Transportation System Assessment
(Breakout 1 of 3)

Michael Walton, *Chair*

This breakout session was dominated by representatives from various public-sector agencies and authorities, and the discussion centered on issues pertinent to their interests. The group focused on transportation system assessment tools and knowledge base as set forth in the draft Strategic Implementation Plan.

Overarching Comments

The following statements summarize the group's beliefs:

1. Policy research is an important component of systems assessment. Although technology also is important in systems assessment, there are critical issues that are more institutional or policy oriented than technical. Therefore, both components—technology and policy matters—must be included in systems assessment.
2. Several modeling issues must be addressed:
   a. Attention should be given to the appropriateness of various models and the use of their products in guiding decisions (accuracy versus precision).
   b. Less emphasis should be placed on precision in policy-based models.
   c. There is concern about models, particularly current state of the art, emphasis, complexity, and uniformity/standards.
   d. Much work must be done to integrate modeling of land use and transportation, specifically the linkages.
   e. There is a need for more advancement in the area of modeling institutional arrangements.
3. It is important to use accessibility instead of mobility to measure performance. Similarly, measures that more adequately reflect the consumption of resources are essential to systems assessment.
4. It is important to match research priorities and programs with the organization of institutions. For example, the national emphasis on intermodalism and the national trans-

portation system has not been matched with funding or an organizational structure to support infrastructure requirements and other deployment programs.

5. Where appropriate, geographic references should be given in the draft Strategic Implementation Plan (e.g., international, North American, domestic/national, state, local, regional, urban, and rural).

6. The importance of equity cannot be overstated. Questions of who pays, who benefits, and how distributional effects are manifested are essential in systems assessment.

7. The draft Strategic Implementation Plan should provide more direction on how program objectives will be met.

8. Concerns exist about how the process of systems assessment will enforce innovation, flexibility, and other important attributes implicit in the process's framework.

9. It is important to find ways to effectively integrate citizen involvement into systems definition and assessment. Various means of focusing on the future should be explored (e.g., the utility of visual preference surveys in such a process).

10. It is important to price schemes in systems assessment.

11. Training in the use of tools and new knowledge for techniques/technologies is critical and should include information on nonfederal studies.

With respect to the key finding in the draft Strategic Implementation Plan that there is a need for improved data, analyses, and assessments in all aspects of transportation system performance, the group recommended that the term "models" be included to ensure a more complete understanding of this important statement.

Program Objectives

Seven fundamental program objectives are cited in the draft Strategic Implementation Plan. The group discussed each objective, made suggestions where appropriate, and added an additional objective.

No revisions were suggested for Objectives 1 and 7; they were endorsed as stated. The following suggestions were made for Objectives 2 through 6.

Objective 2: Assess existing and innovative transportation technologies and their potential impact. This objective should include assessing the equity and distributional effects of technology and should make explicit references to impact on land use.

Objective 3: Assess other technologies of potential importance to transportation systems and operations. Of particular note was that this objective stress the ability to consider and assess new or otherwise different, yet interesting, technologies.

Objective 4: Develop and disseminate data concerning transportation system safety, economics, environmental impacts, and other societal concerns. The maintenance of data, which is an extremely important function, should be added to this objective. In addition, the group recommended that travel be listed among the data elements.

Objective 5: Understand and characterize all types of environmental impacts of transportation, and assess alternative prevention, mitigation, and remediation strategies. There is an opportunity to advance the concept of partnership with other federal agencies by explicitly listing them (e.g., Department of Energy, Environmental Protection Agency, etc.). This objective also should include the role of transportation in a sustainable society.

Objective 6: Develop focused and broad models for analysis of transportation system operations, functions, and impacts. This objective seems to provide a basis for including citizen participation in the assessment, as per the group's overarching comment 9.

In addition, the group recommended that a new objective be added; namely, to encourage and support objective alternatives analysis in selected (strategic) high-density corridors for passenger and freight movements.

Conclusions

The following summarizes the immediate priorities identified in the breakout group discussion:

1. Ways must be found to establish cross-agency direction and accountability of systems assessment.
2. Because stakeholders support the National Science and Technology Council's initiative and the opportunity to provide input into the process and the products, a concerted effort should be made to sustain future stakeholders' involvement.

Transportation System Assessment

(Breakout 2 of 3)

Alan Pisarski and T.R. Lakshmanan, *Cochairs*

Transportation plays a multifaceted role in a highly industrialized society such as ours in the United States. As transportation moves goods and people between and within production and consumption centers, it is seldom desired for its own sake. Instead, some of its functions are clearly economic, such as providing low-cost, reliable mobility, facilitating production, raising agricultural productivity, exploiting natural resources, supporting participation in a global economy, and expanding per capital income. Other functions are noneconomic, such as strengthening the nation's defense, promoting political cohesion, providing greater personal safety in transportation, improving the quality of the environment, and ensuring choice in and access to the transportation system to all groups in society.

The transportation system, which must address these multiple objectives, is a decentralized, largely private, system composed of the following:

- Vehicle systems,
- Physical (material) infrastructure systems, and
- Nonmaterial infrastructure—namely, the set of policies, regulations, laws, and institutions that govern transportation.

The transportation system is a vast enterprise, the product of countless decisions and actions of a large number of private and public players, who respond to economic and social opportunities in the context of technological and organizational changes.

In today's complex, rapidly changing, and customer-oriented environment, it is critical to engage in strategic thinking on transportation at the federal, state, metropolitan planning organization, and local levels. Strategic thinking is oriented to anticipating and resolving issues that are nationally significant, long-term, and systemwide in scope. This requires data to track system performance and analysis to convert data into knowledge useful for making policy choices that determine the future transportation system. In other words, it is necessary to know how well the transportation system performs from the perspectives of various objectives and relevant transportation stakeholders noted previously. The monitoring, measurement, and interpretation of such performance form the scope of transportation system assessment.

Viewed this way, system assessment consists of (*a*) modeling or analytical systems that relate various actions to specific impacts and outcomes in the transportation system and (*b*) a variety of indicators that signify consequences observed in the transportation system.

The analytical system should be broadly conceived so that the framework considers not only the direct consequences of policy actions but also the relevant indirect and induced consequences. Such an approach facilitates consideration of the perspectives of the different stakeholders in transportation. For example, the Program for a New Generation of Vehicles (PNGV) initiative focuses on the creation of an energy-efficient vehicle. If such a program led to a future vehicle fleet dominated by PNGV-type vehicles, there would be far-ranging consequences: not only sharp drops in fossil fuel usage, but also drops in fuel imports, changes in the balance of payments, changes in the highway trust fund, demand for new materials in vehicle production, economic structural change, and resultant economic dislocation. Thus, a full system assessment of PNGV should be framed in the broader context.

Transportation system assessment indicators are most useful when structured not in terms of issues or objectives but by major system attributes. These attributes may be thought of as falling into four classes: supply, demand, performance, and impact. The supply and demand attributes provide the basic descriptors of the infrastructure, its service providers, and its users. The performance and impact attributes describe how well the system functions and with what external effects—on the economy, national security, environment, and energy use.

Performance assessment is carried out through the use of indicators of inputs and outcomes. Although these indicators provide valuable information, system assessment focuses strongly on outcome indicators. A preliminary set of transportation indicators, organized around the four key transportation system attributes, is included in Table 1.

Participants in this breakout represented a variety of organizations—federal, state, and regional agencies; airports, ports, and barge companies; industry; universities; and environmental associations. The group noted that the preceding morning discussions had neglected to recognize and take into account the protocols by which transportation functions. Protocols are the set of understood or learned rules of the road—operating procedures and rules of interaction by which each player knows how to interact with and what to expect from other players. In some respects this set of protocols can be seen as the "nonmaterial infrastructure," which is a central part of the system that makes transportation function effectively.

The group believed that what is required is linkage to human purposes, economic activities, and the needs of society. Greater understanding of the role transportation plays in society and the economy is key to making appropriate public policy decisions. It was agreed that a discussion of these principles should precede any treatment of the three basic topics of system assessment:

1. *Data collection,* including data needs, statistical systems, and knowledge bases;
2. *Tools,* including the models and other systems needed for analyzing key issues; and
3. *Performance measurement,* including the delineation and specification of attributes and goals in transportation.

The group identified the following needs related to system performance:

- To define success.
- To understand why we are collecting data.
- To provide mechanisms for feedback from diverse groups.
- To recognize the speed of change today. In a dynamic period such as this, the half-life of data is brief.
- To focus on short-term and long-term impacts of the system.

TABLE 1 Transportation System Indicators

Data Attribute and Descriptor	Indicators
Supply	
System	
General characteristics	Inventory information (e.g., miles of system)
Coverage	Unit of system per land area or population
Physical condition	Index of condition (e.g., pavement serviceability rating)
	Age of facilities
	Maintenance expenditures per unit of system
Capacity	Vehicles/persons per hour, tons per hour
Fare or fee structure	Range of prices, prices per passenger mile/ton mile, price/service options
Elasticity of supply	Percent change in supply relative to a 1 percent change in cost
Providers	
General characteristics	Number and size of public providers/common carriers/private carriers and providers
Financial condition	Balance sheet and income statement data
Demand	
User characteristics	
Passengers	National demographic and economic data (e.g., age, sex, income, etc.)
Freight	Bulk, density, shipment sizes, containerization, hazardous contents
Activity levels	Traffic counts, volumes, arrivals/departures
Flows	Origin-final destination volumes by trip purpose, distance, mode, passenger, and freight characteristics
Elasticity of demand	Percent change in demand relative to a 1 percent change in price or other measurable attributes of service quality
Performance	
Safety and personal security	Total number of accidents, deaths, and injuries, by market
	Number of accidents, deaths, and injuries per mile/per capita, by market
	Percent of accidents by severity level, by market
	Number and type of security incidents, by service population, by mode
Access	Share of population and households living within defined distances and travel times from airports and for scheduled surface transportation
	Percent of system facilities and services handicapped accessible
Level	Frequency (e.g., runs per hour/day), average wait time, headways
	Number of transfers per commuter or freight shipment relative to average trip/shipment length
Efficiency	Load factors per unit of capacity available, by market and mode
Quality	Percent on-time performance, average delay time, by market
	Percent service interruptions and cancellations, by market
	Value of goods damaged in transit
	Value of inventory in transit (average day)
Cost	Cost per trip and unit of travel
Impacts	
Economic growth	Average days in inventory held by industry
	Distribution costs as percent of domestic retail prices/landed export prices
	Tourism receipts, domestic and international trips
National security	Condition and capacity of commercial transportation facilities and special military transport requirements in defense-essential corridors
	Percent of defense-essential facilities above capacity limits
Environmental quality/ land use	Vehicle emissions level in nonattainment areas
	Tons of greenhouse gas emissions from transportation sector
	Acres of wetlands affected by construction of transportation facilities
	Number of incidents and extent of spills from transport carriage on waterways
Energy use	Energy use by appropriate energy measure per mile of travel, by market

• To express the current transportation system's ambiguity in a new system of characterization.

• To reconsider the past focus on peak capacity as the measure of a transportation system's effectiveness. In the current environment there is a compelling need to measure such items as flexibility and vitality (survivability) in the system. Incorporating flexibility and vitality may be new objectives of our analyses of the system.

• To measure transportation against a broader set of needs and goals.

• To consider public goals and values as measures of success of a transportation system, as opposed to the measures of success used for a market-based system.

The group identified the following shortcomings in analytical models:

• Modeling is a limiting factor in transportation because models operate in narrow areas only. As a result, more subtle costs and benefits of transportation cannot be treated in the modeling systems. We make more demands on transportation today, and models must be more sensitive to this. For instance, the interactions between transportation and economic development cannot be handled effectively by current models.

• Transportation models tend to suboptimize because they cannot take into account such effects as "just-in-time" and plant relocation opportunities. There was considerable discussion of impact modeling—modeling of both short-term and long-term impacts were seen as deficient.

• Freight transportation today is primarily driven by the needs of customers. Suppliers of transportation must provide more productivity—more output per dollar—to succeed. Models and data must permit transportation suppliers to take the pulse of system users and enhance the sensitivity of both private and public planners to user needs. The models must be able to take into account the interactions of transportation with warehousing and with other markets.

Transportation System Assessment
(Breakout 3 of 3)

Barry Kantowitz and Robert Clarke, *Cochairs*

This group focused on human performance in the transportation system, as set forth in the National Science and Technology Council's draft Strategic Implementation Plan. The plan was viewed as an excellent first step toward emphasizing the need to include human factors and related behavioral science research in a transportation research program. The plan authors clearly understand human factors and the benefits that human factors research can bring to transportation. Group members were impressed that human factors are a prominent component of the plan.

Because most group members were not human factors experts, some time was spent reviewing and defining human factors. This perhaps implies that the Strategic Implementation Plan could be augmented by adding a section to better portray the service and knowledge that human factors experts provide to the transportation community. The group discussed why human factors should play a prominent role in transportation research and development (R&D) efforts:

1. *To put people first.* Human factors is a discipline that stresses the importance of people in ensuring transportation usability and efficiency. Although this goal is implicit in the plan, it is worthwhile to emphasize this key point and make it more explicit.
2. *To make the United States a world technology leader.* In the United States, the science of human factors is the most advanced, and this is emulated throughout the world. It is in the nation's competitive interest to keep its worldwide preeminence in human factors technology.
3. *To improve inadequate products and procedures.* The need for input on human factors is evident when one considers existing products with poor human factors design that make it difficult and sometimes unsafe to operate vehicles and move freight.
4. *To advance in world markets.* Better human factors design improves the nation's ability to produce transportation products that are the best in the world.
5. *To ensure safety.* This is the traditional justification for most human factors work. The long-established recognition in aviation of the value of considering human factors principles has spread to all other modes of transportation.

6. *To promote intermodal transportation.* Human factors technology is inherently intermodal. There is no special science of human factors for each separate transportation mode.

7. *To improve quality of life.* Designs that consider human factors principles are easy, safe, and efficient to use; therefore, they lead to a better quality of life.

8. *To encourage innovation.* Understanding human needs drives innovation.

9. *To incorporate diversity.* By providing technology that tailors systems to people, human factors technology supports our societal goal of promoting diversity in the workplace and helps us succeed in the international marketplace by making U.S. products usable worldwide.

10. *To provide decision-making information.* Human factors research helps us understand why people make certain decisions about travel choices, transportation modes, and public transport. This information is crucial to transportation providers.

Priorities

The group identified 20 high-priority research areas for human factors and behavioral science. The group did not have time to rank these areas in order of priority, but the following topics were considered to have potentially high payoffs:

- Human-centered automation,
- Consumer/user acceptance,
- Guidelines,
- Simulators,
- Decision aids,
- Design for diversity, and
- Measurement/data collection.

The remaining areas include the following:

- Human performance assessment,
- Information management and display,
- Fitness for duty/fatigue,
- Workload,
- Human factors support of regulation development,
- Warning signals,
- Analytic models/theory,
- Alertness/shift work,
- Attitudes/preferences/choices,
- Physical qualifications (commercial),
- Selection/job matching,
- Data bases, and
- Occupational safety/health.

The private sector was deemed most appropriate for proprietary research that leads directly to commercial products. Thus, it would be inappropriate for the federal government to design specific products, such as a turnkey in-vehicle navigation system. Shared research that benefits private industry, however, is appropriate for the federal government. An example of this research is producing human factors guidelines for the development and evaluation of in-vehicle navigation systems. This kind of research is especially valuable for small companies that cannot afford to maintain a human factors staff and in situations in which commonality is imperative.

Decisions about public-private partnerships have to be made on an individual basis. Participants believed that it is undesirable to formulate an arbitrary rule about such partnerships.

Similarly, no decisions about basic versus applied research were reached. Participants believed that no algorithm can be formulated to decide which areas need basic versus applied research or what the mix of basic and applied research should be.

Improving the Plan

Although the Strategic Implementation Plan was received positively, participants did offer some general suggestions to build on what has been proposed. First, there was a consensus that the implicit emphasis on people needs to be made more explicit by emphasizing that people, rather than systems, must be considered first. Transportation systems must serve a broad public, and human factors technology should improve how people are served by these systems. This includes not only passengers, but also employees of both freight and passenger transportation systems.

The second suggestion was that transportation policies be driven by human factors and behavioral principles. Examples of such policies are applying human behavior methodologies to (*a*) assess how and why individuals make travel decisions, including modal choices, and (*b*) foster an understanding of travelers' attitudes, choices, and decisions to enhance transportation system policy decisions. These policy-level research efforts should employ the proven scientific tools of human factors, instead of relying solely on marketing surveys and advertising techniques.

Conclusions

To be effective, a federal transportation R&D policy on human factors requires that researchers stay close to the user. Indeed, the first commandment of human factors is "Honor thy user." Violation of this principle will diminish research results. Continued close cooperation and coordination among the human factors research staffs of all transportation agencies is highly recommended.