ONFERENCE PROCEEDINGS 12

National Conference on Setting an Intermodal Transportation Research Framework

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National Conference on Setting an Intermodal Transportation Research Framework

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Preface

The conference on Setting an Intermodal Transportation Research Framework brought together a distinguished assembly of public officials, academicians, commercial leaders, and military specialists. During the conference, each of these groups of professionals found noteworthy synergies in their intermodal interests. Papers contained in these proceedings reflect those synergies.

At a preliminary meeting of 75 intermodal experts, held in December 1995, the scope and objectives of the conference were developed. At that meeting, representatives of the Port of Oakland, California, and the Port of Savannah, Georgia, presented carefully prepared case studies of actual and projected stresses related to military surge moves through their ports. The Port of Oakland case study, presented by John Glover (Oakland's Director of Planning), and the Port of Savannah case study, presented by Charles Griffen (Director of Port Planning and Harbor Development with the Georgia Ports Authority) and M. John Vickerman (CEO of Vickerman-Zachary-Miller), provoked insightful discussions. These case studies focused the committee's attention on the profound consequences that the nation's landside and seaport infrastructure will face in striving to accommodate military traffic.

For the March 1996 conference, graphics that conceptualized the nexus of intermodal interests, the potential benefits of intermodal research, and the five broad areas for future research were used to focus discussions (see Figures 1 through 4 in the Executive Summary). The graphics serve as perhaps the most succinct way of capturing the complex array of topics and interactions the conference and town hall discussion was intended to extract. M. John Vickerman, who supplied the graphic support, deserves grateful recognition; the visual displays provided significant insights into the concepts underpinning the need for intermodal research. In many cases, the picture was worth a thousand words.

The March 1996 conference was another step toward a strengthened intermodal partnership. Each member of the steering committee, attendees at the December 1995 meeting, and those who were part of this conference were stimulated, informed, and perhaps changed by the events. The contributions of many individuals deserve recognition for this advancement and are deeply appreciated.

To quote John Schaar:

> The future is not a result of choices among alternative paths offered by the present, but a place that is created—created first in mind and will, created next in activity. The future is not some place we are going to, but one we are creating. The paths to it are not found, but made; and this activity of making them changes both the maker and the destination.

It was a privilege and an honor to lead this group of individuals who are both defining and creating our collective intermodal future.

C. Michael Walton
Chair, Conference Steering Committee

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Executive Summary

Anne Strauss-Wieder, Anne Strauss-Wieder, Inc.

In March 1996 the Transportation Research Board convened 140 prominent professionals from industry, academia, government, and the military to discuss the possibility of developing a framework for intermodal transportation research—one that would respond to a nexus of intermodal interests among three sectors of intermodal activity: the private/commercial sector, the public sector, and the U.S. military (Figure 1). TRB organized the conference at the request of the Defense Advanced Research Projects Agency (DARPA), U.S. Department of Defense (DOD), and the Office of Intermodalism, U.S. Department of Transportation (DOT). The conference and town hall meeting were designed to review current practices as well as the future vision of these three communities. The event brought together innovators from each of the three sectors to discuss the internal and external forces that are shaping their intermodal logistical activities.

What we are here to do:

- Present a preliminary framework for intermodal research issues.
- Suggest that the intermodal future will be most efficiently addressed by a robust partnership involving the world-class U.S. commercial intermodal community, the U.S. Department of Defense, the U.S. Department of Transportation, and local, state, and international counterparts.
- Obtain your professional critique and input on the framework as a dynamic project rather than a static document.
- Discuss intermodal strategies aimed at
  - –removal of institutional barriers,
  - –strategic partnering,
  - –technology investment approaches,
  - –management of a transport "system,"
  - –development of intermodal management tools,
  - –improving system capacities, and
  - –determining responsibilities for funding and carrying out research agenda.

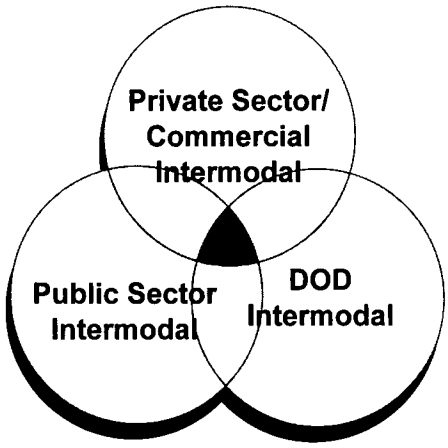

FIGURE 1 Three sectors of intermodal activity—the private/commercial sector, the public sector, and the U.S. military sector—create a nexus of intermodal interests and research issues.

What we are not here to do:

- Present a static approach to an intermodal future.
- Replace the resident excellence of the
  –military command structure or
  –the U.S. Department of Transportation's modal administrations.
- Advocate any specific technologies or programs.
- Advocate any specific companies or research laboratories.

The conference was designed to examine and test four basic hypotheses that suggest a rationale for a research framework to study the integrated use of multiple modes of transportation. These four hypotheses were the focus of this conference.

1. *Integration of Transportation Modes Is Crucial: Intermodalism Adds Value.* Intermodal transport is a value-added complement to modal transport, not a substitute. The capital-intensive, infrastructure-building era has largely ended in this country and is being replaced by an intermodal era—the focus shifts from building to managing for optimization. There is additional economic value to be derived from transport: it comes from exploiting the existing infrastructure to increase capacities. This integration of modes should take full advantage of the potential offered by rapid advances in information technology.

2. *A Nexus of Interests Has Formed: An Enterprise-Level Response Addresses All Sectors.* There is a nexus of interests in the United States that must be addressed on a transportation enterprise level. It encompasses the public intermodal, the private intermodal, and the military transportation systems. These three transportation sectors realize that intermodalism is an inevitable and strategic method of doing business.

3. *Complex and Multiple Imperatives Drive the Need: Now Is the Time to Respond.* A multiplicity of imperatives drives today's needs. Those imperatives include global, economic, and social trends; customer demand; information technology advances; and a just-in-time operating strategy for both people and goods. Intermodal transportation has developed at a different pace and along different timelines for each community; but now, in an era of doing more with less, there is a tacit mandate for the three sectors to forge a new framework for cooperation. Emerging from the conference came the clear understanding that the efficiency of one of the sectors of intermodal activity will directly affect the efficiency of the other two.

4. Coordinated and Collaborative Research Highlight Complementarity: Benefits Are Multiplied. Coordinated research and analysis of applied intermodal practices can yield benefits to consumers, shippers, and military transporters. Some aspects of the nexus of interest are more clearly defined than others, and research and oversight will help better define areas of complementarity, etc. Collaborative research efforts can multiply those benefits to a broadly defined set of public interests (that own, maintain, and regulate or promote the nation's transport infrastructure), to the intermodal private sector (which moves the goods and directly contributes to the nation's global competitiveness), and to the military sector (an exceptionally large and unique user of intermodal transport infrastructure and services).

To investigate these hypotheses, background papers were commissioned, and key panelists examined the driving forces behind intermodalism; thus, a framework was presented. The presented papers, the various panel presentations, and the open forum discussions suggested a logical progression for envisioning an intermodal future and developing a national research program to support it. From different vantage points, the three communities examined what has changed, the pace of that change, what is working, and what needs to be done. From these discussions, a framework to guide future progress emerged. The entire conference was structured as an interactive forum with a town hall meeting on the second day to elicit the collective opinions of the participants. Major themes were identified that confirmed a ground swell for change is under way and that the time has come for a serious national reorientation that focuses on intermodalism.

Partnerships That Build on Respective Strengths

The three communities comprising the nexus are at significantly different points in their intermodal evolution. Leading the discussion on intermodal innovation was the private sector, which has been growing more intermodally efficient since the rail, trucking, and shipping industries were deregulated in the 1970s. Industry, with 20 years of intermodal expertise and clear bottom-line imperatives, has positioned the U.S. commercial intermodal system to serve as a world-class model with technological expertise that could be adapted to the public and military sectors.

DARPA, as the research arm of DOD, has launched the "Transtech" program to support advanced logistics. The department has also been developing its transportation systems along intermodal lines since the creation of U.S. Transportation Command (TRANSCOM), which is the Defense Department's single manager for defense transportation. Desert Storm/Desert Shield immediately sharpened the need for strategic management of the total trip through advanced logistics and in-transit visibility. In short, DOD, the single largest shipper in the nation, has significant intermodal challenges to bring to the nexus.

DOT brings significant technical expertise as well as national priorities to the discussion of intermodal logistics. The Transportation Department's move toward unified intermodal transportation management intensified with the passage of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). That legislation advanced the vision of a national intermodal transportation system that is economically efficient, environmentally sound, and provides the foundation for the nation to compete in the global economic arena. The Act set the stage for the Transportation Department to build on and add value to its modal strengths; and it opened the door for flexible financing for multiple transport options based on need rather than categorical funding.

The public intermodal sector (DOT, states, and localities) owns and manages the majority of the nation's infrastructure. Ownership gives the public sector the unique ability to promote, regulate, and manage a transportation system that can leverage synergies between the strengths of each sector, thereby promoting a unified transport system.

Changing Needs, Changing Mandates

The issues facing the U.S. transportation community today include new regulatory and financial concerns, increased global competition, and a new set of national security requirements. "Doing more with less" summarizes the financial imperative emerging in both the public and private sectors. The ramifications of this imperative are so profound that the topic dominated the conference discussions. For public sector agencies, doing more with less means managing with increasingly limited funds for research and infrastructure investment. For DOD it means making greater use of commercial services to meet national security needs. For private sector firms, it means improving customer service while simultaneously reducing costs. Nevertheless, a common theme emerged from these divergent concerns: the need to maximize the use of existing assets through leveraged partnerships and the need to integrate or rationalize systems by applying new technologies to manage intermodal transport (Figure 2).

The challenges of the global economy have also become more pressing in the last 5 years. Expansion of the international marketplace is generating new demands for transportation services with more competition among firms. Geographically divergent locations for manufacturing and commerce result in more international cargo and passenger movements. Increased competition generates more pressure to reduce costs while expanding service to new markets.

Private sector firms have been factoring global competition into their business strategies for several years; however, conference participants observed that public sector agencies need to become more cognizant of America's membership in a much larger community. Practical considerations, such as facilitating and handling more international freight and passenger movement through U.S. gateways, were highlighted. Domestic market pressures that require intermodal solutions are just as significant as the obvious congestion at key ports such as Los Angeles and Long Beach in California. Concerns about falling behind the rest of the world in transportation infrastructure investment and technology deployment were voiced. Participants also saw the opportunity to learn from the experiences of other countries. Just as other countries studied U.S. operations before investing in their own facilities, conference participants felt that U.S. organizations could benefit from evaluating best practices and emerging technologies overseas.

In addition, the military is emerging as a major new customer for commercial services and civilian facilities, bringing extraordinary challenges to the transportation community. The end of the cold war refocused the Defense Department's transportation objectives. The emphasis is now on rapid deployment for delivering strategic support and supplies to any place

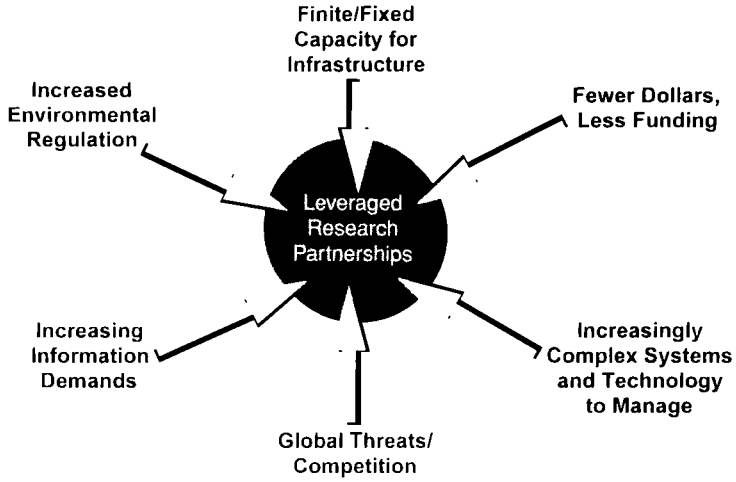

FIGURE 2 External institutional pressures demand that more be accomplished using fewer resources. A solution is intermodal transportation leadership through leveraged research partnerships.

in the world at the right time in the proper quantities. Increased budgetary constraints also require the military to rely more on commercial services to meet its needs.

Because the department is already a major transportation user, spending in excess of $2 billion annually on commercial freight services alone, its emphasis on intermodalism cannot be overlooked. DOD relies on commercial providers for 90 percent of its peacetime passenger and freight transportation needs and an estimated 85 percent of its wartime movements. The military will soon place even greater demands on the civilian transportation system: by 2001 the department must be able to respond to two nearly simultaneous and geographically divergent major regional contingencies (MRCs), each the size of Desert Storm. An evaluation of Desert Storm concluded that the logistical operation could have been shortened by 100 days and decreased by one million tons had there been more coordination of planning and execution, optimization of lift scheduling, and greater visibility in the process. Nevertheless, Defense is still concerned that, even optimized, such surges—i.e., their need to ship 7,000 containers a week, along with troop and rolling stock movements—could overwhelm the commercial transportation system and the public infrastructure. Meeting the new military requirements will necessitate an assessment of existing U.S. transportation facilities to identify where they can be reconfigured to handle such massive short-term surges and where auxiliary capacity may be necessary. Like the private sector, the military is seeking to improve in-transit visibility and control so that it can respond to situations faster, with greater agility, and at lower costs. Concerns were voiced about the ability of current information and logistics systems to keep up with, track, and, if necessary, redirect the vast quantities that have to be moved.

Adapt Best Practice: The U.S. Private Sector is Leading the Way

In the past 5 years the private sector has led the way by proving that an integrated transportation system makes economic sense. Commercial providers have also developed the information systems necessary to enable in-transit visibility and management and demonstrated the benefits of partnership arrangements.

The systems approach (intermodalism) to providing transportation services grew from the private sector's embracing the "total trip" concept—managing and profiting from a movement from point of origin to final destination. Those in the private sector realized early on that the customer is more concerned about receiving the shipment at the right time and place and at the lowest price than in knowing how the shipment got there. Routing and modal selection are then optimized to provide the best door-to-door service at the lowest price.

In many cases, intermodalism—the use of more than one mode during the trip—is the most cost-efficient way to facilitate the total trip move. Intermodalism does not replace or compete with modal transportation. Rather, private sector transportation providers are improving the efficiencies of individual modes and then using intermodal connections and information technologies as system integration tools.

The total-trip concept, which originated in the freight area, is now being adapted to passenger movements. Better connectivity between modes is being advanced through a variety of approaches including joint terminal planning and advanced, coordinated passenger information systems, such as kiosks and web sites. The military has also embraced the concept and is trying to optimize the movement from "factory to foxhole."

Information systems are enabling a new era of highly coordinated logistics. In-transit visibility and management, that is, knowing where your shipment is at all times and having the ability to redirect it, is becoming commonplace in the commercial distribution industry. Kodak, Wal-Mart, and many other firms can respond to their customers faster and more flexibly, while reducing costs, through the use of advanced information systems and partnership arrangements with transportation providers. "Just-in-time" was the first wave—replacing inventory with transportation. Information management is the second wave—replacing the need for physical possession of inventory with the real-time, in-transit management inven-

tory. In-transit visibility is being realized through the development of advanced logistics software, communications technologies, electronic tagging of cargo and equipment, and remote sensing.

The potential of these information systems to improve customer service and cost efficiency goes beyond the commercial goods movement industry. Just as the total-trip concept spread from the freight sector to passenger and military operations, advanced information systems will make the same progression through the transportation community.

Partnerships are another success story from the private sector. Beneficial partnerships have occurred within modes (such as vessel-sharing agreements among shipping lines and code-sharing agreements among airlines) and between modes (such as agreements between trucking firms and railroads). Successful partnerships allow each partner to capitalize on their strengths. In the same vein, public-private partnerships are evolving; in a financially constrained environment, partnerships present a logical approach to advance transportation projects and investments.

Seize the Leadership Opportunity: Harvest Intermodal Synergies

A "nexus of need" exists. DOD relies increasingly on commercial freight and passenger services for the strategic mobility requirements related to national security. DOT, along with state and local agencies, recognizes that passenger and freight transportation practices are changing. The public sector must, therefore, change the way it conducts business so that it may respond accordingly. Finally, private sector transportation organizations are seeking to maintain their world-class status and look to the public sector for continued infrastructure investment, system safety enhancements, capacity management, modified regulatory requirements, and policies that advance the technology.

The framework to move forward should address the nexus of needs, as well as help the transportation community go beyond today's paradigm, by exploring and disseminating new intermodal technologies in order to move people and goods. With increasing budgetary constraints, the research undertaken must also be cost effective, either benefiting multiple end users who will partner to support it financially or producing research that can be leveraged to solve a variety of related problems (Figure 3).

Within this framework, five broad categories of initiatives were identified:

1. resolution of institutional issues aimed at integrating end-to-end services from several providers;
2. best-practices research, data bases, and T^2 technology transfer;
3. exploration of surge or peak capacity requirements and solutions;
4. advancement of information technologies, while protecting security and privacy of information; and
5. examination of system impacts of next-generation vessels and vehicles.

- Resolution of institutional issues is crucial to the continued competitiveness of the U.S. transportation system. Conference participants urged public sector agencies to move from a regulatory relationship with the private sector to more of a partnership arrangement to facilitate transportation in today's globally competitive, financially constrained environment.
- Best-practices research would examine current practices, benchmark best-practices, and recommend action where needed. Current U.S. operation and investment practices, technology applications, and institutional relationships as they affect the movement of passengers and freight would be identified and assessed. Current U.S. best-practices would be used as a benchmark by other countries against which to compare themselves. Best practices from the private sector that are applicable for the military and public sector agencies would also be identified, allowing the U.S. transportation community to build on its own strengths.

• Development of timely, validated, and publicly available data bases on passenger and freight movements was also urged by conference participants. These new data bases would use information from commercial electronic data interchange (EDI) systems, yet maintain enterprise-level security and privacy requirements. The development of system-wide simulation models to aid in integrated operational planning for joint use of public and commercial infrastructure was also recommended.

• Dissemination of information can expedite the implementation of best practices and technology advancements, thus helping the transportation community move into the future. Conferences, training courses, on-line forums, and education were seen not only as mechanisms for disseminating information, but also as the means for turning the concepts of today into the practices of the next generation of transportation professionals

• Exploration of surge movement requirements and solutions could simultaneously address military and civilian needs. Although the surge movements required by the military may be unique in terms of scale, they are analogous to the problem of handling peak-period congestion and natural disasters, which cause widespread disruption in transportation. Sim-

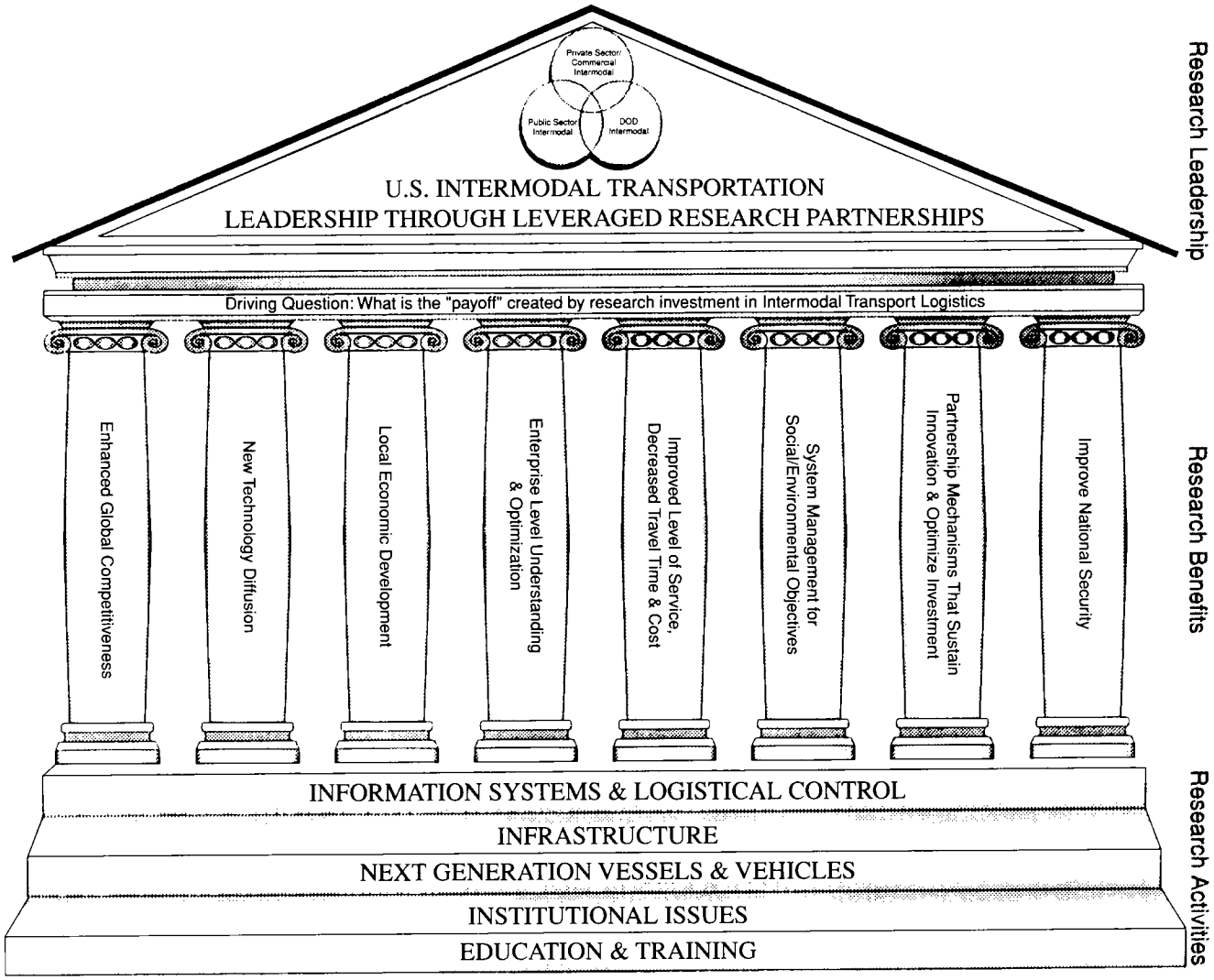

FIGURE 3 The nexus requires leadership to do more with less. External leadership under a neutral structure can ensure success.

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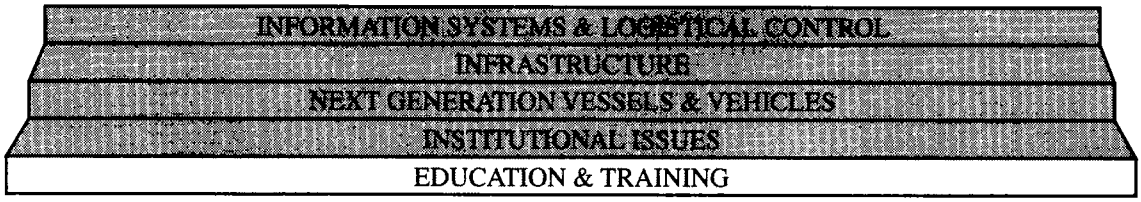
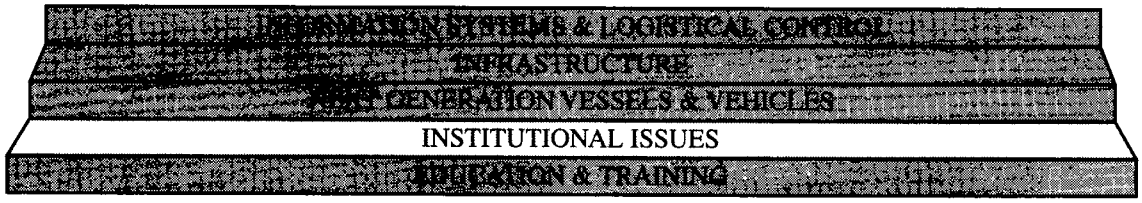
FIGURE 3 *continued*



	Commercial	Military	Public
Strengths	World class intermodal leaders that provide: – Management Models – Service Delivery Models – Training Models Logistics/Intermodal Associations – CLM – Freight Stake holders Network World Trade Center(s)	Generates Nation's most complex transport surges Logistics systems emphasis – DARPA – DLA – Service Branch Logistics Partnership Learning Models – CRAF, VISA – NDTA Military Academy(s)	National Intermodal Initiative, ISTEA National Highway Institute University Level Programs
Needs	Mechanisms to effectively and efficiently partner with the military and public sectors	Adaptation of interoperable environments while ensuring – Asset Control – Asset Visibility	Ways to reengineer management structures Development of university level and mid-career level training

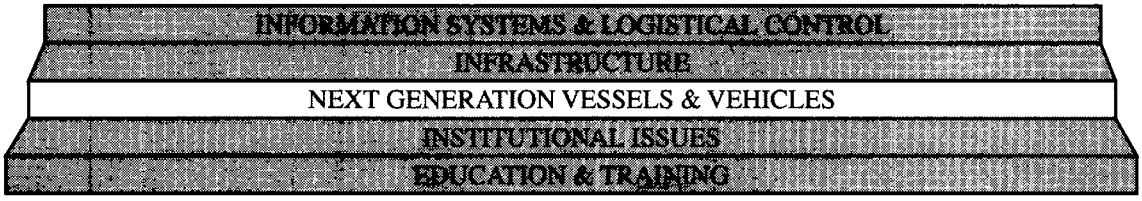
Disseminate Best Practices



	Commercial	Military	Public
Strengths	World-class intermodal practices – Maximize returns from capital assets – Performance-based transportation – Customer driven transportation	User of both commercial and public systems National security mandate – High-level complex demands with maximum agility – R&D resources and technology expertise	Can mediate conflicts between system users Can regulate for system efficiency or deregulate Can stimulate change through focused seed funds, grants Protector of social and environmental aspects of transportation
Needs	Challenge to understand and accommodate military and public transport cultures Often military and public needs (which detract from commercial needs) do not complement	Seeks cost-efficient, flexible, and rapid deployment response capability Seeks interoperable integration of corporate and public models	Need broad-based – System management information – Information on corporate and military transportation culture – Diversified and flexible programming

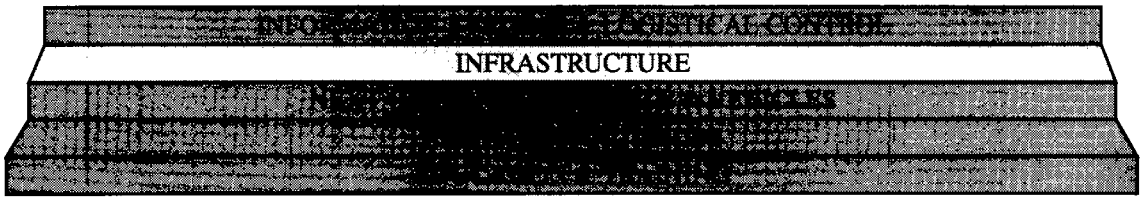
Partnership Building Tools

FIGURE 3 *continued*



	Commercial	Military	Public
Strengths	FastShip(s) Smart Cars/Trucks Advanced Train Control Iron Highway Road Railer Jumbo Airships AEI 5th Generation Container Vessels	FastShips Jumbo Airships Expanding intermodal role in deployments Advanced component technologies System level perspective	Smart Cars/Trucks ITS intermodal initiatives Oversees green factors of new vehicles/vessels
Needs	Impacts and cost to public and military Leverage solutions	Impacts on and cost to commercial and public system	Impacts and cost to total system Need complete information for stewardship role

Enterprise level understanding of new vessel/vehicles



	Commercial	Military	Public
Strengths	Strategies to minimize capital asset expenditures wherever possible Ability to invest in optimization strategies	Superior ability to deliver transport on a command-and-control basis	Can stimulate – Modal shifts – Modal optimization – Improved hub access Funds, oversees – Highway complex – Ports—navigation systems – Some public terminals – Transit properties – Airports – Traffic control systems
Needs	Public infrastructure operational dependencies – Highways – Ports – Access to congested terminals	Limited intermodal infrastructure ownership necessitates: – Increased partnerships for joint use of public and private facilities – Immediate access to public and private infrastructure for capacity surge requirements	Management strategies that: – Focus on and fund intermodal solutions – Adapt commercial models – Balance conflicting system demands – Minimize capital asset expenditures

Integrated operational planning for joint use of public and commercial infrastructure

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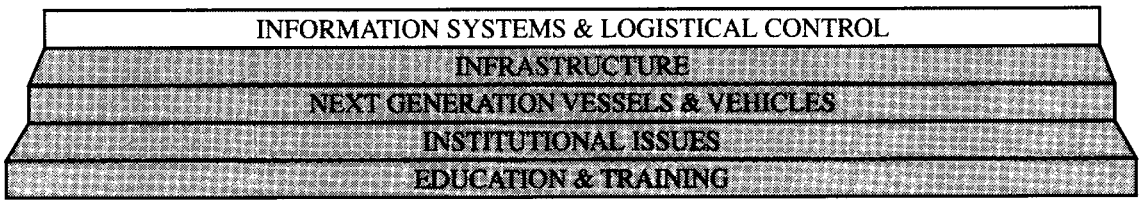
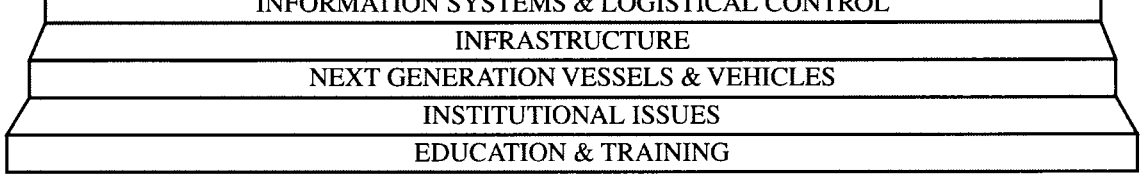
FIGURE 3 *continued*



	Commercial	Military	Public
Strengths	Simulation modeling Valid data bases that are shared on discreet basis with partners for strategic effectiveness Ability to rapidly collect and sort data	Strategic global simulations and gaming scenarios System Security – Physical – Electronic Controlled data and information sources – Extensive command-and-control systems for global movements	Ability to collect vast amounts of data – On traffic flows – Capacity availability

Needs

Dramatic reductions in travel time and cost with improved level of service
Large-scale systems analysis that accommodates multiple needs
End-to-end performance analysis
System analysis that addresses a variety of proprietary issues
Harmonization of AEI platforms for data collection
Protection of information and communication security issues



Summary of Intermodal Research Issues

- **There is a need for an intermodal research partnership driven by**
  - **Common reasons**
  - **Shared commitments**
  - **Diminished resources**
- **Significant challenges to this partnership exist**
  - **Varying cultures and dispositions**
  - **Varying strategic needs**
- **An action plan is vital to realize**
  - **Benefits of current technologies, particularly information technology, to optimize transportation**
  - **Tighter links between U.S. Department of Defense public-commercial sectors**
  - **Intermodal R&D resources and program coordination**
  - **Increased level of partnering with the private sector**

ilarly, commercial operators are seeking new ways to improve throughput at their facilities. Research in this area may involve investigations of new technologies, modal shifting, and operational approaches for increasing the efficiency of existing facilities, as well as analyses of optimal locations for capacity management.

- Advancing information technologies could lead to improved efficiencies throughout the transportation community, resulting in new economic opportunities, and improved national security. Within this context, DOD identified two urgent research initiatives: (*a*) the need to formulate cost-effective approaches for linking divergent information and logistical systems, with an emphasis on enhancing in-transit visibility across modes and transportation providers; and (*b*) the need to conduct research that will improve the security of information systems and data transmissions.
- A systems-level evaluation of next-generation vehicles and vessels was also called for by conference participants. For example, participants sought an evaluation of the next generation of railcars, ships, airplanes and over-the-road vehicles. Any innovation such as improved capacity or speed of the vehicle/vessel immediately affects intermodal system performance. Capacity and investment decisions must be viewed from an intermodal system perspective.

Mobilizing for Intermodal Realities

The four hypotheses structuring this event were all answered in the affirmative.

1. YES, there is a nexus of interests, but that nexus will require nurturing and leadership so that it can do more with less. External leadership under a neutral structure is needed to ensure success. Ideally the departments of Defense and Transportation will partner to remove barriers and promote high-risk research and development of mutual interest.

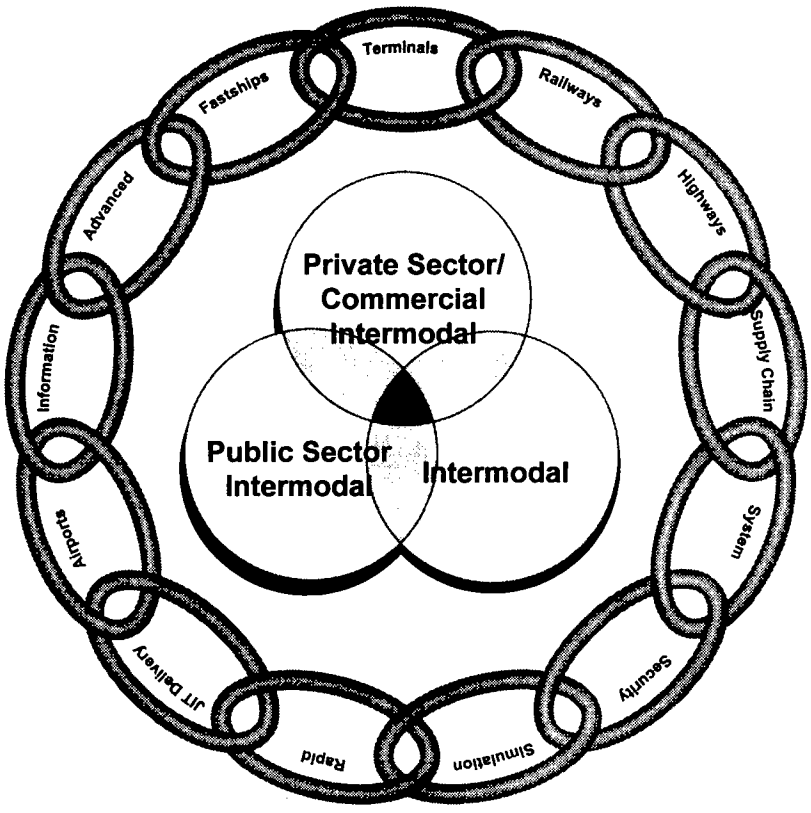


FIGURE 4 Leveraged partnerships for research benefits.

2. YES, changing times necessitate changing responses. The intermodal vision remains the same—the need for an efficient, fully integrated intermodal transportation system. The need is even more imperative today than it was 5 years ago.

3. YES, intermodalism is a value-added complement to the existing transport enterprise. This was convincingly conveyed by all three sectors.

4. YES, coordinated research and dissemination of best intermodal practices will yield benefits; but without such an effort, the intermodal advantage that the current systems enjoy could be lost. Without integrated intermodal research to support and build on current practice the modal components will be suboptimized. Collaborative research will multiply benefits (Figure 4); this is a natural corollary of the three preceding conclusions.

Conclusion

The conference closed with a general agreement on the vision, the framework, and the need to elevate cooperative efforts. Commercial transportation services must maintain and enhance their world-class status. There is a military imperative to meet national security transport requirements at a commercial equivalent level. Finally, DOT and other public sector agencies play an immensely important role in promoting an intermodal system and in supplying the infrastructure to facilitate and sustain civilian and military transportation.

The U.S. transportation community can reach the next level of sophistication and efficiency by leveraging the nexus of intermodal needs, capitalizing on emerging technologies, and creating partnerships for mutual benefit. Funds will be needed to support intermodal cooperative research, and a leadership structure must be forged between these three communities to realize the intermodal future. Absent such action, U.S. economic competitiveness and national security will become increasingly vulnerable to threats from foreign industrial competitors and global political instability.

DARPA's Advanced Logistics Program

Larry Lynn, *Defense Advanced Research Projects Agency*

I am impressed with the effort and cooperation shown by this diverse group over the past several months as you have tried to define and articulate the research agenda for the intermodal industry. The task becomes increasingly complex because of the vastness of intermodalism and its impact on all sectors—commercial, government, and military. I would like to present a view of the future from the Defense Advanced Research Projects Agency (DARPA) perspective—not what the U.S. Department of Defense (DOD) logistics will look like in the next few years, but a view of where it ought to be a decade or two decades from now.

DARPA is a DOD agency that is and always has been strongly focused on military capabilities. Although this was recently reemphasized by the Congress, by once again changing the name from Advanced Research Projects Agency to Defense Advanced Research Projects Agency, the agency has never waivered in that respect, only the name has changed.

DARPA's mission is to develop imaginative, innovative, and often high-risk technology and systems for the military that offer a significant military impact. And they must go well beyond the normal evolutionary developmental approaches. DARPA is beginning a new program this year that focuses on logistics and the complex problems of projecting and sustaining combat power.

The Challenge

The logistics challenge for DOD is summarized by Figure 1. Since the end of the Cold War, our national security strategy has shifted from a force that is forward deployed to a force that is domestically based and must respond to operations anywhere in the world on short notice. As a result the demands on our logistics systems have increased dramatically. As a nation we must be able to project and sustain overwhelming combat power sooner—in other words, put the right stuff in the right place at the right time with full knowledge that our inventory of supplies will be smaller.

Logistics is a critical problem to the military because the current approach is to overwhelm the problem with brute force. In doing so we must incur an enormous expense, which can no

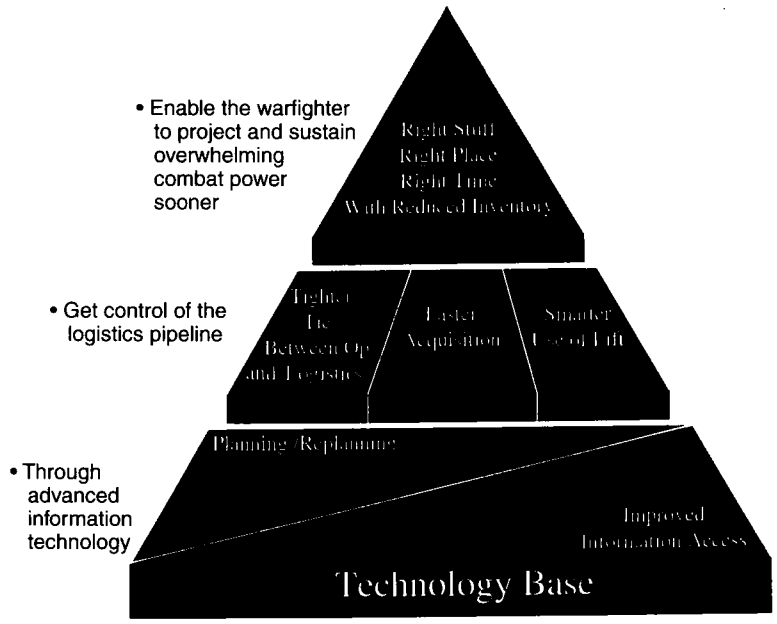


FIGURE 1 The logistics challenge for DOD. (*source: DARPA*)

longer be tolerated. Therefore, we *must* get control of the logistics pipeline. I have set that as the number one goal of our program. We must have tighter ties between operations and logistics, acquire material faster, and make smarter use of lift.

The only way this can be done is through aggressive development of advanced information technology systems; this will cause a fundamental change in the way logistics planning and operations are conducted today. Simply stated, military logistics is far and away an information-system problem.

Generally, I do not see research (as we use the term at DARPA) as needed in the logistics area. Research done more generally for information systems is adequate and applicable; although almost surely there are exceptions. What is needed is the application of modern information technology and techniques within the context of a solid system design and architecture. There also must be agreement and adaptation to achieve protocols and standards, and it is essential that these be compatible with the nondefense equivalents in the civilian intermodal system. That military system design must enable and encourage maximum use of commercial capabilities through TRANSCOM and the Defense Logistics Agency (DLA).

The major impediments are as follows:

1. The sampling rate is not high enough to allow a clear enough assessment of what is happening within the logistics pipeline system to permit a closed-loop approach—in other words, monitoring;
2. Practical monitoring is not feasible in combat or crisis surge situations—for example, at a beach head. This is particularly troublesome for DOD, since the surges are likely to take place under conditions when proscribed procedures and rules are lost to the press of combat or crisis.
3. We are not yet able to create interoperability with a large variety of existing and planned systems and data bases.

The papers by John King and Jacques Gansler raise a number of important issues (many of which involve policy decisions) and also include practical problems that must be studied and dealt with.

The Warfighter's Logistics Problem

Figure 2 shows the amount of material that was moved as part of Desert Shield and Desert Storm—over 3.5 million tons of materiel to southwest Asia. This was roughly the equivalent of moving the entire city of Atlanta (the people, all their food and belongings, and cars) halfway around the world. However, we had time to prepare, and the lift was conducted under favorable conditions. We had unopposed transits, host nation support, the best port facilities in the world, and we used foreign flag shipping .

Even so, this was an inefficient operation. Innumerable things were lost in the sheer quantity after arrival, or reported as lost because the user did not know whether it was en route, and were sent again—and again.

Today our strategy calls for the capability to conduct two large operations almost simultaneously. And the time to respond is significantly shorter. In short, we must move the mountain to the left, know where everything is so the summit is lower but equally effective, and do it twice. If this scenario occurs, the U.S. transportation infrastructure and our strategic mobility assets will be severely taxed. To meet this stressing requirement, logistics and transportation assets must be deployed, tracked, refurbished and redeployed more efficiently than ever before. In this era of downsizing, DOD will become more and more dependent on commercial intermodal transportation.

Background

If we are to gain control of the logistics pipeline, we must have complete control of the logistic information that runs it. To illustrate, we conducted a detailed analysis of Desert Storm logistics movement to test the impact of advanced information systems (Figure 3). We determined that the operation could have been shortened by 100 days and the amount of material shipped could have been reduced by 1 million tons. By so doing we also could have avoided spending over $650 million dollars in transportation costs alone, let alone the cost of materiel. The lack of quality and timely information led to just about every logistics problem encountered.

Two most noteworthy findings are:

1. Overall sequencing of unit moves was not orchestrated. The same required-delivery date drove all units to close (or try to close) at the same relative time frame. The resultant queues and chaos became a great disruption to the deployment and in theater support capabilities.
2. The actual material shipped grew in size without anyone's knowledge and certainly without any tools to predict the eventual impact. This caused a considerable waste of shipping resources and led to delays that rippled throughout the deployment.

Our analysis of Desert Storm convinced us that there is a wide range of problems in deployment, redeployment, and retrograde operations caused by our inability to plan and retain visibility over what is going on relative to that plan. Had we seen the problems coming, we may have been able to take some corrective action.

What we did see in Desert Storm was what we had seen in Vietnam, and we saw it repeated in Operation Restore Hope in Somalia, and it continued in Joint Endeavor in Bosnia. In December 1995, 50,000 pieces of cold weather gear were bottlenecked at Dover AFB. There was no advance knowledge it was coming, there was insufficient documentation, and there was difficulty in coordinating actions with EUCOM. As a result, the cold weather gear just sat there.

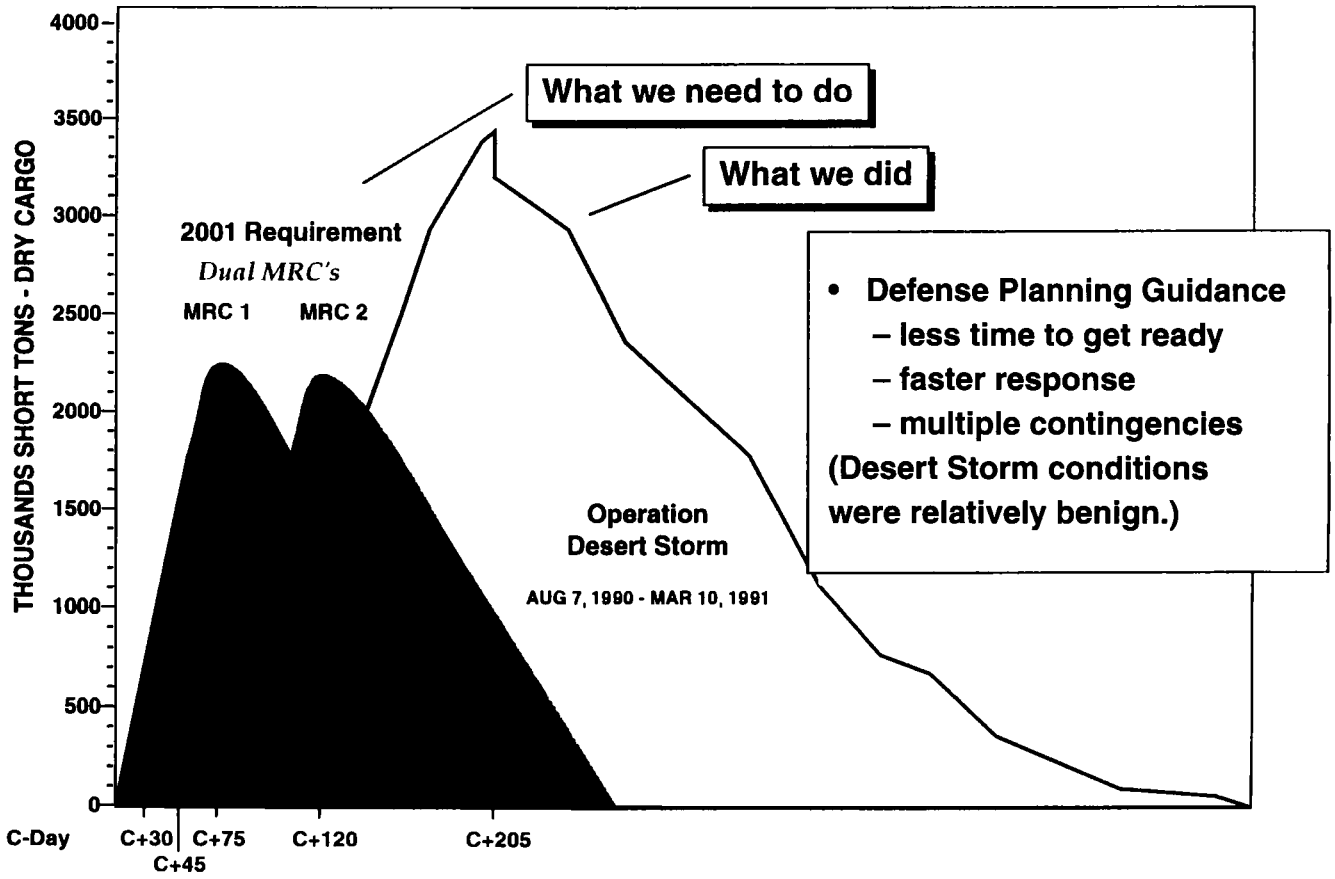


FIGURE 2 The warfighter's logistics problem, more than 3.5 million tons of materiel moved to southwest Asia as part of Desert Shield/Desert Storm. (*source: DARPA*)

Planning and Execution Today

Today's planning and execution domains remain separated. Logistics plans are developed at a high level that provides only summarized details of what the intended movement requirement may look like (Figure 4).

Planning is hampered by a serialized process. The warfighting commander delineates the overall mission and concept of operation. The operations staff (J3) outlines the alternative courses of action and the requirements seen as necessary to fight and win. Only after a lengthy series of actions to "source" the forces and resupply requirements is a plan seemingly finished. Unfortunately, it remains at the summary level. The information usually does not reflect what will eventually move.

When it becomes necessary to deploy forces, the move is almost never executed in the manner in which it was planned. When execution begins, the unit or installation or depot decides what and how much equipment and material will move. Distinctly different logistics systems are used to execute the actual movements and resupply demand actions.

There is very little real-time feedback to commanders to tell them whether there are deviations from the plan they had built. As unforeseen events begin to impact the actual movement, operators and planners cannot predict the magnitude of or the location where breakdowns in the system will occur as a result of the new set of circumstances. The planning and execution process today suffers greatly from compartmentalized systems that lack the necessary level of detail on which to make timely and accurate decisions.

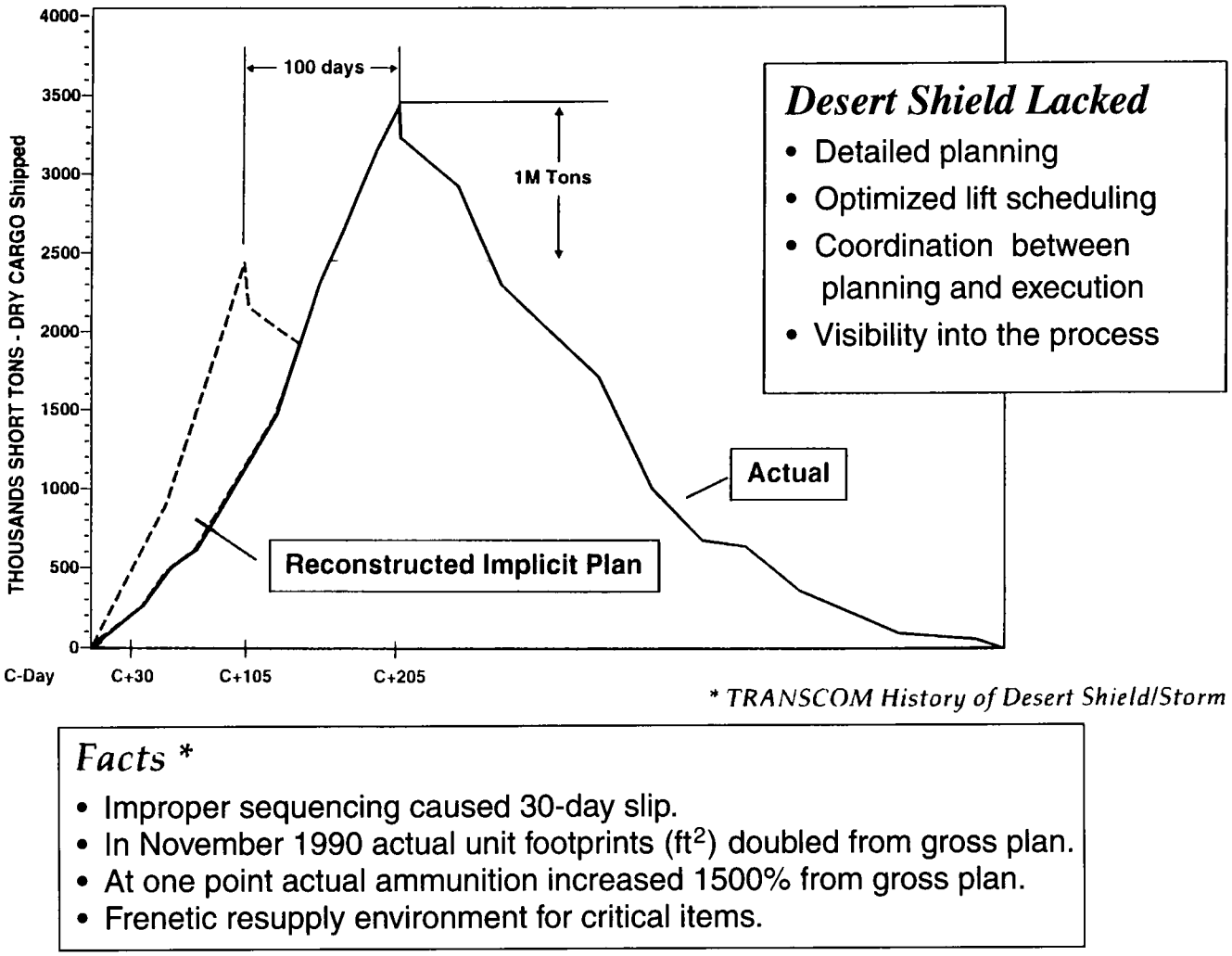


FIGURE 3 Analysis of Desert Storm logistics movement, testing the impact of advanced information systems. (*source: DARPA*)

The DARPA Program Vision

Control of the logistics pipeline demands a radical shift in the way planning and execution are done. Operations and logistics must be viewed as a tightly coupled, closed-loop system. As shown in Figure 5, the system must be a much more concurrent process in which participants work together to create a detailed plan. Operators and logisticians, at all levels, must be brought together in a distributed interactive planning environment to plan, execute, monitor, and rapidly replan.

A key element of this coordinated process will be the ability to plan in sufficient detail to execute directly from the plan. The logistics plan must be developed in consonance with the war plan and, as such, have explicit representation of the assumptions and expectations used to develop the plan.

These assumptions are critical to detecting deviations from the plan through the creation of trigger processes or "plan sentinels" that can be placed at key nodes or links in the logistics pipeline to detect deviations. "Plan sentinels" will provide the necessary closed loop feedback to maintain control of the logistics system.

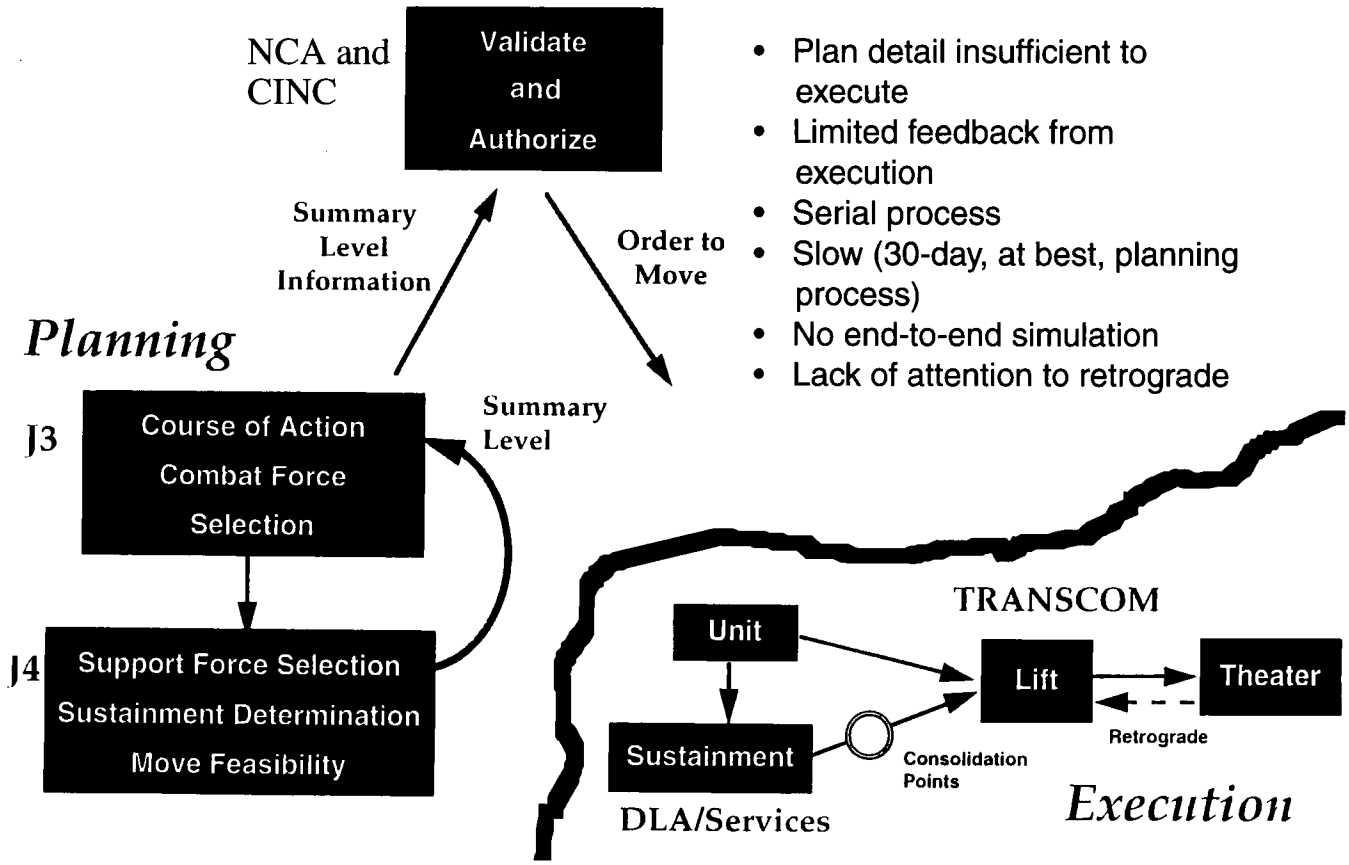


FIGURE 4 Problems with planning and execution result because logistics plans are developed at a high level. Only summarized details of what the intended movement requirement may look like are provided. (*source: DARPA*)

In the field, it is essential that the capability to know what is where includes detailed monitoring of aggregation/disaggregation processes so that the information system can track what is happening. For example, when a container is opened in the forward area, its contents must then be individually dispatched and tracked. That key set of events must be "user friendly." Soldiers in combat zones cannot be expected to manually provide accurate monitoring of these events, as we attempt today. The errors rapidly build to the point of system failure.

Combined with rapid replanning capability, sentinels provide the oversight process required to maintain a continuous loop of planning, execution, monitoring, and replanning.

Program Focus

The future concept of operations is envisioned as an interoperable environment for the operators in J3 and logisticians in J4 to coordinate their activities (Figure 6). A tightly linked J3 and J4 environment will enable the impact of logistics to bear directly on the decision-making process during course-of-action evaluations. The J4 will be tightly coupled between sustainment and transportation allowing rapid assessment of transportation feasibility.

Program Goals

To achieve the vision of an advanced logistics system of the future, two categories of technology (Figure 7) must be developed: 1. planning, execution, and monitoring; and 2. infor-

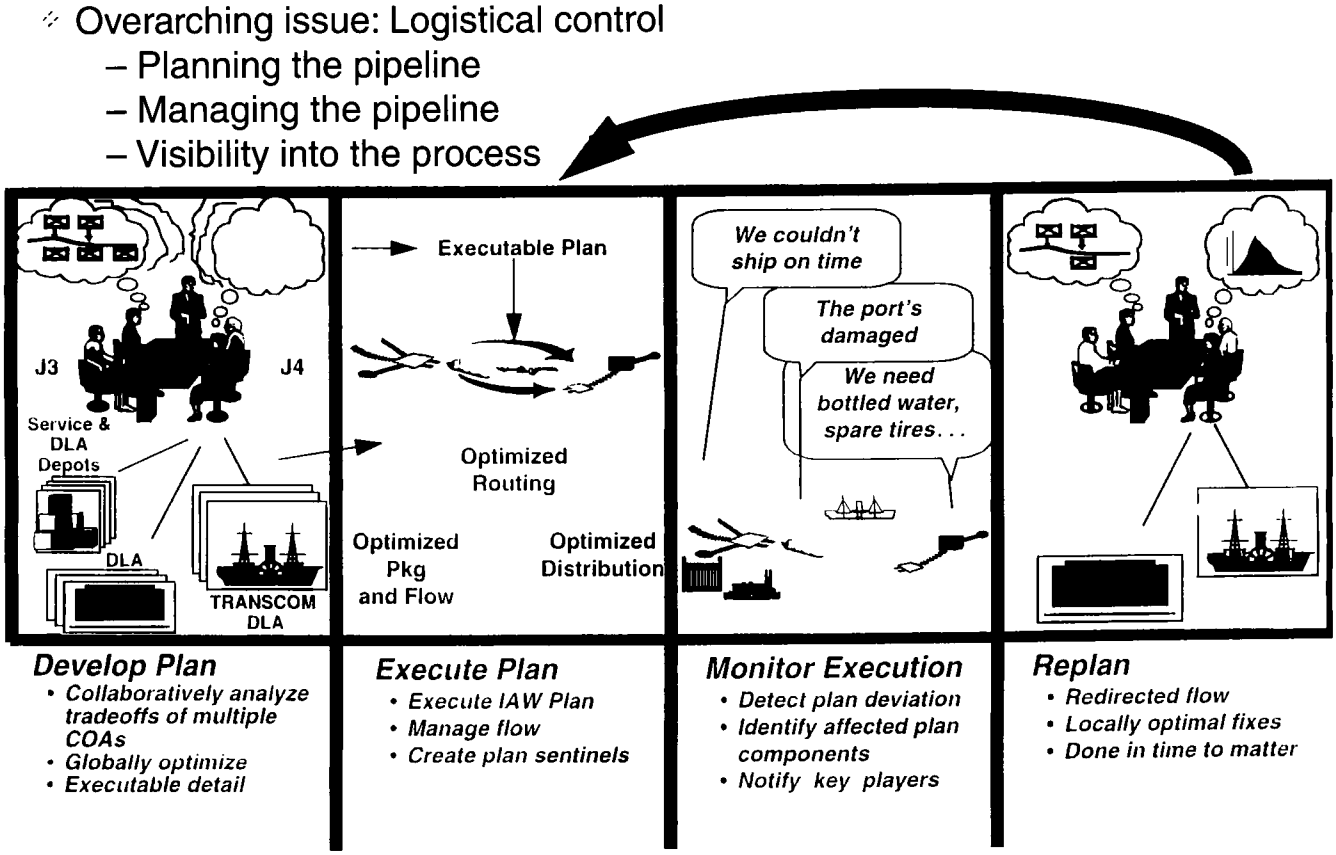


FIGURE 5 Envisioned is a more concurrent system process. Participants must work together to create a detailed plan. (*source: DARPA*)

mation assistants. These must be pursued within a system design and architectural framework that assures compatibility with non-DOD intermodal systems.

Controlling the logistics pipeline hinges on technologies developed for planning, execution, monitoring, and rapid replanning. These technologies will enable the logistics plan to be developed in consonance with the warfighting plan, the execution to be accomplished based on the details of the logistics plan, and responses to deviations made in time to matter.

Accurate and accessible information is the foundation on which the logistics systems must be built. We are developing technologies to support the autonomous connection of heterogeneous and distributed data bases, semiautonomous search and retrieval, and intelligent query for information. We envision that successful implementation will allow the operator to know where his stuff is and monitor its condition.

Concept of Operations

If there is to be success, the logistician must gain control of the logistics pipeline (Figure 8). Only by building on a foundation of advanced information technology can a fundamental change in how logistic planning and operations execution be achieved. Three components must interact to address this issue:

1. closed-loop planning to assure and implement tighter ties between operations and logistics,
2. faster acquisition to compensate for reduced inventory, and
3. intelligent use of lift to improve execution.

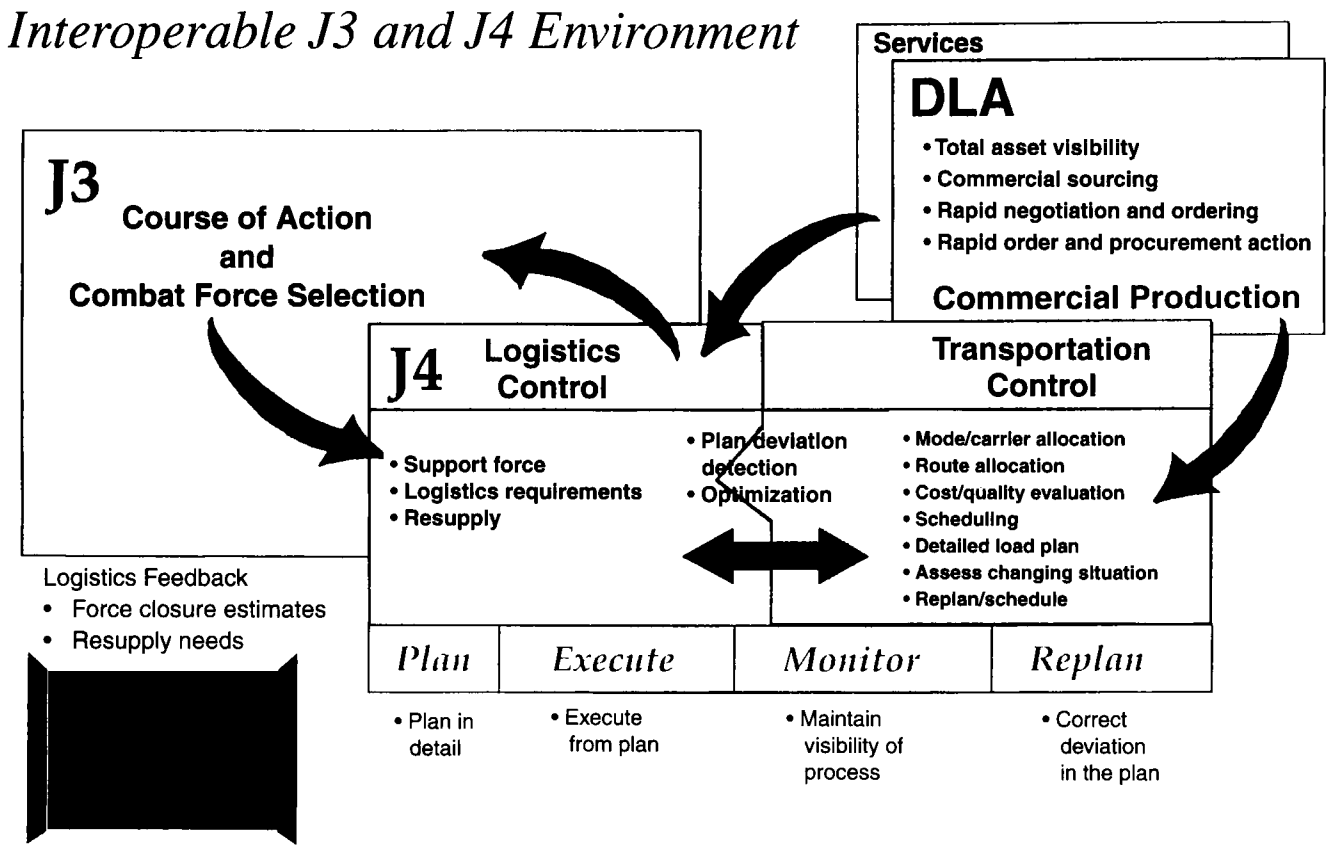


FIGURE 6 The solution is an interoperable environment in which both operators in J3 and logisticians in J4 coordinate their activities. (*source: DARPA*)

Technology must be developed that speeds logistics planning, execution monitoring, and replanning; ensures accurate, reliable, and timely information; and creates plan sentinels that ensure the accuracy of the information system and provide early warnings of events that deviate from the plan.

Oversight of the feasibility and cost of alternative courses of action is maintained throughout the cycle. It is supported by a closed-loop group of sustainment and transportation tools

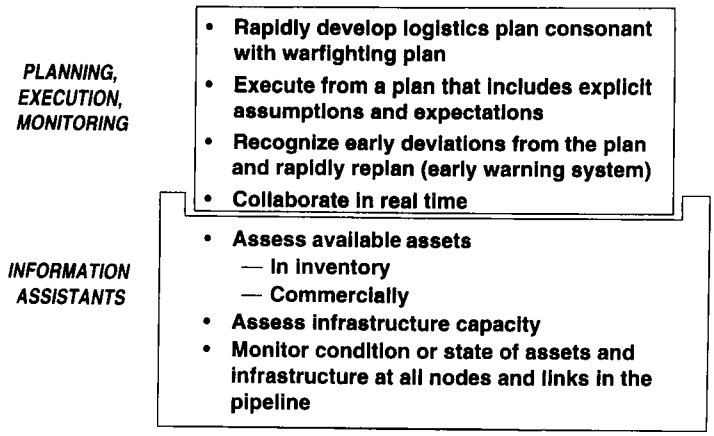


FIGURE 7 Program goals: planning, execution, and monitoring must be developed and information assistants must be trained to achieve the vision of an advanced logistics system. (*source: DARPA*)

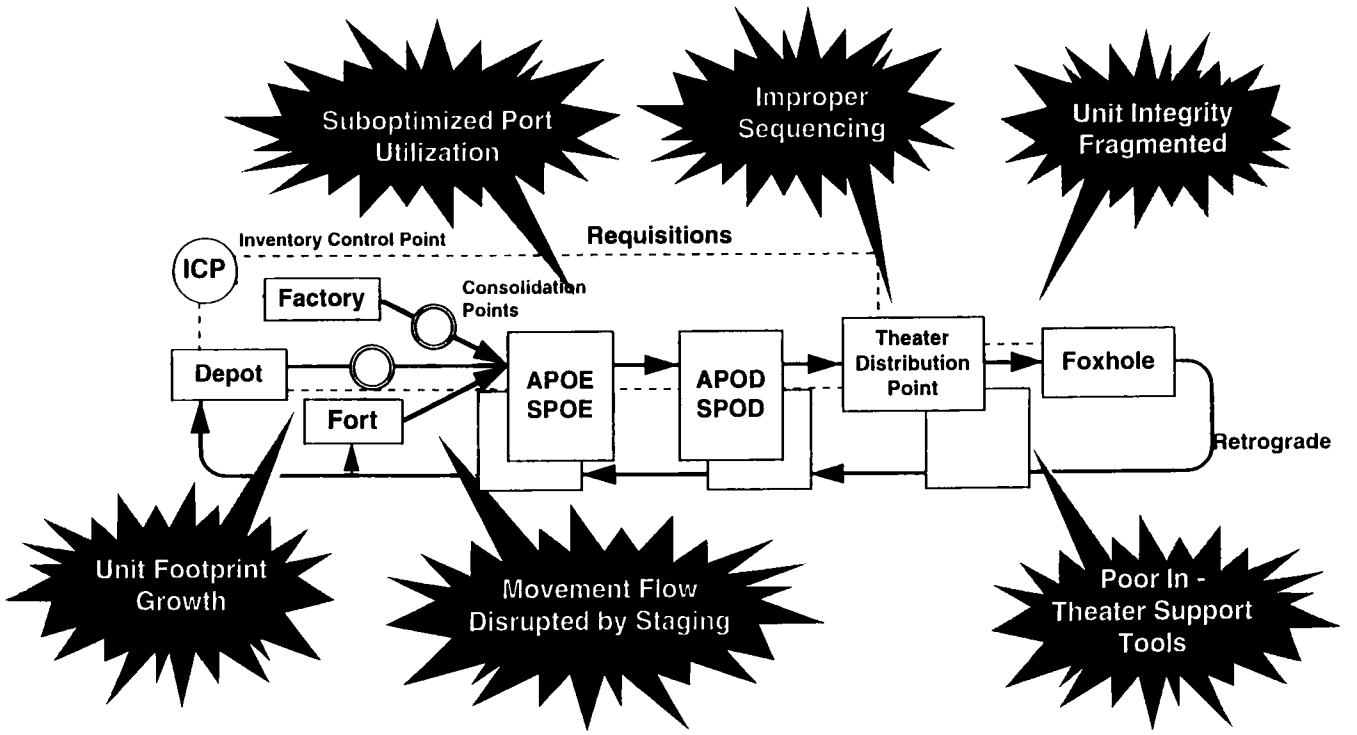


FIGURE 8 To achieve smarter use of lift, the logistician must gain control of the logistics pipeline. (*source: DARPA*)

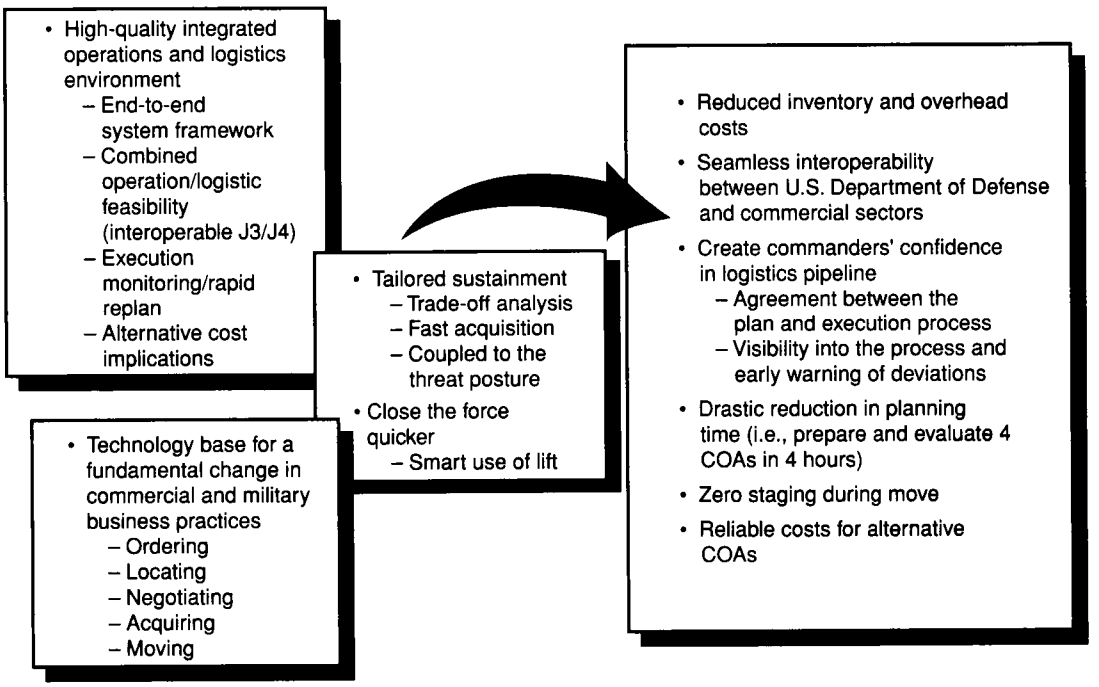


FIGURE 9 DARPA's Advanced Logistics Program will have direct and immediate impact on the warfighter and his logistics pipeline if we meet our goals. (*source: DARPA*)

that link with supply and procurement tools. The tools provide optimization, simulations, advanced data access services, and interface with commercial data services. The components together allow a complete end-to-end feasibility analysis.

Intended Impact of the DARPA Program

The DARPA Advanced Logistics Program will have direct and immediate impact on the warfighter and his logistics pipeline if we meet our goals (Figure 9). That means also a direct impact on the intermodal community. For the first time an operation will be planned with complete visibility into the logistics process. Planning time will be reduced from days to hours, there will be zero staging because all loading will be planned ahead of time, changes will be made while material is traveling en route, planners will have reliable cost estimates and be able to evaluate alternatives in real time, and operators will have seamless access to data and information without regard to query languages or data base structure.

U.S. Department of Transportation's Research and Development Needs for the Future

Mortimer L. Downey, *U.S. Department of Transportation*

Let me begin with a transportation example from nature, Canadian geese. Have you ever watched them flying in their V formation? Ever wonder why one wing of the V is longer than the other? After years of study and research, we have the answer. The long wing has more geese.

The fact is geese instinctively know the value of cooperation. For example, they regularly change leadership—every few minutes—because the leader fights the head winds to make flying easier for the geese behind him. When he or she becomes exhausted, another goose takes over. Scientists have discovered through wind-tunnel tests that a flock of geese can fly 72 percent faster and farther by cooperating in this way.

The lesson is applicable for us in intermodalism. "Intermodalism" is a buzzword if there ever was one, but in fact it means nothing more and nothing less than "cooperation." It is easy to get caught up in process and forget what intermodalism is all about. It means cooperating to increase our transportation system's efficiency and its benefits for the American people. Intermodalism's promise has been somewhat obscured by the questions that surround it, questions that over the last few years have gone from "Huh?" to "Why?" to "How?" and finally now going to "When?"

There has been tremendous progress on improving intermodal connections both in the private sector and in military traffic, advances like double-stack trains. Projects like the Stark County, Ohio, Intermodal Project are becoming so common they are almost taken for granted. There has been a tendency to forget or to dismiss the progress that we have seen. Indeed, some people see that 4 years have gone by since 1991 when the Intermodal Surface Transportation Efficiency Act (ISTEA) was passed and wonder why its full promise has not yet been realized. Well, neither Rome nor the Interstate Highway system nor the New York subway system was built in a day, and we are not going to have full intermodal connectivity in a day or even after 4 years.

Integrating our transportation systems with their physical and technological differences, geographic dispersions, different owners, different customers, and different patterns of labor organization will take an ongoing effort that stretches over many years. But that effort, no matter how complex, no matter how demanding, is essential and we need to continue it. We

continue to face growing travel demand, inadequate capacity, bottlenecks, poor connections between modes and an aging and deteriorating infrastructure. We cannot take any of that lightly, and we do not.

Investing in National Prosperity

DOT's recent report on the nation's surface transportation system did not surprise anyone when it concluded we should be putting $57 billion a year into our surface transportation systems alone just to maintain the current conditions. And of course, simply maintaining the current conditions will not give the economy the capacity it needs to grow. That is why the report also concluded that an additional $23 billion a year could be invested in projects whose quantifiable benefits, such as savings from congestion reduction, would outweigh their costs. So that is $80 billion that as a nation we ought to be investing each and every year. But when you add up what all levels of government now spend, it is only about $40 billion a year on surface transportation infrastructure, suggesting we have a gap of almost $40 billion.

Closing that deficit in today's environment of limited public funding, especially when other public services have their own legitimate needs, means going beyond the ways of doing business that have driven transportation policy for the past 40 years. Let us face it, we cannot just build our way out of the congestion and the other problems we face. We do not have the money to do so. Not even the military has the money to do so. We do not want the impacts on environment that doing so would bring, and there are serious questions about the long-term effectiveness of a build-build strategy.

But that does not mean that we can turn our backs on legitimate needs or on the opportunity to support economic growth; nor can we turn our backs on the national security needs that our transportation system supports. Our existing transportation facilities will continue to be the backbone of our mobility, and we are going to have to maintain and even expand the network of transit systems, roads, ports, and railroads that has been so critical to our nation's prosperity.

Intermodalism will help us enable the system users, the military, private shippers, and government transportation agencies to use the best mode or combination of modes to meet their needs in moving people and goods and reduce the burden on system segments, especially when such a strategy is cheaper than major new construction. Doing that means ensuring good compatible connections between modes and providing genuine consumer choice.

These choices, however, are becoming more complex. Simple point-to-point options and modes are being replaced by complex routing through networks and options to locate economic activities anywhere on the globe. Although government (especially at the federal level, which by definition must take a national perspective) clearly has a critical role to play, much of the investment has to be done through market mechanisms that build on the transportation systems that have been built up over generations and that on the whole still work well.

This cannot happen through top-down government directive. That approach has failed around the world in recent years. Instead, government's role in promoting intermodalism has to take different forms. We should continue our efforts at deregulation to end economic distortion, and allow markets to take their natural shape, which should provide greater authority to state and local decision makers in their provision of investments.

Acting first under President Carter, and now in this Administration, the federal government has essentially ended economic regulation in the trucking, rail, air passenger, and cargo sectors and recently closed the doors on the 107-year old Interstate Commerce Commission. This has given consumers more choices and billions of dollars of savings while enabling providers to enter into new markets and introduce new efficiencies.

The federal government, with its resources and its national perspective, can help to develop the analytical tools and the data bases that can enable businesses to make sound choices. For example, DOT has been working with the Los Alamos National Laboratory on developing innovative performance and operations systems models and other new analytical frameworks that will help us better understand entire transportation systems and how they work.

ISTEA's Role

The federal government can also empower state and local agencies to use federal funds more flexibly and to make investment decisions that are right for them as linkages into the national network. Two billion dollars in ISTEA funds have already been transferred to mass transit in this way, which has helped relieve pressures on congested urban highway corridors. ISTEA funds have also been used not only for passenger service but for freight projects as well. These dollars improved road connections to the Columbus Inland Port facilities in Ohio and financed bridges for what will become the Alameda corridor, rail access to the ports of Los Angeles and Long Beach.

As ISTEA has mandated, government at all levels must improve their transportation planning process to ensure that the best projects are chosen for investment of federal funds—projects that meet genuine needs. At all levels of government and in the private sector, we can work to ensure that the new technologies now being developed and deployed, such as intelligent transportation systems or global positioning satellites, are by design intermodal and make the transfers between systems as seamless as possible. These new technologies can also be developed to link into the information systems that allow military and private users to more effectively manage their operations, as some already do through just-in-time delivery systems that in reality are mobile logistics programs. Government also can encourage transportation system optimization, but do it in ways that do not involve top-down control of civilian systems.

America's evolving transportation systems have some of the same attributes as the Internet—decentralization, immense capacity, and unique opportunities for creative use. We need to enable the development of systems to harness and integrate the transportation system's power without impeding it. All of these things most of us could agree with in principle, but I am sure there will be great debate about the specifics; that is why conferences such as this one are so valuable—representatives from transportation agencies, from the military, and from business brought together to discuss how to better integrate and improve the transportation network of which we are all a part. These meetings can help to develop a common language, a shared understanding. That such meetings and other activities are now common is a big step in itself, but only a first step. It is results that count. We are now cooperating to achieve results through the topic of this conference—research.

DOT's Role

We at the federal level believe we can provide the leadership in this effort. We have already done some of this through steps that I mentioned earlier, and we will continue to build on those. We are also continuing the integration of activities that in the past have been confined within the modal stovepipes.

The creation of the Office of Intermodalism and of a DOT-wide Directorate of Technology Deployment are steps in this direction. We have also ensured that the newly created Bureau of Transportation Statistics (BTS) is intermodal in its orientation and available to provide data that are useful for all modes and all sectors. BTS is already a key player in the development of vital information analysis tool kits being used by private- and public-sector analysts.

DOT is also devoting increasingly greater proportions of its research to intermodal topics and to programs that transcend the modes. Through this research, we hope to develop solutions to the nontechnological obstacles that intermodalism faces—the institutional, the financial, and the educational barriers. For instance, although ISTEA requires consultation among the various interests, including freight operators, during the development of metropolitan transportation plans and programs, many areas lack the mechanisms and the structures to really carry out such consultation effectively.

Who pays for intermodal projects is another issue. Given funding constraints, some are reluctant to contribute to projects that they do not see as wholly their turf. The Stark County,

Ohio, project I mentioned earlier actually shows how those barriers can be overcome through innovative financing that can bring together public and private interests. We need to bring those kinds of results to people's attention. On the other hand, there are legal and regulatory barriers that discourage intermodalism such as the prohibition against using airport revenues for off-airport highway or rail links, even when they would clearly benefit airport users, or the limits on states' abilities to invest in Amtrak capital improvements.

There is also a genuine lack of training in cross-modal or intermodal issues. We still train people to be highway engineers or railroad designers or transit planners and then fail to provide them with the information and tools they need to assess and meet challenges in a world that increasingly is looking for intermodal solutions.

Given this, DOT believes it is critical to shift some of our research resources into the soft side, that is, into policy and institutional research. And although we must continue our longstanding commitment to hardware (and we are doing that often in partnership with DOD through ARPA in areas like Intelligent Transportation Systems and Global Positioning Systems, where we have greatly expanded our federal commitment), we have to do more in terms of policy and institutional research.

Over the past few years, we have heard from many of you that we should place less emphasis on conventional activities and develop a broader research agenda that will help you better understand how transportation shapes the economy, affects the environment, and influences the quality of life. Moreover, transportation organizations at all levels are continually interacting with each other and need to increase their ability to do so effectively. Areas like public participation, awareness, consensus building, mechanisms to involve the private sector and other levels of government, technical tools, and policy alternatives are all vital and they demand research.

We have a number of ongoing efforts that respond to these needs in each of the three areas I mentioned—institutional, informational, and educational. We have taken steps on the institutional front. Many of you participated in the 1995 TRB meeting in Irvine, California, that focused on building a joint research agenda for intermodal freight issues. Our highway policy research now includes analyses of investment requirements and alternative funding strategies, better quantification of highway's economic importance, better travel forecasting and data collection methods, and studies of the implications of alternative fuels and of demand management. Through FHWA, we are identifying barriers to local-level intermodal planning and operations. We are also improving such analytical tools as geographic information systems to support national program evaluation for information and data sharing with other levels of government and with business.

On the informational side, DOT is acting to improve data availability on all aspects of system performance and for the systems that collect and distribute these data. That is essential for effective intermodal planning and decision making in both government and business. As I mentioned earlier, BTS has expanded its initiatives. They have been producing and distributing data both to the public and the private sector. They are now doing major surveys, the first in recent years, on domestic freight movements and domestic passenger movements and the flow of freight across the borders; and they are integrating data from a variety of other surveys and studies. This work, bringing together commodity flows and passenger information, can provide leaders with the information they need for investment decisions.

We are taking steps on the educational front. We know that new technologies, concepts and institutional policies are changing the world in which we work; that an intermodal world demands both a broad and deep knowledge of many areas; and that keeping up is not easy. We are providing educational and training assistance through a variety of activities, including targeted third-party training, sponsorship of university programs, and continuous direct outreach.

We do not yet have a national intermodal transportation institute, but both the National Transit Institute and the National Highway Institute support intermodal programs that offer training and employee development in areas across the traditional lines. The Rural Transit Assistance and the Motor Carrier Safety Assistance Program also provide extensive intermodal training and technical assistance.

Our university research programs currently contribute about $60 million annually to these institutions through both the University Transportation Centers Program and the ISTEA established university research institutes. They not only develop the next generation of transportation professionals, but also spur the development of innovations through ongoing research targeted at intermodal needs.

Finally, we are undertaking extensive outreach on research issues through the Volpe Center in Cambridge and through the Turner Fairbanks Center here in Washington. These centers also hold technical forums and provide informational exchanges on a variety of issues.

All of these efforts contribute to an intermodal research agenda that not only will provide technological solutions but also address the institutional, the informational, and the educational issues that can impede progress toward a seamless intermodal system.

I have talked about DOT's vision for intermodal research and development, our guiding principles, and our priorities and objectives. I would like to ask you to consider these closely in your deliberations today and tomorrow, remembering that what we all have in common is far greater than how we differ and that through cooperation we can overcome the barriers we face. Your viewpoints, your knowledge, your experience are going to be extremely helpful as we reach judgments about federal transportation research and development, and we look forward to hearing your views.

Landstar: An Industry and Marketplace Perspective on Intermodal Research

Jeff Crowe, *Landstar Systems, Inc.*

I do not know if we are yet truly in an intermodal system. I know that we are not in a seamless intermodal system and that we have a long way to go, and I believe that we need to move toward greater partnership—an easy word to use and a hard one to execute.

As background, Landstar is not represented only by its 10,000 trucks and 14,000 trailers. In the last several years we have made a major move into the intermodal market both through internal development of a drayage company (the first national drayage company serving all the ports of the United States and most of Canada) as well as through an acquisition. Therefore, my perspective is not only that of a trucker but also that of one who believes that the solutions of tomorrow will be found in moving all of the freight by the most efficient provider from point of origin to point of delivery.

The challenge is not to move from rail yard to rail yard or from airport to airport or from port to port, for if you are not chasing the marketplace and you are not involving the customer, then you are missing the focus of intermodalism. Air, sea, and land transportation, according to everything you read, is getting bigger, better, faster—trains longer, ships bigger. They just recently launched the biggest container ship in the world. All those things are wonderful. I think the planning of the railroad industry is wonderful, as they move from rail yard to rail yard. But are we going to be able to increase an intermodal offering beyond its now present users? Are we going to be able to build a system that becomes truly market driven and time sensitive?

We all know that customers are finding ways to reduce inventory and have inventory in motion and moving it from origin to destination. We must, therefore, not participate in the argument of mode, but participate in the argument of inventory velocity—having things arrive where they are supposed to arrive and on time.

We have a long way to go. The majority of investment dollars that I see the modes spending have to do with their own structural problems, and that makes clear sense to me; I'm certainly biased toward Landstar. But we have to think beyond some of our natural boundaries.

First of all, can we see the port business change dramatically over the coming years? Can we really, as we think about infrastructure spending, begin to include the need to move goods from the port to their ultimate destination, or will all of our planning continue to be to get

goods on the ground at port and make sure those steamships make it out and can continue to keep to their schedules? As the ships get larger, fewer ports will be used. There will be fewer stops, which will mean more support from the trucking community.

How is that going to happen? In the port side of the business, we need to see significant changes in administrative, financial, and operational characteristics. In my view it is a most difficult business to find margin in. In every intermodal market, every intermodal application that I have seen, it is the drayman who is the link; regardless of whether it is domestic or global, the drayman is taking the cargo to the port from the origin shipper and delivering it at the end to the customer.

In the port business, what does the drayman find as he or she goes in to pick up a container? Frequently that it is overloaded. And who is held accountable to make sure an overweight container does not move? Why not ask the poor drayman to do that, also? Does it make sense, that we collectively make the drayman responsible for ensuring that shipments and cargo meet government regulations? Why is it that those in-bound containers do not already conform to the weight laws of this country? When will the ports begin to expand their hours and truly make the gates more accessible?

You can see some of the underpinnings beginning to come loose. Maybe you are aware of that very issue because of the recent strike at the Los Angeles and Long Beach ports, where the ports are open for very short periods of time; and even the time and the hours that they claim to be open, they really are not. People are not at the gates to open up in time, and they close for long extended lunch periods. There are also collection issues in terms of who is responsible for the container and the chassis and, ultimately, for the damage to any unit. Many issues must be worked on.

The railroads are doing a wonderful job of moving between the rail yards, but their major concerns focus on longer, faster, better. Is that going to allow us to expand—myself as an intermodal provider and user included—into new and more time-sensitive markets? I do not think so. We need to see greater reliance on scheduling not only so required crews show up on time, but also so the trains leave on time. And, as I said, I think the idea of frequency is essential to this.

And it is not likely that you are going to see standardization regarding containers. Whether it is road railer or an iron highway, what will develop in the short-haul market remains to be seen; but I think the success will only be based on frequency issues and improved accessibility to and from the customer.

Will the short lines be run as efficiently and effectively and keep some of the smaller communities linked by railroads? The answer remains unclear. It is a wonderful strategy and we will see if the more entrepreneurial managers of those rail systems will be successful; but the issue still surrounds the hand-off—the efficient ending and exiting in and out of the rail yards.

When I think of intermodalism, I certainly think about the airports. They do not have the historical baggage and cultural issues that exist among the other modes. Clearly, one of the things that has an impact on the ability to sit down and think and really work out real issues is the comparative histories between the railroad industry, the trucking industry, and the steamship industry and their need to all compete for relative market advantage.

In the air industry, you do see a rather efficient system, in my humble opinion. Maybe it is the sites of the major airports and the availability of good road systems into most of those airports. You see more modern facilities, you see some planning for significant movement out after the planes come in. Major companies, such as United Parcel Service and Federal Express, depend on an integrated planning process, and a true planning exchange exists between them and the people who are providing surface capabilities to them—a significant difference from the planning process of the railroads and the steamship lines.

I am a firm believer that the people who provide the assets, if they fall behind the curve of being able to run a company profitably and withdraw, will be replaced with another better-run asset provider. In the world of tomorrow there will be just a handful of companies that are asset providers and managers. We may not even use tag words such as railroads and truckers; there are going to be leasing people and all sorts of different capital providers who put

those assets on some sort of mode. Some provider is going to be very good at one mode, and any one of the modes can also be a logistics provider. We will see where the profits end up.

The same problems we have at each of the knuckles in the system is similar to the problems we have with technology. Technology does not flow seamlessly, by any stretch of the imagination, in an intermodal environment. Information can arrive electronically, but there is not a smooth transition to the ultimate provider, to the customer. Each mode has its own technology. We have technology built in separate corridors and not across modes.

I would like to also note safety. Think about simple things like lighting, availability of bathrooms and facilities, and being allowed to use them; simple things like weighing and checking equipment. You do not receive a good safety check unless you monitor it yourself. We need to become more responsible in our intermodal system and think about safety and ensure that the users of the system have a safe environment to operate in.

Finally, I am very concerned about surge capability. The concept that there is an endless supply of underutilized assets sitting around is quickly losing ground. No company that I can think of that is responsible to their shareholders keeps underutilized assets sitting around. So if we will need to fight in two major theaters at the same time, surge capability will have to be dealt with.

The Great Reversal: Information and Transportation Infrastructure in the Intermodal Vision

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The intermodal vision sees the value-added future of transport in terms of the ability to leverage the huge existing investment in modal transport infrastructure in the service of more efficient and effective logistics management in passenger, freight, and military domains. Intermodalism is not a substitute for modal transport and does not displace the long-standing focus on modal research, development, and infrastructure deployment. It is a complement to modal transport, providing vital leverage to obtain greater use from existing assets and provide useful transport services not previously available. Economic and security forces make greater intermodalism inevitable; the question facing transportation leaders is when and how intermodalism should be developed. Much of the needed research in the intermodal domain extends prior work in the modal domain, but it is especially important that research focus on the changes emerging and necessary in the broader technological and institutional areas of transport. In particular, research is required to apprehend and exploit the potential of sophisticated information infrastructure that is bringing about a "great reversal," in which the ancient dependence of communication and information on the transport infrastructure is being reversed, leading to a time in the near future when most transport will be dependent on the information infrastructure.

Meshing the Information Infrastructure

Contemporary transportation systems work remarkably well given the constraints under which they operate. As is shown in Figures 1 and 2, total transportation usage and per capita usage have been steadily increasing. The transport systems that have evolved are highly complex organizations of people, technologies, and knowledge. Yet in spite of these accomplishments, the demand for transportation capacity and services is outrunning the transport infrastructure as it is currently configured. This shortfall has prompted calls for greater attention to intermodal transport as a strategy for leveraging the modal infrastructure to the maximum degree possible.

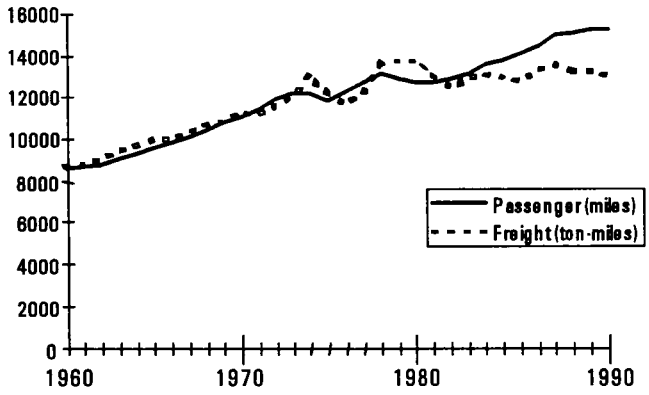

FIGURE 1 U.S. transportation usage per capita [*source: U.S. Department of Transportation, 1994a* (*1*)]

The intermodal vision often arises from concerns about constraints in the existing modal-dominated transport world; certainly, much of the literature on the subject from engineering, planning, and policy focuses on this aspect of the issue. The rationale for the Intermodal Surface Transportation Efficiency Act (ISTEA) is essentially a brief for overcoming such constraints. However, as a derived demand in the economy, transportation usage reflects the circumstances of the underlying economic environment. "Logistics management" and "total cost" are continuing trends in manufacturing that drive the demand for intermodal services. Manufacturing and distribution managers are attempting to squeeze out internal inefficiencies and uncertainties through reengineering and process redesign. They are identifying the critical productive processes and attempting to redesign processes that are more reliable and efficient and add greater value to the core business. Transport is a critical uncertainty in the logistical chain of the production of most goods and services. Managers want to drive out the costs of uncertainty and inefficiency that plague transport and are pushing transportation service providers for improvements in speed, service, and cost. The effort to overcome transportation constraints is part of a still larger struggle to gain a greater return from expensive assets. From this viewpoint, at least in the freight transport sector, the challenge is not to conquer constraints but to add value.

This revolution in logistical thinking is not limited to freight but has driven changes in air and surface passenger transport. Deregulation, the growth of travel and tourism, and advances in aircraft and information technologies have brought about a huge growth in air travel and a fundamental restructuring of the airline industry. The route-and-price regulated

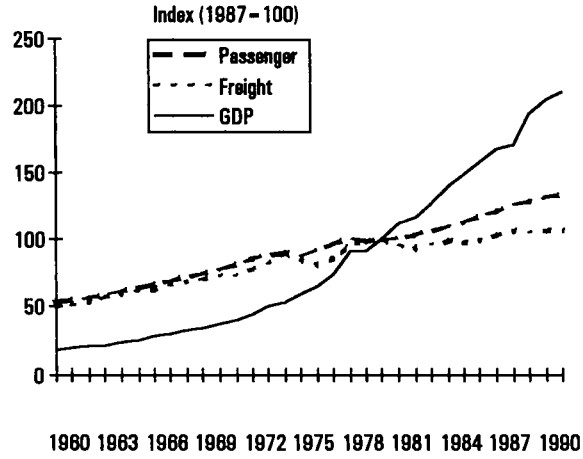

FIGURE 2 U.S. transportation trends [*source: U.S. Department of Transportation, 1994a* (*1*)]

airlines of the mid-century have given way to a complex mix of hub-and-spoke air network operators, "segment" operators, and interline mergers, alliances, and partnerships using strategies such as code-sharing and route coordination. At ground level, frustration with congestion and delays has brought pressure for improvements in road and rail passenger capacity, especially in urban areas. Increasingly, the transit time of the work force is seen as a social cost rather than simply a burden for individual commuters to bear.

The arguments in favor of improved intermodal transport are convincing, but we believe many of the ideas for accomplishing such improvement lack scope and precision. Improvement in intermodal transport will require physical infrastructure improvements but, equally important, it will also require improvements in coordination and control to govern interaction between modes. In many ways, this will pose a greater challenge than improvement of the physical infrastructure; in fact, it is quite likely that investments in physical intermodal transport infrastructure will generate poor returns due to shortcomings in coordination and control. Each mode of transport is governed by its own institutional order and social conventions that have evolved over many years. The changes required to bring these into a new alignment for effective intermodal transport are likely to be difficult to achieve and slow in coming.

The resounding benefits from deregulation, coupled with a political climate that favors even more aggressive deregulation, prompt hope that letting markets "decide" will quickly solve the problem of achieving a new alignment; but this is unlikely. For one thing, markets are themselves socially constructed institutions and slow to change. A large part of the transport infrastructure has been treated as a public good for many years, and most of the rest has been subject to regulations intended to preserve important aspects of social welfare. Even if we wanted to move to "free" markets right away, the property rights embodied in the existing order would have to be reconstructed to allow the investors in the intermodal arena to collect rents that reward their investment. This kind of change usually occurs through complex legislative, judicial, and industry reforms that are at least somewhat experimental. They take time. The existing order has its beneficiaries who will not, without protest, support change that will hurt them financially. In many cases, these beneficiaries are well positioned to block changes in the existing order.

Building intermodal transport infrastructure requires policy makers, planners, and engineers to consider new ways of creating value. This will happen only through the construction of new physical systems at the nodes and a new institutional order that together allow both commerce and society at large to capture the value created by the enhanced intermodal network. The challenge is daunting because we do not yet know how to do many of the things that will be required for these tasks. Indeed, if the public and private pressures to improve intermodal transport and the potential returns to be gained in the process were not so great, it is likely that the challenges would prove insurmountable.

This paper draws a broader picture around the concept of intermodal transport than one usually finds in the literature dominated by policy, planning, and transportation engineering perspectives. It builds on existing policy-, planning-, and engineering-oriented views of the intermodal vision, and adds the perspectives of information management and institutional economics. The fundamental argument of this paper is that a coevolution of needs and capabilities has brought the United States, and many other countries, to the point where a serious investment in intermodal transport improvement is inevitable for competitive advantage (Figure 3), and that the investment in that improvement should begin soon. It argues further that the information management requirements are the key to understanding intermodal transport and that failure to meet these requirements effectively will cripple even the best-laid plans. Finally, it argues that a focused program of research into the high-level requirements for information infrastructure in support of intermodal transport is a necessary precursor and complement to any further development of intermodal transport infrastructure.

Deconstructing the Intermodal Vision

In the literature, the term "intermodal" is often used synonymously with "containerization." However, we use a more precise definition that emphasizes elements of control and coordi-

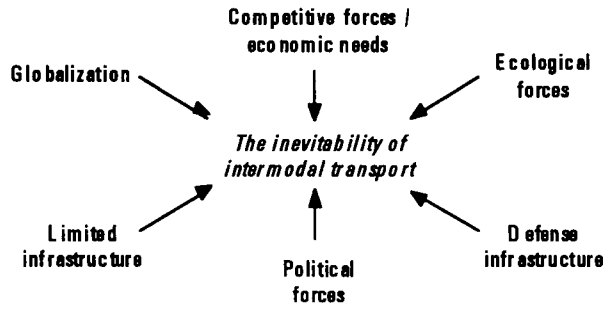

FIGURE 3 The coevolution of needs and capabilities makes serious investment in intermodal transport improvement inevitable.

nation over physical modality. The term "intermodal transport" is the coordinated passage of goods and people by way of two or more of the primary modes of transportation (sea, air, rail, road) from origin to destination, as defined by the passenger or the shipper and consignee, with a single travel directive (bill of lading or ticket) and a single price covering the entire trip.

This definition allows inclusion of a number of intermodal methods that are usually excluded from most discussions because they represent only a relatively small proportion of goods shipped—for example, air/road with less than 1 percent of domestic and exported freight by weight. We find air/road especially interesting because it is an intermodal activity that, in the case of the integrated cargo carriers (for example, Federal Express, Airborne Express, DHL, Burlington Express), has been a sector of exceptional innovation and economic significance. Our definition also shifts the discussion from the important but relatively narrow issues of constraint management to the question of the information required to coordinate the processes that allow the handling to take place at all. This takes nothing away from such technical achievements as containerization that have had a tremendous impact on the handling of freight, but these issues have been treated elsewhere at length, whereas the vital information issues have not.

Domestic/International

We also do not confine ourselves to a discussion of domestic transport only. The ramifications of an efficient intermodal transportation system extend far beyond national boundaries. The important and growing international components of long-distance intermodal transport are driven by changes in the nature of production, commerce, and trade that are altering the global economy. Domestic concerns are rightly a key focus of all segments of the world of U.S. transport, but the real world is quickly becoming interconnected by the closely coupled communications and transport infrastructures that we will discuss at length later in this paper. A restricted focus on domestic intermodal transport is not only shortsighted but fundamentally suboptimal for both economic and national security reasons.

Public/Private

Finally, our definition of intermodal transport deliberately ignores what is an important but distracting distinction between public and private transport activity. In fact, it is difficult to find any significant activity in any mode of transport that is completely public or private. But there are sectors where public or private issues dominate the agendas. For example, much of the urban passenger infrastructure of some cities such as New York is operated by public entities or regulated monopolies. Most of the national road network is public, paid for by tax

monies. Airports and air-traffic control are basically public enterprises, as are seaports. However, many of the vehicles that use this public infrastructure or depend on the public enterprise are privately owned and operated, and most of the purposes behind travel and transport are private.

There is no clear reason to segregate or conflate the public/private dimensions of transport, but there are institutional reasons why we often find a particular preoccupation with one or the other. For example, a good deal of the literature on transport produced by federally funded research centers deals with issues of concern to federal policy makers—the federal highway system, air transport regulations, the state of the nation's railroads, and so on. Predictably, the majority of this literature has a modal focus, in keeping with the mode-oriented institutional structure of federal and state involvement in transport. Similarly, industry-oriented literature tends to deal with the economic and technical aspects of competitive transport business, usually within modes, touching on public issues mainly with respect to public infrastructure and regulation. If this perfectly understandable differentiation in the literature reflects a gap in shared understanding of transport issues across public/private sectors and across modes, achieving the intermodal vision will require a movement of ecumenical proportions that faces serious challenges in bringing together different social communities. We do not underestimate that challenge, but we have deliberately chosen a definition of intermodal transport that dismisses the public/private distinction as completely as it assumes the bringing together of modes.

It is tempting when reflecting on these points to be critical of the policy makers, planners, and engineers in the transport world who have pursued narrow sectoral and modal agendas. This is probably the most serious mistake the true believer in the intermodal vision can make. The transport world has been dominated by communities with very sensible reasons for their sectoral and modal biases. These communities built and sustained the great achievements in transport that characterize the twentieth century. Along the way, they have accommodated and facilitated intermodal transport as need and occasion arose. Modal transport did the heavy work; intermodal transport was seen as a necessary exception. The contemporary intermodal vision in its most aggressive form attempts to reverse that traditional hierarchy, placing intermodal transport on top and relegating modal transport to the role of components in an intermodal network. This view is as misguided as a narrow modal view because it focuses attention on the wrong issues. The question is not modal versus intermodal, but rather the construction of a metavision of transport in which modal and intermodal are simply different views of the same problem.

We do not see transport as a matter of physical and organizational infrastructure, although these are necessary components of transport. Rather, we see transport as an essential human activity that is best considered in terms of social communities in action. A social community is a group of people who share common interests and concerns with respect to basic issues such as beliefs, productive enterprise, geographic proximity, and so on. Most individuals are members of more than one community—for example, a person can be a member of a geographic community such as a neighborhood, a professional community with members scattered across the country, and a religious community that might be global in scale.

Transport exists for travel and exchange of physical goods within and between these social communities. At the same time, transport is provided by yet other social communities, usually professional and commercial communities bound together by shared expertise, technology, and social conventions in addition to ownership and regulatory structures. A technical infrastructure enables transport but it is not the reason for transport and it does not provide value. Rather, social communities in the transport world use technology to make that value available to other social communities who extract that value.

Integration/Coordination

This distinction between transport-as-technology and transport-as-community-activity is important not only in order to understand why transport is socially important and complicated,

but also to draw the distinction between integration and coordination that is essential to our story. We will argue that intermodal transport requires a high degree of coordination, but that does not mean that intermodal transport requires integration. Integration is only one way to achieve coordination, as the integrated cargo carriers have demonstrated. There is a tendency among those schooled in rational management perspectives, especially systems rationalism, to believe that integration is an ideal to be pursued with vigor whenever coordination is needed. As we shall show, this is a pernicious mistake that shows up all too often in discussions of intermodal transport.

The communities who need transport do not think of the modality; they think of the objective of transport which is to move goods and people from origin to destination for reasons that make sense within and across communities. The modality distinction is an issue within the provider communities and, in an important but subtle way, within the communities of policy makers, regulators, funders, and others who bridge the "provider" communities and the larger "user" communities. To the extent that there has been unreasonable fixation on mode, the responsibility probably rests less with the actual provider communities who are just trying to get the job done than it does with those boundary-spanning communities that have built and sustained the institutional apparatus that forces modal distinctions through research, funding, legislative, and regulatory mechanisms. The intermodal vision is nothing more than a new form of conceptual hegemony if it merely reverses the hierarchy, putting intermodal over modal. Instead, the intermodal vision at its best seeks to eliminate the distinction between modes the way the user communities have long done.

Inevitability of the Intermodal Vision

We proceed from the assumption that improvement of intermodal transport is inevitable for continued economic and social well-being. The hope for intermodal transport is based on a simple but significant assumption—that the existing transport assets in roads, rail, airports, and seaports constitute a robust set of links in the overall transport network but that the overall network is operating suboptimally because the "nodes" that allow coordinated use of multiple links are inadequate. The essence of the idea is that underutilized or inefficiently used capacity in the links of individual transport modes could be put to better use if intermodal passage were enabled. Intermodal transport therefore is a form of leveraging assets; it is expected to create value by improving on what is already in place.

The political discourse about transportation will, of necessity, shift in focus from the development of new links to more efficient use of existing links. This is in recognition of the fact that the basic modal infrastructure of the United States is now in place and will not expand significantly in the foreseeable future. The Interstate Highway System will not grow significantly in terms of new miles in the network, although improvements will be made in capacity. The rail network is, if anything, shrinking, although improvements will be made on certain roads (Figure 4). There will be few new airports or seaports constructed, although there will be improvements in the existing facilities. The result is increasing congestion in each of the modalities.

This slowdown in the construction of modal infrastructure links has several causes. One is the simple fact that the great infrastructure building campaigns of the last 5 decades have succeeded in their missions. The infrastructure desired has been largely completed. Another is the rise of concern about the social and environmental trade-offs inherent in building such infrastructure. Experience has taught that building major components of infrastructure displaces communities, disrupts the natural environment, and alters existing patterns of commerce. Organized opponents of such projects can mobilize considerable political power, and the costs of mitigating social and environmental problems have added greatly to the cost of the projects. New projects, especially if they are to be built with public money, face a major challenge of justifying the heavy costs in light of other social needs (Figure 5).

At all levels of government, there is intense scrutiny of public expenditures, especially if they require increased taxation or government administration. Most important to the long-run sta-

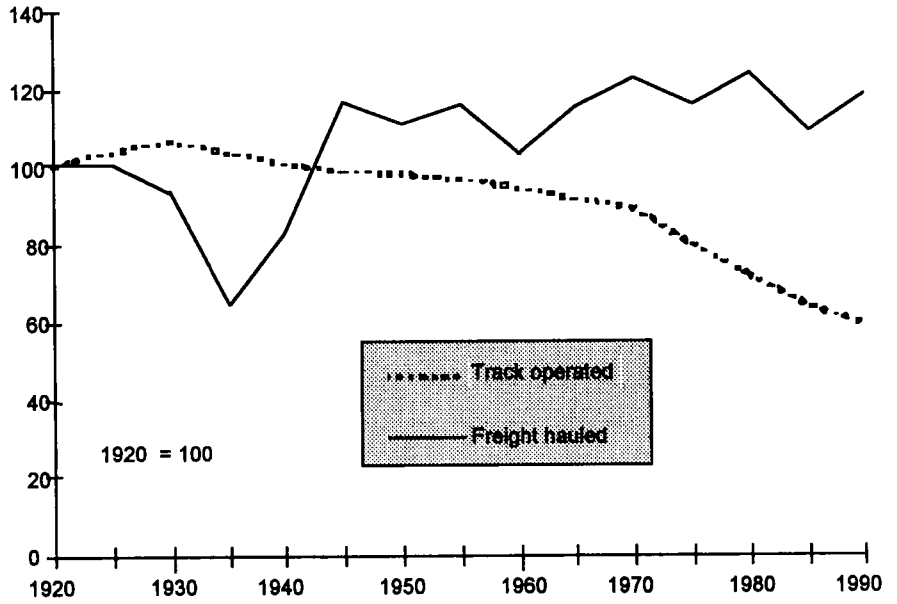

FIGURE 4 Rail mileage and freight growth [*source: Datapedia of the United States: 1790–2000* (2)].

tus of the institutions governing transportation are the subtle changes in assumptions about social welfare and efficient subsidies. The long-accepted argument that infrastructure investments of public monies were generally in the national interest has been weakened, and in some parts of the country the only large-scale infrastructure projects under way involve private financing to be compensated by user fees in operation. There must be an extraordinarily strong rationale to justify a public subsidy for transport infrastructure, and that rationale is not provided by the old modal arguments for infrastructure except in severe cases of congestion.

The critics of large-scale public modal investment at the expense of intermodal investment can also point to the highly efficient intermodal transport provided by the private, integrated air cargo companies such as Federal Express or Airborne Express. These companies came out of nowhere in the late 1970s and within a decade had captured nearly half of the domestic

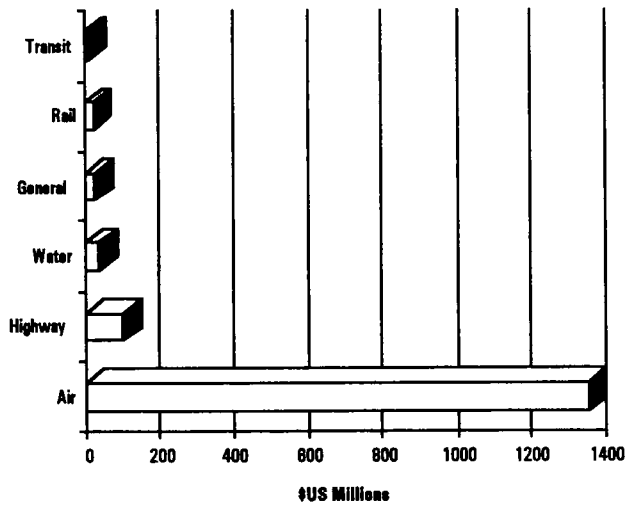

FIGURE 5 U.S. government transportation research, planning, and R&D outlays [*source: U.S. Department of Transportation, 1994a* (*1*)].

air cargo market. Although the air cargo community is not a significant player in terms of global freight tonnage moved (it moves less than 1 percent of cargo by weight), it moves more than 25 percent of the value of all cargo shipped (Figure 6). Also, through time-definite, small-parcel delivery, it has captured the attention of the population at large, displacing in fact and in opinion the public postal service monopoly on first-class mail. Put simply, the integrated cargo community has demonstrated that intermodal transport can be done well and profitably, with great benefits to user communities, and without overt government involvement. Modal transport now has a serious political counterexample to its long dominance. The user communities are now more inclined to accept the idea that alternatives to the traditional order might benefit them.

The reluctance to add to the public debt combined with the visibility of efficient intermodal transport in the integrated air cargo firms sets the mood for change in the modal order. However, they alone do not provide the impetus to move toward intermodalism. There must be arguments that value is gained in the move. Two arguments in particular are relevant here.

One, mentioned earlier, is the increasing globalization of the economy (Figure 7). The combination of international competition that has put severe pressure on production costs, together with growing knowledge and technical support that enable corporate downsizing and restructuring, has made "reengineering" a household word. The user communities of freight and passage services in the business world no longer accept the argument that the inefficiencies that they have wrung out of their own companies are impossible to achieve in the transport communities that serve them. They demand improved services without additional cost and leave it to the transport communities to figure out how to meet the demand.

The scope of the economic change under way is impressive. Fewer goods are being produced for local markets; goods are instead targeted for regional, national, and international distribution. Purchasing is moving away from bulk "economic order point" decisions with warehousing of inventory and toward continuous small orders that shift inventory onto producers or into the transportation system. The new business practices make it possible to take pieces of the existing transportation network and create alternative transport solutions in the logistical gaps of the existing rail, road, sea, and air regimes. Distributed production and distributed markets require appropriate transportation services to match their diversity in degrees of time-definiteness, pricing, and quality. The supply of existing transportation options does not meet the demands of firms competing in an environment that is made less dependent on physical location. The private segments of the freight and passage communities are undergoing radical change as they strive to compete in this new environment. Traditional impediments from institutional constraints and social convention are being challenged and overcome in the effort to survive, and new technologies and approaches are being enlisted. The question is no longer whether change will occur but rather what the newly evolving order will look like.

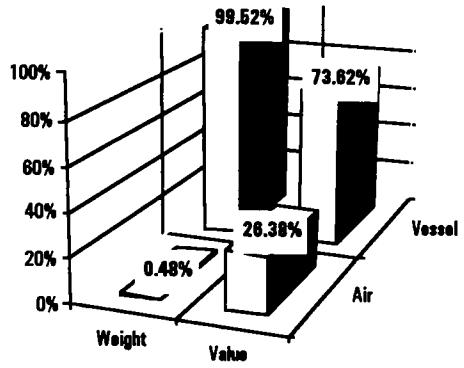

FIGURE 6 Air exports by weight and volume [*source: Statistical Abstracts of the United States* (3)].

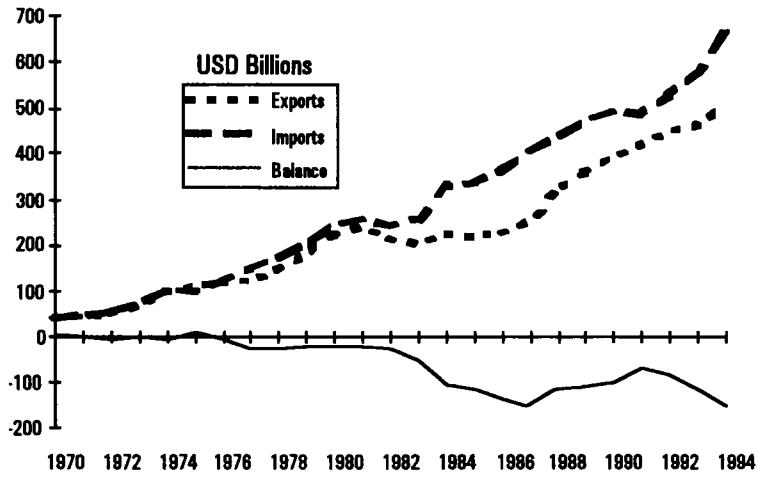

FIGURE 7 U.S. merchandise trade [*source: U.S. Global Trade Outlook 1995–2000: Toward the 21st Century* (4)].

Finally, we turn to a vital but often overlooked incentive to focus on intermodal transport: national defense. The end of the Cold War has shaken the foundation of defense logistics just as it has many other aspects of defense strategy. Defense is fundamentally a matter of risk management; the benefits cannot be counted in what is won but rather by what is not lost in the event of conflict. Ideally, defense is the prevention of conflict by making the likely retaliatory costs borne by an aggressor too high to warrant the aggression in the first place—a highly sophisticated form of game playing with deadly stakes. The logistic model for defense during the Cold War was forward deployment of forces and materiel in the most likely theaters of action in the event of conflict between the two superpowers and their allies. As the Cold War began to wind down, it became clear that the national interests of the country in the future would be threatened by actions of smaller actors with the capacity to upset economic or social equilibrium vital to the United States. It is too expensive, if not impossible, to maintain forward deployment in all possible trouble spots, as the Iraqi invasion of Kuwait and the subsequent Gulf War amply illustrated. The evolving concept of defense based on rapid mobilization and deployment has begun to replace forward deployment.

Rapid mobilization and deployment pose very different requirements on defense than does forward deployment, particularly in the area of logistics. For one thing, it can never be clear in advance exactly where trouble will occur and deployment be required. Given that the bulk of military assets of the United States must be deployed from the United States to the theater of action, and that more than one threatening action could arise in widely separate parts of the world, it has been necessary to plan for a "two theater" contingency in which actions must be supported from both coasts of the United States simultaneously. Another challenge of rapid deployment is the huge volume of materiel that must be moved quickly if the military action is to succeed with tolerable losses to U.S. forces. Using advanced simulation technologies, it is relatively easy to plan for many different deployment contingencies, and defense logistics experts have developed sophisticated planning capacity in this area. But actual deployment depends on the immediately available presence of the necessary infrastructure to deploy the personnel and materiel in conformance with the plans. That is where the defense interest in civilian intermodal transport becomes a key political factor in the intermodal vision.

Defense has always depended on intermodal transport for expeditions outside the United States. Small, elite components of the U.S. armed forces, such as the U.S. Marines, pride themselves on being a comprehensive fighting force using fighter/bomber aircraft, helicopter gunships, armor, and infantry. These can also be looked at as the country's integrated intermodal transport fighting forces, possessing the necessary land-, sea-, and airlift capacity to deploy immediately to anywhere they are needed. These units are important, but they are only a small part of the overall U.S. defense assets. The other components of the armed ser-

vices depend on coordination of various airlift and sealift commands to move the much larger volumes of personnel and materiel required to prosecute a serious campaign. And unlike the elite intermodal forces, the transport capacity required to move these larger units would be prohibitively expensive to maintain as military-only assets. It has long been the policy of the U.S. military to secure private transport in the form of aircraft, ships, railroad cars and trucks to help garrison forward deployment outposts and respond to crises.[1] The need for rapid deployment to unpredictable destinations greatly increases the military's need for a comprehensive civilian intermodal transport infrastructure that can be mobilized and put to work in the case of a national emergency. Thus, it is in the interest of the national defense to build and maintain a highly efficient intermodal transport capacity that will serve the needs of normal user communities in peacetime and the special needs of the military community (and, by extension, the nation as a whole) during conflict.

Curtailed public infrastructure investment, the economic necessity of appropriate transport modalities, defense requirements, and the potential of intermodalism demonstrated by the success of physical innovations such as containers and the informational innovations of air integrators make it inevitable that attention will be given to the intermodal vision. Moreover, this concern is not limited to the United States. Transport is a global phenomenon with global consequences. Communities with traditional dependence on trade such as Singapore, Hong Kong, and the Netherlands have been investing heavily in intermodal transport infrastructure in anticipation of the time when national wealth will depend not only on the goods and services produced but also on the speed and efficiency with which they can be distributed. The issue, as noted earlier, is not *whether* but *when*. The advantages of intermodal approaches are becoming as persuasive as are the disadvantages of the older modal regime. The time to begin serious research and planning is now.

If our argument about the inevitability of intermodal transport improvements is correct, one might wonder why the vision of coordinated intermodal transport is not more widespread. No matter how powerfully motivated the intermodal vision might be, there are major constraints to be overcome before moving ahead with considerations of how to proceed.

The most obvious constraints lie in the nature of the business itself. Modal transport is difficult in its own right, especially as new technologies provide opportunities for competitively powerful changes in service levels and pricing. For example, trucking is a very basic and very old business; but a number of modern trucking firms have upset the industry equilibrium by using information technologies that allow shipment and truck tracking, which in turn make possible a level of time-definite delivery previously impossible in the industry. Multimodal transport is more difficult yet, even with the advent of critical technological reforms such as containerization. New complexities arise such as the establishment and enforcement of container size and weight standards across community boundaries (for example, rail, road, and ship). Intermodal is even more difficult because it takes on all the difficulties of modal and multimodal transport and adds further uncertainty and risk and problems of multiple agency involvement.

The solution, we submit, depends on a fundamental reconsideration of the problems of intermodal transport. It is not enough to change the tools of analysis; we must change our point of view and develop entirely new tools. For this purpose, we will take an historical view of the intermodal transport problem from two angles.

First, we examine the historical evolution that gives rise to the contemporary intermodal vision and the major institutional constraints. This will give us a sense of how and why the constraints we face are perfectly understandable and perhaps even predictable, although they will be difficult to overcome. If institutions are the carriers of history, as has been suggested, then we need to see how the carry-forward of prior institutional action shapes our options for the future. This gives us a sense of the space we can work within and, we hope, some idea of where our energies might be most profitably applied.

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[1] In time of a major overseas deployment, it is estimated that 95 percent of the troop airlift capability and 28 percent of the cargo airlift capability will come from civilian airlines. Most military cargo for international mobilization will be loaded by civilians at commercial ports (*5*).

Second, we examine the problem of intermodal transport from the standpoint of coordination through information processing and communication technology. We make the argument that contemporary intermodal transport solutions are vitally dependent on these new technologies and, in fact, that no serious progress will be made in achieving the intermodal vision without close attention to this set of opportunities.

The Historical Evolution of Intermodal Development

Regulation of transport is an ancient phenomenon, but it is not necessary to go back far into the historical record to see why prior regulations matter to our discussion of the intermodal vision. We can begin with the efforts of the U.S. government in 1887 to preempt the possibility of a railroad monopoly in transportation with the establishment of the Interstate Commerce Commission (ICC) to control entrance and exit to the trans-state rail transport industry, and to assess the fairness of rate structures used by that industry (*6*). In 1935 control of trucking and interstate bus industries was added to the responsibilities of ICC. The rationale behind ICC was to prevent the emergence of monopolistic dominance within or across transport modes and to protect the modes from predatory pricing and other cannibalizing actions that would threaten the stability of the industry. In the case of the fledgling domestic aviation industry, the Civil Aeronautics Board was established in 1938 to oversee the development of the important and highly competitive industry. The federal government set minimum safety standards and regulated fares and, through letting of lucrative air mail hauling contracts, selected the firms that later became powerful within the domestic airline and air cargo industries.

Although there were umbrella regulatory structures that crossed modes, as did ICC, there was considerable isolation of modes through the establishment of dedicated regulatory boards, reporting structures, and administrative hierarchies. Three broad forms of federal regulatory control shaped the evolving transportation industry: economic regulation controlling prices, market entry, and output; antitrust policy to control monopoly power; and social regulation to govern safety, access, and service quality (*6*). State transport regulations add another layer of complexity and increase the likelihood of conflicting regulation. Within modes, industry associations, unions, and other institutional forces added to the evolutionary stew.

Economic Evolution

Beyond the regulatory and other institutional forces shaping the evolving industry, there was the vital issue of capital generation necessary to lay the expensive physical infrastructure. Each major mode developed a largely unique capitalization system and supporting financial and accounting structures that further reinforced modal boundaries.

Seaports were generally capitalized by the local authorities that stood to benefit from the increased commerce the seaports would bring; airports subsequently adopted the same approach. Today, the vast majority of seaports and airports in the United States are owned by local governments, not by state governments or the federal government. In time, arguments favoring national investment to improve the functioning of local port infrastructure led to the establishment of federally administered trust funds to aid in building and improving port facilities.

The rail infrastructure was mostly capitalized by the private capital markets on the eastern seaboard, prior to the federally led effort to build a transcontinental railroad in the mid-1800s. The risks inherent in building such a huge project were deemed too great to attract sufficient private, at-risk capital, so the federal government added the incentive of large land grants along rights-of-way to stimulate investment. These grants were often huge; for example, the Southern Pacific Railroad, one of the original four partners in the transcontinental rail scheme, remains to this day one of California's largest landowners because of land grants more than a century ago. The rail system has since become one of the most complicated modes of transport with respect to infrastructure support. The gradual decline and consolidation of railroad companies following the emergence of road and air transport com-

petition, and the subsequent rise of government subsidy in both passenger and freight rail through Conrail and Amtrak, raised many questions about the appropriate role of government in the transport sector. Generally, it was agreed that government subsidy should be phased out as soon as possible. The freight sector has been largely restored to its private capitalization status, in part through major changes in legislation regulating the rail freight industry that had been in place for many decades. The passenger sector is still heavily subsidized by government sources, both at the interstate level by the federal government and in urban and suburban areas by state and local governments.

The highway sector evolved quite differently than the other sectors, largely because of arguments that highways were inherently "public goods." This argument maintained that most of the road and highway network could not easily be restricted in use to fee-paying users because placing toll collection points throughout the network would impede transit too greatly. Without a means to ensure that users would pay, the free-rider problem would make private investment too risky. Therefore, general levies plus excise taxes on products used mainly on the highways (for example, motor vehicle fuel, batteries, tires, etc.) were used to raise capital for building a road and highway infrastructure accessible to all without direct user fees. Highways, like railroads, are links in a network that crosses state lines; they are essential to interstate commerce. Road building in time became a key focus of the federal government, and federal excise taxes became a keystone in the highway trust fund structure that capitalizes highway building. Similar schemes are used at the state level for state highways and country roads, while it is increasingly common for municipalities to require land developers to pay the full capitalization costs of local roads in new developments. The effect of this evolution of regulations and capitalization structures has been to create tightly integrated and cloistered communities of social and economic interest within modes.

The modal social communities, bound by a common interest in asset use, emerged as powerful stabilizing forces for the status quo. Documentation and reporting methods, work practices, incentives, and community organizations all evolved to make modal transportation efficient for the majority of users. Once these social conventions were commonly accepted in the community, they became self-reinforcing and very stable. The corollary is that intermodal transport, while always part of the actual transport supersystem, has seldom been able to amass significant institutional power at the infrastructure-development level. Whenever a modal interest group hears the term "intermodal," the immediate concern is that the modal trust fund will be raided and the modal regulatory structure will be pressed to change. Neither of these is attractive to the interests served by the modal-oriented institutional order. The perception by the participants of transportation as a zero-sum game is likely to be the most difficult problem to overcome in the pursuit of the intermodal vision.

Interplay of National Security

Another crucial component in this institutional evolution arises, as we noted earlier, from national security concerns. Defense is universally agreed to be the primary responsibility of the federal government, and defense logistics coordinators have always been faced with problems of coordination across modal as well as governmental boundaries. Moreover, substantial sectors of the U.S. transport infrastructure have been profoundly shaped by defense interests. In shipping, World Wars I and II brought major infrastructure improvements to ports as well as great buildup in the merchant marine. Maintenance of a minimal merchant marine capacity has remained a defense issue to this day, and efforts to improve sea shipping for rapid deployment purposes as in the Gulf War brought about the defense sector's first serious efforts to use containerization and other intermodal technologies. The declining rail infrastructure of the country prompted defense concerns about maintenance of a minimal infrastructure for security needs and the strategic railways initiative. The air sector has been somewhat less affected by defense concerns because the armed forces have maintained their own dedicated air bases rather than depend on joint military/civilian fields. Also, the military has largely depended on its own specialized fleet of aircraft for cargo transport. But even in the air sector

defense has been a notable player, contracting with commercial carriers to move personnel en masse for major mobilizations such as the Gulf War.

It is difficult to find a closer relationship between defense interests and transport than in the interstate highway network. In 1922 an obscure Army Captain named Dwight Eisenhower led a convoy of Army vehicles on a cross-country expedition from the Atlantic to the Pacific to test the utility of the national highway system for military mobilization (7). His report was among several that criticized the highway system so severely that the federal government greatly expanded funding for highway construction and maintenance. More than three decades later, then-President Eisenhower signed into law the National Defense Interstate Highway Act to build a national network of limited access, high-speed, divided highways that would stand ready for military use in the event of an emergency and provide support for commerce and private use at all other times. The Interstate Highway System changed the country and its transport industries in profound ways. It is possible that the national highway network we have today would have been built without the impetus of national security concerns, but the great mobilizing power of defense issues at the federal level is unlikely to have been matched by any other institutional interest.

Evolution of Transport Communities

It is easy when focusing on large, visible institutional forces such as federal agencies and the military to overlook some more obscure but equally important players in the evolution. One of considerable significance is the group of research and development communities that have supplied most of the intellectual input to the conceptualization and planning of the transport infrastructure (see Figure 5 on p. 31). The two communities of greatest importance in the early decades of our story were engineering and management. Engineering has always been important because the artifacts necessary for building the infrastructure must be designed to meet tremendous physical demands cost effectively. Management has been important because the greatest driver of capitalization, excepting defense concerns, has been the needs of agricultural and industrial production, commerce, and trade. Moreover, the transport sectors are themselves enterprises that have to be managed efficiently. For nearly all of the nineteenth century and much of the twentieth century, these communities pushed the evolution of the transport infrastructure along the path of reliable technology for economic growth and, when the need was clear, for maintenance of national security.

As early as the 1930s, however, new communities began to arise in the fields of sociology, geography, atmospheric chemistry, and the life sciences that would greatly change the dominance of the efficiently engineered economic growth paradigm. By the 1970s, coalitions of urban geographers and sociologists, ecologists and environmental activists had begun an assault on the simplistic growth-oriented vision of infrastructure. Their tactic was to focus on the negative externalities that arise from large transport infrastructure projects and the subsequent use of that infrastructure. Air pollution, neighborhood disintegration, and increasing alienation and anomie of urban and rural populations were blamed on the huge highway projects of the Interstate system. The noise pollution from airports, greatly increased by jet aircraft, became the critical factor in airport expansion and siting. Rerouting and rehabilitation of rail lines to accommodate increased and/or faster traffic became an environmental concern to those living along the rights-of-way. Transport infrastructure development was no longer just a matter of good engineering and a sound business case.

In addition, transport infrastructure planners were surprised by the fact that the simplest approach to reducing channel congestion in the transport systems—adding capacity—was not working. For example, as each new lane was added to a clogged freeway, more traffic joined the system and congestion rose to previous levels. As early as the 1960s, economists pointed out that the only sensible way to control peak-load congestion was the application of a pricing system that would charge more for use during periods of high congestion, driving cost-sensitive users into less congested periods. But in a freely accessible system in which users did not pay directly, such schemes could not easily be implemented. And in any case, adding

new capacity (especially after the medians of the divided highway interstate network were filled with lanes) had become prohibitively expensive except in the most dire circumstances.

Faced with these new constraints, transportation engineers began to consider channel congestion problems more broadly. They began to implement controls on user behavior to make optimal use of the channels. A good example of this was the implementation of freeway on-ramp meters to slow "births" into the network, thereby keeping congestion below the threshold of flow degradation. This meter system was basically a modified hydraulic model of channel management, and it has worked very well. High occupancy vehicle (HOV) lanes were another innovation to make better use of the highway channel. In rail transport, double-decked passenger and freight container cars pushed the upper limits of capacity (namely bridge clearances). Larger aircraft made better use of constrained airport takeoff and landing slots and gates. Supercargo container ships and tankers made more efficient use of seaports and more economical crossings. And the possibility of load-leveling of demand across channels in different modes—such as shifting passenger traffic off highways onto rail—has made congestion management a major driver of the intermodal vision.

Roots of Deregulation

The big institutional story of the last 20 years has been a gradual reversal and redirection in the regulatory structure governing the various modes of transport. In the 1970s the United States became a net importing nation, interest rates soared, energy costs increased, and international terrorism created intermittent waves of panic in the passenger transport sectors. The United States went through the first of a series of recessionary shocks. Although transport volumes continued to rise, profitability in the transportation sectors declined. Firms were burdened by operating unprofitable lines and restricted by regulatory regimes from expanding services. A wave of liberalizing legislation got under way that relaxed market entry and exit, increased freedom to set rates, permitted horizontal and vertical mergers, extended services, and increased competition within and between modes. Although the specific impact of deregulation has played out differently in each mode, the general effect has been to increase interaction between modes and allow reorganization within modes. There has been innovation in the terms of contracts and services: delivery times, pricing, and quality. This liberalization of regulation enabled new approaches to meeting transport problems, among them intermodal transport.

Nevertheless, this 25-year period of incremental deregulation has not caused the institutional forces of yesteryear to disappear. Some regulatory bodies such as Civil Aeronautics Board have been disbanded, but the capitalization and administration of transportation is still highly modal and the reporting requirements throughout the passage of goods are still considered excessive. Social regulation has remained in place, and even in the current deregulatory environment there remain constraints on the development of new or enhanced infrastructure projects related to safety, noise, air pollution, economic disruption, and other concerns about externalities. These apply to both modal and intermodal projects. The switch of national defense to rapid deployment discussed earlier is both modal and intermodal. It is also worth noting that the strongly felt need among voters to shift much responsibility for government from the federal level to state and local governments gives a political boost to intermodal concerns, precisely because intermodal infrastructure is invariably a matter of local facilitation of bridging modes. The federal government was essential in the construction of much of the huge installed base of modal transport infrastructure we now have, but the major decisions about intermodal projects will be local and not national in scope.

The Intermodal Vision in Historical Perspective

The challenge of intermodal transport goes up a notch when one takes the problem to the international level. Differences in language, in measurement systems, in rules and regulations all compound the already difficult problems just noted. International institutions that might,

at one time, have provided solutions have lost considerable leverage as transport has been deregulated. In fact, in some modal sectors, these international institutions (e.g., the International Air Transport Association) are seen by key actors within the transport sectors they regulate as a major source of impediments and problems in achieving intermodal solutions. Once again, the challenge is not merely to make the existing institutional order and social conventions work but, in many cases, to replace them with a new order and a new set of conventions that meet the growing need.

We repeat here a point made earlier: the intermodal vision is not ideally a reversal of the dominance of modal over intermodal but rather the recognition that transport as a whole depends on both modal and intermodal without such a hierarchy. History matters, and the institutional legacy we have inherited from the age of modal development brings strengths as well as impediments to the rise of the intermodal vision. Evolving institutional needs and priorities will likely be an advantage to the intermodal vision in the near future, along the lines presented earlier in the discussion of inevitability. It is naive to assume that the older institutional order will simply be swept aside and replaced by a new order. The elements of institution, social convention, technology, and changing commercial conditions will coevolve into a new order. In the remaining sections of this paper, we will consider an approach for research that will, we hope, facilitate that coevolutionary development process. We focus our attention on a story about the coevolving relationship between information and transport infrastructures—"The Great Reversal." This story signals a paradigm shift to a new perspective from which researchers, planners, and policy makers can productively approach the intermodal vision.

The Great Reversal

For most of human history, communication beyond the carrying power of the human voice was subordinate to the transportation infrastructure of the time. Written correspondence or other physical tokens had to be carried by the transport infrastructure from sender to recipient. With a few exceptions that depended on line-of-sight transfer (for example, smoke signals, signal flags, semaphore), communication could go no faster than transport conveyances. Rapid conveyance was often developed specifically to speed the post, as in the case of the Pony Express—a novel experiment that lasted only 2 years but became an abiding legend. The dependence of communication on transport lasted until the development of electronically transmitted communication in the form of the telegraph in the mid-nineteenth century. This development freed communication from its enslavement to transport, and subsequent developments in telephony and wireless broadcast of audio and visual signals brought about a revolution of enormous scope and scale. Communication separated itself from transport in many important respects, becoming a separate world of enterprise and, in some cases, engendering substitutes for transport, as in the case of telephone calls and, more recently, videoconferencing and electronic mail, as a means to replace face-to-face meetings.

A less clearly understood consequence of the advent of electronically based communication was the coevolution of communication and transport. The great importance of the railroads to the development of modern industry and commerce has been well documented (*8*), but the essential role of the telegraph in the success of the railroad is more obscure. In fact, the railroad and the telegraph were essential complements in a powerful communication/transport nexus (*9*). The physical infrastructure of the telegraph depended on the presence of a roadway along the telegraph right-of-way to facilitate construction and maintenance; the railroad provided this. The telegraph, in turn, made the railroad manageable as an efficient and safe rapid-transit system.

The railroads were actually responsible for two vital innovations in the information management sector. One was the publishing and distribution of written schedules of operation—departures, arrivals, and so on—that were unheard of before. Such uniform schedules were not for the convenience of passengers; they were vital for coordinating the movement of trains moving in opposite directions on single-rail lines. Unless a train operator could safely assume that opposing trains would meet at bypass sidings on a predictable schedule, safe and

efficient operation was impossible. But schedules were only useful when everything worked according to plan. The other need of the train system was the means to get exception information, such as news of breakdowns or the travel of specials, down the line more rapidly than the trains themselves could travel. The telegraph was not necessary to make the railroads run; it was necessary to make the railroads economically powerful contributors to the dawn of mass production and distribution that characterize the second industrial revolution.[2]

The information revolution with respect to transport goes beyond communications technology to include information processing technologies. Some of this development was in physical process control—the installation of computer processors in many aspects of vehicle operation, most notably in avionics, but increasingly in passenger automobiles and trucks. These developments have greatly improved the safety and efficiency of air and rail operations and have given rise to hopes for improved highway vehicle performance in the form of "intelligent" vehicles and highways.[3] A less heralded development is the creation of technologies such as bar coding and scanners and "radio chips" that store and broadcast bursts of information.[4]

In the freight world, the objective has been to put more intelligence into the package, either in the form of scannable codes that trigger access to records in an information network scanning the packages or in the form of on-board information storage that provides key inputs to the control system regarding routing, contingencies, and so on. Ideally, this would make a package more like a passenger, providing the equivalent of the on-board intelligence systems that make passenger intermodal transport coordination comparatively easy. Ironically, some of the most interesting recent innovations in the passenger market have come through precoordinating transit routes and transfers so that the passenger has to worry about very little of the coordination in an intermodal trip. In a sense, the result has been an effort to "passenger-ize" cargo transport and to "cargo-ize" passenger transport (*11*). The benefits of one can accrue to the other.

In addition to these device-based information processing technologies, both passage and freight transport have benefited from computerization of transport documentation. Documentation in the form of tickets, bills of lading, letters of credit, customs declarations, and so on has always been vital to transport. As computerization spread in the 1950s and 1960s, this powerful technology was applied to transport documentation problems with great success leading to development of EDI standards to facilitate intrafirm and interfirm communi-

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[2] It is also worth mentioning that the railroads contributed greatly to a second revolutionary innovation in communication, the deregulation of the U.S. national telephone infrastructure. One of the first serious attacks on the hegemony of the AT&T Bell System was a railroad implementation of a proprietary, intrafirm telephone system using company right-of-way. AT&T sued the railroad, arguing that the railroad was prohibited by the Communications Act of 1934 and its amendments from operating an interstate telephone system. The decision of this case in the railroad's favor was one of the first breaks in the telephone monopoly structure. Two decades later, another railroad challenged the long distance telephone monopoly again by developing a subsidiary, SPRINT, to provide long-distance service to commercial customers over lines run on railroad right-of-way, using the local monopoly telephone network to route the calls into and out of the SPRINT points of presence. This action, together with the microwave long-haul network of Microwave Communication, Inc., that "jumped over" AT&T's right-of-way constraints, precipitated the actions that led to the Modified Final Judgment of 1984 in the U.S. Department of Justice antitrust suit against the AT&T Bell System. This judgment spun long-distance telephony off into deregulated and competitive markets and began a process that will lead in this decade to the wholesale elimination of the local telephone service monopolies.

[3] Note that this is basically a channel-capacity improvement strategy that probably will not have a big impact on intermodal transport.

[4] One example of such a radio chip is ProfitMAX, a system based on a module that is attached to the shipment and transmits status information to the Texas-based monitoring station. Depending on the configuration, the module has positioning, shock, and video sensors and is being developed to include electronic data interchange (EDI)-messages (*10*).

cations.[5] Much of this development was concealed from those outside the "back offices" of transport firms, but important strides were made in the creation and reconciliation of shipment documentation that would later come to fruition in the form of the sophisticated shipment tracking systems so essential to time-definite delivery in the freight world. More obvious to the public was the rise of the computerized reservation systems that helped revolutionize the air travel industry. This technology has subsequently spread to rail travel and other reservation and ticketing venues.

Developments in the communications and information processing arenas took on greater significance with respect to transport when they became tightly coupled. This enabled the evolution of what might be called "transport governance systems" that could introduce efficiencies and drive costs out of the transport value chains. In essence, the goal of these systems is to make whole transport chains more "intelligent" so that they can operate effectively with greatly reduced labor inputs and at faster speeds.

None of these developments in the transport world would be possible without a rapidly evolving information infrastructure. Moreover, we argue that the future of both passenger and cargo transport is fundamentally dependent on information infrastructure as communication was once dependent on transport. It is not that transport is impossible without the information infrastructure—transport was taking place long before information infrastructure could have been a meaningful concept. Rather, we argue that transport will be impractical without a complementary information infrastructure. The great payoffs in transport over the next 2 decades, as we argued above, are in leveraging the existing modal infrastructure through intermodal infrastructure development and a concerted process of social learning so the user communities can exploit the advantages provided by this new infrastructure.

Through the use of information technology in the integrated air cargo sector, we have provided some examples of the promise envisioned. Let us take another example that is less well developed but has been the source of much speculation. In the effort to move passengers from almost exclusive dependence on one mode of travel—namely the automobile/road system—and onto alternative forms of transport, a great deal of attention has been paid to the physical infrastructure required to exploit the alternative channels (be they bus, rail, or intermodal mixes). Of course, the physical infrastructure is necessary before any substitution is possible, but it is not the only necessary component. There must also be an information infrastructure in place that manages the coordination within and between the various transport legs. This coordination happens on various levels. First, scarcity of goods presupposes the allocation of these resources between various individuals and involves information as well as decision processes. The earlier mentioned reservation systems fall within this category. Once allocation of the transport service has occurred, coordination on a more operational level has to take place. It is the transfer of documents as well as the coordinated use of the infrastructure. We often forget the tremendous investment in coordination facilitators that make the automobile/road system function effectively: provision of maps, signage, driver training (organized and ad hoc), on-air traffic advisories, and so on. There are now active efforts to put global positioning technology to work in automobiles to facilitate this coordination function.

The automobile/road system is comparatively simple to coordinate because the passenger is also the driver and can direct the vehicle expressly to his or her destination, as long as the road network goes there. This is, in fact, the great attraction of the system: it is personal rapid transit. The most serious difficulty facing substitutes based on nonpassenger-directed conveyances such as buses, trains, shuttles, and so on is the precoordination the passenger must do to organize the routing. The creation of an effective intermodal substitute to the automobile/road system will instantly fail if the only provision is an excellent physical infrastructure. The essential shortfall will be the inability of the passenger to make the right choices, in

[5] It is interesting to note that adoption of EDI itself has been slower than anticipated despite the continuing hype surrounding new messages and networked systems using EDI. In our estimation it is not underdeveloped technology that is holding EDI back but rather the institutional capacity of the user community to use the benefits of the technology.

advance, to enable the substitute to be as effective and reliable as the automobile/road alternative. The huge number of origins and destinations possible even in a modest urban or suburban area makes the publication and distribution of point-to-point routing suggestions impossible. And any effort to create a call-in system for routing suggestions will create the worst "help-desk" problem in history. In fact, the only reasonable solution to this problem is likely to be the deployment of an easily accessible, automated, and self-learning help-desk infrastructure that passengers can access for advice and update on the basis of their own expertise. Unless passengers have such assistance as part of the intermodal transport alternative, they will never adopt it in sufficient numbers to make it economically or politically viable.

The beauty of this broad vision for transport, both modal and intermodal, is that the intersecting technological regimes generate new opportunities in transport and create economically valuable "bandwagon" enterprises as well. Providing intermodal transport alternatives increases the size and profitability of the transport and creates demand for information and communications goods and services. The requirements of the supporting informational infrastructure in turn creates demand for specialized skills to support the application of the technologies. At the regional level, increasing the competitiveness of transportation systems creates competitive opportunities to increase regional dominance and to sell transportation services abroad. It is possible that the value-added arising from these bandwagon developments will exceed the value-added from improved operation of the transport systems.

However, to reap the benefits of improved transportation operations, we need an organizational strategy to mobilize and coordinate the resources. Two strategies in particular command attention. The first is vertical integration of a transport value-chain. The second is loosely or tightly coupled cooperative relationships between specialized actors. Both strategies are attempts to manage uncertainty: vertical integration reduces the uncertainty of goal incongruity and supply risk by internalizing potentially unreliable actors; cooperative relationships reduce the impact of changing markets by maintaining flexible resource and labor supplies. Both can be highly effective in their appropriate domains. Vertical integration is the more proven of the two and no stranger to transportation. However, we suggest that there are limits to vertical integration as the dominant strategy in the environment we have foreseen for intermodal transportation.

Coordination in Intermodal Transport

Coordination through Vertical Integration

Vertical integration has been a highly successful strategy where conditions of market stability and standardization of products exist. It extends beyond ownership of the pieces of a value-chain to structuring of the connections between the links in the chain. It is characterized by central planning and authority and formalization of procedures that eliminate decision alternatives that use assets suboptimally within the organization. In our example of air transport this strategy is epitomized by the air integrators. Their strength lies in controlling door-to-door delivery of a well-defined product—in other words, time-definite delivery of packages within a small-weight limit.[6] By controlling the entire physical infrastructure from the trucks, planes, and air hubs, as well as the information and communications infrastructure—from the creation of standard bar coding of packages to the accounting systems—the integrators can monitor and control the entire production process. Ownership provides the security to invest in expensive proprietary systems, the benefits of owning performance information, and the authority to impose uniformity throughout the entire organization. This control translates to reduced uncertainty for the firms using the air integrators services and increases the transport users' ability to plan (*12*).

[6] Currently the small-weight limit is 150 pounds.

While acknowledging the effectiveness of vertical integration, we also recognize that its success relies on certain environmental conditions—namely, high-volume, standardized products in stable markets. The integrators have been successful because they operate in a highly standardized niche market that allows them to gain volume. As geographical and product heterogeneity increases, flexibility becomes more important, thus diminishing the advantages of vertical integration. In the case of intermodal transport, the very essence of this modality is the development of a supply of transport solutions for markets demanding flexible and appropriate transportation. We argue that because of the tight constraints associated with vertical integration, this strategy will not meet the challenges of intermodal transport.

For empirical evidence, we simply note that during the late 1980s the traditional air cargo community of forwarders and carriers was deeply fearful that the integrated carriers would take over the whole air cargo industry. After all, the integrators' growth had been astounding. But much of that growth was in the creation of new business (for example, routine next-day document delivery) and not in the substitution for traditional air cargo services. More important, after a decade of spectacular growth, the integrators seem to have reached the limit of their penetration into the traditional air cargo community. They proved, as others have in the past, that there are problems with as well as advantages from integration. The major disadvantage of integration is the need to specialize in the general—to provide a commodity-like service that appeals to customers with highly similar needs. Thus, the integrators excelled at small-parcel delivery of uncomplicated cargoes such as documents and dry goods. More specialized cargoes such as large and bulky items, live shipments, hazardous shipments, and high-value perishable items do not fall within the competency of the integrators. Much of their business derives from the exceptional or "just-in-case" demand for which users are willing to pay a premium price. In the long run, users will shift much of this business to more appropriate regular intermodal solutions.[7]

Coordination through Cooperative Organization

As an alternative to integration, there are communities of transportation actors each specializing in a segment of the transport chain. To effect intermodal transport they cooperate out of necessity, coordinating physical passage of goods and information flow between their separate organizations. The constraints under which intermodal transport is envisaged to operate coincide more closely with a cooperative organizational environment. Shifting global markets, distributed production, flexible production, and customized transport solutions all make vertical integration risky. Cooperative relationships will dominate where logistical decision making is decentralized and logistical solutions are customized.

Although it necessitates a flexible network of partners, cooperation comes at the cost of coordination. When intermodal capacity is not vertically integrated, but rather is organized among multiple parties (for example, forwarders and carriers, airlines and airport shuttle services), the coordination problems can be severe. An integrated carrier bears all the risks of each segment of the chain. It might wish to reduce risks in some segments and tolerate greater risks in others, but ultimately the objective is to minimize risk to the firm across all the segments. This is in the interest of the carrier but not necessarily in the interest of the shipper or the consignee or the passenger. In a nonintegrated situation, each party in the segments will seek to shift risk to the other segments and reduce its own. The resulting game can be exceedingly complicated and turbulent until an industrywide set of conventions governing such practices evolves and an equilibrium is achieved. Such equilibria can be found in multimodal

[7] The integrators themselves are offering more diverse delivery alternatives. Once overnight service was the only service available; now services such as 2- or 3-day delivery are common. To maintain the multiplicity of services, we expect the integrators themselves will move toward a more cooperative organization to better provide these services.

transport in both passage and freight, but they have not been established in intermodal passage and freight. It will take time and a good deal of experimentation (with winners and losers) before such equilibria can be established.

The next challenge facing intermodal transport is the achievement of coordination across modes without integration. Equivalent levels of learning and technology mastered by the integrated air cargo companies, and other integrators in other transport domains, will have to be accomplished without the inherent advantages that come from integrated ownership. This will be much more difficult because different actors in the game would prefer to have others bear the costs and risks necessary to make the system work, without threatening the interests of the late-adopters. Given the huge front-end investments required to make nonintegrated intermodal transport function, and the fact that these are shared infrastructure investments that cannot be turned readily into proprietary rents for specific investors, nonintegrated intermodal transport faces a serious "bootstrapping" problem. For example, consider the Alameda corridor project in Los Angeles to put an above/below grade rail link between the Ports of San Pedro and the rail yards of central Los Angeles. There is consensus among all parties—ports, municipalities, county, state, railroads, steamship companies—that this project is essential for future economic welfare in the region. But, more than 10 years after the initial feasibility study, despite continued calls for its development, the project is still $700 million short of the estimated $1.8 billion required for the construction of this essential intermodal facility.

This bootstrapping problem also applies to the information infrastructure. Although the network externalities of cooperation might be recognized in the transport community, information asymmetries and vested interests inhibit shared information solutions. Developing shared data bases of community schedules and services is essential for origin-to-destination control. However, disclosure of information between actors shifts dependencies, and not accepting this fact may make participants reluctant to join. A single standard may be desirable for simplicity, but in a cooperative environment information standards and systems must support heterogeneity and diversity among the actors.

Numerous attempts have been made in the air-cargo sector to develop cargo community systems (CCSs) to extract the benefits of a coordinated community system in international transport. However, none of these systems has lived up to expectations primarily because the shared information benefits the carriers but not the forwarders who are responsible for the majority of international business (*13*). One of the largest systems, Encompass, owned by AMR (American Airlines) and CSX has spent $100 million to date on the development of a system that has had repeated cutbacks in services and generates only an estimated $10 million in annual revenues.

Our quest must be for solutions to industry organization other than vertical integration. As noted several times earlier, this is a difficult quest because, as the integrators have demonstrated, a complicated set of organizational, technical, and institutional factors had to come together to enable the rise of this single solution. Although this swarm of innovations can be rightly attributed at the descriptive level to the genius of the leaders of Federal Express and the other integrators who proved the concept could be done, we guess that there were other, failed innovative efforts in the intermodal air cargo arena that would prove the search has been hit-or-miss, as all learning-by-doing efforts are. Indeed, the subsequent problems with implementation of the CCSs and other information infrastructure approaches to coordinating the nonintegrated intermodal air cargo sector suggest precisely this. If we wish to make more rapid and profitable progress toward the intermodal vision in the air cargo world, we must improve our ability to capture the learning benefits from both the disappointments such as the CCSs as well as the stunning successes such as the integrators.

A RESEARCH AGENDA FOR INTERMODAL TRANSPORT

The challenge for those who conduct research into information and transport infrastructures is significant, but it can be met. In addition to the traditional lines of research into improve-

ment of transport technologies and infrastructure, which should continue and in some cases increase, we see a clear need for research in the following areas:

- *Socio-Institutional Reform.* Research is needed to document and evaluate the ongoing learning-by-doing experimentation in the transport world, especially with regard to innovations in use of information technologies and new organizational forms. A great deal of information is available on a few exemplary cases, such as computerized reservation systems, the integrators in the air transport domain, and the time-definite delivery trucking firms. But few of these studies are sufficiently deep and critical to provide the necessary level of social learning. More serious is the lack of careful evaluation of instructive but less spectacular experiments that might reveal innovations that, in different circumstances, could produce great payoffs. There is much new information being created as part of the experimentation under way, but we are not capturing this precious asset as social knowledge. The modest investment required to do this would produce manifold returns.
- *Complementarities in information and transport infrastructure.* Focused research should be conducted into the interdependent relationship between information infrastructure and transport infrastructure in both modal and intermodal transport. There is a need for theoretical work on the economic relationships between information management and transport that gives rise to these infrastructural interdependencies. This research must go beyond engineering and policy perspectives tied to the status quo. It must build on contemporary theories in institutional economics (for example, agency theory, game theory, transaction cost theory), as well as organizational sociology (for example, social network theory and new institutional theory). There is also a need for robust qualitative research to describe, in detail, the work worlds associated with existing intermodal transport activity, with particular attention to the techniques, practices, and conventions used to allow participants from different communities in the transport world to interact effectively. Recent work in industrial anthropology is suggestive of the kind of research needed.
- *Coordination with and without integration.* Experimental research should be undertaken on the technical components of intermodal information infrastructure that appear to offer advantages, especially in non-integrated circumstances. This experimentation should focus on the underlying technology, especially emerging information processing technologies illustrated by client-server systems, distributed data bases, expert systems, neural networks, and machine learning. It should also focus on emerging communication and processing technologies as seen in value-added network services, the Internet and World Wide Web, and "applet" based models of networked computing. Equally important, this experimental work should introduce and control for conditions that will confront such systems in vivo. The ability of a technology to perform in a tightly controlled, unrealistic setting yields little information about what will happen when the technology is subjected to the problems of real-world production environments. There is a real need for "testbed" capacity, similar to that provided for development of the Internet and the high-speed data communication networks that have been a focus of DARPA-sponsored research in the computing and communications field.

The purpose of such a research agenda is to build the knowledge base generally but more particularly to build capacity for what we call "high-level requirements analysis" related to the coming intermodal revolution. If, as we argue, the future of intermodal and modal transport is inextricably linked to information infrastructure, the creation of those coupled infrastructures will pose great challenges for designers and system builders. Much progress has been made on low-level requirements analysis that formalizes task sequences and derives from them the specifications for systems that will facilitate the doing of those tasks. What we seek is the means to assess the higher-level requirements for the system as it will be deployed in a complex milieu of organizational behavior and culture, which in turn is influenced by larger institutional order. Even an elegant technical system that meets low-level specifications exactly will fail in deployment if it fails to meet the requirements of the broader organizational and institutional order in which it functions. The payoff from improved high-level re-

quirements analysis capability is primarily in the avoidance, or at least reduction, of costly system failures.

Conclusion

The main driver behind the intermodal vision is economic opportunity. The demand for transportation is growing, and investment in transportation is essential for ongoing national and international economic development. This growth creates investment opportunities that call to the transportation community. Intermodal transport improvements are inevitable and are already under way, as the integrators have shown. But the larger intermodal vision will not happen through vertical integration. It will happen through value-added improvements that facilitate harmonization and cooperation. The pieces of the modal infrastructure have been built, but they are crudely stuck together with inefficient and inflexible "fixes." To create interconnects we have to work on the nodes between the modalities.

In this process, we must turn to information technology as a key enabler. We now have leverage at the intersection of technology and knowledge that has never been available before. We have the capacity near at hand to create a world of complementary information and transport infrastructures that will bring changes to transport that go beyond differences in degree; they will bring differences in kind. The future of transport in this vision is very different from that envisioned by the traditional transport communities, even at their most enlightened. Intermodal and intramodal transport must be thought of as a more profound challenge than simply dealing with congestion management. The real problems in congestion management lie with the precongestion problems upstream. Information technology has already been put to work as an upstream servant of infrastructure building, in the form of computer-aided design, transport simulation, and so forth. It is being used to improve vehicle performance and to substitute for transport such as with videoconferencing. The next major frontier is the integrated communications and transport infrastructure that makes possible what never was before.

There are lessons for all the different communities in the transport world. For the governmental policy and regulatory world, there are the lessons of deregulation, reregulation, devolvement of power from the federal to the local level, and a renewed and altered need for transport infrastructure for national defense. There is also the coincidence of greater capitalization difficulty from traditional government sources and new capitalization opportunities from private sources and public/private partnerships. For the private firms in the various transport modes there are the lessons of increased sensitivity to the user communities, with their focus on the objective of transport rather than the means. Their demand for easy to manage, time-definite delivery at reasonable prices will not go away; it will grow as they see evidence that it can be provided. The competitive pressures will grow, and only the innovative will survive.

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Realizing an Intermodal Future Through Research and Development

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In 1968 the U.S. Department of Transportation (DOT) was established to unify and coordinate America's transportation programs, previously administered by various Cabinet and independent agencies.[1] The defined responsibilities of the new Secretary of Transportation were to facilitate the development and improvement of coordinated transportation services provided by the private sector (to the maximum extent feasible) and to encourage the cooperation of the federal, state, and local governments as well as carriers, labor, and other interested parties. The specific achievement of the objectives was to administer to the needs of three complementary transportation factions:

- the public, consumers of transportation,
- the providers of transportation, and
- the military, or national defense (*1*).

Until recently, effective U.S. domestic and international transportation operations could be realized largely by each commercial and public mode (air, highway, rail, and sea) doing its planning and budgeting largely independently; while the U.S. Department of Defense (DOD) could assume that, in times of national emergency, it could complement its unique transportation capability by preempting the commercial and public sectors. Thus, the "coordination" required of DOT could be relatively loose—requiring little in the way of overall national transportation systems integration and optimization.

However, in recent years the field of transportation has changed rapidly. A large variety of significant causes can be listed: widespread deregulation, globalization of industry (and the associated internationalization of competition), the explosion of information-age technology, the collapse of the Soviet Union, and the rapid growth in commercial and public transportation demands. These are but a few of the more dramatic drivers. It is the compounding effect of these events that is causing the need for rapid changes in America's overall transportation system and in the required actions by its principal participants.

[1] *PL 89-70. The Department of Transportation Act. October 15, 1968.*

The most obvious changes are in the national security area. The end of the Cold War necessitated a dramatic shift in defense planning. Most visibly, the defense budget plummeted, putting pressure on all aspects of national security; while, simultaneously, the United States was withdrawing from many of its overseas bases and thus increasing its demand for long-range logistics support. The shifting military focus from a high-intensity, central European war with the former Soviet Union to a varying set of responses to a highly unpredictable mix of scenarios anywhere in the world required a shift to a rapidly responding, domestically based military posture. Additionally, when DOD looked at the huge logistics infrastructure it had developed for the Cold War era, it realized that such a structure was no longer affordable or effective. In fact, it was clear that commercial firms were moving to a "just-in-time" inventory system, while DOD was struggling to maintain a "just-in-case" inventory system. The latter was not only incredibly expensive, but it took months for its logistical system to respond, while the commercial world was responding in days. For example, even during the heightened intensity of the Persian Gulf crisis, DOD took 40 to 60 days to resupply parts for which Caterpillar guaranteed commercial delivery of the identical parts anywhere in the world within 4 days (2). Similarly, for commercial aircraft parts, Boeing delivers worldwide within 24 hours; and many other suppliers provide such support. The contrast to the DOD logistics system is shocking. Thus, for reasons of affordability and effectiveness, DOD now realizes that it has to depend far more heavily on commercial transportation systems and, similarly, it must adopt many of the transportation management approaches employed by the commercial arena.

At the same time, the transportation demands of the commercial industry were also changing rapidly. Deregulation was moving ahead, requiring transportation systems to be far more competitive and, thus, much leaner—a growing conflict with DOD's desire to tap into commercial systems' excess capacity in time of crisis. By contrast, some of the changes favored a closer integration of the commercial and military needs. The commercial sector was rapidly going global; U.S. transportation systems were increasingly competing in a world market, and the planning for freight shipments had to take on an increasingly international perspective. Additionally, the U.S. freight transportation system was expanding rapidly; and, together with its modernization, its larger size offered greater potential to be able to handle the relatively smaller needs of the military. Finally, and perhaps of widest impact, in the public arena there was growing recognition of the large, and adverse, effects those transportation systems were having on the quality of life for Americans—regarding safety, environment, and, particularly, commuting time. Increasingly Americans were demanding action. However, adding highways at $100 million per mile (in Los Angeles) not only was not affordable but also did not solve the nodal bottlenecks—an increasing problem for public, commercial, and military users of the transportation system.

Overriding these changes (in the last decade of the twentieth century) has been the revolution in information technology. The information age has the potential to dramatically enhance traditional ways of doing business in all arenas, particularly in the transportation world. It has become recognized that applying advanced information technology can have a truly revolutionary impact on all three of America's transportation missions—that is, national security, economic competitiveness, and quality of life. This impact involves both improving the overall efficiency of transportation and reducing the need to transport. Its applications are unlimited; advanced information technology can integrate trade and trip transactions with financial management systems as well as transportation systems planning, operations management of carriers, etc. By addressing the end-to-end flow time for information as well as for goods and people, dramatic improvements in the processes associated with all of the modes of transportation can be enhanced—at the nodes as well as in the links. In fact, applying such advanced information technology to intermodal transportation systems (in the new deregulated environment) represents the critical competitive advantage that a nation can have, since it allows the optimization of the intermodal system from end-to-end in a seamless fashion. In many cases, it actually eliminates significant steps in the process, and in other cases it simply optimizes the transfer at the nodes and/or the selection of the best mode between the nodes. Similarly, the overlap between the needs of freight, commuters, and DOD can be addressed through modeling and simulation of the various systems, using real-world

and real-time data bases to validate the models and then apply the models to address "what if" situations that could arise and as they arise.

The difficulty, of course, lies in taking advantage of the potential that such advanced information technology offers because it represents a cultural change from "the way we do business." Entrenched practices, corporate behavior, government institutions (at all levels), etc., are all structured around the old way, and there is enormous institutional resistance to such a revolutionary cultural change. Nonetheless, there is growing recognition of the need for such change; and recognition of a crisis is a necessary first step before significant cultural change can occur.

Advanced Technology for Twenty-First Century Leadership

In the National Performance Review issued by the Vice President in September 1993, it was stated: The development of new technologies for maintaining and improving the nation's transportation infrastructure . . . [is a] key to the productivity growth of the United States" (*3*). Consistent with this, Transportation Secretary Federico Peña stated that he represented "an Administration with an absolute determination to strengthen the federal government's support for technology" (*4*, p. 1). In April 1994, the National Science and Technology Council's Interagency Coordination Committee on Transportation R&D stated that the U.S. objective should be "world leadership in transportation technologies" (*5*, p. 1). Following this, DOT's strategic plan of 1994 stated that DOT's objective was to "create a new alliance between the nation's transportation and technology industries to make [transportation] both more efficient and internationally competitive" (*6*, p. 3). Specifically, DOT stated that its objectives would be to "accelerate technology advances to make our transportation system more efficient, environmentally sound, and safe" and to "promote the development and export of transportation technology" (*6*, p. 7).

Thus, the nation's transportation public policy makers were declaring that they had a clear national strategic goal for transportation technology leadership, a DOT leadership commitment to such an objective, and the definition of some specific targets that are measurable and could focus transportation technology investments.

The problem is that DOT is neither funded nor organized to achieve such advanced technology objectives. Such a shortcoming was recognized in the Vice President's National Performance Review where it was stated that "the lack of long-range and systems-oriented R&D has left DOT unprepared to address current national needs, such as transportation-related air quality issues and intermodal and urban capacity problems" (*3*, p. 41). A similar finding was stated by the National Science and Technology Council in 1994: "the Committee's initial assessment is that the areas [of system assessment, physical infrastructure, information infrastructure, and vehicles] currently appear to be receiving a level of investment significantly less than is warranted by their importance" (*5*, p. 1). It is this shortcoming in R&D in the transportation arena—particularly in the intermodal area—in terms of both funding and, especially, DOT leadership (beyond speech making) that must be remedied if we are to achieve the stated objective—that is, for America to have twenty-first century transportation leadership. The issue here is not the total level of funding to DOT, it is the priority of allocation and the need for a refocusing of the existing dollars.

The required role of the government is to aggressively remove the barriers and create incentives for technological leadership as well as provide financial stimulation in the high-risk, long-term research and infrastructure investments (often in the form of seed money) that will have the greatest overall benefits for national security, economic competitiveness, and quality of life. Clearly, this is an arena in which partnerships among diverse public and private stakeholders is absolutely critical, and the federal government must take a leadership position in this time of rapid cultural change to

- bring the groups together,
- identify and eliminate institutional barriers to innovation,
- exert leverage over technological issues (such as systems architecture and interoperability standards),

- assure the development of tools (such as simulations, data bases, and special-purpose communication links),
- allow optimization among various modes of transportation,
- efficiently effect their interfaces at the nodes,
- foster consensus among the many stakeholders as to priority objectives,
- develop decision aids and evaluation tools to assist this process, and
- ensure that measurable progress is achieved

It is somewhat reassuring to note that the need for funding and government leadership in this area has received increasing recognition in recent years. For example, initial actions have been taken to apply technology to enhance the commuters' quality of life, and recent steps have been initiated by DOD to address changing national security transportation needs. However, the area of transportation intermodalism—and, particularly, its effect on the movement of freight—is perhaps the key area in which far greater efforts are now required. This is a critical, yet missing, piece in the transportation puzzle for the twenty-first century. To assess the overall needs in greater detail, let us examine the intermodal actions being taken in the three aforementioned areas: the public's needs, national security needs, and commercial needs.

Stepping Up to the Public Need

The first area in which the government acknowledged increased intermodal transportation demands (in terms of the growing problems and opportunities) was in the public arena. This was most dramatically illustrated by the passing of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). This important Act focused on the critical, but previously neglected, interfaces between the traditional modes of transportation, and it recognized the need for significant funding increases in both R&D and procurement in order to realize the potential benefits that such an intermodal perspective could achieve. Its intent was to use intermodal connectivity to enhance the quality of life for the American population in such areas as safety, the environment, reduced commuting time, cost savings, and dependability of transportation systems. ISTEA recognized the importance of metropolitan transportation system integration and the role of the metropolitan planning organizations (MPOs) in achieving this integration. It also provided an enormous technological push—and funding—for the intelligent transportation system (ITS) of the future; a system in which information technology would be a major facilitator in providing enhanced benefits from America's transportation systems, rather than continuing to focus exclusively on building up the physical infrastructure (as had largely been the case in the past). Although ISTEA emphasized public transportation needs, it also recognized that the needs of freight transportation must be considered; however, it placed the burden of response on the commercial sector, rationalizing that corporations are the dominant players in the freight arena.

Clearly, the hundreds of millions of dollars a year for R&D and billions of additional dollars for infrastructure enhancements available through ISTEA, as well as a number of significant demonstration experiments of ITS implementations, represented a significant step forward in the public-sector portion of moving America into a technological leadership position in the twenty-first century; and it would clearly also be a complementary benefit to the commercial transportation needs of the nation. Yet, without systematic deployment and, particularly, evaluation programs, the full potential of the program cannot be realized. Unfortunately, such problems are not being addressed.

National Security and Twenty-First Century Transportation

After the Gulf War, DOD realized that future response scenarios would be unlikely to have a 6-month, nonhostile time period to build up forces prior to a conflict. DOD also began to assess the problems that were routinely encountered (even in this benign environment) such as an inability to keep track of where their resupply parts were and to move them efficiently and

effectively. Also, with the huge cutbacks in defense procurements during the first half of the 1990s, DOD was faced with a significant budget shift, which projected up to 70 percent of their total dollars going to logistics and support functions rather than to armaments and warfighters. The so-called "tooth-to-tail ratio" had gotten out of hand, and a totally new look at defense logistics, and the transportation system that drives it, was clearly required. The need was to look at the whole, end-to-end movement and see how one could arrive at a seamless and rapid new process, one in which parts could be ordered, made, shipped, and delivered in hours rather than months. Today, the contrast between the expensive and unresponsive DOD logistics system and that of a modern, world-class corporation is striking. The DOD system is characterized by slow transportation; long pipelines; major storage points; extensive human intervention; huge inventories; antiquated, duplicative, and vulnerable information systems; and a high error rate. The commercial world, on the other hand, is moving (and will be moving more rapidly, if the recommendations contained herein are accepted) to take full advantage of modern, secure information technology; seamless, multimodal, high-speed transportation; just-in-time inventories; flexible manufacturing of parts and end items on demand; and highly reliable, continuous monitoring of assets and stock in transit.

Clearly, there are some defense-unique requirements, particularly at the end of the chain (for example, in getting from the receiving port or airport to the "fox hole"); but reducing waiting time and optimizing the intermodal linkages as well as the transportation efficiencies within each of the links are common to the commercial world and must be addressed. Some argued that the lessons learned from Federal Express (which handles 1.5 million orders per day in comparison with DOD's maximum of 35,000 per day at the peak of the Gulf War) or those of companies such as Walmart or 7-Eleven (some of the early leaders in applying advanced information technology to their logistic support requirements) were not applicable to DOD because of the "unique" military surge requirements in time of war. Yet, it was pointed out that Federal Express, Walmart, and others have similar "surge" requirements for their inventories at Christmas time (when there is a dramatic increase in demand relative to the rest of the year). Thus, DOD, led by the Advanced Research Projects Agency (ARPA), initiated the TransTech program in an effort to enhance visibility and rapid motion of end-to-end defense logistics through the expanded use of simulation and process flow optimization analyses. The idea is to optimize the overall logistics system and to provide real-time viewing and simulation of "what if" scenarios that can be used to prepare for real-life, peacetime, and, particularly, wartime situations. With such tools, potential transportation time and cost savings can be "demonstrated" as can be the improved system's robustness (flexibility) to unanticipated changes; and appropriate actions can be initiated in order to be able to realize these potential benefits for DOD.

TransTech reflects DOD's recognition that it will become increasingly dependent on commercial transportation systems in the future. This raises two associated concerns. First, DOD must not lose sight of trends in commercial systems, so that the latter remain interoperable with DOD's transportation systems—in terms of coding, containers, information systems, and bulk transportation. In many cases, this will require DOD to actually fund the incremental costs of any of their added requirements. Such expenditures would be analogous to the Civil Reserve Air Fleet (CRAF) program; DOD pays for the changes to commercial aircraft that would be required if they get diverted to carry military equipment. Second, this commonality of DOD and commercial system interests forces the military user, as well as the commercial world, to recognize the increasing vulnerability of commercial systems to both electronic and physical interruption—a concern that neither DOD nor the commercial world have adequately addressed and that is becoming increasingly real (for example, to attacks by computer hackers). The overall transportation system must be sufficiently flexible and secure to be able to resist tampering and accommodate unexpected problems (natural or man-made) without interfering with public safety, commerce, or national security. The challenge, of course, is that as the elements of the overall transportation system become increasingly competitive, there is less and less excess in the system. Thus, there is considerable emphasis in the TransTech program—and a need for similar emphasis in DOT's intermodal R&D arena—on end-to-end simulations that assess intermodal capabilities on a wide geographic basis and provide for rapid

rescheduling should the need arise. Similarly, there is a need for extensive analysis and testing of the "electronic vulnerability" of the transportation information systems.

Sophisticated transportation models are heavily dependent on large and validated data bases for their credibility. Such models and data bases must be built up far in advance and exercised frequently in order to be of value when a crisis demands their immediate application. To develop this overall capability, DOD's TransTech program will begin (in FY96) to spend tens of millions of dollars per year as DOD's contribution to achieve transportation technological leadership for America in the twenty-first century. However, DOD cannot and, more important, should not, drive America's intermodal transportation system. Here, commercial interests must dominate, and DOD must "fit in."

Intermodalism as the Key Element

In a 1992 seminal conference on intermodal planning (7), the majority of the participants defined intermodalism as encompassing the "total trip" with seamless connectivity. Thus, intermodalism includes the points of connection (e.g., the ports, the transit terminals, the airports, the warehouses, etc.) as well as the links between the points (the rails, the roads, the sea lanes, the airlanes, etc.). Given this scope, the intermodal arena has the greatest potential for twenty-first century U.S. technological leadership in transportation. It directly addresses the interfaces with both the public and the defense world and it clearly has the largest economic impact on the nation, through the freight arena. Therefore, intermodalism is the key the three transportation objectives of (a) meeting the needs of national security, (b) enhancing global competitiveness, and (c) improving the quality of life for Americans.

The gap here is that, while ISTEA addresses primarily the public transportation concerns and DOD is concerned with national security, the freight interests have been solely left up to the operation of market forces. While the latter is obviously a necessary condition, and extremely desirable as the dominant force, there are many areas—such as long-range R&D, impacts between freight and public transportation, impacts between commercial freight and the DOD world, standards for information systems interoperability, common container systems, communication systems, etc.—in which the federal government must fully understand the freight industry and become a proactive force for advancement. Here, the government must

- act as a facilitator to resolve the conflicting interests of the various major players;
- serve as an active agent to remove the barriers to effective intermodal transportation, including regulatory and institutional barriers; and
- stimulate the development of technologies and tools for long-term effective intermodal operation, which no individual company has adequate incentives to initiate but that will greatly serve the nation's common good.

All three of these broad areas for government involvement (conflict resolution, barrier removal, and technological advancement) are areas requiring increased R&D. The steps being taken under ISTEA and TransTech are important elements of this process, but significant additional efforts by DOT are essential.

Intermodal R&D

The problem requiring research is optimizing the overall transportation system, rather than assume that continued optimization of individual transportation modes can collectively produce intermodal improvements. The objectives encompass

- reliable service (on time with no damage),
- full visibility (of cargo and vehicles at all times),
- accurate "documentation" (paperless, worldwide, and immediate),

- safety (minimize accidents, contamination),
- maximum flexibility/recovery (to delays, load variations, etc.),
- minimum overall costs (to users and carriers),
- continuous, seamless intermodal transport, and
- security (protection from electronic or physical disruption).

Clearly, the problems are both technological and, particularly, institutional. Thus, the areas of research are wide ranging—from improved intermodal transfers to dealing with hazardous material; from interoperable and effective information systems to advanced decision aids in the presence of widely diverse interest groups; and from revising Congressional budget structures to overcoming DOT institutional barriers. The issue for the federal government (and particularly DOT) is to isolate those specific R&D areas that will not be handled by the private sector, in their own narrower interests, and thus will require stimulation from federal funding.

Here, it is important to note that even though technology diffusion will be sponsored by the federal government, it must be done in a way that it will most rapidly move those technologies into the private sector for application, so that they become driven by market forces. Thus, it is believed that the majority of government-funded R&D should be done in the private sector, rather than by government research laboratories (as is presently the case). Government maintains an important function as a stimulus to innovation and a disseminator of technical information (for example, "best practices"), but the rapid application of research to the transportation system is best achieved through the market-pull within industry. (It should be noted that the "private sector" referred to here includes not only the firms in the business of moving goods and people, but also the many firms that are independent of them but do systems engineering, modeling and simulation, and other transportation related technical and policy work.)

Five specific areas warrant enhanced transportation system research, development, and evaluation activities:

1. applied information technology,
2. systems engineering/systems assessments,
3. policy analysis,
4. infrastructure/vehicle enhancements, and
5. technology transfer (information dissemination).

Much has been recently initiated in the first area, applying advanced information technology to the transportation arena, and the role of the government is to accelerate this activity in order to give U.S. firms the maximum competitive advantage. Here, issues such as system interoperabilities, architectures, data bases, information access, and, particularly, information security are key areas for government involvement. While the government's role is often that of facilitator and catalyst, in many cases it also serves as the initiator and sponsor—through R&D funding. This category of R&D is listed first because it can have such a dominant impact on totally restructuring future transportation systems, by accelerating the flow process for both goods and people in the early twenty-first century. This activity should be defined in its broadest sense and would include navigation and geographic information systems, as well as computers, communications, and other related fields.

The second area for intermodal R&D addresses systems engineering/systems assessment—including technology evaluation. Here, the focus is on the development of broad models and data bases for the overall transportation systems of the future. The important elements involve the links between simulations and the real world. Demonstrations should first be modeled then the data gathered and fed back into the model, so that the models become increasingly valid and the data bases continue to expand over time. Much of the work in this area will be site-specific, but it will be necessary to develop linkages between the models so that eventually even larger transportation system models can be built up. These models must encompass not just speed of transportation, but also costs, dependability, and, particularly, flexibility. Measures of effectiveness must be established in order to make comparisons of

different "what if" situations, and the models must be amenable to changing the system so that it can be continuously "reengineered" to improve the process. A key element here is the experimentation that will go on at various sites for ITS and requires sponsorship in high-priority national freight corridors. Here, the MPOs and state departments of transportation can play major roles in monitoring and evaluating the linkages between data being gathered under their local auspices and the broader data bases and models that will be used for intermodal analyses. These areas of building up relevant and valid transportation data bases (object oriented and for all modes) and of making far greater use of this data are critical to understanding current system performance and to being able to make valid predictions of future performance. Another essential area for credible systems analysis in that of obtaining behavioral information—such as how costs, time, and reliability of systems affect modal choices, and how new and improved intermodal facilities would affect future business locations. Today, large quantities of data are being gathered, but they are not linked into models or larger data bases and they are not effectively providing nearly the benefit that they could. Much of this work will have to initially be sponsored by the federal government (some under TransTech but a lot more of it under DOT sponsorship). A start has recently been made in this area, but much more is required—particularly in gathering field data to quantify benefits indicated by simulations.

The third major R&D intermodal area is associated with public policy analysis (including financial). This has two major subcomponents for research. First, current legislative, regulatory, and institutional barriers to effective intermodal operation must be analyzed for the actions required to remove them. Second, the decision-making and partnership-building tools for the wide range of players involved in intermodal transportation must be developed. Sophisticated techniques have recently begun to be applied in addressing a wide variety of problems with multiple players and many variables; these must be expanded and used to strengthen the decision-making and partnership-building capability of those in the intermodal transportation community. Again, demonstration cases will be extremely effective in showing the great value of such tools.

The fourth major R&D intermodal area is the most common area of transportation R&D, namely, infrastructure and vehicle research. This must still be pursued, but here the focus must be on enhanced, seamless, multimodal operations. One area requiring considerable additional research is that associated with hazardous materials transportation and its interrelationship with the rest of the intermodal transportation network. In general, this whole research area will be mostly driven by the users and the carriers rather than the government; but it is in the interface among and between these parties' interests that the federal government can play a significant role in advancing U.S. competitive technological leadership.

Finally, for the fifth major area for intermodal R&D—technology transfer—research is required in developing enhanced mechanisms for achieving more rapid dissemination of "best practices" among U.S. transportation participants—whether it be on ITS, for public use, or improved simulations for contingency planning of goods shipments after a natural disaster. The range of interests here is boundless. The problem is that in the information age, technology is advancing extremely rapidly, and if we are to achieve the primary objective of making the U.S. transportation system a leader in the twenty-first century, there must be widespread and rapid dissemination of the relevant knowledge. Again, the government can play a catalytic role in assuring the development of the tools for achieving this rapid dissemination and assuring that such dissemination activities continue into the future.

While most of the research in each of these five areas is "dual-use" in nature (applicable to both civilian and military transportation needs), there are areas specifically requiring added DOD investments to address its military-unique requirements. Some of these will be addressed by TransTech (particularly in the information technology and simulation areas) but far more is required to move DOD from its current, twentieth-century logistics system into the integrated, twenty-first century model that it will need. Each area of defense-uniqueness (for example, munitions movement, oversized loads, wartime surge, vulnerability to military attack) and each of the interfaces with the civilian transportation system (in peacetime and crisis environments) must be carefully analyzed, modeled, appropriately changed, and evalu-

ated. The desired DOD end result is a user-(warfighter)-driven ability to control the transportation system so as to achieve just-in-time sustainment flow throughout the intermodal system—eliminating any build up at the high-vulnerability nodes—with an ability to instantly compensate for any system interruptions. Achieving this objective, at minimum total system costs, will require not only added DOD attention but also—particularly—the dual-use research described above. Thus, besides the specific DOT and DOD actions that are required, there is a need for a far stronger DOT/DOD joint effort in their future research efforts. A start at such coordination has begun with TransTech, but this must be greatly strengthened.

Steps Toward Realizing the Potential

Four critical actions by DOT are required. First, increased funding of R&D in the intermodal arena will be necessary for the U.S. to realize the desired technological leadership in transportation that is required to meet the threefold objectives of enhanced national security, global competitiveness, and improved quality of life. This does not mean an increased R&D budget for transportation; rather it means a shifting of funds. Currently, there are hundreds of millions of dollars being spent annually on transportation research in the United States; so it is simply a redirection of a small share of these funds that is at issue. Of a total surface transportation R&D budget for FY95 of $516 million (*8*, p. A–29), there is only something between $2 and $5 million being spent by DOT on intermodal R&D. [The uncertainty is in the question of how much of the "planning research" by FHWA is devoted to intermodal activity. There is, of course, a larger question as to how to define "intermodal activity" (*8*, p. A–20)]. This very minimal level of R&D is simply inadequate to support the needed efforts defined above. All the speeches in the world will not close the gap between what needs to be done and what is being done for $2 to $5 million a year. The Administration and the Congress simply must reallocate transportation resources toward greater efforts in intermodal R&D. Only in this way can the true benefits of an optimized transportation system be realized. Specifically, these benefits include:

- the enormous impact on the global economic interests of the United States and its corporations (in enhancing their worldwide competitiveness through improved transportation),
- the importance to states and municipalities (for example, the gains to Los Angeles of efficient transfer of goods to and from its ports as a result of the Alameda Corridor project), and
- the importance to the public's quality of life (for example, new factories can be located outside of congested urban areas, as a result of the availability of reliable, seamless, just-in-time transportation).

As the second essential step to help achieve the required resource redistribution and to assure that the benefits are realized, DOT needs to have stronger centralized oversight and control of its R&D budget. This is necessary in order to broaden the purely modal focus that currently characterizes DOT's R&D budget. Three decades ago, when DOT was formed, the intent was to have an Assistant Secretary for Research and Development, analogous to the Director of Defense Research and Engineering at DOD (*9*). The position at DOD was created to oversee and sponsor research that cuts across or integrates the activities of the military services that are analogous to the transportation modes in DOT. The only way that more oversight and control can be achieved is with greater budget authority over competing R&D programs. The objective would be to shift some of the funds toward optimizing DOT's overall R&D program, rather than suboptimizing the R&D programs of individual modes.

Third, DOT needs to have the ability to rapidly and effectively contract for R&D work with the private sector, recognizing that contracting for R&D is significantly different than grants for highway construction or other traditional activities of DOT. Here, DOT might use the ARPA model to contract with industry for research activities. To effectively oversee this R&D, DOT needs to enhance its in-house capability to understand systems engineering and

systems evaluation. Staffing in this area would be done with the recognition that this type of work is dramatically different than that which had been done in the past in the majority of the transportation modes, particularly when it is information systems intensive.

Finally, a fourth step would be for the Secretary of Transportation to establish an outside R&D advisory board similar to that of the Defense Science Board (DSB). This group would not look at pure science (anymore than the DSB does), but would look at applied technology and technology policy issues in an objective and expert fashion. To overcome the expected resistance to the needed changes in U.S. transportation systems, an outside, nonpolitical, advisory group is absolutely essential to assure that research is performed that will provide greater national benefit. Naturally, this board would have to have strong representation from those with a state and local perspective (perhaps a few retired MPOs), as well as experts with backgrounds in the other transportation system elements (both users and suppliers). However, the overall vision of this group must be that of the common good—not that of any individual set of stakeholders.

These four steps—(1) increased government intermodal R&D funding to industry, (2) centralized oversight and control of R&D for DOT, (3) enhanced institutional capability for R&D contracting and systems engineering, and (4) a senior R&D advisory board for the Secretary of Transportation—are all steps that should be taken immediately if the United States is to achieve the desired transportation leadership position at the beginning of the twenty-first century.

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1996 ISTEA Report Card: Building on the Foundation

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When the Intermodal Surface Transportation Efficiency Act (ISTEA) legislation became law in 1991, it represented a significant departure from the Surface Transportation Acts of previous decades. Expectations were that ISTEA would become a catalyst that would help usher in a new era with respect to the federal transportation role. It was to be characterized by a focus on intermodalism, flexibility, private sector initiative, and enhanced R&D.

So it was not surprising in 1992 that at our first intermodal meeting in Irvine, California, we spoke of ISTEA in terms of its promise. And of particular interest to those of us here today, were the provisions that promised a wider role for transportation research as the basis for decision making in the new world of transportation that would emerge, both as a result of ISTEA itself and the technological and other changes the industry was and is continuing to undergo.

With several years of experience behind us, we are now able to evaluate how and where ISTEA has either fulfilled or failed to achieve its promises. (And I think it is a critical stage setter for the framework discussion that we are in fact talking about ISTEA's reauthorization.) As we prepare for reauthorization, the dialogue we are going to engage in will become a critical part of all the efforts to be undertaken to forge a transportation bill that will address the challenges of the future while recognizing the realities of our contemporary resources and the changing roles of the various partners in the transportation community.

I listened intently to Secretary Mortimer Downey in his grading of ISTEA implementation efforts and his explanation of the range of efforts the U.S. Department of Transportation (DOT) has undertaken, but I'm giving ISTEA the report card as well. In doing so, I think we should grade it on a number of dimensions. I think for its overall aims it deserves a B+ or maybe even an A, to be really generous. For its overall performance, though, it deserves only a C. Certainly on the performance of individual elements like R&D, I would give it a C+.

I am going to limit my comments to the R&D aspects of ISTEA–the scope of R&D that ISTEA authorized, an assessment of the actual work that has been done so far, and a framework for evaluating future R&D efforts that was developed last year by a joint National Science and Technology Council (NSTC) and Transportation Research Board Forum on Future

Directions in Transportation R&D. I will follow my comments with some thoughts about where we need to go in the future.

What did ISTEA offer? The ISTEA R&D provisions offered us an array of new or enhanced research opportunities, an intermodal approach to transportation research, particularly in studying modal connections, and a greater latitude in what we could study. We added policy as an area of evaluation and study. Technology transfer, the impact of transportation on the environment, and the social and economic impacts of transportation—all of those were new. They freed us in ways that gave us the opportunity to do things differently. The bill also gave us more flexibility in conducting R&D. It gave us the ability to collaboratively conduct research with other public entities, like the U.S. Department of Defense (DOD) and state governments, and with private entities. And it gave us the ability to contract directly with the National Academy of Sciences, the Transportation Research Board, and the American Association of State Highway and Transportation Officials.

Congress mandated a wide range of studies on a variety of topics, including international technology transfer; transportation in urban, suburban and rural areas; the use of recycled material in the transportation infrastructure; seismic research on infrastructure design. Also mandated were key studies on an integrated national surface transportation R&D plan, development of performance indicators to measure productivity, identification of current transportation research and technology development both domestically and abroad, including gaps in existing research and development programs, a long-term pavement performance program, and an Intelligent Vehicle Highway—now called Intelligent Transportation Systems (ITS)—program, designed to move intelligent transportation systems ahead as quickly as possible.

The legislation also required the development of new data bases to include data on intermodal transportation systems. It made provisions for technology transfer very explicit, including transfer from private industry sources, from public entities including military applications, and to and from foreign countries; and it insisted on a new applied research and technology program. Add to all of that new funding for education and training, the establishment of a new transit institute, the addition of five new transportation research centers, the establishment of five university research institutes, the broadening of the National Highway Institute to include private sector trainees and foreign nationals, funding for the training of state and local highway employees and the establishment of a Dwight Eisenhower Fellowship Program.

ISTEA also authorized funding for transportation planning, research, development, and technology transfer activities very specifically. It provided that up to 2 percent of the federal fuel tax be conveyed to the states to carry out these activities. For specific programs, the act authorized more than $1.1 billion between 1992 and 1997.

But where have we been? Well, a number of things have happened. There is a major focus on the long-term pavement performance program, on applied research and technology programs, on highway safety R&D, on the National Transit Institute, and on the new university research institutes. The Urban Fellowship or the Transportation Fellowship Program was enacted and ITS has gotten DOT's attention and financial support.

Congress and DOT recognize the need. At the outset of the ISTEA era, we clearly faced a very ambitious and widely varied agenda. On the positive side, a broad agenda of transportation research is now supported. The government is establishing through BTS the necessary intermodal data bases. Commodity and passenger flow surveys are being undertaken now for the first time since the mid–1970s. They are critical to our understanding of what happens, why it happens, and now how it is happening. And we have moved forward on the development of new technologies like ITS at a faster rate than I believe would have occurred without ISTEA.

There are more opportunities to pick up on some of the themes of the comments that have been made in the past and move forward now while we are going through a strategic initiative to frame the new legislative approach, to deal with the various interests in the community, to begin to generate alliances and support.

Out of that Forum on Future Directions in Transportation R&D that I mentioned earlier, we developed a framework for the evaluation and guidance of federal transportation R&D

efforts. At the outset of the forum, we recognized that the transportation research environment is constantly changing and that there is some uncertainty about the future role of the government in transportation R&D funding and in carrying out responsibilities for program initiatives. The forum's consensus was that we need as a community to take a more strategic view toward transportation research in order to provide guidance for long-term development of R&D programs.

We looked at the federal research agenda, specifically the strategic information plan produced by the NSTC, which had been gathered from every federal agency including DOT. We found that it focused on four areas—physical transportation infrastructure, information infrastructure for transportation, the next generation of vehicles, and system performance. It was our assessment that this scheme fits the way federal transportation R&D is typically authorized, budgeted, and appropriated.

There is a potential problem, however, that we discovered and talked about quite frankly and directly: the scheme places an undue emphasis on monetary inputs to R&D instead of placing emphasis on desired outcomes. In other words, we were not listening enough to what the community of users needs. What is it that the customer requires (if they can articulate it), and how should we fashion that R&D agenda to help accomplish a meeting of those needs?

We said that the strategic planning process for federal R&D should include clear linkage from a vision statement to the goals, objectives, and policies and finally to the federal role; and that those goals, objectives, and policies needed to include not only national objectives but also the objectives of the users. In structuring the strategic planning process, we said the inputs needed to be inventoried and the outputs needed to be defined. We concluded that there is a need for a comprehensive national transportation R&D agenda that should be dynamic, should clearly represent an expectation that the federal role is to help identify areas of focus as well as to contribute to the development of funded research from which the private sector can jump off.

Where do we go from here? At the same forum last year, Secretary Federico Peña presented a paper on the need for federal support for transportation R&D. In it he outlined the major roles that the federal government can and should play.

- It should be a catalyst, a source of seed money and expertise. It should be a standard setter, providing certain measures of uniformity for consumers and transportation providers, while maintaining enough flexibility to support progressive change and new technologies. In other words, to provide incentives.
- It should be a facilitator and promoter, building alliances with the private sector to advance projects that are in the national interest.

As we look ahead to the coming ISTEA reauthorization debate, I think we need to concentrate our efforts at enabling the public sector to fulfill these roles in the most effective ways possible. We should also understand that the legislative process, which is always filled with interesting twists and turns, is likely to be even more complex this time.

I think one of our challenges will be to look at alliances between interests, to help us achieve our objectives, once we are clear about the framework of our agenda. And therefore, I think that DOD and DOT need to be at the table together as both funding partners as well as describers of what the needs are that they are trying to fulfill through the direction of R&D funds.

As transportation professionals in both logistics and defense, as well as in service provision, we know that adequately funded and directed R&D programs are needed to make the nation's transportation system function effectively, efficiently, safely, and intermodally. From our perspective, we need to argue that under the next transportation bill, the following goals should be achieved, either through the legislation itself or through the institutional and regulatory changes that will result from the bill.

First, research efforts should not be kept in modal cubbyholes. Our strategic R&D efforts need to be aimed at producing practical results and disseminating them rapidly. We can extrapolate lessons from the ways that the commercial sector has in the past converted military research and transportation systems into commercial use. And there should be flexibility in

practices regarding the contracting for transportation research. We are still too restrictive, and it takes too long.

We need to do more evaluation and feedback at strategic points in the R&D process, looking specifically at the program delivery and how it matches up to policy objectives in infrastructure, in vehicle, in technology, and in new quality of life or economic strategy areas. We should also be cognizant of the importance of information technology as we move ahead with the national research agenda, particularly the role that information technology will play in the development of ITS.

A number of questions that need to be answered include:

- What will be the components of our future intermodal system?
- Are they sized and linked appropriately?
- What is the information flow of the logistics system of the future likely to be?
- How can information be captured to effectively address traffic safety and security issues?
- What emerging technologies (like the Internet or electronic warfare) are likely to have an effect on the industry?
- How can we employ ideas and system approaches that exist in the private or public commercial sectors to meet defense community needs? For example, what is it that already works in the commercial sector on in-transit visibility that is applicable and appropriate from the defense community's point of view? But also, what is it that the defense community has already developed that we may or may not know about that could foster greater value in the commercial community and therefore better product for the defense community?

In times of constrained resources, we have got to achieve multiple national goals—strengthening both our economy and our defense—by achieving the effectiveness that mutual efforts can obtain for us.

Most important, we have to come back to some basic questions about the expectations of users. The air passenger and the shipper in the commercial system are fairly clear about what their needs are. We have to talk about what the expectations are and assume that those from the defense side may be very similar.

We also need to talk about change and cost. Jeff Crowe talked about the free market and about the free market directing how infrastructure investments—or how those who fail to make the appropriate investments—will fall out of the system until only the strongest remain, whether it is strongest port system or the strongest air system. We need to examine that thinking and talk about it because, from a public port perspective, we believe the system should allow that all participants in funding gain some return on the use of the system. The private operator operating the truck or the ship or the rail car; the port and others who are in the system; the forwarder, broker, and the shipper all deserve to gain some return.

The debate taking place with the shipper community suggests that that may not be the case, that not all of us will be able to get a fair share return. It is a very critical component that needs to be looked at, particularly as the defense community is going to rely more and more on the commercial sector. And as more and more resource constraints are imposed, we need to decide and talk through who pays and how much.

A discussion of economic policy needs to also take place. It will happen, both in this legislative round on ISTEA and on shipping act reform and on the discussions about whether the Federal Maritime Commission survives.

As we consider all of these points, we should be reminded of the executive summary from last year's R&D forum, in which it was noted that emphasis should be placed on building consensus, developing a collective national vision to guide system development and transportation policy. With austere federal funding, an understanding of public values and a common vision are essential to strategically setting affordable priorities and keeping them current. Self-interest and intersections among those interests need to be defined.

The key to making our efforts work today and tomorrow is to remember that our nation's transportation R&D efforts will work most effectively when we involve collaborations, identify alliances, and understand the policy. We will further enhance R&D efforts when we de-

velop structures that will bring about our willingness to work together, and when those structures help us to support and fashion the next generation of legislation. We must get to the point where we are not fighting the mode that has the paramount interest, but rather finding that that mode understands that the other modes' dependencies work because their interests are being sufficiently financed.

Whether it is the highway community or the transit community or the aviation community or the ocean or rail carrier communities, we need to get everybody at the table talking about how the system needs to work more effectively and what it will take to make that happen. All of this means that we have to be practical, we have to be rooted philosophically and politically, and we have to understand how it is possible to make change. And most of all, we have to assure adequate information flow. DOT and DOD can have wonderful conversations with all of us, but if we are not really sharing with each other what is going on, what it is that we want to accomplish, and how we are going to accomplish it, we will not achieve the change that is realistic and possible that is still ahead of us.

Perspectives on the Research Framework: Freight Stakeholders National Network

Michael P. Jackson, *American Trucking Associations Foundation*

I preface my remarks about the research framework by considering the word *research*. In fact, the word *research* is perhaps too narrow to describe adequately the range of tasks discussed at this conference. Our goal is to create a more efficient intermodal system. What is most needed is not research in the formal sense, but leadership—leadership based on facts and a deep knowledge of intermodal operations.

Frankly, we already have before us many of the "facts" we must have if we are to make intermodalism work more efficiently. We also have much of the basic technology. So we do not really need to go out and reinvent the wheel. We need to leverage what we know with, in some cases, technology to build new partnerships that get the job done. I would suggest that a successful intermodal strategy for the nation will come from leadership and partnerships.

Today I will discuss three topics. The first involves the market forces that impel us to make improvements in our ability to move intermodal freight. The second involves the freight industry's need for partnerships of two types: innovative partnerships in the private sector and effective, targeted partnerships between the private sector and the public sector. In this regard, I aim to speak on behalf of the Freight Stakeholders National Network, which is a coalition of freight carriers and shippers formed to improve freight transportation in our cities. Finally, I will offer a few personal observations about elements of the research framework draft, with a view to illustrating the types of partnerships that will enhance intermodalism.

We have already spoken about many of the pressures on the intermodal system. Speaking on behalf of people who move freight, I would highlight one basic fact: we are going to be moving increasingly larger amounts of freight for the foreseeable future. A recent study by DRI/McGraw Hill, commissioned by the American Trucking Associations Foundation, contains a baseline account of the size of the U.S. freight transportation industry and a 10-year forecast for freight growth.

In 1994, the baseline year, the U.S. freight transportation industry overall generated $463 billion in revenue and moved 9.9 billion tons of freight. By 2004, with only a modest 2.6 growth rate in GDP, this will grow to $574 billion in revenue and 11.6 billion tons—a cumulative growth rate of 24 percent and 17 percent, respectively.

Seventy-eight percent of that freight (by revenue) is moved by trucks. Over the 10-year period, the number of over-the-road tractors will increase by 13 percent; both the total number of miles driven and the total volume of truck tonnage will grow by 29 percent. At the same time, the most explosive growth will come from air freight and rail intermodal. DRI forecasts that air freight will jump by 93 percent over this period and rail intermodal by 53 percent. Air and rail intermodal will erode several percentage points from the overall market share of trucking. The bottom line is there will be a significant growth in freight transportation overall and with it, more pressure to make our freight transportation infrastructure more efficient.

It is important to focus for at least a moment on the word *freight*. We are here to speak about intermodalism, but I would like to suggest, as a bit of a contrariant, that our focus on intermodalism can be somewhat misleading. Speaking more precisely, our core objective should be moving freight more efficiently, not simply improving intermodalism. Intermodalism tends to make people focus more narrowly on connections. To be sure, as Jeff Crowe said earlier, one of the crucial problems with intermodalism is precisely in the pass off, not just between the modes, but between the modes and their customers.

But, in a way, intermodalism is a transitional point of focus. It shifts the emphasis from the single modes toward discussion of moving freight end to end. The words *logistics* and *freight* keep the focus on the real bottom line. Public policy makers must focus on the entire supply chain, as has industry in recent years. Developing strategies to improve intermodal movements is a subset of the larger task of improving freight transportation.

To improve freight transportation, we have to form partnerships. It is pathetic how often you can hear that word—*partnership*—invoked, yet how seldom you see true partnerships in the real world. Nonetheless, the real thing is just what is needed. We are getting better, but it is slow work. There are two categories of issues for which the freight industry needs to develop better cooperation. We need real partnerships for common public policy objectives and we need real partnerships that will deliver operating efficiencies.

Today freight does not move with maximum efficiency—particularly intermodal freight—in part because carriers have not yet learned well enough how to work with each other. There is a history of conflicting cultures, modal hostilities, and business competition, all of which have made it difficult for us to tackle freight industry problems.

Will we get past this? Yes, but it will entail a reeducation process. It is a process we are experiencing, and it is pretty darn tough; but I think we are making some progress. As an illustration, an agreement about the need for private-sector partnerships that are focused on common public policy objectives has given birth to the Freight Stakeholders National Network. The Network is an alliance of carriers and shippers. It includes the modally based national trade associations for the railroads, the air cargo industry, ports, and trucking. It also includes the Intermodal Association of North America and shippers—the National Association of Manufacturers and the NIT League.

What is our purpose? In short, to improve freight mobility in metropolitan regions. The Intermodal Surface Transportation Efficiency Act gave metropolitan planning organizations (MPOs) a new and substantial grant of authority and an expanded role in making freight move efficiently. Do they know how to do it? No, not so well. Are they eager to try? For the most part, clearly yes. Does the freight industry know how to make it happen? No, not yet; but we are learning.

The various modes and individual firms first tried going it alone. They tried working with MPOs, state and other regional planners to improve freight mobility, tried inserting themselves in the local planning process. It just did not work very well. It was like pulling taffy. So eight national associations decided to leverage their resources and work together to build locally autonomous freight advocacy coalitions that can work with regional governments to make freight move more efficiently. We did not invent this idea, it was already happening in several places across the country; but such stakeholder coalitions need to grow, and grow stronger.

In effect, we must build new institutions to deal with new opportunities and new problems. The freight industry must itself create these institutions where they do not exist. I would like to suggest, perhaps somewhat selfishly, that the private sector needs to take control of its own public policy future. We should not wait for policy makers to tell us what they need. We should be more proactive in promoting freight mobility.

There is also a considerable need for the freight community to sit together and solve the industry's operational problems—to seek efficiencies in electronic data interchange (EDI), terminal operations, asset use, container tracking, and similar matters. Let me give one example of an operational issue masquerading as a policy issue: overweight containers. Congress passed legislation to sort out the problems related to the movement of overweight containers and the U.S. Department of Transportation (DOT) has been struggling with implementing regulations. The real problem is that the freight community has not found a common approach to the very real operational issues that will make the legislation work. We need to do that together; in fact the freight industry is now negotiating among themselves to achieve that end.

Let me turn, then, to the research framework to say a word about four of the seven specific strategies. At the risk of repetition, to make the framework successful we must create new partnerships.

1. *Remove institutional barriers.* The first strategy is to remove the institutional barriers to efficient freight movement. DOT is really the federal agency that has to take the lead in cracking that nut. It must be the source of leadership in identifying institutional barriers and then exploding them. The Intelligent Transportation Systems (ITS) program, for example, is very much focused on that objective. Transportation users need more coordination and stronger partnerships within the government at all levels and—only after that—the focused involvement of the freight transportation community.

To give you an example, DOT has an ITS demonstration project under way to apply information technology that will make truck border crossings more efficient. It is a great idea, but the U.S. Customs Service was not part of the initial plan. At the same time, the Customs Service is deeply involved in the development of a complex EDI modernization program with industry. We need to loop these elements together. DOT must be the advocate for making such connections.

2. *Strategic partnering.* The freight industry can certainly profit from strategic partnerships with government, which will, of course, take many forms. All too often we look at the government exclusively as a regulator. We are worried more about what they are going to do to us than what they can do for us or what we might do together. This is a gap that has to be bridged. Much of the proposed intermodal research framework is aimed at trying to bridge that gap in a coherent and intelligent way. But even on the regulatory front, those who are regulated must grow new relationships with the regulators.

The freight industry looks at the U.S. Department of Defense (DOD) somewhat differently. Rather than a regulator, DOD is a customer—either a potential customer or an actual customer. Partnerships with DOD to promote freight mobility are typically going to be relationships of a different sort. It is probably easier for the freight industry to build that type of partnership because they are more adept at working with customers.

In dealing with DOD, we have to make some distinctions about customer relations. There are some services the freight industry can provide and other very important transportation services that are beyond our capabilities. We can, for example, help the Defense Logistics Agency operate their delivery structure more efficiently by applying state-of-the-art logistics techniques or outsourcing certain functions, but we cannot deliver freight to a theater of combat and into a foxhole. So, since clearly we cannot do everything that DOD needs to meet its logistics requirements, we should therefore explore how far we can go to meet defense transportation needs. It is probably a heck of a lot farther than the military community anticipates; there are certainly more options than they are currently using, but not full functionality.

3. *Technology investment.* I would simply say that the technology investments needed by the freight community are mostly an obligation of the private sector. Government should be cautious in this area—that is, ask first whether there is an indispensable government function. However, the government does have an important function to serve in stimulating technology research with practical applications.

Numerous examples could be given in the ITS area, but perhaps one related to national defense will suffice. One of the Holy Grail issues for the freight transportation world is in-transit visibility of container movements—tracking container movements throughout the freight pipeline. In this area, DOD and the private sector have the same basic need. I am ter-

rifically excited about some of the technology prospects here, and I think we will see low-cost, accurate solutions before long. Industry will connect the ocean shipping data bases that track containers to the trucking data bases and the rail data bases, and they will make this information available in real time to the shipper, who will be able to obtain data on container location globally via the Internet. DOD can accelerate this process, perhaps by sponsoring a demonstration of the technology. If it works well, DOD can spur development by making such capability part of its contracting with the industry.

4. *Improving system capacities.* With the substantial growth in freight movements as forecast by DRI, relieving congestion and improving the capacity of the transportation network is even more pressing. Already there is a massive backlog in needed highway and bridge construction and repair. Dredging ports, improving rail crossing safety, and other capacity improvements will be essential if we are to meet the transportation needs of tomorrow. Effective strategies to improve system capacity of the public infrastructure are an indispensable task of government, deserving aggressive support by the entire freight industry.

When building system capacity, it is helpful if the government can support market forces rather than try to alter economic demand. By liberating and stimulating market forces, we will see intermodalism, and freight transportation generally, prosper.

U.S. Congressional Staff Perspectives on the Research Framework

Roger Nober, *House Surface Transportation Subcommittee*

I am Counsel to the Subcommittee on Surface Transportation of the House Committee on Transportation and Infrastructure. The Subcommittee on Surface Transportation has jurisdiction over the nation's highways, transit, safety, research, and motor carrier and pipeline provisions as they relate to safety. It is the largest subcommittee in the House. It has 33 members and if it were a committee it would be the sixth largest committee in Congress.

The Transportation and Infrastructure Committee, as many of you may know, has jurisdiction over all of the nation's transportation programs and is chaired by Bud Shuster of Pennsylvania. This committee is responsible for authorizing the nation's highway, transit, and research programs. As many of you do know, the National Transportation and Research Program was authorized as part of the overall transportation law back in 1991 in the Intermodal Surface Transportation Efficiency Act (ISTEA). That law expires on June 20, 1997, and the committee's primary work in the second session of the 104th Congress and in the next session will be reauthorizing all of these programs. It is a daunting task that the committee is just now beginning to undertake.

ISTEA really gave a substantial federal commitment to research. It authorized that research funds would be paid out of the Highway Trust Fund from a number of sources. The general operating expenses of the U.S. Department of Transportation (DOT) is one source from which we authorize that up to 3.75 percent of the overall program could be deducted for operations of DOT as well as for research ends. This has generally meant that between $100 million and $300 million annually has gone from DOT's general operating expenses to fund basic research or Intelligent Vehicle-Highway System (IVHS) research.

In conjunction with IVHS research, Congress set out some specific research programs, such as strategic R&D and the Strategic Highway Research Program (SHRP), which it funded at approximately $120 million per year. Together this made a fairly substantial investment in the research program. In fact over the first 5 years of ISTEA, nearly $1 billion from the Highway Trust Fund has gone into the various DOT research programs.

This shows that in the last bill, basic research was seen as a real national priority, something that was important for the national program to be doing and something from which there was a real benefit to all citizens. This is the framework within which the research

program has been viewed in the past; and the research program has gotten much larger over the years. The size of the DOT research program has grown substantially and is now, roughly, twice as large as it was 5 years ago. There is some debate as to how exactly to measure it; in fact, DOT might debate exactly how to measure it.

As we head into the next reauthorization, as we sit down and take a look at what has gone on in the research program over the past 5 years, the real question, from the point of view of the members of Congress, is What have been the benefits from it? This is the question we must ask as we attempt to identify what is the national interest in maintaining an active and well-funded research program.

If in the process of reauthorization Mr. Shuster were asked, Who do you think is going to be the most important player in the next reauthorization? His answer would be the Budget Committee because in a large sense the drive toward a balanced budget by 2002 is going to be a major factor in most programmatic decisions. If we truly are going to have a balanced budget by 2002, pressure will be put on almost all discretionary spending, of which the highways is one component. Mr. Shuster's response to the squeeze put on transportation spending would be to take the Transportation Trust Funds off budget, which would eliminate the incentive to reduce spending out of the Highway Trust Fund to finance other programs. So we are assuming for the moment that that is going to happen. But if it does not happen, and there is going to be substantial pressure placed on all parts of the transportation funding, as we look forward to 1997, it is through that prism that the research program is going to be looked at.

As with all programs, I think Congress will in its hearing process undertake a fairly rigorous examination of basic oversight of each and every program and to try to figure out what in each and every program is in the national interest. For those of you who have an interest in and are concerned about the research program this is a real opportunity for you to think about and begin to make the case for why the federal government should be coordinating basic research, what the basic benefits to the country can be, and why it makes sense to continue. I think the case for research is fairly compelling, but it is something that anyone who has an interest in any sector of the program is going to have to make because in a declining budget when there is more and stiffer competition for resources, survival is much more difficult for all programs; that is just a fact of life.

The connection between the research program, DOT, and DOD: I think this is an area that over the past few years has not really been brought out as clearly as it could have been. As many of you may know, one of the primary impetuses behind the major transportation program in the last half century—the Interstate system—was the need for a national system of roads to link military installations and allow for mobilization in case of war. That was the compelling reason behind the formulation and funding of the Interstate program and, in fact, the reason why the Interstate system is called the National System of Interstate and Defense Highways. One of the rationales for the Interstate system came in 1920 when General Eisenhower tried to lead a convoy across country to demonstrate the difficulty in linking the country and the lack of adequate infrastructure.

Ever since then, the importance to national defense of maintaining an adequate level of transportation infrastructure in the country has been predominant and remains a compelling reason why the federal government should be involved in this area. With the completion of the Interstate system, the focus began to shift a little bit from the defense needs and the demands defense would place on the system and focus more on things like congestion and economic growth and other factors, which are admittedly very important but could arguably be more local in nature, involve local competition, and did not have the sort of compelling overall national interest that the defense mobilization had.

In the last session of this Congress, the National Highway Designation Act of 1995 was enacted. The National Highway System, as opposed to the Interstate system, was intended to focus the federal resources on the National Highway System—a 161,000-mile system of Interstate highways, major principal materials, and evacuation routes—and a major component of this was the strategic highway network, which is about 15,000 miles. This act

began to again recognize the defense sector's important interest in maintaining adequate infrastructure and being able to mobilize men and materiel.

The committee heard testimony from the U.S. Military Traffic Management Command about the demands that would be placed on the military in a time of mobilization and the need to move men both on the highways and from defense installations to railheads and airports. The fact is, having an adequate, efficient, and safe highway system has even more importance now at a time when the United States is positioning fewer men overseas and is keeping more of its materiel and troops that would be moved out in time of crisis located in the United States.

As we head into the reauthorization process, those that have an interest in the defense area would be well suited to make the case for the importance of and the critical link between investing in highway infrastructure and meeting our defense needs.

As I said, I think the biggest factors, as Congress looks at all of the various programs, are going to be the overall size of the program and how much funding can be allocated, or how much the Budget Committee permits us to allocate, to transportation. And since a number of groups are concerned about various programs or parts of the programs that they are interested in, I urge everyone to step back and look at the most important factor in all this —What is the overall size of the program and how big is it going to be? And an important component of that is, What is the national interest in transportation and how much of our scarce federal dollars should be allocated to the transportation sector?

As many of you may know, even though the transportation programs are funded through a trust fund as part of the unified budget, the amount spent on transportation counts against the other programs. So despite many claims that it may or may not be in competition with other programs, as long as transportation is part of the unified budget, it ultimately will be in competition with the other programs for allocations out of the federal budget.

I urge all of you, as you meet like this, to keep your eyes on the forest as opposed to the trees, and to look at and make the case for the overall size of the program, make the national case for transportation, make the national case for research, make the national case for funding defense programs, and the national defense interest in transportation infrastructure.

Educating and Training Tomorrow's Transportation Professionals

Michael D. Meyer, *Georgia Institute of Technology*

The purpose of my presentation is to discuss intermodalism from the perspective of transportation education and training. In addition, I will add my own thoughts about the research framework that has been presented by previous speakers.

Having been involved in research for over 15 years, I know how important it is to understand the trends and changing societal characteristics that will likely influence whatever research program you are involved with. Intermodal transportation is certainly an area in which many such trends and characteristics will greatly affect the efficiency and effectiveness of the intermodal movement of people and goods. The modern revolution in telecommunications and information technology is an example of how the application of such technology could provide significant technological innovation and improved efficiencies in intermodal transportation. Sustainable transportation, the relationship between transportation and the consumption of nonrenewable resources, is a big issue that will likely become even more important over the next several years. The technology used to manufacture vehicles and new materials will change the design and economics of many transportation facilities and systems. Globalization and trade will continue to be dominant characteristics of successful national economies. The focus of infrastructural improvements will be on the enhancement of system management and productivity. Mobility and accessibility will surface as the key motivators of public policy and investment in the transportation system. Urbanization, suburbanization, and exurbanization will continue to characterize many of our metropolitan regions.

All of these characteristics are important. Each should guide us in identifying the type of research that should be undertaken to understand intermodal transportation and the likely benefits of intermodal transportation in the future. They also affect education and training in that one of the major responsibilities of the educational system is to make sure that the education today will prepare transportation professionals for the world they will face tomorrow.

The transportation industry itself is also changing. The following themes emerged from a Transportation Research Board conference, held in New Orleans in 1994, called "Intermodalism: Making the Case, Making It Happen." If you look at some of the themes that emerged from that conference, you see the challenge we have with regard to training and educating transportation professionals. Some of the themes included the concept that we

can no longer use a business-as-usual approach to the provision of transportation. Rather, we need to develop new and nontraditional partnerships; adopt a total trip perspective in planning and operations; develop market-driven planning, providing a customer orientation in all aspects of service provision; explore innovative financing; incorporate intermodalism in all aspects of policy, planning, and design; use new technologies in system operations; and view intermodalism as a series of opportunities to enhance system productivity. Putting these concepts into the education and training system, however, is a real challenge. Many who teach transportation and logistics courses are not sensitive to or do not understand these types of issues.

In preparation for this conference, I reviewed several materials from the defense logistics arena. The most interesting material focused on training of U.S. Department of Defense (DOD) personnel for the logistical challenges of deploying large numbers of troops and materiel. One quote from this material stands out:

> Given the lack of integrated deployment training, we may be able to deploy only a marginal force in the time available for a future deployment. Viewed positively, integrated deployment training as one element of a comprehensive and balanced program of investments and power projection will ensure the efficient operation of our mobility system.

In essence, this quote states that there must be a mindset established in those responsible for mobilization and deployment that adopts a total systems perspective, which will result in the maximum deployment efficiency.

Mr. Gansler in his excellent paper notes some of the mindset issues that the U.S. Department of Transportation (DOT) is facing in adopting an intermodal research perspective. He talks about the important linkages between freight and passenger transportation, which are often missed by the modal orientation of our institutions. He notes the critical challenges of setting standards for information systems and common design of containers, and standardization of communication systems and of other key elements of an intermodal transportation system. Although Mr. Gansler focuses on the technological and institutional aspects of these issues, I would also argue that there are very clear educational and training challenges associated with each.

A good example of how these issues can be incorporated into the education of transportation officials is found in the Army Civilian Training Education and Development System (ACTEDS), which is a training program for officials responsible for Army logistics. The intent of the training program is "to provide broad skills and knowledge, leadership and transportation management training, and managerial knowledge of organizations and missions." Many of the courses listed under this program were fairly typical of what one would find in a transportation and logistics program. All of the challenges and themes from the TRB's New Orleans conference could be easily incorporated into these courses. But who will do so?

Let me end my presentation with some thoughts about what an intermodal transportation education really means. Such an education should offer students four basic categories of knowledge:

1. a clear understanding of the functions of transportation systems;
2. a sensitivity to the relationships and linkages between transportation and its surroundings, whether they be the natural environment or communities;
3. analytical approaches to solving problems, which includes an understanding of what types of solution strategies are feasible, how they can be analyzed, and the analytical requirements of effective problem solving; and
4. how to implement the recommended strategy.

Of these four, it is the "how to implement" that we do not do very well in educational programs. My belief, after almost 15 years in universities and 5 years in state government, is that there is a great deal we can learn and teach in an educational program about implementation. Issues such as what to look at from a strategic perspective, funding, institutional barriers to

implementation, and the technology of implementation are all very critical for success in the transportation industry.

With regard to the research framework, the focus seems to be one of vertical integration. I suggest that in fact a real need is to have horizontal integration. We can learn a great deal from all of the groups shown in the framework—such as what their needs are—and bring all of these challenges together in a comprehensive way. The other observation I would make about the research framework is that it seems to focus on today's issues and problems. However, as noted earlier, we are educating tomorrow's professionals. There must be some temporal dimension to this framework that notes the dynamic nature of the intermodal transportation system. The educational and training component of the research that results from this program is critical to making this temporal dimension work. I have always found it strange that the research projects funded by the National Cooperative Highway Research Program or DOT never have an educational element attached to them. By this I mean a well-defined but separate section of the final report that in essence offers an outline of how the research results can be incorporated into courses. I recommend that every research project that emanates from such programs be required to have an educational module that allows those involved in education and training to incorporate the material into courses. My greatest fear is that all of the great work that will result from this integrated research program will come to naught as the professionals of tomorrow either are unable or unwilling to take the results of this research and incorporate it into their day-to-day operations. That to me is the challenge of linking education and training with the research results of this program.

U.S. Transportation Command: Perspectives on the Research Framework

Frank R. Weber, *U.S. Transportation Command*

I want to give you a perspective of this thing we call "intermodalism" and the intermodal research framework from the standpoint of the U.S. Transportation Command (TRANSCOM). I am probably not as pessimistic as a lot of folks. I think, as a nation, we are on the right path, moving to do the right things; maybe not as quickly as some would like, and certainly not because we have any kind of overarching grand national-level strategy to deal with the intermodal issue. I echo the sentiments of a number of speakers who have said that what happens in the private sector is going to lay the path for those of us within the U.S. Department of Defense (DOD).

But those same kinds of activities that have caused us to become, quite frankly, global leaders in the respective modes in the nation's transportation industry will ultimately lead us to do the right things that we are all after in dealing with that mystical seamless intermodal system. We are not quite sure how to define it, but we are moving on that glide path to improve it.

I want to focus on the implications for and the potential of this movement as regards the DOD's transportation system from the perspective of TRANSCOM. TRANSCOM is a unified command designated as DOD's single manager for the Defense Transportation System. That means that on a daily basis, we are engaged in a wide range of activities anywhere in the world. If it is on CNN, odds are in some form or fashion we are supporting it.

And within the Defense Transportation System, we spend each year in excess of $2 billion in the commercial sector to ship DOD cargo around the world. But the real reason that we exist is to assure DOD's ability to project military forces anywhere around the globe at a moment's notice. We rely heavily on the commercial sector.

Commercial partners are a critical part of our wartime force structure. They provide 90 percent of our passenger airlift capacity, and 35 percent of our cargo airlift capacity. Over 50 percent of our total strategic sealift capacity and nearly 90 percent of our surface capacity in CONUS, rail, seaports, and motor assets comes from the private sector. As a result, we are vitally interested in what is happening within the commercial sector; and that impacts the close relationship we have with that industry. A professional partnership between a strong commercial transportation industry and the military remains absolutely crucial to our national defense—now and in the future.

During a contingency, DOD needs to expand rapidly across modes and national boundaries. We define the requirement as being able to surge in excess of two Army divisions and a Marine amphibious task force out of CONUS within days and weeks. We need to be able to ship over 7,000 containers, ammunition, and supplies per week to support our force at its peak. To do that, we need assured access and a high degree of confidence that the intermodal system will work in war as well as in peace.

Why intermodal? First because that is where industry is moving and therefore it is inevitable that the Defense Transportation System must also adapt to it. Second, intermodalism really is key to meeting the requirements of those warfighting commanders; we have been among the earliest practitioners of intermodalism since early in our existence. In its present sense, it is the most efficient and effective use of the total capacity of our transportation sector. Force projection is nothing more than the synchronization of each of the modes in an attempt to gain maximum throughput of the right stuff. That is the measure of merit to the warfighting commander—can we push enough through the pipeline of the stuff he needs?

When we talk intermodalism, we are not talking just about containers. We are thinking in terms of troop movements to and through airfields, of moving the rolling stock of several heavy divisions through commercial seaports, and moving and marrying the right equipment with the right people as quickly as possible from fort to foxhole.

Equally important to us today—as important as the inherent carrying capacity of each mode of the intermodal network (particularly after the lessons of the Gulf War) and as important as the high operations tempo of modern conflict—is access to the information needed to effectively and adroitly control mobility operations on a global basis, providing what I term not "strategic mobility" but "strategic agility." Just as private enterprise is seeking to get their goods to market more quickly, strategic agility is the benchmark of the military strategy.

We are losing that distinction in theaters of operation between the rear area and forward area. The transportation community cannot work independently of the forward area. The operations tempo and the type of threats we face simply do not permit those kinds of distinctions. We have to be able to very quickly respond to the changing tactical theater situations. Transportation force must go where and when the warfighting commander directs. When I first started reviewing the research framework, my first reaction was to tell you the standard spiel that you have heard so often—how different we are in DOD from the private sector. Our challenges on the global scale are so much more daunting than anything a private enterprise might face; and to some degree that is true. Certainly, in the private sector, time is money. In DOD, time equals lift and lift equals lives. It was Napoleon's famous comment of course, "You can ask me for anything you like except for time." And it holds as true now as it did then.

Proctor and Gamble certainly does not have a joint task force commander relying on containers to use as warehouses or perimeter defense. It is easy to issue a policy directive that stipulates use of containers for transportation purposes only. However, when you are in Mogadishu getting shot at, use of a container in perimeter defense as a bullet catcher is a perfectly legitimate use of an intermodal asset.

I would offer that there are few seasonal rushes that compare to the need to be able to pick up those two heavy divisions and an amphibious task force on just a few days notice and project them halfway around the globe with American lives and interests at stake. Clearly, there are other differences, but what I want to do is focus a little more on the remarkable similarities because the more I read the research framework, the more I became convinced that the similarities in many cases outweigh the differences. To survive in today's competitive environment, successful civilian and military transportation companies/units must be flexible and efficient on both a national and a global basis.

Industry is leading the way in just-in-time delivery concepts, merging the manufacturing and transportation systems in ways never before envisioned. In DOD, the demands of today's and tomorrow's warfighting strategies mandate just-in-time force delivery and sustainment. Velocity management is really the word of the late 1990s. Velocity management in the private sector has to come into DOD to keep pace with velocity warfare. "Just-in-time" force delivery and sustainment is a far cry from what has been termed the "just-in-case" approach

we have used before. Industry has been forced to streamline organizations and reengineer processes to drive out costs and increase productivity. The ongoing budget debate is clear evidence that we face the same pressures. Industry has learned that to survive it had to enter into partnerships with its shippers and, to some degree, its competitors. We are coming to those same conclusions in DOD, as we understand the impact of our actions on the economic viability of those commercial partners on whom we will rely in wartime.

We have much in common. We both need strategic agility to be successful, and intermodalism is key. As Jeff Crowe pointed out, intermodalism still is not the seamless system it is supposed to be. As a nation, we have some of the world's leading ocean carriers, first-class railroads, a sophisticated trucking industry, and ports competitive with any on the globe—clearly world-class competitors within those modes.

But as an integrated intermodal system, much remains to be done. We still have containers that have to be trucked 20 miles or more from the waterfront. We have heard about the labor issues, the ramp-space issues, highway congestion into and out of major port complexes, and other problems at the point of exchange between our modes; and our information systems in many cases cannot keep up with the speed of movement. Velocity management, whether in the private or military sectors, includes information management of what we call "command and control." Data entry, the old garbage in-garbage out problem, continues to plague us just as much in the private sector as within DOD, and it degrades our ability to fully capitalize on the capabilities of the intermodal system.

The challenge of this conference and future conferences is really not just to develop an R&D framework because it is "intermodal" or to be caught up with technology and information systems. Technology will not fix cultures. Putting systems and tools in the hands of the G3 or the operations officer is not going to make him sit down with the transportation or logistics officer any more in the future than he does today because from his perspective the transportation or logistics officer is one of many people there to support the decision process as does the intelligence officer, the medical officer, and every other member of the staff. So the tools are not going to fix the culture, and war is just as real today as it was in Napoleon's time. Furthermore, competitive pressures will still cause industry personnel, despite the framework we set out, to do what they think is important to do in their own interest and for their own economic survival.

From a DOD standpoint, I see three major areas of focus within the intermodal framework. First is infrastructure enhancement—not the port complex itself, not the rail lines going in, not the container handling system; I mean the interface among them—how to smooth ingress to and egress from our key nodes, be they airports or seaports.

Second, information technology is key. Unless and until we improve our ability to exchange accurate data in real time, we will reach a point of diminishing returns on our infrastructure and modal investments. Information is time and, as I said earlier, time is money to you (industry). Time is lives to DOD.

The third thrust is in the policy arena. How do we get to this thing that we call joint planning between the public and private sectors and leverage our collective efforts? As the research paper notes, industry is operating in a dynamic competitive marketplace; operating, in many cases, sophisticated national even global systems. DOD needs to tap into that expertise and move away from the notion that somehow we can run those systems in wartime more efficiently than industry. Joint planning is still in its infancy, but we need to explore where we can exploit its potential.

Those of us in DOD are not going to tell commercial entities—commercial shipping lines, trucking lines, railroads—how to run their business better in wartime. The human factor is very, very important. The expertise that industry can access when it deals with these kinds of requirements on a daily basis is something we need to bring into DOD and capitalize on. We do not just focus anymore on getting the assets, the equipment; it is now also how we bring that expertise to bear. But it is very difficult. It is simpler to think in terms of "private sector" and "public sector." I think that was one of the problems we found when DOD tried to actually do some things with ISTEA. When we looked at ISTEA we asked how we could leverage the ISTEA initiative to do something. Nobody was in charge—you look at the public

sector, you have local governments, state governments, and the federal government; and they are all competing interests. Who is the public sector and how do we bring their interests together?

But the private sector has similar problems. When we sit down and talk to industry, the problem becomes how to weed out the competitive discussions and issues and prejudices that players bring. For example, if you are talking to an ocean carrier when there is a port operator or a labor official in the room, trying to get everybody onto the same sheet of music can be a difficult challenge.

We need to find ways and opportunities to determine common interests. That is a tough challenge. But until we do that, all the other things really cannot be maximized. We can invest in the platforms, we can invest in the infrastructure; but until we bring expertise to bear, through joint planning and through partnership, our mission is left undone.

Implementation and Policy Challenges for the U.S. Department of Defense

John F. Phillips, *U.S. Department of Defense*

In my job I learned very quickly that all that we are doing at the U.S. Department of Defense (DOD) in logistics—velocity management, maintenance or engineering efforts to streamline the process—to reduce the overhead costs is dependent on an assured transportation system. I, therefore, rapidly gained an appreciation for how critical transportation is.

We are about delivering parts to the right place at the right time. Our vision is quite simple; it is intermodal transportation. We are also beginning to privatize. We are doing more partnering with industry. We are doing more dual-use initiatives. We are beginning to embrace industry; not that we have not in the past, but we are expanding the role of industry in all that we do in the world of transportation. Development of advanced technologies is clearly a part of this reengineering effort.

In 1995, we spent about $10 billion, distributed across personal property, freight, and passengers. Of significance is the fact that 85 percent of those dollars were spent on commercial providers in wartime and 90 percent in peacetime. Privatization is really not a new concept; what is new is that we are beginning to contract for more processes.

If we look at the assets, we can see that in terms of airlift, we have got quite an arsenal—about 177 aircraft and about 8 of those are fast-transport vessels. In the commercial world, we have about 286 in the civil reserve air fleet. The civil reserve air fleet, as you know, is probably one of our first large commercial ventures and it actually goes back to World War II. In seacraft in the commercial world, we have got about 759 vessels, and that will probably expand.

We have no option but to continue to privatize. Based on what is happening to our budget now, by 1999 our manpower will have to be cut by about 50 percent from what it was in 1989; yet, we are deployed currently at about 29 locations throughout the world. That is a logistician's nightmare. If we are going to maintain a fairly high operations tempo, it means we are going to have to rely on commercial transportation and expertise to make up that difference.

At Sacramento and San Antonio, we are privatizing in place. That contract was awarded some months ago and it has proven to be a successful endeavor. Functions and inventory con-

trols that were considered inherently governmental, such as cataloging and procurement, data management, and installation services we are considering privatizing.

The fact is we have a contract in Bosnia for running much of that operation. But an interesting side is that they contracted with a Russian airline to do much of their in-theater air. We are looking at our policies about buying American, but they are doing a great job. If you talk to the warfighters, they are very comfortable. You are going to see more and more of this kind of a partnering activity in all of our operations other than war.

Look at the civil reserve air fleet—this has been around since World War II, but the first time we actually called it up was in Desert Storm and Desert Shield. We also have international cargo that is worth about $600 million; that is to entice the civil structure to participate in the civil reserve air fleet program.

We would like to do the same thing for sealift. So far in our initial commitment, we have about 22 carriers; that represents about 92 percent of the capacity out there.

All this takes money, and of course we are concerned about maintaining the infrastructure—we are talking about our ports of embarkation, our ports of debarkation, about the rail lines—things that are absolutely critical to our ability to ensure that we can flow the resources through to the region of conflict. And this year we are spending about $41 million.

We are busy with the business of reengineering and trying to streamline the acquisition process. We are streamlining the payment process and also conducting an assessment of the infrastructure; so we are certainly open to any ideas that industry might have about how to do it. The kinds of results we are looking for are in the acquisition and financial management process, contracting, and interfacing with the customer. Those of you who track goods from factory to foxhole may recognize the five segments of that movement. In times past, we had separate billings for each of those segments. We are trying to come up with a single payment point, a single bill.

Intermodalism has certainly been one of the key themes today, and we have conducted several exercises that have proven the worth of intermodalism. The Army has an exercise to actually deploy troops from Fort Parsons down to Oakland by way of air and then by way of container ship overseas. That had not been done before. We also have Team Spirit Exercise, which is reinforcing our troop support over in Korea. That has proven to be an excellent exercise in intermodalism. We think that intermodalism is here to stay, and we will support it in policy as well as in practice.

There are two things that typically are offered as reasons why we cannot do a lot of reengineering in DOD. One is that transportation is critical; we must have dedicated transportation. The other is lack of data systems and technology. We are in the business of coming up with electronic data interchange, electronic funds transfer; to my mind all this compresses the acquisition life cycle. Within the world of logistics, the difference as a result of compressing that cycle is about $71 million a day. You can see how things like electronic data interchange and all the other computer capabilities are actually going to allow us to compress the process and save money. Those dollars will be rolled back into force modernization.

We are also putting money into quality of life, some $4 billion last year. Moving is one of the major irritants of military life. We had some 1,400 carriers; and about 25 percent of the moves resulted in claims totaling a fair amount of money. That is a major source of irritation. Troops are forced to move almost every 18 months, and we are trying to streamline and improve that process.

It is clear that we have run out of options not to change. We simply have to streamline the process. Our reengineering effort is on track and there is a commitment from Secretary Kelly all the way down, and we consider industry a critical partner in this reengineering effort.

Implementation and Policy Challenges for the U.S. Department of Transportation

Michael P. Huerta, *U.S. Department of Transportation, Office of Intermodalism*

There has been a great deal of discussion and, in fact, consensus and agreement on the need for a systemic view of transportation that reflects the overall user perspective and for greater participation from the private sector that seeks broad industry consensus to determine project priorities as well as to participate in project funding. The U.S. Department of Transportation (DOT) recognizes the importance of systemic research to improving the efficiency and the connectivity of the transportation system; and this conference has addressed the relationship between information technology and transportation and how to strengthen that relationship.

Given the agreement on this issue, the obvious question is, "What's the problem?" There are factors that make the implementation of this vision extremely difficult, and many of those factors are represented by interest groups not at this conference. I think it is important to address the diverse perspectives of these interest groups and to figure out a strategy for identifying intermodal research that generates useful products for a variety of users.

The first factor that we must consider is the diffuse nature of the transportation industry—there are many players and we tend to deal with them on a variety of different levels. Deputy Secretary Downey characterized the transportation system as being in many ways like the Internet; when we talk about trying to coordinate intermodal transportation, we try to do it in that same framework—where we do not want to stifle creativity, but we want it to be workable for a wide variety of independent players in the system.

Frank Weber pointed out that it seems that no one is in charge; and that is in fact the case. While there is a federal transportation program, under our current surface transportation authorization, the states have a great deal of authority in deciding how those funds get spent. Local governments are important players as well. And we are all aware that industry has an awful lot to say and do in areas that pertain to the movement of freight; in fact, that is where the majority of the creative advances have come from.

Coupled with these very diffuse interests is the notion of an intermodal mindset that Michael Meyers raised. For example, a couple of years ago when we were reauthorizing the Airport Improvement Program, DOT suggested that a small portion, a very small portion, of the funds that would be dedicated to the Airport Improvement Program should be set aside for

intermodal planning to tie airports to the broader transportation system. That proposal basically went nowhere because of significant concerns on the part of an important constituency—specifically, the airlines and the aviation industry—that these funds would be diverted for nonairport uses. This is the argument that we will need to deal with day in and day out.

That particular point is starting to play itself out once again as we move toward reauthorization of the Intermodal Surface Transportation Efficiency Act (ISTEA) in 1997. While we can all talk about the need to build on and advance the vision that was set forth by ISTEA for greater intermodal planning, thinking, and ultimately project funding, I think it is also important to point out that there are extremely significant and powerful segments within the transportation enterprise who are concerned about possibly reversing some of the advances that we saw in ISTEA. And so, at the same time that we are talking about building on the principles of ISTEA, I think it is also fair to point out that a significant part of that conversation will be focused on how do we hold on to the principles that we were able to originally incorporate into ISTEA.

There was also a discussion today about how shortage of funding suggests an imperative to cooperate, and that is true. If there is less money to go around, we all need to invest it more wisely. But there is also an indisputable fact that a shortage of funding does not exactly encourage distinct players in the transportation enterprise to cooperate. In many instances, a shortage of funding encourages people to protect turf and to hold onto their portion of funding that might be allocable.

This plays itself out in many different ways. My example about the Airport Improvement Program is but one; we have seen many others. And this is compounded by the fact of how DOT is viewed when we propose expanded eligibility for funding. Michael Jackson pointed out quite correctly that DOT is viewed as the regulator; but when we propose something that an interest in the transportation system might view as punitive, we are viewed as adversaries. Building on intermodal program investments, planning criteria, and research agendas consensus is going to be extremely difficult.

Many would agree with John King's assertion that the evolution to intermodalism is irreversible. But we also have much more in the way of evidence that it is extraordinarily difficult to embrace that vision. Jeff Crowe talked about getting around our divergent self-interests, and Michael Jackson further elaborated on the difficulties we have had in achieving consensus both in industry and in government. For example, it has taken many years to come to some consensus as to how we should implement the Intermodal Safe Container Act. We have a lot of work to do in this area.

There has also been a lot of discussion about making the transportation system as efficient as it possibly can be. That is certainly an extremely important objective. If we cannot invest in new capacity in the system, then at least we have to ensure that we are managing the system as well as we possibly can and that we are getting the full benefit from it.

Optimization, however, also raises some difficult questions about levels of access to the transportation system. While markets are efficient, they are sometimes messy, and one of the things that we hear a lot about DOT concerns providing a full range of choices to users of the transportation system. Witness the annual argument that we have in the appropriations process about things like essential air service or local rail-freight assistance—programs that are intended to provide a base level of service across more than one mode of transportation. We are expected to balance the efficiency of the system with a level of access to the system, and we need to recognize that these objectives are often in conflict with one another.

Funding and institutional issues are the easy ones to deal with. There is no question that these are important issues, and in fact I agree with the framework developed by this conference. However, we need to shift the discussion away from defining where we need to go, there is a great deal of consensus around that; instead we need to focus the discussion on determining how we get to where we need to be, because that is the problem. It is these issues that are really the key to realizing the intermodal research vision, and DOT alone will be unable to break through them without some significant help from our partners in industry and from the U.S. Department of Defense.

ISTEA did not address the issues of distinct modal organizations or how research funds are parceled out among the modes. Lillian Borrone pointed out that these are still in what she termed "modal cubbyholes." Changing this arrangement is not going to be easy.

We only need to point to our experience of last year in proposing a dramatic restructuring of the funding resources and DOT's institutional structures. At that time, we actually proposed many of the things that we have been talking about today—greater funding flexibility for research and development and a centralized focus for research and technology. However, what we found is that while there has been some support, there are also many significant concerns; and these will take time to resolve.

We need to search for a way to build "enlightened self-interest," which I guess is convincing your opponents that what you want is what they want. Building interests and incentives so that we can all collectively understand what it is that we need out of this total transportation system is where we need to focus our efforts.

While DOT does have the capacity to lead, those to be led have a choice as to whether they will follow. It is in this area that we all need to join forces to overcome the narrower interests that provide not just a hindrance but actually a barrier to realizing the intermodal vision that we all believe is inevitable.

Forecasting Intermodal Markets from a Manufacturer's Perspective

Ralph Castain, *Eaton Corporation*

The forecasting of intermodal markets is a difficult process. The complex factors associated with bringing new products to market, developing standards across the different modes, and changing government regulations create a process that cannot be modeled with traditional trend analysis tools. In my opinion, however, it is vital that we do undertake such an effort.

To understand why I believe this to be necessary, I would like to take a few minutes to describe the problems we see in developing the intermodal system. As many of you know, Eaton is not an intermodal transport company. In fact, we are not in the shipping business at all. Instead, we are one of the companies that manufactures products for the freight industry. Our products range from transmissions to logistical systems, primarily for heavy trucks.

The point of view I am presenting, therefore, comes from that of a manufacturer trying to supply products that will be needed to make the intermodal movement of freight actually work. Accordingly, let us look at a few of the things that might hinder us from bringing such products to the U.S. market.

One of the problem areas is the lack of standards. The establishment of appropriate standards is crucial for creating a viable market in intermodal equipment. I know some may think it stifles creativity, but a look at such examples as the computer world can quickly show the validity of my statement. The explosion of the personal computer industry can be directly traced to the establishment of standards for hardware, thus ensuring compatibility between the products of an entire industry.

We need for something like this to happen in the intermodal world. Unfortunately, right now we seem to be moving in the opposite direction. The U.S. Department of Transportation (DOT), U.S. Department of Defense (DOD), and various states are looking at their own systems. On top of it all, the Intelligent Transportation System (ITS) effort seems to frequently go off in its own direction; and none of these systems is necessarily compatible with the other.

As an example of how this impacts the industry, consider the situation of one of our customers who recently described the problems associated with taking his truck across the country. Because of the different systems he may encounter along the way (depending on the

route), he has had to place as many as 12 different highway tags on his containers and trailers. For someone operating at the typical small profit margin, this represents an unacceptable cost. The most likely result is that this shipper will avoid intermodal solutions.

A second major problem area is product liability. We have heard a great deal about this in relation to other industries such as airplanes, but it really does filter down to our industry as well. As we have recently seen in the courts, it is quite possible to be sued for not putting a piece of equipment on a vehicle even though it was not required.

Consider, for example, the impact this ruling can have on a company thinking of developing a new braking system for trains or trucks. By undertaking the development of such a system, the company is potentially assuming the burden of liability for future accidents regardless of whether the product is actually deployed. This is a serious impediment to future safety-related R&D and needs to be discussed and resolved.

The final problem area I wish to discuss, and the one I consider most important, is the lack of an adequate intermodal system definition. What we as an industry need is a set of requirements for the freight system as an entirety. This is something we have never had; the industry has instead developed in kind of a hit-or-miss manner. Continuing in our current process will, however, make establishment of a true intermodal system difficult if not impossible.

Consider, for example, the latest introduction of the mega-sized container ship. This is a ship that can handle a large number of containers. However, many ports do not have the facilities to load and unload such a ship. In addition, many of our ports are already bottlenecks in the intermodal system. Throwing more containers into them may well slow down the overall movement of freight across the country.

What I would suggest is that we take some time and actually develop an intermodal system plan for the country. There are a number of ways this can be done, but I would like to recommend a process (known commonly as "reg-neg") that has proven reasonably effective in the environmental arena. The process consists of the following steps.

- Government meets with industry, academia, and various trade organizations (for example, the Society of Automotive Engineers) to define the overall system requirements. In this case, we would want to establish reasonable objectives for things such as the time it takes to transfer a container between modes, how well we need to know the location and contents of a container, how many containers we expect the system to handle, etc.
- Industry and the trade organizations take the lead in developing a consensus on how we might meet these objectives. This invariably will require some trade-off between the different factions. For example, some modification of existing railcar design may have to be traded for similar adjustments to the standard truck trailer, with both sides bearing some of the cost of making the system work. Proposals for development of prototype systems can then be submitted to industry and government for funding, with final demonstrations scheduled for an agreed upon set time.
- Finally, we bring all the parties back together and define a set of standards for the various system elements (for example, truck-rail transfer systems). This provides the stability necessary to ensure an active market and provides a mechanism for companies to introduce new technology into the system with some assurance that it can operate effectively.

How then do we take that first step and begin defining the requirements for a national intermodal system? Ideally, we would like to develop a model of the national freight system. This is a difficult proposition, as I am sure many of you realize. The system is a highly complex one, and cannot be considered in isolation—the international aspects of freight continue to grow and must be considered. In addition, many of the factors involved in such a model are not really numerical. For example, the preferences a shipper places on use of truck versus rail, or on the relative value of time versus contents, are better expressed in less precise terms.

We do, however, believe that this might represent a good first step to resolving the key problem facing development of a national intermodal freight system. Some of us in the fore-

casting business have investigated the potential of various probabilistic modeling schemes that may be applicable to this problem. We would welcome the opportunity to share that experience as desired.

In summary, I would like to reiterate that development of the intermodal system is, in my opinion, "not" primarily a technological problem. It is the lack of an adequate system definition that is constraining the growth of the system. Meeting that need should be the primary (and urgent) goal for all of us interested in this industry.

Opportunities for Technology Transfer

Matthew Coogan, *Consultant*

I am particularly interested in an analysis that keeps the focus where the focus should be: on learning from this remarkable logistics revolution that happened as a result of the leadership of the American freight industry and on looking for its obvious applications to the U.S. Department of Defense (DOD) and the U.S. Department of Transportation (DOT). But at the same time, I would like to discuss some possible spin-off implications for two subjects—passenger intermodalism and public management.

What we are doing in a project called the I–95 Corridor Coalition is looking at the idea of an advanced passenger information system, an intermodal passenger information system. The purpose of this system would be to allow you, sitting at your desk or talking to your travel agent, to understand the full characteristics of one total trip—say, by air—versus another total trip—say, by train. I would like to suggest that the themes that you have developed through the work of this committee are remarkably appropriate and applicable to the subject of passenger intermodalism, particularly in our case. We are looking, in the I–95 corridor, at a program that is going to be first applied to traveler need but, most important, it also applies to certain public management and public planning issues.

Here are three observations about our situation. First, along the corridor, resources are scarce, resources are limited. We have got to do more with what we have. So the problem becomes how to manage existing resources better through application of information technology. Second, the existing information systems for passengers are finite but they are very channeled. They are single-mode in nature. If you want information about an airline trip, it is there. However, if you want information about other portions of this sort of horizontally integrated trip, you cannot get that information. Third, the work that we are doing is going to have multiple ownership. Some of the information we need to organize will be owned by people operating at the origin end of the trip, some of the information will be owned by people concerned with the long-haul portion of the trip, and some will belong to the destination portion of the trip.

Making a trip within our corridor, you might pass through several states. In each of these states, there are local policy concerns—for example, a congestion management strategy or an air-quality management strategy (in some cases, the airports are aware of their contribution

to these problems). Our problem is to get you the information you need to make rational choices so you can help, in your travel behavior, with their local strategies. The question is, Can information technology improve the dissemination of the information? The goal is not necessarily to have you change the mode that you use but to provide necessary information for you.

You talk about the creation of a research framework. Here is our model. In order to make sense of this, working down, we are trying to find out how people need information, about what, and when. In terms of time, we think there are three phases. There is the pretrip planning, which might happen 1, 2, or 3 weeks before the trip; the time of trip commencement; and the time en route, detailing and rerouting. For example, look at a trip from Princeton, New Jersey, to Stowe, Vermont. There is a collection segment where you get to the terminal; the long-haul segment, in this case by rail; and there is a distribution segment to get out of the train. The same trip taken by air would have information needs that would be totally different. This is what we mean by the three categories of trip segments.

What would these segments look like in each of these phases? Let us assume our travel is going from San Francisco to Utrecht in the Netherlands. What they have done in the San Francisco area is give information about how to get to airports, for example, how to travel from Richmond in the Bay area over to the airport. The information exists; that segment is available. For the long-haul segment, there is lots of information that helps you plan your trip from Oakland to Amsterdam, approximately seven programs are now available. To answer the question of what a corridorwide or nationwide intermodal information that also incorporated rail would look like, we can turn to the Netherlands. There a remarkable program of trip planning has been built. It essentially asks what day do I want to go, where am I leaving from, and where do I want to get to. Say I want to go from Schiphol Airport to the town of Utrecht. At the computer terminal, on the left window I choose my train, on the right window I get a picture of the train trip, and I get a printout, so when I get off the airplane in Amsterdam I have the written directions in my pocket that tell me to change twice. At Utrecht Station, I am going to change to a pedestrian mode. I am going to take a bus. So you see, our multimodal trip, our intermodal trip, has been planned out for us by some remarkably straightforward technology.

Other pieces of technology that might fit in the mix are in evidence in the trip planning kiosks available in Portland and the kiosk under development in Seattle. All of these could work together in a program.

What is amazing about this subject is the timeliness of it. Five years ago when you went to an airport (except Boston) and asked, What are you doing to tell people about connecting modes? the answer was, Nothing. But it has changed. From Frankfurt, Germany, to Norfolk, Virginia, to Baltimore-Washington International Airport to Oakland, people are now vying for the opportunity of providing exactly the same kind of ground information they were not at all interested in providing 5 years ago.

People are already organizing trip-planning information at the origin, at the destination, and, for some modes, in the long haul. From a point of information technology, how would we organize it? I think it is pretty clear that the best place to update data about the origin of your trip is in the origin metropolitan area. Likewise, the best place to organize information about options at the destination is at that metropolitan area; and probably you would want a national data source about the characteristics of interstate travel. So some of the data needs to be managed locally and some of the data needs to be managed in a central place. We are trying to figure out which information is most appropriately left at the local level and which should be centralized.

The most exciting aspect may have to do with the issue of public policy that Secretary Huerta was talking about. This kind of information is needed by the planner to monitor the system, to model the system, and to use in taking part in performance-based planning.

In addition to having a dimension where we want to service the traveler as well as service economic development (which we have not talked about), the third dimension is to serve the public policy purpose and provide data to support that.

It is much too early to generalize about which technology is needed and what kind of institution could develop it. But judging by the speed at which local areas are putting high-quality trip-planning information on the Internet, it seems that now is the time to prepare standards and protocols to build toward the day that we do have a national system.

From the documents put together for this seminar and the lessons to be learned from the freight industry about the public process, it is clear—particularly if you are a public manager looking at freight and looking at the logistics revolution—that what you want to do is learn to manage better. From the studies that have been prepared, it is clear to me that in order to manage better, we have to learn to measure performance better. That is key to the logistics revolution. To learn about performance, we have to learn to monitor; we have to learn to track.

In the case of passenger information systems, we are involved in monitoring—finding those services and monitoring how well they work. We are involved in the evaluation, in looking at performance measurement, building up to the evaluation of the national transportation system. We hope we will end up with better management resources through information technology.

There is a nexus of intermodal interests; a research agenda is needed to address the very obvious implications of the logistics revolution, first for DOD and second for DOT in the management of freight. In addition to primary motivation and primary interests, there are some strong implications that we should not lose sight of, the spin-off implications of this logistics revolution, to help us understand passenger intermodalism and to help us understand public management.

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