Grand Challenges in Transportation:
The Role of Geographic Information Systems and Science

Committee on Geographic Information Science and Applications (ABJ60)[i]
Transportation Research Board

Introduction

Globally and locally, demand for travel and transportation has increased dramatically over the past two decades. Electronic communication has made the world more mobile and inter-dependent (Bannister and Stead 2004). International trade relationships have altered the dynamics of manufacturing and consumption, doubling the volume of freight traffic (FHWA 2006). Personal travel demand continues to rise at all geographic scales from local to global (Hanson 2004; Schafer and Victor 1997). While in the past the solution to transportation demand growth was simply to build more infrastructure, the present reality is that financial resources, environmental clearances and urban rights of way are constrained. The convergence of these trends has created unprecedented pressure on the transportation system, which has to be addressed principally by better understanding of needs, and improved management.

Geographic Information Systems (GIS) and the underlying *Geographic Information Science* (GISci) are well positioned to provide useful tools to meet this challenge, as they address a broad range of spatial dimensions in supply and demand for transportation services, and the complexity of environmental issues, asset management, strategic security, safety and operations.

This discussion paper provides an overview of trends in GIS and GISci, Grand Challenges facing transportation systems, and relevant research needs in GIS and GISci.

Transportation Challenges

Through a cooperative process involving ABJ60 committee members and other stakeholders[ii], several Grand Challenges in transportation were identified (see Table 1). These challenges harmonize with the latest Critical Issues in Transportation report issued periodically by the Transportation Research Board (TRB) (TRB Executive Committee 2006). This report identified critical issues facing the U.S. transportation system; these include *congestion*, *emergencies*, *energy and the environment, equity*, *finance*, *human and intellectual capital*, *infrastructure*, *institutions* and *safety*. In addition, the human capital issue is addressed in our strategic planning by identifying educational needs to meet these challenges.

- Infrastructure renewal and asset management
- Operations and congestion
- Environment
- Safety
- Security
- Planning and programming
- Science

Table 1: Grand Challenges in Transportation

- **Infrastructure Renewal and Asset Management.** Higher demands are being placed on transportation systems at the same time that transportation infrastructure is maturing and public investment is declining (TRB Executive Committee 2006). How do we preserve and renovate saturated transportation systems while minimizing expected increases in the investment of resources?

- **Operations and Congestion**. The increasing need for efficient and responsive transportation to support the global economy and mobile lifestyles is occurring in an era when the ability to expand networks is increasingly limited. Can we maintain current or achieve improved levels of performance without substantial physical expansion?

- **Environment.** Transportation systems have a direct and large environmental footprint, as well as an indirect footprint through inducing other systems such as cities to manifest in environmentally unsustainable forms. Can we reduce the direct and indirect environmental footprints and achieve a sustainable transportation system despite increasing population and travel demands?

- **Safety**. More people and objects within a transportation system with minimal physical expansion implies higher incidence of crashes, injury and loss of life. Can we substantially reduce the number of transportation crashes without significantly reducing the efficiency and responsiveness of transportation systems?

- **Security**. September 11th 2001, the London underground bombings and Hurricane Katrina vividly illustrate the vulnerability of transportation systems to terrorism and natural disasters, both due to direct harm as well as the disruption of economies and lifestyles. Can we prevent the improper and unauthorized use of transportation systems, and reduce our vulnerability to their disruption, without seriously restricting mobility or violating individual rights?

- **Planning and Programming**. The performance problems facing transportation systems present ever more difficult challenges for transportation planners who are charged with envisioning, planning, and developing systems that address these issues. A challenge is to enable planners to effectively utilize the rapidly growing body of geo-spatial data and information technologies in order to better address critical transportation issues.

- **Science**. The challenges facing transportation systems are great and require new modes of thinking and analysis for their solution. Indeed, the transportation challenges offer a type of visionary "moon shots": substantial problems whose solution will require major scientific and technological advances.

Traditional design, planning and investment methods are unable to meet these challenges. These methods tend to view transportation problems as well-defined and isolated. Transportation modes such as road, rail, water and air cannot be viewed in isolation; transportation solutions are likely to be multimodal in nature. Transportation systems are tightly coupled with economic, settlement and social systems: transportation systems affect, and are affected by, the broader systems in which they are embedded. It is also increasingly clear that human systems such as transportation and cities are complex and cannot be totally engineered. We learn this lesson repeatedly as attempted changes in these systems lead to disproportionate, unintended outcomes. Rather, human systems must be nuanced: we can only set the framework for the evolution, not control its specific trajectory. This framework is often context-specific. This is not defeatist; it simply suggests that we must be more clever and subtle than we have in the past.

Trends in Geographic Information Systems and Science

Geographic Information Systems (GIS) include software tools for capturing, storing, processing and communicating data and information about the Earth and related phenomena. *Geographic Information Systems for Transportation* (GIS-T) involves the application of these tools for understanding transportation systems and solving problems associated with their planning, construction, operation and maintenance. While research and development frontiers remains, GIS-T have matured to the point that their focus can shift from solving internal representation and analytical problems to meet broader challenges in transportation.

There are several contemporary developments in GIS and GISci that can inform efforts to meet transportation challenges. These include:

- The development and deployment of high resolution environmental monitoring systems such as satellite and airborne remote sensing.

- The development and deployment of location-aware technologies that can report their precise geo-location with respect to time, allowing fine-grained tracking of vehicles, objects and people.

- The increasing ability of GIS to maintain and display spatio-temporal and moving objects data.

- Improving science and tools for exploring and analyzing complex and massive spatio-temporal data.

- Improving science and tools for simulating transportation, urban and other human systems from the "bottom-up" – at the level of the individual person, vehicle or object.

- The development and adoption of data standards and information infrastructures for integrating and interoperating data.

Transportation Challenges and GIS: Visions and Needs

Infrastructure Renewal and Asset Management

Vision. Effective transportation infrastructure renewal and management requires optimized business processes for asset management, sound decision making practices and assessment techniques to ensure that customer/practitioner/decision maker asset management needs are being met. At present, spatial data is regularly used in applications such as pavement management, bridge management, and linearly referenced inventory programs. However, it is not regularly used for more advanced applications such as right of way asset management, maintenance scheduling and routing, and spatial analysis, querying, and reporting.

New emphasis areas for GIS applications include: system performance assessment, resource allocation, program development, project management, multi-agency communication, coordination and data integration, and maintenance/operations integration. Ultimately, GIS can serve as a mechanism for real-time data inventory and real-time access to up-to-date asset management and maintenance data from anywhere at anytime.

Research and development needs.

- **Data collection**. New data collection methods such as location-aware technologies, sensors and imagery capture can greatly increase the volume and spectrum of information about transportation infrastructure and its condition. However, these data are not scientifically sampled, noisy and are often ill-formed (e.g., geo-referenced video). Methods are needed for extracting information from these data streams and quantifying the positional and attribute error in this information.

- **Data integration.** Spatial data collected about infrastructure can come from a wide range of sources and exist in a wide range of formats. In addition, infrastructure data can be combined with other operational performance data (e.g., traffic flows) to improve forecasting of infrastructure lifespan and renewal cycles. Required are methods for integrating these diverse spatial data.

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- **Data archiving and access.** Supporting planning and budgeting for infrastructure renewal requires information on trends in infrastructure conditions and performance. Required are methods for designing and maintaining long-term repositories of data collected about infrastructure. Also beneficial is a spatial information infrastructure that facilitates enterprise-wide sharing of these data.

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- **Data mining**. The wealth of new data being collected about infrastructure may contain hidden and unexpected trends and patterns that may provide new insights and better forecasts of infrastructure performance. Efficient methods are required for exploring these massive and diverse databases. There is also a need for closer integration between the hypothesis-generating process of data mining with the hypothesis-confirming process of traditional statistics

- **Spatio-temporal data modeling**. Real-time data on infrastructure conditions requires new data models that can support spatial, temporal and spatio-temporal querying.

- **Visualization/communication.** Effective methods are needed for visually summarizing voluminous infrastructure data and communicating these data to decision-makers.

- **Enterprise deployment strategies.** While GIS and related technologies have great promise, they are new, innovative technologies that do not fit in well with traditional procedures and processes. Consequently, new methods for financing and supporting the development of these tools and infrastructure are required.

Operations and Congestion.

Vision. Over the next ten years, transportation system performance will be monitored at unprecedented spatial and temporal resolutions and will generate massive volumes of operations data. If managed and interpreted appropriately, the data can provide detailed, actionable information to policy makers, system operators, and transportation planners. The data will be generated from a wide range of fixed and mobile technologies including airborne cameras, roadside sensors, in-pavement sensors, in-vehicle devices, and personal communication devices.

Research and development needs

- **Data collection.** Data collection strategies are generally designed to support a single business function. The resulting data, however, can provide value beyond a single purpose. Guidance for collecting operations data should be generated to ensure that increased value is achieved.

- **Data quality.** Operational data has systemic and device-specific errors/anomalies that must be recognized and cleaned through imputation. Many techniques for imputation require spatial and temporal analyses. The spatial and temporal aspects of data imputation must be understood.

- **Data reduction.** Proper data reduction strategies are needed for processing detailed operations data to useful spatial and temporal levels.

- **Data models.** Traditional network data models are not sufficient for handling data on mobile objects or rapidly changing traffic conditions. There is a need for new transportation network data models that can handle these objects and conditions, as well as methods for spatial, temporal and spatio-temporal querying. These data models must include methods for integrating to other network representations typically used in planning and cartography.

- **Data integration.** While operational data provides a wealth of information about the dynamics of vehicles and systems, an even deeper understanding can be achieved through the integration with other spatial and temporal datasets (i.e., weather, land use, special events, and construction).

- **Data mining and visualization.** The magnitude and temporal nature of operational data presents significant opportunities for data visualization. Techniques and guidelines for the spatial and temporal visualization and presentation of operational data need to be researched.

- **Better performance measures.** Transportation data for characterizing operations and planning has historically relied on average numbers (travel time, speed, annual average daily traffic (AADT), etc.). Other statistical measures that characterize distributions and errors can provide better information about operational performance.

- **Privacy issues.** Many innovative operational data collection techniques involve the observation and recording of activities and travel patterns of individual people or vehicles. Privacy protection is of great concern and spatial masking techniques should be developed and standardized to prevent the transfer of private information.

- **Improved forecasting methods.** Operational data has the potential to improve the understanding of existing travel patterns and therefore improve our ability to forecast travel in the future. Research should be continued on spatio-temporal travel and behavioral modeling and on a better understanding of model variability and error propagation.

Environment.

Vision. Advances in geospatial science and technologies can support the development of applications and methodologies that provide a coordinated and cooperative enterprise-based process for early detection of all facets of environmental constraints in transportation planning. The vision is to develop *universal applications* (the creation of a uniform design of information exchange that can be shared by many) and *universal methodologies* (creation of an interchangeable design of project implementation that can be shared by many across different platforms). These can provide a coordinated and cooperative enterprise-based process for early detection of all facets of environmental constraints in transportation planning. It is anticipated that these goals be accomplished through effective communication exchange, data integrity standards and cooperative training.

Research and development needs

- **Data integration.** Environmental factors span a wide range of variables, including geology, hydrology, vegetation, fauna, human phenomena, infrastructure and archaeology. Consequently, these data will exist in a wide range of formats. Required are data standards and methods to facilitate integration.

- **Data sharing.** Environmental issues concerns a wide range of transportation decision-makers and stakeholders. Required is the creation of an interchangeable project implementation design that can be shared across different platforms and delivery modes.

- **Coordinated and cooperative enterprise-based process.** Resolution of environmental issues requires an organized partnership for peer exchange of information and methods. This includes meeting, conduction, and effective use of technology transfer (data repositories and development of list-serves)

- **Early detection of environmental constraints**: GIS can provide advantages with respect to cursory environmental reviews at the start of projects to detect environmental constraints that require more detailed investigation. This includes emphasis on inclusion of both planning and environmental stakeholders early in the analyses process, convey savings that can be gained by GIS use early in the environmental analyses process and enhanced risk avoidance when GIS is used early to identify potential problems to effectively avoid more comprehensive reviews.

- **Education and training.** New methods and tools require strategies for education and training, both as pre-requisites for a professional career as well as continuing education to maintain skills as technology and methods evolve.

Safety

Vision. In the US alone, over 40,000 deaths and $150B are lost due to road crashes annually. A significant proportion of these crashes can be prevented or mitigated by appropriate design or improvement of infrastructure, identification of needed emergency response and enforcement investment, training and education, and by harmonization of the transportation system with the environment to avoid conflicts with animal migration and other natural processes. As travel continues to increase, geospatial data and information processing techniques can enable engineering, emergency response, enforcement, and education to significantly reduce losses. Safety should also be treated and addressed using tools previously applied to other areas of transportation such as asset management. Reactive safety initiatives will be supplanted by proactive measures and planning and optimization techniques.

Research and development needs.

- **Data quality and accuracy.** Recent technological advancements have led to the use of personal digital assistants, laptops, and laser technology to collect crash data. There is an increasing need for and benefit from widespread and automatic collection of large scale, high quality crash data using advanced technologies (Global Positioning Systems and/or smart maps, in-vehicle data recorders). These technologies can significantly reduce the time required to collect data, as well as subjectivity and errors. The effect of spatial and temporal data quality issues (application of advanced spatial statistics to crash patterns, sensitivity analysis of network topology, and segmentation issues) need to be better understood and fed back into resource allocation processes. However, the benefit of such systems is not widely quantified and may not fall to those who pay the cost of such technology.

- **Data collection standards.** Responsible agencies in relatively few urban areas have developed tools and systems to use advanced technologies. The equipment and tools to collect and store crash data by agencies are often different even within an urban area, leading to inconsistency in the data collection process. Inconsistencies in data collection standards and format limit the application of guidelines, methodologies, and selection/implementation of countermeasures to improve traffic safety. There is a need to develop consistent national / international standards for the collection of crash data. Tools and systems for data collection, and analysis should be based on these standards.

- **Data integration.** Collecting the required data for safety analyses plays a vital role in safety improvement. For example, spatial accuracy of the crash location should be relative to conditions at the time of the crash. Safety analyses often involve integration of crash data with other data such as roadway inventory (including geometric conditions, turn lanes, and bays), roadway operating conditions (including turning movement counts, signal phasing and timing), road users data (driver characteristics, pedestrians and bicyclists), population, medical records, vehicle characteristics, and weather. Integrating these data (crash data and other pertinent data) will help better explain the causes of crashes. Remote sensing technology and spatial image processing techniques need to be explored for collection of inventory data (e.g., curve and grade information).

- **Data archiving.** Video imagery is collected at many scales and locations. While potentially useful for post priori analysis, the data are often discarded shortly after collection (due to storage limitations or intentionally to protect privacy). Data size is a problem – even if available, as reduction of the data into useful information is costly. Research is needed to study the benefits of access to such information and to the tools and techniques to process, store and retrieve useful components.

- **Implications of legislation.** SAFETEA-LU Section 1401 (Highway Safety Information Systems) requires all states to identify and publish the top 5 percent of high crash locations on all public roads. Data and tools to identify high risk locations are of utmost importance. Agencies need to geocode crash data to enable integration with local geometry and attributes. However, limited data are available pertaining to local road attributes outside the urban areas. Road attribute data outside urban areas is sparse in many cases.

- **Automated detection of high risk locations.** Another critical issue that needs to be explored is on research and development of automated tools to identify the high risk locations (point sites, linear extents, or areal zones) using relevant data. These tools will help better plan and focus deployments to enhance safety at high risk locations and maximize derived benefits from limited available safety funds.

- **Vehicle tracking and dynamics.** Understanding the circumstances leading to a crash plays a vital role in identifying appropriate safety mitigation strategies. There is a need for automatic tracking of vehicular action in time and space that avoids violation of privacy and helps integrate black box information (last few seconds of vehicular dynamics) to capture highly accurate readings of space and time. In combination with similar information from all involved vehicles (and perhaps nearby vehicles), this information could be used to better understand the circumstances leading to the event for proper adjudication and mitigation. Also, spatial tracking of violations leads to more effective enforcement.

- **Tools for analyzing and disseminating information about crashes and congestion.** Studies have shown that crashes and incidents contribute to significant portion of congestion costs. Automatic crash data collection and integrating traffic information systems with locations of crashes will help influence traffic patterns and transportation network performance in near real time. For example, once detected, dissemination of information about location of crashes, their severity and estimated clearance time disseminated to the transportation system users using advanced technologies such as changeable message sign displays help transportation system users better plan their trips (congestion mitigation strategies), and, thus reduce congestion and its impacts.

- **Tools and analysis for special needs clientele.** Two classes of drivers generate a disproportionate amount of crashes and therefore require specialized tools for analysis. i) *Older drivers***.** Development and application of tools to address travel needs and concerns of the growing elderly population is another area. Access for elderly to locations of various resources (such as quick care centers, hospitals, senior centers, mental and emotional health services, hospitals, social security administration offices, and so on), potential routes to travel to these location from major elderly trip generating areas, and methodologies to identify high crash locations, and possible solutions to improve safety along these routes are a few critical issues. Such efforts would also serve as a building block to develop strategies to address driver anxiety and limitations, safety concerns and records, and licensing implications for this population group. ii) *Younger drivers***.** Inexperience to recognize or drive in hazardous situations, speeding, red light running, making illegal turns, and driving under the influence of alcohol are a few major causes of crashes involving young drivers. Identifying hazardous situations that young drivers are more vulnerable with remedies and appropriate warning devices, in addition to educational programs such as "Driver's Edge" and graduated licensing, would help address safety concerns of young drivers.

- **Real-time information and response.** Providing good emergency response within the "golden hour," especially in rural America, will help significantly improve survivability of crash victims. This also helps reduce congestion and its impacts. Deployment of real time provision of occupant and vehicle information to emergency rooms and emergency response dispatch for appropriate response and preparedness is needed. Mapping patterns for planning of emergency response capability and possible pre-deployment would be invaluable in this regard.

Security.

Vision. The effects of natural disasters and terrorism are now painfully real and on the minds of many. Less clearly understood is how the vulnerabilities of transportation infrastructure and the organizational challenges of the American transportation system can be best addressed by the use of GIS and related technologies.

Research and development needs

- **Coordination and jurisdictional issues.** Hurricane Katrina and the response following the disaster made it clear that the multi-jurisdictional nature of the American transportation system present major challenges. In the words of Governor Blanco of Louisiana, "There were failures at every level of government." We must consider three phases of transportation security: protection, response, and recovery. In each phase, information concerning infrastructure, flows and actors, and organizations and jurisdictions must be managed and analyzed to minimize the likelihood of a disjointed response. The challenge for the GIS community is to develop methods and approaches that treat the transportation system as an integrated enterprise. Transportation is not just multimodal but also multi-jurisdictional.

- **Design for resiliency.** Much of the research on transportation network design has focused on economic efficiency. While efficiency is an important consideration, the vulnerability of the transportation system is also a concern. One must develop the science and methods of exploring the tradeoffs between resilient systems and efficient systems. There is also a need to develop methods of design and analysis that allow for the creation and management of systems that provide an acceptable level of efficiency while addressing security concerns.

- **Information challenges**. Responding properly to a security crisis requires the use of many types and sources of information. Such information, much of it real-time information, is collected on transportation than ever before. Technologies such as global positioning, sensors, and image feeds provide us with a wealth of information. However, managing and integrating that information are difficult tasks. Two related research challenges are integrating these sources to provide coherent security information, and developing methods for extrapolating from existing information to fill in our knowledge gaps. There is a need to move from data to information and from ignorance to intelligent guessing.

- **The need for speed**. When faced with a security crisis, intelligent decisions need to be made quickly. Data streams can be quite large as can be the scope of problems. Existing GIS methods need to be adapted to take advantage of advances in high performance computing. This will require the adaptation of data models and analysis algorithms to a grid-computing environment.

- **Improving data models.**. Data models for transportation have undergone a significant development. Efforts such as UNETRANS and the FGDC 20-27(3) are well established. However, these were not developed to explicitly consider security issues. Research needs to be conducted on how we should adapt these data models to best address security issues and the computing demands those issues raise.

Planning and Programming

Vision. The role of GIS and related technologies can enhance all aspects of the transportation planning process, including: i) effective prioritization of future transportation investments, weighing safety, environmental integrity, aging infrastructure investments, and equity considerations; ii) financial planning through demand-based revenue forecasting; iii) improving analysis and planning through better understanding of the relationships between land use, transportation infrastructure, and traffic operations, and; iv) enhancing public involvement and equity considerations through interactive visualization tools.

Research and development needs

- **Data collection and extraction.** Identify the additional requirements to create transportation networks from spatial data, including positional accuracy, network topology, and supplemental attributes, and develop procedures to facilitate this process. There is also a need to develop efficient methods for extracting planning model data from remotely sensed imagery.

- **Data quality.** Identify positional accuracy requirements for spatial data that supports transportation planning applications.

- **Data integration.** Identify methods for streamlining spatial data capture and integration. This might include such things as improvements to geocoding methods, improved links between models and parcel level data, improved links between local land use data and census geography, or dynamic links between planning model data and various sources of roadway and transit data.

- **Data mining.** Develop efficient methods for mining the enormous amounts of traffic monitoring data that are becoming available to validate current planning models and to better understand the phenomenon of traffic congestion.

- **Model integration.** Integrate various planning models through their spatial components to enable a clearer understanding of relationships between land use, travel demand and traffic operations.

- **Scenario planning and decision support.** i) Identify and resolve the pitfalls of using maps to visualize travel demand and environmental impacts of alternative modes and alignments; ii) test the feasibility of interactive, map-based scenario planning; iii) develop performance measures and methods for visualization of equity impacts in transportation planning forecasts; iv) test the feasibility of forecasting safety implications of future plan scenarios; v) develop methods to improve the planner's ability to analyze activity-based and tour-based spatial relationships through interactive map-based tools.

- **Public involvement.** Develop methods for enhancing public involvement in the planning process using GIS technology for visualization and interactive scenario planning.

Science

Vision. It is often commented that transportation planning, programming, design and maintenance occurs in a "stovepipe" manner: different stages of the process are isolated, as are modes from each other, the public from decision makers, and transportation from other initiatives such as land-use, social and environmental policy. Geospatial science and technologies can serve as the foundation of an integrated, holistic approach to guiding transportation systems towards more efficient, effective and equitable outcomes by providing a common base for data collection, modeling, alternatives analysis and decision-support across stages, modes, domains and stakeholders.

Needs. Several cross-cutting research and development themes emerge from the domain-specific needs identified in the previous section.

- **Data infrastructures and representation.** New technologies allow the collection of geospatial technologies at unprecedented scales and scope. It is unclear how best to deploy and support these data collection networks and how to deal with varying levels of data quality. There is also a need for new representation models that can accommodate these new data.

- **Data integration and access**. There is no longer a need to collect data a single, targeted purpose. Data can be archived and used across many applications and domains. An open research and development question is how best to integrate and archive these data as well as make the data accessible to authorized individuals while preventing its use by unauthorized individuals.

- **Knowledge extraction and communication**. The unprecedented scope, spectrum and detail of geospatial data collection technologies present a major challenge with respect to making sense of these data. Required are new methods for exploring these data, confirming discovered information using statistical methods, and communicating discovered knowledge to researchers, decision makers and stakeholders. There is also a need for automated detection of relevant as well as unusual patterns in data for real-time response to problems.

- **Integrated modeling**. GIS can serve as a platform for supporting a wide range of methods for scenario modeling and predictive analysis. Required is research on how to integrate models that operate at disparate scales and time frames and with varying entities and relationships.

- **Decision support.** Better transportation systems will evolve from better decision making; this is the ultimate goal of applying geospatial science and technologies to transportation problems. There is a need to develop new methods for decision support, ranging from tactical decisions responding to events in real or near-real-time to collective and collaborative strategic decision making about transportation futures.

- **Education and training**. New science, technologies and data will place unprecedented demands on the education of the transportation student as well as the continuing education and training of the transportation professional. Students will require foundations in transportation science as well as the science underlying new geospatial technologies and data. It will be challenging to fit these demands within two or four year higher education program, particularly those with strict accreditation requirements. There will also be a need to continue education and training throughout the career of a transportation professional as the technologies and software evolve in response to continuing advances in GIScience. A possible template is the *Geographic Information Science and Technology Body of Knowledge*; a model GIS curricula recently developed by the University Consortium for Geographic Information Science (DiBiase et al., 2006)

Partnerships with TRB Committees

Progress on GIScience research and applications, as well as the performance and process challenges facing transportation systems, can best occur through partnerships working within the TRB committee structure. Potential collaborations may include, but are not limited to, the following TRB committees:

ABC40	Transportation Asset Management
ABE30	Transportation Issues in Major U.S. Cities
ABE40	Critical Transportation Infrastructure Protection
ABE50	Transportation Demand Management
ABG20	Transportation Education and Training
ABG40	Library and Information Science for Transportation
ABJ10	National Transportation Data Requirements and Programs
ABJ20	Statewide Transportation Data and Information Systems
ABJ30	Urban Transportation Data and Information Systems
ABJ40	Travel Survey Methods
ABJ50	Information Systems and Technology
ABJ70	Artificial Intelligence and Advanced Computing Applications
ABJ80	Statistical Methodology and Statistical Computer Software in Transportation Research
ABJ90	Freight Transportation Data
ABJ95T	Task Force on Visualization in Transportation
ADA10	Statewide Multimodal Transportation Planning
ADA20	Metropolitan Policy, Planning, and Processes
ADA50	Transportation Programming, Planning, and Systems Evaluation
ADA60	Public Involvement in Transportation
ADB10	Traveler Behavior and Values
ADB20	Telecommunications and Travel Behavior
ADB30	Transportation Network Modeling
ADB40	Transportation Demand Forecasting
ADB50	Transportation Planning Applications
ADB60T	Task Force on Moving Activity-Based Approaches To Practice
ADC10	Environmental Analysis in Transportation
ADC20	Transportation and Air Quality
ADC30T	Task Force on Ecology and Transportation
ADC70	Transportation Energy
ADD30	Transportation and Land Development
AFB80	Geospatial Data Acquisition Technologies in Design and Construction
AHB10	Regional Transportation Systems Management and Operations
AHB15	Intelligent Transportation Systems
AHB45	Traffic Flow Theory and Characteristics
AHB65	Operational Effects of Geometrics

ANB10	Transportation Safety Management
ANB20	Safety Data, Analysis and Evaluation

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[i] Members of the committee directly involved in the development of this discussion paper include:

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- Val Noronha - *Chair, Subcommittee on Research*
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- Elizabeth Harper and Bruce Spear, *Focus Group Leaders, Planning*
- Wende Mix, *Focus Group Leader, Science*
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[ii] The ABJ60 committee held an informal discussion at the Transportation Research Board annual meeting in January 2005, a workshop in Washington DC in August 2005, a workshop at the TRB annual meeting in January 2006, and a presentation and discussion at the Geographic Information Systems for Transportation annual conference and symposium at Columbus, OH in March 2006.