Realizing an Intermodal Future Through Research and Development

Jacques S. Gansler, *TASC*

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 evaluated. 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.

REFERENCES

1. Hassler, F.L. *Intermodal Freight Transportation: Observations on Where It Came From and Where It's Headed.* U.S. Department of Transportation, Volpe National Transportation Systems Center, Cambridge, Mass. September 11–12, 1995.
2. Rich, M. "Toward a New Government-Industry Partnership in Aerospace." Rand Corporation, Santa Monica, CA. Speech delivered in Orlando, Fla., February 24, 1993, p. 6.
3. Executive Office. *National Performance Review.* Government Printing Office, Washington, D.C., September 1993.
4. Secretary Federico Peña. Speech delivered to the Transportation Research Board, Washington, D.C., January 12, 1993.
5. National Science and Technology Council, Interagency Coordinating Committee on Transportation R&D. Washington, D.C. April 1, 1994.
6. U.S. Department of Transportation. *Strategic Plan.* Washington, D.C., January 7, 1994.
7. *Special Report 240: ISTEA and Intermodal Planning: Concept, Practice, Vision.* TRB, National Research Council, Washington, D.C., 1992.
8. *A Report to Congress: Surface Transportation Research and Development Plan, 2nd Ed.* Volpe National Transportation Systems Center, Cambridge, Mass. March 1995, p. A–29.
9. House Report Number 1701, Legislative History, Department of Transportation Act. Government Printing Office, Washington, D.C.