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Fast-Forward

Key Issues in Modernizing the U.S. Freight-Transportation System for Future Economic Growth

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Supported by the Supply Chain Policy Center Executive Committee

RAND Supply Chain Policy Center

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Summary

The Need to Modernize the U.S. Freight-Transportation System

During the past two decades, increasingly efficient supply chains[1] have transformed businesses, promoting distributed, on-demand manufacturing, low-cost retail outlets with automatic stock replenishment from suppliers throughout the world, and home-shopping and home-delivery services responding to Internet ordering. This efficiency is now threatened by capacity bottlenecks in the transportation system, inefficient use of some components of the freight infrastructure, interference from commuter transport, the supply system's vulnerability to disruption, and the need to address important emission and energy constraints.[2]

In late fall 2007, the Supply Chain Policy Center embarked on a project to identify the key policy issues associated with improving freight transportation and its capacity in the United States. We approached this project by reviewing recent literature, interviewing many stakeholders in the system, and conducting meta-analysis of existing data and quantitative reports.

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1 A *supply chain* is the system of suppliers, shippers, transportation links, vehicles, warehouses, distribution centers, management processes, and information that connects manufacturers and retailers and that connects suppliers to manufacturers. The freight-transportation system is a crucial component of most supply chains.

2 Rising fuel and labor costs also increase the freight-transportation-system cost to users and influence logistical choices by those users.

Stakeholder Views

To help focus the study, we interviewed a broad range of users, suppliers, and planners in the U.S. freight-transportation system about key issues, problems, and needs of the system.[3] While many interviewees expressed views consistent with or biased toward the special interests of their particular stakeholder group, there was also considerable consistency regarding the needs and preferred approaches to modernization. With respect to the performance of the system, the significant points consistently made were as follows:

- Speed and reliability have deteriorated in the past few years, in all freight-transportation modes. Reliability was judged by most users as a key attribute in their transportation choices, sometimes more important than speed.
- Congestion in urban areas is a factor that significantly degrades freight-system performance.
- Operational improvements that increase efficiency (and reduce cost and environmental impacts)—for example, 24/7 operations at a port—are important as the most effective near-term source of increased capacity.
- Potential operational improvements vary from new labor agreements and changed regulations to various information-technology (IT) applications to increased visibility and control of the system.

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[3] We conducted 35 interviews, sometimes with multiple interviewee participants. We interviewed operators of many of the U.S. ports and some non-U.S. ports. We interviewed users of the freight system from different economic sectors, including large and small retailers, auto manufacturers, raw-material shippers, and chemical-product suppliers. We interviewed representatives of the various associations for components of the logistics chain. We interviewed a number of railroad executives and representatives of the trucking industry and sea shipping companies. And we interviewed local and regional transportation planners, discussing key regional initiatives, such as the Chicago Region Environmental and Transportation Efficiency Program (CREATE), a public-private partnership initiative in the Chicago area, and the Clean Truck Program to reduce port-related truck emissions in the Los Angeles–Long Beach area.

- Users also claimed that they are not adequately consulted about operational changes, infrastructure developments, or new regulations.
- There is a need for system-level consideration of changes, better data, and more transparency into the operations of private suppliers and users of freight transportation.

Stakeholders also expressed concerns about the robustness of the system:

- Many users commented that they were concerned about possible disruptions at ports and in other parts of the transportation network, but they also indicated that they did not utilize alternatives, mainly because of the lack or cost of supporting logistics infrastructure.
- Some companies have made choices to utilize multiple alternative ports (including some not in the United States) to have options in place if a disaster, labor disruptions, or other circumstances occur that would limit the port capacity or raise its costs.
- A few large users performed tabletop contingency exercises to study responses to disasters and disruptions in their supply chains.

Most individuals we interviewed were supportive of a smaller freight transportation–related environmental footprint, but had concerns and differences of opinion about how to pay for achieving it:

- Reduction of greenhouse-gas emissions through efficiency measures is consistently supported across the stakeholders because it is related to fuel savings as well. However, proposed methods of funding capital improvements to achieve efficiency, such as increased container fees, was a concern of users.

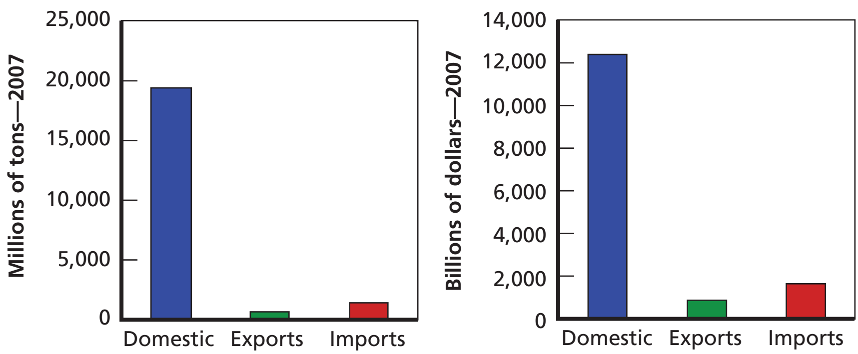
Ports realize that they must address increasing community concerns about their contributions to noise, road congestion, and pollution as a prerequisite to capacity expansion.

The U.S. Freight-Transportation System and Its Growth

The U.S. system currently moves about 60 million tons (worth about $40 billion) per day, which is equivalent to 2.4 million truckloads per day. Because this amounts to inventory stored in the freight-movement component of supply chains, delays and uncertainty in performance of this system translate directly into increased costs of inventory and, ultimately, the cost of the goods. And changes in freight-transportation costs directly affect supply-chain costs.

Although much attention is given in the literature to international transport of containerized freight, most freight movement is domestic—that is, going from a domestic source to a domestic destination. Figure S.1 graphs this fact. And most of the goods are carried by truck, as shown in Figure S.2. As to another measure, *ton-miles*, which expresses the intensity of use of the freight-transportation network (and is closely correlated with the expense), rail and road use are about the same, movement on barges on inland waterways is more significant, and air (despite long distances) is a relatively small player. See Figure S.3.

Figure S.1
U.S. Freight-Transportation Volumes, Domestic and International, 2007



SOURCE: Derived from *Freight Facts and Figures 2008* (Federal Highway Administration, Office of Freight Management and Operations, 2008).

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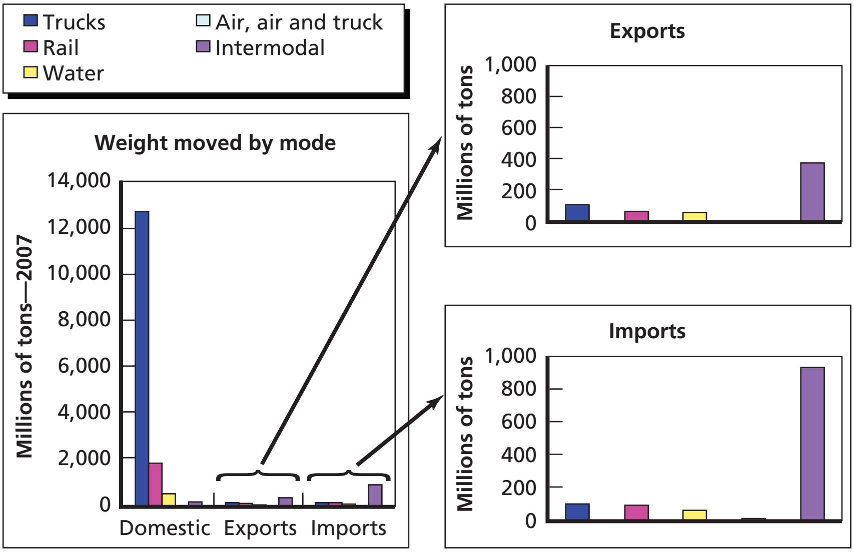
Figure S.2
Comparison of Domestic and International Shipping, 2007



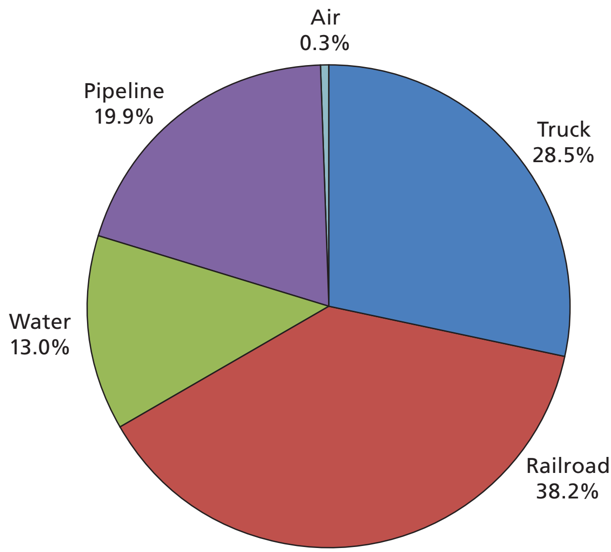
SOURCE: Derived from *Freight Facts and Figures 2008* (Federal Highway Administration, Office of Freight Management and Operations, 2008).
RAND *MG883-S.2*

In general, the rail system carries bulk goods and *intermodal* (i.e., movement by two or more modes) shipping containers over longer distances, whereas trucks move more-expensive, time-sensitive freight over shorter distances. Ships and barges on inland waterways generally carry bulk goods, such as grain.

The volume of freight moved across U.S. borders as a result of international trade is more than $3.1 trillion per year. The largest U.S. trading partner is Canada—and has been for more than a decade. China recently surpassed Mexico as the second-largest trading partner; Japan and Germany are the third- and fourth-largest, respectively. Trucks carry about two-thirds of the goods traded with Canada and Mexico, as measured in value.

With respect to international trade, oceangoing, containerized cargo constitutes a significant portion of the total value of goods

Figure S.3
Comparison of Freight Ton-Miles Across Transportation Modes



SOURCE: DOT, Research and Innovative Technology Administration (2007).
RAND *MG883-S.3*

imported to the United States. Of the roughly $2 trillion in imported goods for 2006, about 50 percent was waterborne (sea shipping), and, of that amount, about 60 percent was containerized cargo.

Trucking ton-miles in the United States grew by 22 percent between 1997 and 2007, and rail grew by 25 percent during the same period. However, containers moved through U.S. ports showed a 7–8 percent *annual* growth rate during the same period. Value hauled by trucking grew faster and is consistent with GDP growth.

Accompanied by this growth have been the negative social effects of large volumes of freight movement, including increased congestion, greenhouse gas and polluting emissions, oil dependency, and safety problems. And, at least in the long term, the growth and negative effects are expected to increase dramatically. The need to deal with the consequences of this growth is one of the issues we raise in this monograph.

Determinants of Capacity

Efficient freight movement throughout the United States and across its borders requires significant infrastructure and adequate capacity of the rail, highway, waterway, and port infrastructures. Delays and uncertainty associated with inadequate capacity ultimately result in the requirement for additional inventory and higher costs of manufacturing and retail goods.

The interaction between capacity, demand, and reliability (assured delivery; on time, no loss) can be complex. The users of the transportation system adapt to constraints in various ways—shifting modes, shifting demands in time and space, moving points of manufacture, choosing alternative points of entry, and changing prices. At any point in time, only some parts of the system will be constrained, permitting other parts to substitute, if feasible. Capacity is also a nonlinear function of demand, in which a little more flow on a congested link can force a tipping point at which the overall flow is dramatically reduced. Interactions between demand and capacity do not always mean a stoppage of flow, but they do increase costs, add uncertainty, cause delays, and decrease demand. Thus, any study of the capacity, reliability, and consistency of the freight system requires a corresponding study of the pattern and flexibility of the demands on the system.

Until recently, most data and projections have indicated that the capacities of ports, highways, and railroads were beginning to be limiting factors in freight movement, especially in urban areas, and, extrapolating from growth history, will be severely constraining in the next 15 to 25 years. Although the current severe economic recession has reduced the growth projections and made capacity concerns less immediate, even the revised long-term growth projections will continue to imply large future demands for freight transportation and concerns about future capacity. Consider the following projections of demand and capacity for highways, railroads, and ports.

Highways

As we have shown, trucking is the primary mode of travel for most freight. Trucking growth in weight hauled is expected to double between 2002 and 2035. The average annual road delay in the United States per peak-period traveler increased from 14 hours per year in 1982 to 38 hours per year in 2005. In some urban areas, it can be much worse. In Los Angeles, for instance, it is 72 hours per year. This delay not only adds to the time and uncertainty in goods shipment but also leads to other inefficient practices, such as servicing routes with multiple trucks to meet pickup and delivery schedules that could otherwise be handled by a single truck. Of course, this adds to the congestion as well as the cost. Figure S.4 illustrates the U.S. Department of Transportation (DOT) estimate that, by 2035, approximately 14,000 miles on the National Highway System (NHS) will see a volume of at least 10,000 trucks per day, with more than one in every four vehicles being a truck. This means that more than 8 percent of the NHS will have a high volume, and a large percentage of that volume will be trucks.

Rail

Although the physical U.S. rail network has contracted from its peak of approximately 254,000 miles in 1916 to 141,000 miles today, several technological and operational advances have improved the productivity of the rail network and have actually increased the effective capacity of the network. Nevertheless, without further enhancements to capacity (although not necessarily more track), the Association of American Railroads (AAR) predicts that, by 2035 (using 2005 as a base), there will be a projected volume increase in rail freight of 88 percent more tonnage.[4] In this case, without increasing rail infrastructure capacity, approximately 55 percent of the national rail network will be operating near or above capacity, with significant resulting delays and limited ability to accommodate maintenance of tracks and equipment. The implications of such capacity overload go beyond rail in that highways may be forced to handle not only the expected growth in truck traffic but also growth in moving goods that would otherwise be expected to travel by rail.

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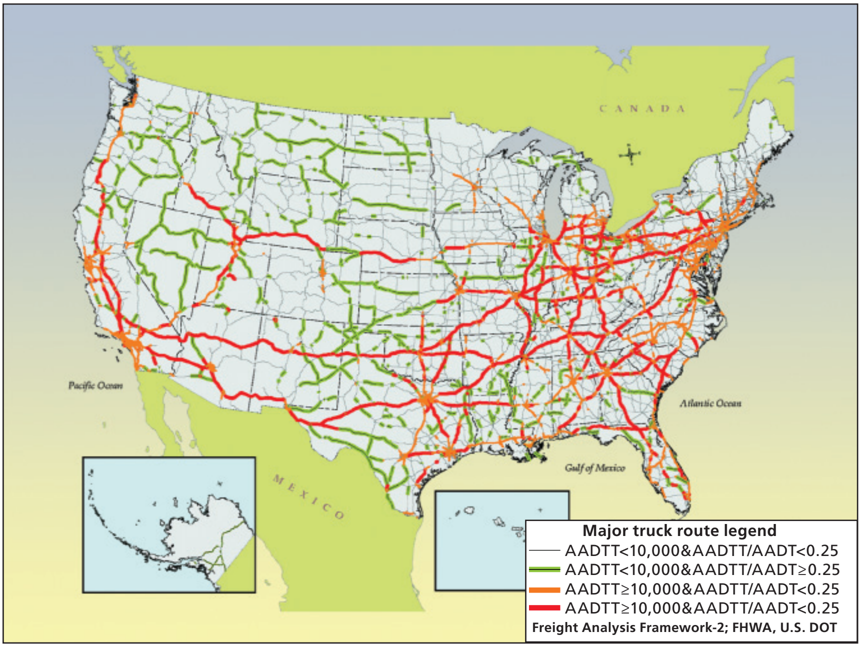
4 The 88-percent increase for rail is consistent with the 100-percent increase in freight-tons moved that was projected for the freight system as a whole.

Figure S.4
Concentration of Trucks and Routes on the National Highway System in 2035



SOURCE: *Freight Facts and Figures 2008* (Federal Highway Administration, Office of Freight Management and Operations, 2008).
NOTES: AADTT = average annual daily truck traffic, and includes freight-hauling long-distance trucks, freight-hauling local trucks, and other trucks with six or more tires; AADT = average annual daily traffic, and includes all motor vehicles.
RAND *MG883-S.4*

Ports

Linear projections of the 7- to 8-percent annual increases in container handling experienced by the ports between 1997 and 2007 would require the major ports to process as much as four times the number of containers in 20 years. The current drop-off in container movements at the ports raises questions about this type of linear projection. However, even if the long-term increases are half those projected, there is a need for significant additional capacity. It appears that operational changes, such as labor agreements that would make it more feasible for 24/7 port operations, and other operational measures that spread demand and make more efficient use of port land area, should go a long way toward providing increased capacity at the ports themselves.

The real problem related to port growth is the capacity of the connecting infrastructure (the highways and rail systems linking the ports to the hinterlands) and the infrastructure's effect on the urban areas surrounding the ports. This monograph discusses a number of alternatives to enhance the capacity of port connections to the hinterlands, including the development of additional capacity at more ports and the use of alternative modes (short-haul rail and short-sea shipping) to remove and spread out the highway-connecter traffic associated with the main ports.

Overarching Issues for Improving Freight Transportation and Some Implications for Policy

We suggest four freight-transportation and freight-infrastructure issues that appear to be the most significant as the nation moves forward with infrastructure developments and refurbishment to foster future economic development. Their significance is drawn from reviewing data about freight-transportation growth and factors underlying system capacity, discussions with stakeholders, a study of proposals for improvements, and review of the potential effects on measures of freight transportation.

Issue 1: Increasing the Capacity of the U.S. National and International Freight Systems Through Operational Improvements and *Selective* Infrastructure Enhancement

As shown in the monograph, long-range projections of highway, rail, and international flows of freight indicate the need for systemic improvement, a plan to use existing assets more efficiently, an improved public-private planning system and a decision to address the need for additional capacity in all parts of the freight-transportation network.

Enhancing freight-transportation capacity does not necessarily mean adding and upgrading infrastructure, such as highway lanes, port terminals, and rail track everywhere, nor even at all apparent bottlenecks. Rather, it should be done by utilizing all the tools at hand, including regulations, pricing, and technology, and selective infrastructure improvements, to increase the overall productivity, reliability, consistency, and capacity of the system. As we noted, the important advantages of operational enhancements to capacity are that (1) they can often be implemented in the near term (in contrast to the long lead time of infrastructure-construction projects), (2) the increased productivity of the resulting system reduces costs, and (3) such productivity often reduces energy use and emissions. However, operational improvements may require additional specialized infrastructure, such as that to increase IT-based connectivity and control.

Elements of a robust solution include the following:

- Use operational tactics to mitigate freight congestion of roadways. Such tactics attempt to spread transportation demand in time and location (using congestion pricing, for example) and to reduce the overall demand (providing alternative modes and reducing packaging are two such tactics).
- Reduce passenger traffic on congested highways. Generally, passenger traffic is a significant cause of roadway freight congestion in urban areas, so decreasing freight congestion will require tactics to reduce this traffic. Such tactics include increased urban mass transit.
- Integrate freight and passenger planning on urban rail and highways.
- Provide more opportunities for mode shifts from road to rail or waterway (more streamlined and transparent intermodal connections, for example).
- Develop an IT-based "infostructure" to facilitate freight movements across modes and increase the efficiency of the system.
- To increase rail system capacity, plan a mix of operational improvements and selected infrastructure developments, such as centralized control systems,
- To reduce the congestion and other negative social effects of moving goods to and from ports in urban areas, develop port-

connector strategies. Such strategies may include short-sea shipping and using short-haul rail to shift truck traffic from the main port.

Issue 2: Creating an Adaptable, Less Vulnerable, and More Resilient Freight-Transportation System

The transportation system will need to continue to adapt to future unknown changes in supply chains as the world economy evolves. This adaptation may include less outsourcing (depending on labor and fuel costs), shifts to U.S. Gulf and East Coast ports with the expansion of the Panama Canal, increases in exports relative to imports, and population shifts to urban areas. The system must also remain survivable and have the ability to recover quickly from disruptions of various kinds, both natural and those caused by human actions. The current recession has shown some parts of the system to be particularly vulnerable to changes in demand, and experience with disruptions suggests a system with insufficient adaptability and resilience. An important aspect of this vulnerability is the dependence on too few ports and routes for the bulk of goods movement in the United States and across its borders.

Elements of a robust solution include the following:

- Provide incentives for the use of alternative ports of entry and debarkation. Such incentives may include differential container fees, which could be used to pay for additional infrastructure development and environmental-pollution mitigation in the more heavily used ports.
- Increase system-level modeling of the U.S. freight system to include interactions between modes, regions, and components of the freight infrastructure. Such a model should be capable of simulating the reactive behavior of independent users of the freight system to congestion, prices, constraints, new infrastructure, and disruptions at nodes and links of the infrastructure. Congruent with the development of such a model would be the development of an expanded freight-data system to support the modeling.

- Identify and analyze key freight-system vulnerabilities to disruption within the transportation system and simulate possible responses to those disruptions.
- Construct infrastructure that separates freight and passenger traffic on railways and highways, particularly in urban areas. These include grade separations and rail "flyovers" to separate passenger and freight rail.

Issue 3: Addressing the Energy and Environmental Issues Associated with Freight Transportation

Reducing energy use has become an important priority for the United States: to reduce dependence on foreign oil, to accommodate the higher cost of fuel, and to be responsive to increasing concerns about global warming. Transportation is responsible for about 25 percent of the U.S. greenhouse-gas emissions, and freight transportation accounts for about 25 percent of that. The environmental impacts of local and international freight movement can be large: "In 2000, container vessels calling at the ten largest U.S. ports polluted the air with more sulfur dioxide than all of the cars in the sates of New York, New Jersey, and Connecticut combined" (Bailey, 2004). Freight movement accounts for approximately half of U.S. nitrogen oxide (NOx) emissions and 35 percent of fine particulate matter. Increasing freight-movement efficiency should reduce greenhouse gases and polluting emissions, as well as generally decreasing the cost of freight movement.

Elements of a robust solution include the following:

- Implement direct mitigation. *Direct mitigation* includes reductions in truck, ship, and rail emissions and fuel use through development of cleaner fuels, improved engines, and better aerodynamics. Driver education, training, and monitoring for efficient truck driving falls in this category, as does speed limiting through engine modifications. Providing electric shore power for docked ships and replacing diesel equipment in ports with electric equipment reduce local sources of pollution and energy use.
- Make efficiency improvements as discussed earlier under the issue of managing and improving freight-transportation capacity. Such

improvements attempt to remove unnecessary trips and miles (better routing, for example), reduce trips with no load (developing IT-based virtual container yards that alert returning truckers about where to pick up a container for their return leg, for example), provide real-time information as a way to avoid congestion, and reduce or shift demands for freight movement in time. Eliminating some packaging might reduce some demand, as could shipping more-concentrated fluid products. Increasing truckload factors through IT-based load management, scheduling, and routing could reduce local truck trips.

- Make the most efficient use of various modes of transporting freight. In cost per ton-mile, trucks are less efficient than trains and barges. To the extent that goods can be shipped economically by rail and barge rather than by truck, the energy and environmental impacts can be reduced. However, because routes available for these other modes are limited and the service they provide is generally slower and more uncertain, this alternative is inefficient for local deliveries, largely done by truck, and is difficult for most regional deliveries involving distances of less than 500–1,000 miles. However, for those goods traveling longer distances, minimizing delays due to rail-truck and truck-rail transfers within the trip (reducing dray trucking[5] at ports, for example), provides benefits/reductions in the time and cost to move goods. Direct rail transfer from docks to distribution centers is an example of improved infrastructure to facilitate more-efficient mode use.

Issue 4: Making the Case for Public *and* Private Investment in Freight-Transportation Infrastructure and Establishing Sustainable Priorities for Funding

Generally, the funding for freight-infrastructure projects is problematic. The projects take many years or even decades to plan, gain public approval, and construct. Funding for freight-transportation projects comes from a multitude of sources—federal, state, local, and private. It also makes the coordination of support and priority-setting difficult.

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5 *Dray trucking* is generally trucking to move containers at ports.

Often, projects have perceived and real detrimental effects (increasing congestion, noise, pollution) for one or more local constituencies during construction or after completion. Transportation-infrastructure projects that benefit primarily freight movement can be even more difficult to allocate and sustain because the indirect benefit to the economy is not an argument that the public can easily appreciate. On the other hand, projects that directly benefit both freight transportation and passenger movement can generate the local support to be successful. We discuss some examples in this report.

A lack of transparency into cost and benefit (and types of benefits—e.g., noise reduction, emission reduction, reduced energy use, congestion, jobs), owing to the extent and complexity of the U.S. freight system, is an issue to be resolved. Ultimately, developing equitable and sustainable financial strategies and priorities for freight-infrastructure development is a key aspect of the problem.

Elements of a robust solution include the following:

- Establish a framework for priorities in freight-infrastructure development and strongly link the priority developments with public benefits. The framework should include a complete set of freight-impact measures, including various economic measures (jobs, added value, costs), emissions, energy use, congestion, survivability and resilience (to man-made and natural disasters), noise, and safety. Multiple future scenarios for economic development and transportation demand need to be considered. The validity and uncertainty associated with projections of freight movement are important. Scenarios should reflect how the demands for freight shipping might change in character, location, and quantity because of such factors as future economic growth or lack of growth, new business models, or changes in population and consumer demands. Robust priority-setting would consider these alternative futures and help to define solutions that work best across the full range of possible scenarios. Priority-setting should include quantified, model-based assessment of the effect of alternatives on the freight-impact measures.

- Develop a planning process that involves all stakeholders, including the private sector, at an early stage and continuously throughout the process.
- Establish local and regional priorities in the context of the broader system model of freight transport in the United States, to consider how local and regional changes in infrastructure, costs, or constraints affect the broader freight- and passenger-transportation systems.
- Develop equitable and sustained funding approaches that utilize the best information from transportation economic theory and actual experience with the tactics (in the United States and elsewhere) and that take advantage of advanced technology (such as Global Positioning System [GPS] tracking) where appropriate. Develop public-private partnerships where possible.

The following monograph details these issues and possible solutions.