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The identification of critical research needs in land use, transportation, and air quality was the focus of the biennial summer meeting of the Transportation Research Board Committee on Transportation and Air Quality, held in Irvine, California, in July 1992. Participants convened to build on the fundamental findings of the committee's workshop on environmental research needs held in Denver, Colorado, in November 1991, at which attendees identified 10 categories of national air-quality-related research needs that they considered highest priority. The 10 categories are summarized in *Transportation Research Circular 389 (1)* and are listed here in priority order:

1. Improvement of Urban Transportation Planning System-type travel demand models and development of tools to quantify vehicle activity by operating mode;
2. Development of techniques to apportion fine particulate matter ( $PM_{10}$ ) by source;
3. Identification of relationships among land use, urban form, and trip-making behavior;
4. Development of emissions modeling capabilities by vehicle operating mode;
5. Modification of the highway performance monitoring system for air-quality analysis;
6. Quantification of the suspected existence of latent demand and the potential impacts on area source growth;
7. Establishment of the effectiveness and public acceptability of various transportation control measures (TCMs);

8. Quantification of the direct costs and externalities associated with congestion;

9. Quantification of the contributions of various sources to high carbon monoxide concentrations near intersections; and

10. Improvement of the ability to estimate vehicle activity and emission rates for heavy-duty vehicles.

This list served as a baseline from which summer meeting participants developed additional research project needs.

The three-day summer meeting was organized in a presentation and discussion format. Technical sessions were held on the following topics: (a) mobile source emissions estimates; (b) TCM and transportation demand management (TDM) effectiveness analysis and monitoring; (c) land use, travel patterns, and air quality; (d) transportation demand modeling for air-quality plans and control strategy analysis; and (e) top-down approaches to obtaining data for air-quality analysis. Each session focused on a different piece of the transportation and air-quality puzzle, and theoretical modeling and practical application were included. After each technical session, meeting participants met in groups of 10 to 12 to discuss issues raised by the speakers and to develop a list of what they believed to be critical research needs associated with the session topic.

### Critical Research Needs

The needs identified by the six groups were both short- and long-term. The groups clearly reached consensus that a high priority is the determination of cause-effect relationships between vehicle activity and emission rates. The groups all indicated that mobile source emission inventories and emission modeling capabilities are critical for a number of reasons. First is the need to use these models in the preparation of state implementation

plans, including the development of effective TCMs in transportation and air-quality conformity analysis. Second, models are needed to accurately evaluate the local impacts of transportation projects. Third, there is a need to accurately assess the effectiveness of proposed TCMs in many urban areas. Specific issues raised by most of the groups are summarized in the following sections.

### Mobile Source Emissions Estimates

One major concern that emerged from the session on mobile source emissions estimates is the need for new emission rates to better quantify the impacts of TCMs. Hence improved emission rates related to engine starts and changes in traffic flow are necessary for evaluation of policy options.

Creation of new emission testing cycles more representative of on-road operations, perhaps by time of day or trip purpose, was recommended. With or without new cycles, however, development of real-world emission rates for emission-producing vehicle activities (especially for activity under different vehicle operating modes, such as acceleration, deceleration, idling, etc.) was clearly established as the highest priority.

All of the groups believed that quantification of off-cycle emissions should be vigorously pursued. Some groups indicated that potentially significant explanatory variables, such as cycle work and speed variability, should also be investigated. One group suggested that the investigation of these critical emission parameters be ranked in priority order by potential emissions impact.

Nearly all of the groups believed that improving the capability to estimate  $PM_{10}$  emissions and their impacts is important. It is currently difficult to determine what percentage of  $PM_{10}$  concentrations is transporta-

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tion-related, and it is even more difficult to determine what percentage of  $PM_{10}$  concentrations is associated with vehicle emissions versus re-entrainment of road dust.

The expansion of research programs to improve estimates of heavy-duty vehicle emission rates and vehicle activity was listed as a high priority by most groups. Some indicated that the ability to identify and quantify emissions of toxic air contaminants from motor vehicles should also be improved. Finally, addressing uncertainty inherent in emissions data and emission factors was mentioned as a priority. By making uncertainty more explicit (i.e., providing error estimates), policy makers can better evaluate the emission reduction potential of proposed policies.

### **TCM and TDM Effectiveness Analysis and Monitoring**

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The primary focus of group discussions following the session on TCMs and TDMs was the need to develop tools to evaluate the impacts of TCMs and improve the ability to analyze non-work trips. The consensus was that existing TCM analysis tools require significant improvement. To this end, the collection of new data associated with trip-making behavior (for discretionary and nondiscretionary trips) was listed as a high priority by most groups. Further investigation of potential barriers to use of TCMs, such as geographic, social, personal safety, or economic constraints, was recommended. Examination of public acceptance of TCMs, in terms of effectiveness and longevity, was also identified as a primary need, as was evaluation of the leverage and synergistic effects of TCMs.

Participants noted that the focus of most TCM research has been on TCMs designed to affect commute trips. Given the ongoing increase in nonwork trips, they agreed that TCMs affecting nonwork trips deserve more attention.

Evaluation of consumer responses to market-based strategies, the TCM approach usually considered to have the greatest potential for modifying transportation demand, was identified as a top priority. Development of "total social cost" analysis tools that could account for the presence or absence of single-occupancy vehicles and alternative transportation mode subsidies was impor-

tant to some groups. Evaluation of TCM side effects and equity impacts that may result from the implementation of these strategies was also critical to some. Development of monitoring methods designed to evaluate TCM effectiveness was proposed. Finally, further investigation of the feasibility of substituting the use of telecommunications for vehicle trips was identified as an important issue.

### **Land Use, Travel Patterns, and Air Quality**

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Basic research designed to evaluate the effects of numerous land use characteristics on trip-making behavior and on the effectiveness of TCMs was deemed paramount by the discussion groups following the session on land use, travel patterns, and air quality. Collection of more detailed data related to trip generation rates is critical to this end. One group suggested development of a detailed revision of the Institute of Transportation Engineers trip generation manual. Policy impact studies based on new research and improved models were recommended; such studies should be focused on evaluation of consumer response to land use policies. In addition, several groups indicated that the impacts (e.g., housing affordability, distance to employment, access to services, and transportation costs) of land use and transportation policies on various socioeconomic groups should be evaluated. Better defining the role of government in land use decision making was also noted as a high priority.

Development of feedback loops among land use, transportation demand, motor vehicle emission, and air-quality models was deemed necessary by all groups. Integration of geographic information systems (GIS) capabilities that provide spatial resolution in land use, transportation demand, and vehicle emissions was also recommended, and most groups suggested that GIS capabilities be introduced into the overall land use, transportation, and air-quality modeling framework. A number of groups noted that existing and future data will be used most efficiently if land use and transportation models are developed with a built-in compatibility for the GIS-based systems used (or being developed) in other branches of government.

### **Transportation Demand Modeling for Air-Quality Management Plans and Control Strategy Analysis**

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The outputs of transportation activity models, both regional demand models and micro-scale traffic simulation models, often do not produce the data or information necessary to answer important policy questions. It is difficult to assess the potential impacts of TCMs, market-based incentives, special events, and traffic flow changes using existing models. The clear consensus reached by the discussion groups following the session on transportation demand modeling was that transportation activity models need to provide the important information required to make these kinds of policy decisions. This implies that the cause-effect relationships between vehicle activities and their emission rates

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**Policy impact studies . . . should be focused on evaluation of consumer response to land use policies.**

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must be known. Thus the emission rate research described previously must progress in concert with the enhancement of existing activity models or the development of new models.

The discussion groups emphasized improving the accuracy of activity models so that accurate outputs may be coupled with emission models and emission results may be used in air-quality planning. However, no clear consensus emerged on whether research should focus on upgrading existing models and improving integration between transportation and air-quality models or if the focus should be on developing completely new modeling approaches. Nevertheless, as one group noted, "Research for enhancements to models must consider land use, travel, and emissions model sets as a continuum." The debate on modeling approaches deserves much additional attention and is likely to continue well into the future.

With either general approach to activity-model improvement—enhancement of existing models or wholesale development of new models—the discussion groups all believed that the collection of additional vehicle activity data is critical. Of course, data related to emission-producing activities (e.g., cold starts and high acceleration) should be a focus of data collection. However, even the general data associated with vehicle trips, vehicle miles traveled, and vehicle speeds need to be enhanced in most areas. To this end, some groups recommended the preparation of “strategic data collection plans” designed to gather appropriate and necessary data.

The groups also noted that the majority of transportation activity models are not user friendly. The operational characteristics of the models are complex, which limits participation in the activity modeling process. In addition, when model documentation is unavailable, the outputs of the models cannot be examined in light of the assumptions that inherently limit the use of the outputs. Thus accountability associated with using model outputs is often lacking. Most of the groups indicated that new or improved models should provide simplified user interfaces and should be supported by documentation enabling users to better interpret modeling results and establish ranges of uncertainty about their findings.

### **Top-Down Approaches to Obtaining Data for Air-Quality Analysis**

The long-term needs discussed by the groups were generally related to data enhancement. Collection of pertinent emission-producing vehicle activity data and improvement of the estimates for activity-specific emission rates were the focus of most of the research agendas.

Development of strategic data collection plans is of paramount importance. Most groups indicated that collection of important data that can be employed in various modeling routines should be a priority and should be shared when possible. Data sharing requires good communication between agencies so that data may be formatted for use by multiple parties. Investigation of the capabilities of high-tech approaches to data acquisition should be explored; many intelligent vehicle-highway systems technologies

may be implemented to collect useful transportation and air-quality analysis data. For example, “typical” trip-making and traffic flow data could be collected by observing the trip-making behavior of a select sample of households, much as data on television-viewing habits are collected by Nielsen surveys. Privacy issues were also broached by two of the groups as a research need for data acquisition and sharing.

### **Additional Points of Consensus**

Providing estimates of uncertainty in transportation and air-quality analyses was identified as a critical research need, as was incorporation of the concept of the total social costs in evaluating planning decisions. All of the groups indicated that agencies and industry need to improve communication related to modeling and research. Sharing of data is critical, but sharing of research results is even more so. Development of a research clearinghouse was also recommended (perhaps with the Federal Transportation Data Center taking the lead and the TRB Committee on Transportation and Air Quality serving a role in disseminating research results). Development of research consortiums capable of undertaking major research projects and sharing data and results, through combined public and private funding, was recommended as a high priority by some groups.

Finally, all groups recommended that steps be taken to help researchers, government agents, and the general public better understand transportation and air-quality relationships. The public needs to know how transportation behavior affects air quality. An informed public will help to make transportation and air-quality programs both politically supportable and ultimately successful.

### **Conclusion**

Each discussion group at this summer meeting was composed of representatives of local, state, and federal government agencies from the land use, transportation, and air-quality disciplines. A number of research universities and one vehicle manufacturer were also represented. The depth and breadth of the focused presentations and discussions at this meeting should provide a reasonable spectrum of the research needs faced by

transportation and air-quality planners. The research priorities outlined may be supplemented through the work of future research groups entailing even broader-based participation from industry and public interest groups.

The organizers of this summer meeting hope that the research summaries will aid in the development of a comprehensive transportation and air-quality research plan, established with direct participation and support from government agencies, private industry, and public interest groups. An efficient research plan that avoids duplicity and is directed at solving common problems should be a primary goal.

The majority of the working groups at the summer meeting believed that broad-based research consortiums should be established nationwide to pursue air-quality research. Peer-reviewed research coupled with the efficient sharing of data and research findings will move transportation professionals quickly toward a greater understanding of how to best assess the impacts of land use and transportation on air quality and how to best mitigate potential impacts.

Active participation from a variety of players is necessary if research is to progress efficiently. Participation involves technical expertise as well as financial support. Hence the next steps associated with developing a detailed working agenda for land use, transportation, and air-quality research should probably entail the development of consortiums.

Given the need for a national research agenda, the consortium process should be established as soon as possible to ensure active participation from industry, state and local governments, academia, and public interest groups. Development of research consortiums that provide adequate funding, technical expertise, peer review, and information dissemination will enhance the ability to make rational decisions on future land use, transportation, and air-quality policies.

### **Reference**

1. *Transportation Research Circular 389: Environmental Research Needs in Transportation*. TRB, National Research Council, Washington, D.C., March 1992, 65 pp.