About 3 million messages per day are exchanged through Raillinc, and U.S. Customs can communicate with U.S. and Canadian rail companies via Raillinc.
- The American Trucking Associations (ATA) has a task force preparing for a "Motor-Customs EDI Implementation Guide" to facilitate greater motor carriers participation.

Issues of concern of the Customs AMS are:

- Access, cost, and complexity. The U.S. Customs supports the Sea and Intermodal AMS system and two ED1 standards (the American National Standards Institute, Accredited Standards Committee, ANSI ASC X12, and the proprietary Customs Automated Manifest Interface requirements, CAMIR standard) for electronic bill of lading cargo information. Participation requires only electronic interfaces, hardware and data links, and supporting personnel expertise to utilize the SEA-AMS network intermodal operational capabilities for cargo tracking and control.

4. EMERGING INTERMODAL FREIGHT TRANSPORTATION TECHNOLOGIES

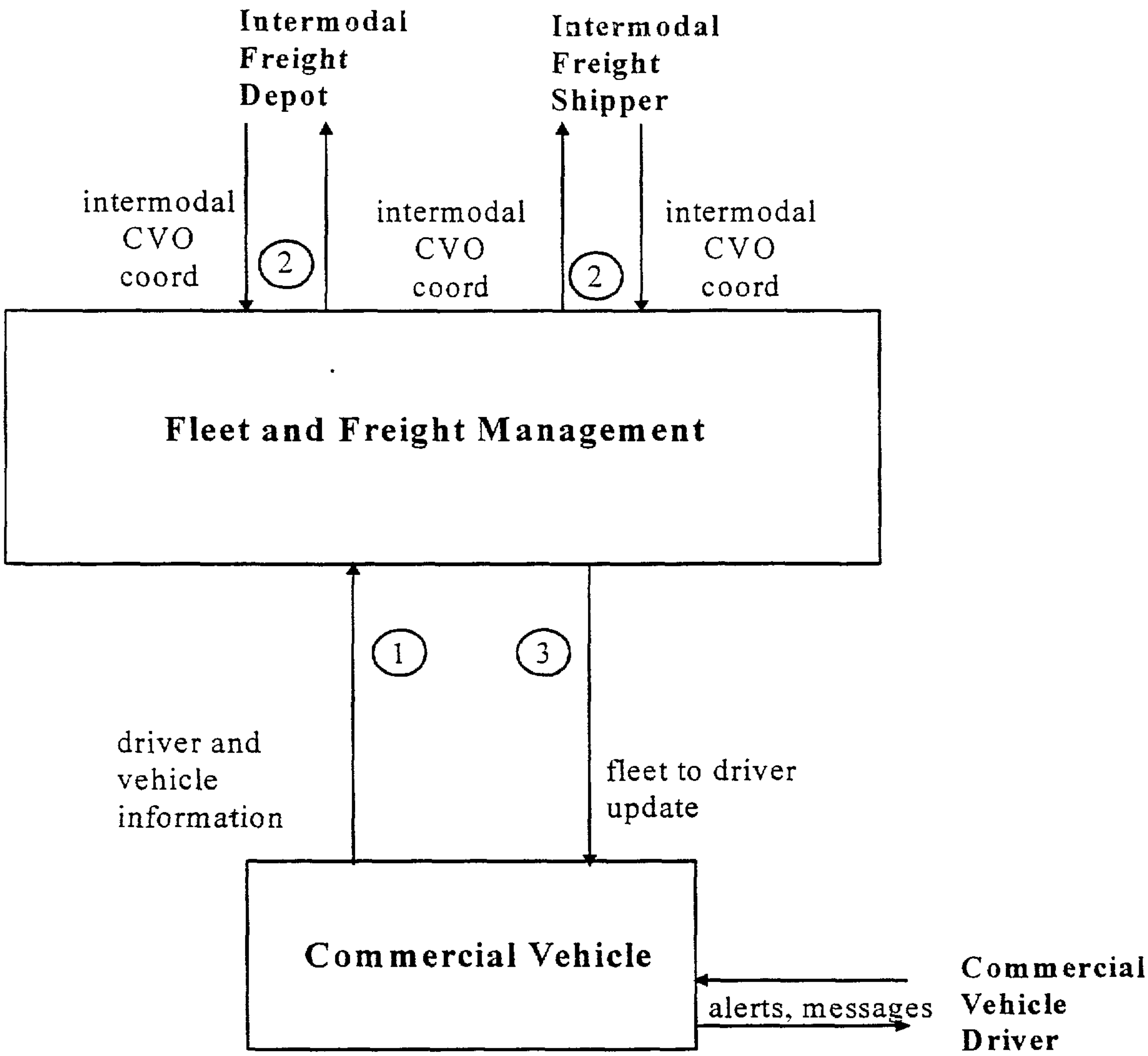
4.1. Intelligent Transportation Systems (ITS)

Intelligent Transportation Systems (ITS) applies advanced and emerging technologies in such fields as information processing, communications, control, and electronics to service transportation needs(12). If these technologies are effectively integrated and deployed, there could result in a number of benefits including(13) :

1. Increase of operational efficiency and capacity of the transportation system.
2. Enhancement of personal mobility, convenience, and comfort.
3. Improvement of safety of the transportation system.
4. Reduction of energy consumption and environmental costs.
5. Enhancement of the present and future economic productivity of individuals, organizations, and the economy as a whole.

Under the CVO program. several ITS technologies are used to improve the safety and efficiency of commercial vehicle operations(13). The Commercial Fleet and Freight Management service is one of ITS-CVO services that provides real time traffic information and vehicle location for commercial vehicles. This service significantly enhances fleet operations management by heiping drivers to avoid congested areas and improving the reliability and efficiency of pickups and deliveries. These benefits are particularly important for operators of intermodal and time-sensitive fleets who can use this ITS service to make their operations more efficient and reliable. The physical architecture for Commercial Fleet and Freight Management subsystem is illustrated in Figure 6(14). The circled numbers signify the order of this process.

In addition to ITS technologies applied for congestion management, collision avoidance, and in-vehicle navigation or communication, a number of enabling technologies are directly related to many intermodal ITS-CVO integrated functions. The enabling technologies are listed below (the last four technologies are shared with other ITS applications)(13)



Source: U.S. Department of Transportation, 1996.

Figure 6. Physical Architecture of Commercial Fleet and Freight Management.

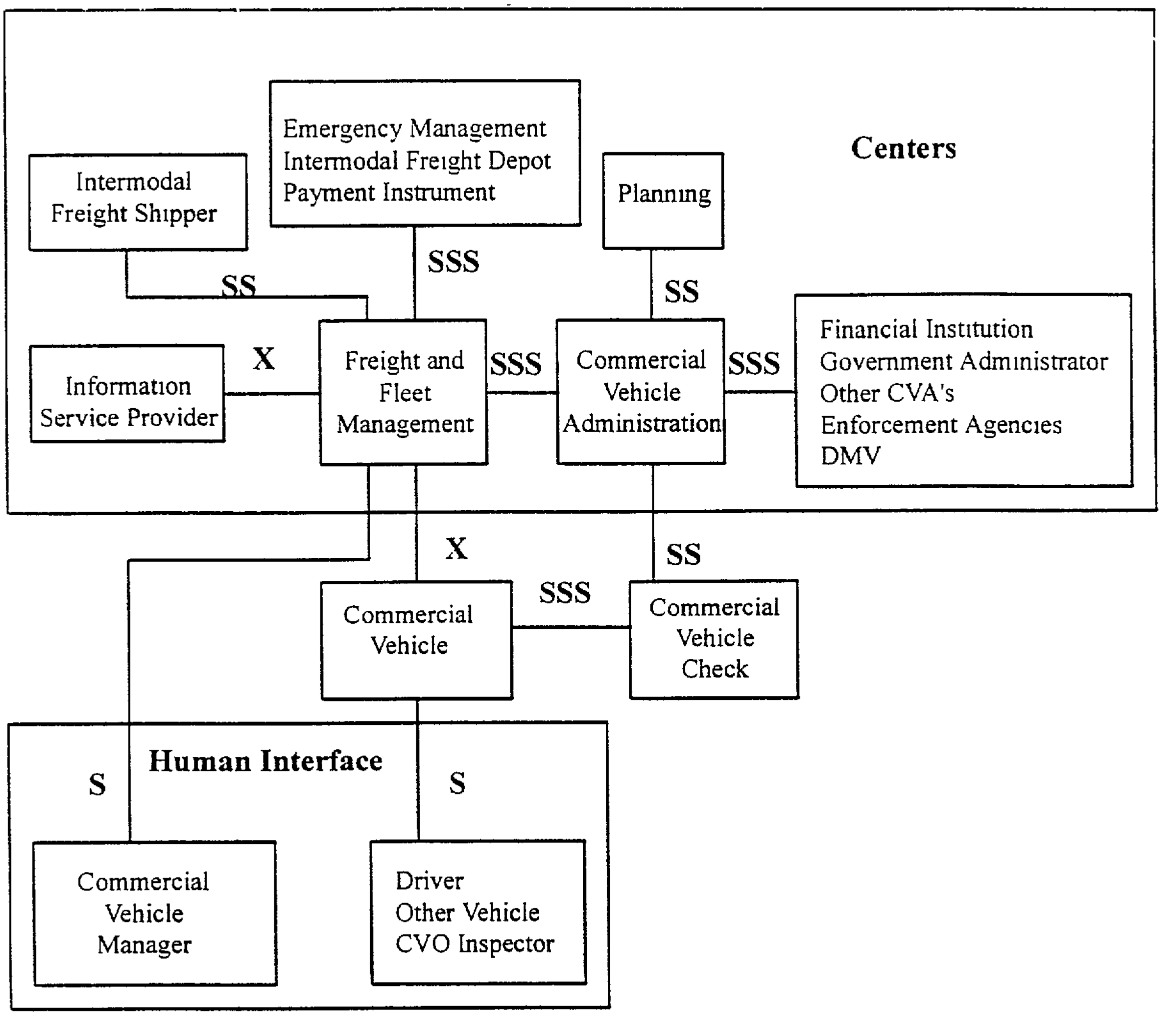
- Automated VehicIe identification (AVI), Classification (AVC), and Location (AVL).
- Automated Clearance Sensing (ACS).
- Weigh-In-Motion (WIN).
- Digital real-time traffic broadcasts.
- Two-Way Real-Time Communications (TWC).
- On-Board Computer (OBC).
- Dynamic network routing and scheduling.
- Roadside beacons.

The National ITS Architecture preserves maximum choice for the interrnodal freight transportation industry while recommending standards for key interfaces within and between the diverse public sector agencies that administrate. regulate, and operate commercial fleets(15). Standards for interfaces between the commercial fleet and the public sector facilitate the regulation of commercial fleets with mutual benefits to the public and private sectors. In contrast, standards for interfaces that do not involve the public sector are left to industry and market to develop. Figure 7 focuses on the interfaces identified by the National ITS Architecture that are directly support freight and fleet management(15).

4.2. Intermodal Container Technologies

Commercial marine containerization, a major step in the growth of intermodal transportation, resulted from the actions of Malcolm McLean, a North Carolina trucker, in the early 1950s(16). Possibly the most significant trend in freight transportation is the continuing trend of containerization. To many transportation professionals, intermodalism is synonymous with the movement of intermodal freight containers by ship, truck, and rail.

Standardization and modularization are the key issues in intermodal container design for ease of handling and durability(11). The trend has been increasing sophistication and diversity for both platforms and containers, including the high cube, overweight containers. Domestic and international containers lengths are 20,24, 35,40,45 and 40,45,48, 53 feet, respectively(8). The



SSS	SS	S	X
Standards support National Interoperability	Standards support Regional Interoperability	Standards support Product Interoperability	No Standards Recommended

Source: U.S. Department of Transportation, 1996.

Figure 7. Freight and Fleet Management Standards.

range of sizes has been expanding and they are stackable. rollable, or solidable onto freight trains, trucks, or ships.

Recent innovations have included use of advanced materials for higher capacity at lower weight, better performance, and longer life. Other innovations arose in response to special purpose platforms and mated designs for containers, such as raodrailers and autostacks designed to transport cars; refrigerated or climate-controlled containers with self-contained power plant or thermal insulation for perishable foods; high strength steel containers for pressurized gases cargo, cryogenic liquids, and hazardous of flammable chemicals. These containers may have side doors or open tops.

Container manufacturers and carriers and terminal operators would benefit from common standards for container load equipment, similar locations for handles and grapple or pin attachment, and common modularization technologies. Streamlined transfer is not possible today because each facility must currently handle non-standard domestic containers as well as international containerized cargo, roll-on, roll-off, Peggy-backs, stacked or open hatch cars for bulk commodities, refrigerated cars for perishable produce, high strength or pressurized or fire-proofed cars for hazardous cargo, etc.

4.3. Terminal Automation and Design

Technologies that promote efficient loading and unloading of container cargo, and cargo sorting and routing at intermodal terminals are often the result of integration of container design, equipment, computer software, and staff operations. Transfer equipment is highly specialized: maritime cranes, gantry cranes, straddle carriers, sidelifts, terminal chassis, and intermodal hybrids, and appropriate mode conversion equipment transfer time(11).

Several Intermodal Container Transfer Facilities (ICTF) around the country represent industry models for best practices. These facilities, for example, as in Los Angeles, illustrate the benefits to the regional economy accruing from port upgrades and intermodal linkage. Other more advanced facilities in major European ports have developed robotics and automated systems for computer control of unload, transfer, and load operations.

4.3.1 Seaport Access Problems

Seaport access problems, when they occur, are usually substantial enough to impede intermodal freight. Such problems include the following”?

- Congested truck access.
- Numerous at-grade rail-highway crossings.
- Inadequate clearances for high-cube double stacks.
- Limited land for improvements.
- Environmental impact regulations (dredging, land filing, air emissions, noise/vibration, traffic congestion).
- Conflict with city/regional plans.

To alleviate such problems, a number of seaport access improvements are proposed as follows:

- Road improvements.
- Schedules changes.
- Mode shift to rail.
- Route restrictions.
- Bridges at-grade rail crossings.
- Rail line consolidation.
- Tunnel improvements.
- Trackage improvements.
- Consolidated terminals or operations.
- Mode shift to rail.
- Rail/truck corridor consolidation.
- Soundwalls.

4.4. Advanced Control and Communications for Freight Trains and Trucks

Exploitation of tracking, control, and communication technology-based services have led to the success of integrated carriers like Federal Express and United Parcel Service (UPS). These technologies have been mated to real-time control and logistics decision-making software. The concept is becoming widely adopted by trucking firms and distribution service providers. Technology-based improvements. such as real-time grade crossing supervision and warning systems, supervisory control distributed networks, solid-state interlocking controls will enhance railroad safety operational efficiency.

5. POTENTIAL COSTS AND BENEFITS OF ITS-CVO INTERMODAL FREIGHT TRANSPORTATION

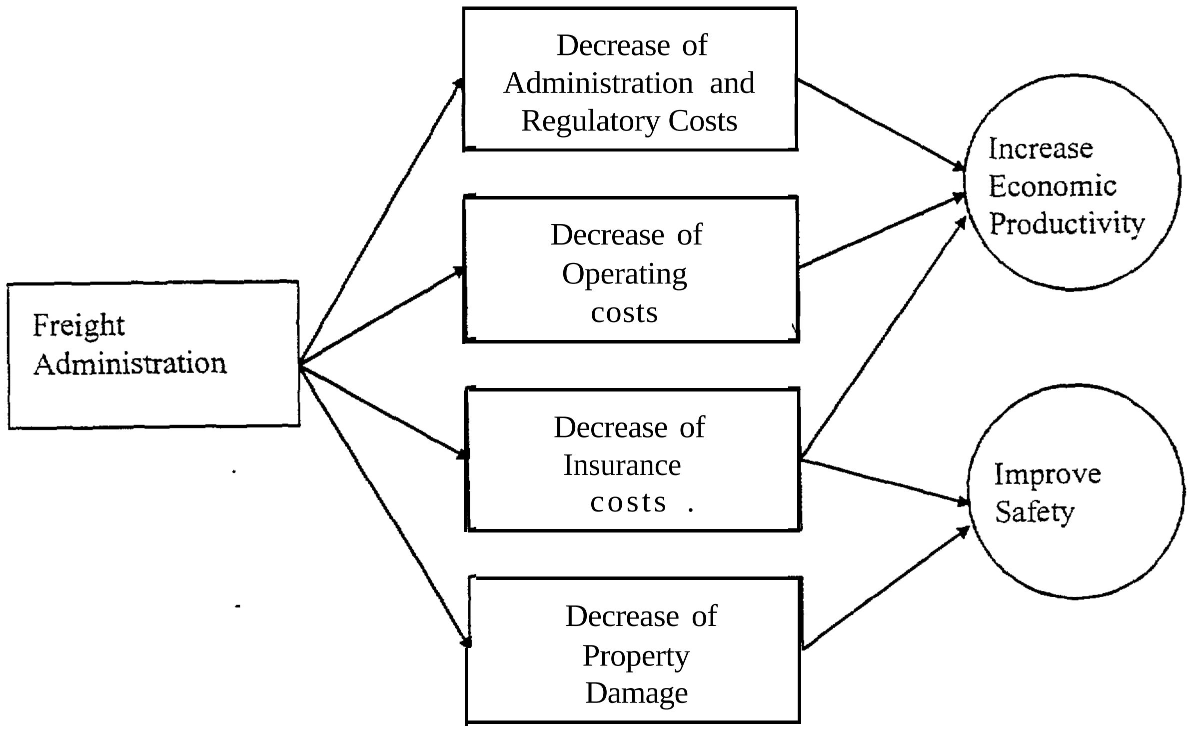
The ITS/CVO market packages in the National Architecture include those relating to commercial vehicle operations and administration. The packages are(17):

- Fleet Administration.
- Freight Administration.
- Electronic Clearance.
- International Border Electronic Clearance.
- Weigh-In-Motion.
- Roadside-CVO Safety.
- On-board CVO Safety.
- HAZMAT Management.

The freight administration market package provides real-time tracking and monitoring of cargo condition. Any changes in cargo condition are reported both to driver and to the fleet manager. In this way, benefits may be realized by preventing or minimizing damage or other adverse conditions among the freight. By tracking movements, fleet managers may also be able to reduce some operating and fleet management costs. These benefits are shown in Figure 8(17).

The costs associated with the freight administration market package include?

1. Non-recurring cost (initial capital investment) of communication interfaces to inter-modal freight depot and shipper. Each interface costs $1,000-2,000 (in 1995 dollars).
2. Recurring cost (operations and maintenance) of freight depot and shipper communications. The cost for each is $600-1,200 per year (in 1995 dollars).



Source: US. Department of Transportation 1995.

Figure 8. Freight Administration Benefits.

A study conducted by the American Trucking Associations (ATA) forecasts that both the private and public sectors will benefit from the freight administration market package implementation(19). The benefit/cost ratios of using mobile communications and computer-aided routing and dispatch by the private sector are 3.25: 1 and 2.0: 1, respectively. The ATA study indicates that the public sectors will also benefit from implementing this market package, but stops short of giving a quantified estimate.

5.1. Non-Technological Barriers to ITS-CVO Deployment

Non-technological barriers to the ITS-CVO market packages deployment are identified as(20):

- *Absence of nationwide capital markets and understanding of benefits in a competing global markets.* The existing U.S. markets are inadequate for meeting the investment needs for large scale projects where the benefits are not fully captured by the investors. The nature of benefits from many ITS-CVO technologies, however, is such that allowance should be made for external benefits (e.g., safety, congestion mitigation, pollution reduction) that are not directly captured by private investors.
- *Industry fragmentation and lack of coordination to close technology-organization gap.* The industry is fragmented and spread across a wide variety of parties, to the extent that it is difficult to encourage one party to invest in a project where all the benefits are captured by the investor. As designing and deploying technological solutions involve a complex interaction of public and private agencies, the size of the industry and the large number of stakeholders involved in the freight community make communication difficult.
- *Under-realized potentials of electronic information commerce replacement of transportation.* ITS-CVO are designed to provide a corresponding information infrastructure that complements the physical transportation. Most of the freight information system is owned and operated by the private sector, and often parallels the ITS-CVO services that are currently provided on a pilot basis by the public sector. The freight industry's use of the ED1 is approaching universal dimensions, Understanding the relationship between ED1 and ITS-CVO communication systems is critical to a successful deployment of these technologies.

Timeliness. accuracy. consistency, and security are major issues in data handling of the freight movement. In each of these instances, institution issues consistently affect technical ones.

- *Barriers to formation of multi-beneficiary freight strategic alliances (private/public).* Given the momentum in the industry to form strategic alliances, a possible solution to the industry fragmentation and lack of coordination is formation of regional cost-sharing consortia. Funding common-user terminals, pooling equipment and freight. and forming information networks to share data on backhaul are among the strategies such alliances pursue.
- *Absence of an analytical framework for performance standards and benefits assessment.* Currently, no single credible benefit/cost framework exists for evaluating the impact on a corporate entity of adopting new ITS/CVO technologies. As a result, the common perception that the operational tests may not have generated the expected benefits.

6. Public Sector's Role in Intermodal Freight Transportation

Governments often impose regulations, documentation, inspection and other requirements which negatively affect the providers to offer timely, effective, and advanced intermodal freight services. For example. many requirements affect the import and export of goods in many countries, including customs, taxes, hazardous materials, health, safety, the desire to bar drugs and criminal activities, and other requirements. Thus, many public agencies must often inspect the documentation of shipments and the shipments themselves before they can be imported or exported. The concern of governments are valid, and usually must continue to be met. However, there are many possibilities for innovations in government processes together with innovations in shipper or provider processes which can significantly reduce the time and costs associated with delays for performance of government-required inspections and other checks. For example, inter-agency coordination and the appropriate use of information technologies can significantly reduce the time a shipment is delayed for inspections, whether at roadside checkpoints, at quashed or in air cargo sheds.

6.1. Why Should Governments Have Any Interest in Intermodal Freight Transportation?

There are several important reasons why governments need to be actively involved in advanced Intermodal freight transportation?

- The availability of quality-focused, cost-effective intermodal freight transportation services can affect how well the firms in a region can compete economically in the battlefield of regional and global economic competition. Thus, jobs, incomes, and growth all depend significantly on logistics capabilities. Governments have an interest in promoting inter-modal freight transportation expertise: in stimulating the development of up to date interrnodal freight transportation services providers; and in reducing regulatory and other barriers to the ability of providers to offer attractive services.
- Intermodal freight transportation services and the fees paid by service providers for facilities, transportation, information services, and taxes can be important sources of revenues to governments.
- Actions in the intermodal freight transportation domain can have important environmental, health, and safety consequences and these are important concerns of governments.
- Often, governments are the major providers of transportation infrastructure that supports the provision of inter-modal freight transportation services, such as air and ocean cargo facilities, intermodal transfer terminals, and others.
- For some modes, the levels of congestion and delays in transportation and terminals are an important issue. Therefore, governments are actively involved in planning, investment, pricing, and/or operational decisions that influence the provision of capacity and the pricing and time dependent availability of facilities and services.
- Often, the logistics services sector is a sector with many small and medium-sized enterprises. In many countries, governments are concerned with viability and survival of such enterprises, and want to ensure this survival through providing awareness programs, educational and resource-expansion export. For example, in some countries governments

acting directly or through trade associations provide support for adoption of EDI (Electronic Data Interchange) or computerization.

- New technologies, such as Intelligent Transportation Systems (ITS), are being introduced to support passenger traffic and enhance commercial fleet management, providing significant opportunities to improve logistics services provisions as well. Governments usually support the development and deployment of such new technologies, and so should have a concern with how they may be used effectively.

For all these reasons, governments should have an understanding of advanced logistics and consider proactive actions to increase the effectiveness of logistics providers in the regions.

6.2. What Governments Can Do?

The most important thing that governments can do is to recognize the importance of logistics services and freight transportation due to their impact on economic competition.

Governments can shift from the perspective of treating individual modes, to the approach of integrated multimodal transportation of freight. Moreover, they can also shift from viewing logistics and freight transportation issues as concerned with infrastructure, such as roads, ports, terminals, etc., to viewing them as concerned with facilitating the more effective utilization of facilities through operational pricing, coordination, information technology, and other means.

Governments may need to change their approaches even further, to *"promote the ability of their industries to compete internationally, by facilitating advanced logistics strategies through reducing barriers to logistics efficiency and promoting innovations, coordination, and advanced service offerings."(7)*

Governments can promote increased capabilities through developing improved human resources, through attracting new people with new skills into the logistics sector. Particularly important is the role of govemnients in stimulating and supporting a wide range of educational offerings designed to promote the quality of professionals and the dissemination of knowledge in the logistics sector.

Governments can have a significant impact by promoting the use of information technology throughout the intermodal freight transportation sector. Particularly important are actions that reduce barriers to rapid adoption of innovations, as well as those that promote an atmosphere of positive managerial actions to exploit current innovations.

7. FUTURE RESEARCH ISSUES AND CHALLENGES IN INTERMODAL FREIGHT TRANSPORTATION

7.1. What is the Objective of the Intermodal Freight Transportation Research?

The objective of the intermodal freight transportation research is to optimize the whole transportation system. rather than to assume that continued optimization of individual freight transportation modes can collectively produce intermodal improvements. The objectives encompass(21):

- Reliable service (on time with no damage).
- Full visibility of cargo and vehicles at all times.
- Accurate and paperless, worldwide, and immediate documentation.
- Maximum flexibility/recovery to delays, load variations, etc.
- Minimum overall costs to users and carriers.
- Continuous and seamless intermodal transportation.
- Security (protection from electronic or physical disruption).

7.2. What are the Benefits of Intermodal Freight Transportation Research?

The benefits of the intermodal freight transportation research can be summarized as follows(21):

- Improve national security.
- Partnerships mechanisms that sustain innovation and optimize investment.
- System management for social/environmental objectives.
- Improved level of service, decreased travel time and cost.
- Systems level understanding and optimization.
- Local economic development.

- New technology development.
- Global competition.

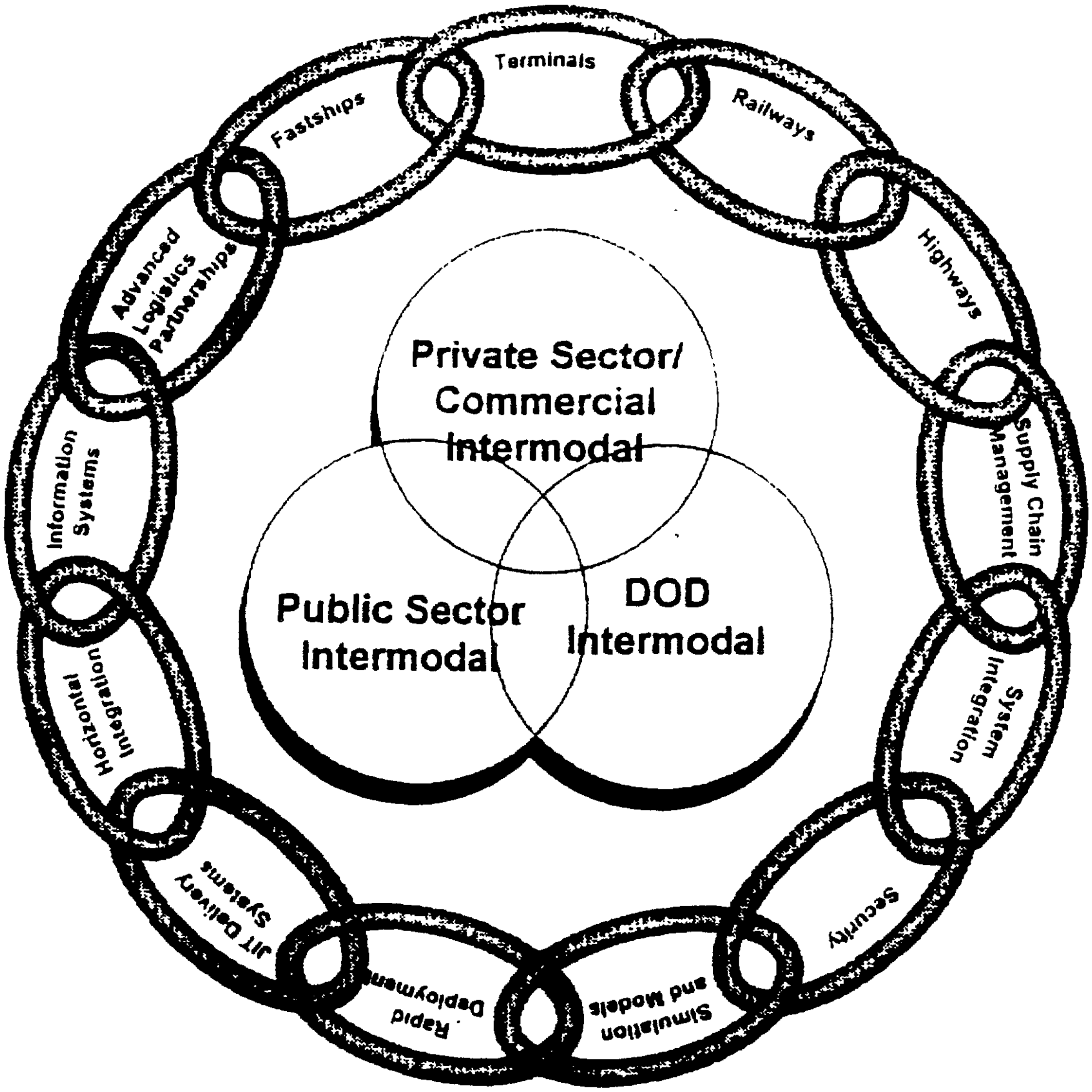
7.3. Who are the Intermodal Freight Transportation Research Partners?

The freight intermodal transportation future will be most efficiently addressed by a robust partnership involving the U.S. commercial intermodal community, the U.S. Department of Defense (USDOD), the U.S. Department of transportation (USDOT), and local, state, and international counterparts(22). This leveraged partnerships for research benefits is illustrated in Figure 9(22).

7.4. What is the Proposed Intermodal Freight Transportation Research Framework?

Five specific areas warranted enhanced intermodal freight transportation system research, development, and evaluation activity(21):

1. Applied information technology. Interoperability, architecture, data bases, information access, and, particularly, information security are key areas for intermodal freight transportation research issues.
2. Systems engineering/systems assessments- including technology evaluation. Here, the focus is on the development of broad models and data bases for the overall freight transportation system. The important elements involve the links between simulations and the real world. Measures of effectiveness must be established in order to make comparisons of different "what if' situations, and the models must be amendable to changing the system.
3. Policy analysis- including financial. This area has two major subcomponents. First, current legislative, regulatory, and institutional barriers to effective intermodal freight transportation operation must be analyzed and the actions required to remove them should be determined. Second, decision-making and partnership-building tools for the wide range of players that are involved in intermodal freight transportation should be developed. Again, demonstration cases will be extremely effective in showing the great value of such tools.



Source: Transportation Research Board, 1996.

Figure 9. Leveraged Partnerships for Intermodal Freight Transportation Research Benefits.

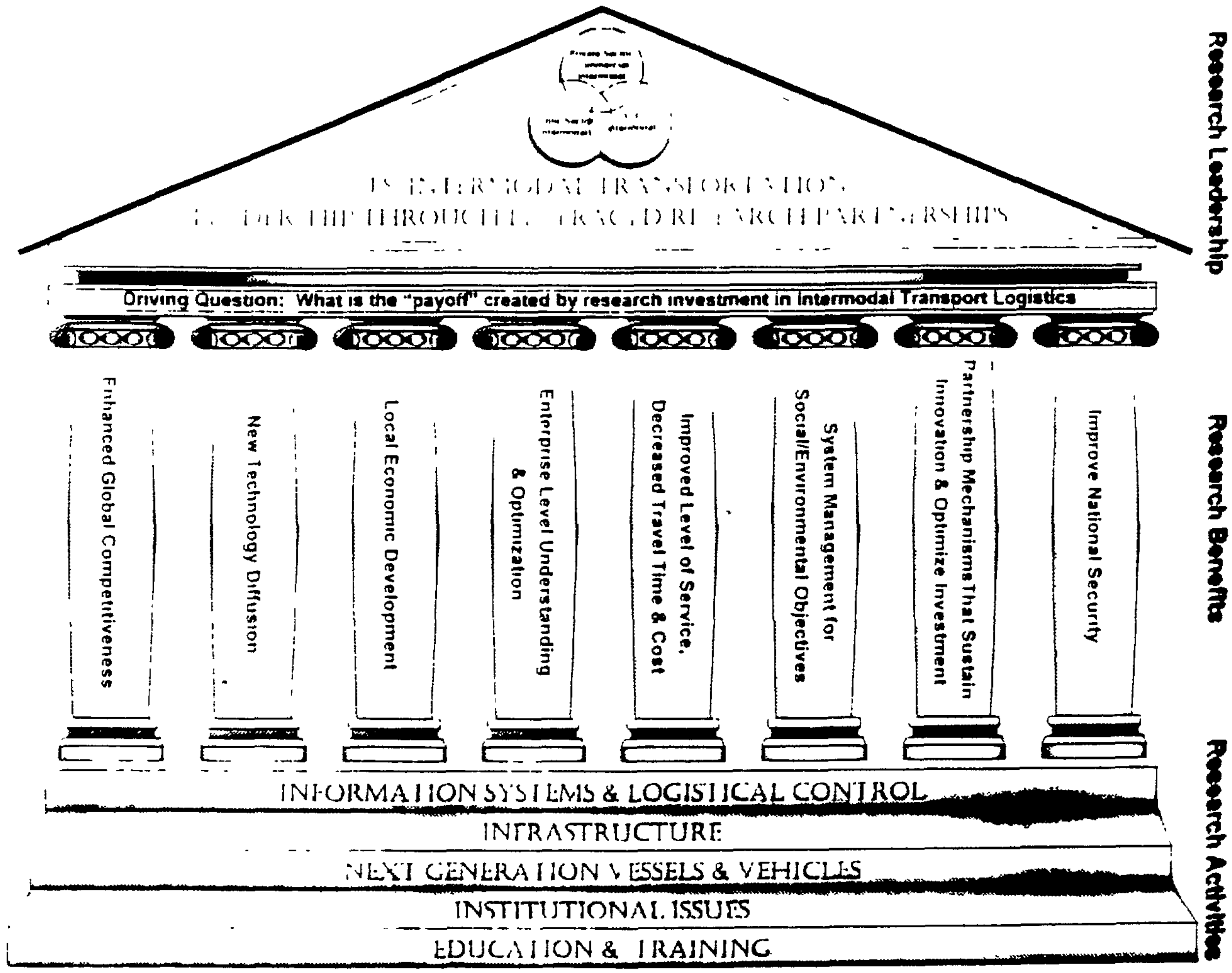
4. Infrastructure/vehicle enhancements. The research in this area shall focus on enhanced. seamless, multimodal freight operations. One area requiring considerable additional research is that associated with hazardous materials transportation network.
5. Technology transfer (information dissemination). Research is required in developing enhanced mechanisms for achieving more rapid dissemination of "best practices" among U.S. intermodal freight transportation participants.

Intermodal freight transportation research leadership, benefits. and activities are illustrated schematically in Figure 10(22).

7.5. What is the Government Role in Intermodal Freight Transportation Research?

The required role of the government is to aggressively remove the barriers and create incentives for technological leadership; as well as to provide financial stimulation in high risk, long-term research, and infrastructure investments that will have the greatest overall benefits for national security, economic competitiveness, and quality of life(21). The Federal Government must take a leadership position in this arena to:

- bring the stakeholders together,
- identify and eliminate institutional barriers to innovation,
- exert leverage over technological issues (such as systems architectures and interoperability standards),
- assure the developments of tools (such as simulations data bases and special-purpose communication links),
- allow optimization among various modes of freight transportation,
- efficiently affect the freight transportation modes interfaces,
- foster consensus among the many stakeholders as priority objectives,
- develop decision aids and evaluation tools to assist the intermodal freight transportation process, and
- insure that measurable progress is achieved.



Source: Transportation Research Board, 1996.

Figure 10. Intermodal Freight Transportation Research Leadership, Benefits, and Activities.

8. CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study was to give a better understanding of the intermodal freight transportation industry and identify the USDOT's role in this arena. To accomplish this research. the author dedicated the research fellowship to reviewing literature, participating in industry conferences and meetings, attending related research activities, and interviewing some members of the industry.

Several conclusions can be drawn from the research. These can be summarized as follows:

- Intermodal freight transportation is the concept of transporting goods using more than one transportation mode in such a way that all parts of the transportation process are effectively connected and coordinated. Interaction among logistics, institutional, and information layers is the key element for its success.
- As the American economy depends more and more on producers and customers all over the world, it is expected that the overall tonnage moved through the U.S. ports will triple over the next 30 years..
- Advanced communication and electronics technologies, such as Automated Equipment Identification (AEI), Automated Vehicle Location (AVL), and Electronic Data Interchange (EDI), currently exist to assist in intermodal freight transportation implementation.
- Intelligent Transportation Systems applications, new intermodal container technologies, terminal automation and design, and advanced control and communications for freight trains and trucks are promising emerging technologies for intermodal freight transportation growth.
- The American trucking Associations (ATA) forecasts that the benefit/cost ratios for using mobile communications and computer-aided routing dispatch by the private sector are 3.25: 1 and 2: 1, respectively.

- The federal government's role in intermodal freight transportation is to promote the ability of the industry to compete domestically and internationally, reduce barriers to logistics efficiency and promote innovations, coordination, and advanced service offerings.
- The actual responsibilities for freight transportation, including intermodal services implementation, should remain in the hands of the commercial freight industry.
- Intermodal private sector, the Department of Transportation, and the Department of Defense cooperation is the leadership of the intermodal freight transportation research.
- Applied information technology, systems engineering/systems assessments, policy analysis, infrastructure/vehicle enhancements, and technology transfer are warranted intermodal freight transportation future research activities.

The study recommends to the U.S. Department of Transportation the following:

- The Department should not take direct responsibility for freight transportation, including inter-modal, as it is a private sector activity.
- The Department's role in intermodal freight transportation is the cooperation with the inter-modal freight private sector and the Department of Defense to aggressively remove barriers and create incentives for technological leadership as well as to provide financial simulation in high risk, long-term research, and infrastructure investments that will have the greatest overall benefits for national security, economic competitiveness, and quality of life.

BIBLIOGRAPHY

1. Toward a National Intermodal Transportation System, Final Report. *National Commission on Intermodal Transportation,* pp. 6, Washington, D. C., 1994.

2. National ITS Program Plan, Synopsis. *US Department of Transportation/ITS America,* pp. 1, Washington, D. C., 1995.

3. National ITS Program. *US Department of Transportation/lTS America.* Vol. II. pp. 228. Washington, D. C., 1995.

4. Muller, *G. Intermodal Freight Transportation,* 3rd. edition, Eno Transportation Foundation, Lansdowne, VA, 1995.

5. ISTEA and Intermodal Planning, Concept, Practice, and Vision. *Proceedings to the Intermodai Planning Issues Conference,* Irvine, CA, 1992.

6. Intermodal Freight Transportation; Impediments, Financing, and Background Information. *US Department of Transportation/Cambridge Systematics, Inc.,* pp. 16, Washington, D. C., 1995.

7. Scientific Expert Group TT6 on "Integrated Advanced Logistics and Innovations in Freight Transportation", Final Report. *Organisation for Economic Co-Operation and Development,* pp. 11, Paris, France, 1995.

8. Landside Access to U.S. Ports. *Transportation Research Board/National Research Council,* Washington, D.C., 1993.

9. Statistical Abstract of the United States. *U.S. Department of Commerce/Bureau of the Census,* pp. 664, Washington, D.C., September, 1996.

10. Landside Access for Intermodal Facilities. *US Department of Transportation/Federal Highway Administration/National Highway Institute,* Washington, D.C., November 1995.

11. Brecher, A. *Intermodal Freight Technologies: Overview and* Issues. US Department of Transportation/National Transportation Systems Center, pp. 3, Washington, D. C., 1994.

12. National ITS Program Plan, Volume I. *US Department of Transportation/ITS America,* Washington, D.C., March 1995.

13. Strategic Plan for Intelligent Vehicle-Highway Systems in the United States. *US Department of Transportation/ITS America,* Washington, D.C., May 1992.

13. ITS Architecture Theory of Operations/Draft. *U S Department of Transportation/Joint Architecture Team*, Washington, D.C., April 1996.

15. ITS Architecture Implementation Strategy/Draft. *US Department of Transportation/Joint Architecture Team*, Washington, D.C., April 1996.

16. Chttejee, A. et el. *Intermodal Freight Transportation and Highway Safety*. US Department of Transportation/Southeastern Transportation Center, Raleigh, North Carolina, 1995.

17. ITS Architecture Performance and Benefits Study/Draft. *US Department of Transportation/Joint Architecture Team,* Washington, D.C., April 1996.

18. ITS Architecture Cost Analysis/Draft. *US Department of Transportation/Joint Architecture Team,* Washington, D.C., April 1996.

19. Benefit/Cost Analysis of the Intelligent Transportation Systems/Commercial Vehicle Operations (ITS/CVO) User Services/Draft. *US., Department of Transportation/The American Trucking Associations (ATA) Foundation, Inc., Washington, D. C., February 1996.*

20. Norris, B. B and Kennedy, N. *U.S. Freight Industry: Non-Technical Barriers to the Application of ITS/CVO Technologies/Draft*, U.S. Department of Transportation/John A. Volpe National Transportation Center, Cambridge, Massachusetts, November 1995.

21. Gansler, J.S. *Realizing an Intermodal Future: R & D Issues in the Commercial, Military, and Public Arenas/Data,* A Presentation to the "Setting the Intermodal Transportation Research Framework Conference", Transportation Research Board, Washington, D.C., March, 1996.

22. King, J.L. and Vickerman, M.J. A Research Framework Presentation to the "Setting the Transportation Research Framework Conference", Transportation Research Board, Washington, D.C., March, 1996.