

NJDOT Strategic Research Planning

FINAL REPORT
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Submitted by

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In cooperation with

New Jersey
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TABLE OF CONTENTS

	Page
EXECUTIVE SUMMARY	1
Research Questions	1
Key Research Conclusions	3
BACKGROUND	4
OBJECTIVES	4
INTRODUCTION	4
SUMMARY OF THE LITERATURE REVIEW	4
SUMMARY OF WORKED PERFORMED	7
Task 1 – Briefing Books on National Research Areas	7
Freight Briefing Book	8
Climate Change Briefing Book	8
Technology Briefing Book	8
Sustainability Briefing Book	9
Energy Briefing Book	10
Socio-Demographics Briefing Book.....	10
Task 2 – NJDOT Staff Survey and Focus Groups	11
Survey Design.....	11
Survey Results	13
Round-Table Focus Group Sessions Description	21
Round-Table Focus Group Sessions Results	22
Task 3 – Gap Assessment of Existing Research Areas	26
General Research Trends	27
Gap Assessment.....	29
CONCLUSION AND RECOMMENDATIONS	32
Research Conclusions	34
IMPLEMENTATION	35

LIST OF FIGURES

Figure 1. Length of Employment	14
Figure 2. Immediate Challenges	15
Figure 3. Long-Term Challenges	16
Figure 4. Challenges Deemed Irrelevant.....	17
Figure 5. Agree-Disagree Statements	19
Figure 6. 2013-2017 Completed Research by Lead Agency	28
Figure 7. 2013-2017 Completed Research by Research Theme.....	28

EXECUTIVE SUMMARY

The New Jersey Department of Transportation (NJDOT) Bureau of Research is working to develop a strategic plan documenting future research, operations, and staffing needs. Through this research, NJDOT sought to identify key national trends and internal agency needs in order to best position the agency to fulfill its operations. NJDOT contracted with Cambridge Systematics, Inc. (the “Research Team”) to research and identify those related best practices and internal agency needs, including those related to knowledge transfer and management.

The Research Team developed six briefing books based on the National Cooperative Highway Research Program’s (NCHRP’s) Foresight 750 Series, conducted a research needs and technology transfer survey, conducted six corresponding focus groups, and conducted a gap assessment of existing research areas. Based on this information, the Research Team developed a strategy to address those research gaps, address internal agency needs, and best position NJDOT to carry out current and future operations.

Research Questions

This research effort was guided by the following key questions:

What are the global, domestic, and local trends that could impact NJDOT’s ability to meet goals and achieve desired outcomes?

Based on the NCHRP Foresight 750 Series, consisting of six theme volumes, a number of global, domestic, and local trends could impact NJDOT. These major themes include freight, climate change, technology, sustainability, energy, and socio-demographics.

- Key freight-related trends include the continued growth in e-commerce and the corresponding demand for fulfillment center space, as well as the need to accordingly upgrade New Jersey’s multi-modal infrastructure system.
- Key climate change trends include increased threats from sea level rise, extreme temperatures, and severe weather, especially in and around coastal and low-lying areas of New Jersey.
- Key technology trends include the continued growth of transportation network companies (TNCs) and connected and automated vehicles.
- Key sustainability trends include increased demand for bicycle and pedestrian modes of transportation, driven by growing desire, especially by millennials, for walkable, urban neighborhoods.
- Key national energy trends include improved vehicle fuel efficiency standards and the growth of alternative fuels, which may have implications for the funding of transportation projects that are tied to New Jersey’s gasoline tax.

- Key socio-demographic trends within New Jersey include growth in and around major rail corridors and urban areas, increased ethnic diversity, and the aging of baby boomers who have traditionally been accustomed to lower density, suburban neighborhoods.

What are the key organizational challenges that NJDOT faces?

Based on the ‘Research Needs and Technology Transfer’ survey distributed to NJDOT staff, as well as certain staff at member metropolitan planning organizations (MPOs), and New Jersey public agencies, the Research Team identified multiple immediate and long-term challenges.

Key immediate challenges include the data-based decision making capabilities, extreme weather risks, intergovernmental relationships and partnerships, talent acquisition and retention, and changing transportation and communications technology.

Key long-term challenges include the changing roles of the public and private sectors in managing transportation infrastructure, intergovernmental relationships and partnerships, energy supply and demand, transportation funding and finance, and talent acquisition and retention.

What are NJDOT’s key research gaps?

NJDOT’s key research needs can be divided into primary and secondary research needs as identified through this strategic planning process. Primary research needs include the following:

- **Staffing:** How can NJDOT continue to attract, retain, and effectively train new staff? This takes into account factors such as compensation, inter-departmental training, and perhaps most importantly, knowledge transfer.
- **Project Delivery:** Including issues of compliance with Buy America requirements and the Americans with Disabilities Act and effects on departmental operations.
- **Technology Access & Guidance:** Including the need for better access to new technologies and corresponding guidance and accurate decision making processes to accompany new technologies.
- **Information on Freight Generators:** Freight is an important yet complex subject given that such operations are carried out almost exclusively by the private sector which is often reluctant to release valuable data.
- **Streamlined Methods of Infrastructure Management:** Including the need for improved and efficient decision making support systems for managing infrastructure. Such systems should be able to determine the best allocation of funding, and effectively predict the degradation of infrastructure.

Secondary research needs include the following:

- **Declining Public Transit Use/Impacts of Transportation Network Companies (TNCs):** Public transit use has largely stagnated in recent years,

alongside the rapid rise of TNCs. Given these trends, what are the implications for statewide travel demand and NJDOT planning and transportation system management and operations (TSMO)?

- **Connected and Autonomous Vehicles:** Research into connected and autonomous vehicles continues to be significant for all DOTs, given the potential impacts on statewide travel demand and corresponding operations.
- **Truck Parking:** Research into truck parking shortages continues to be important, especially as e-commerce continues to drive freight traffic. Given a number of factors, truck parking shortages are increasing which also has significant implications for safety.
- **Impacts of Climate Change:** Given New Jersey's coastal setting, climate change has a number of implications for NJDOT.

Key Research Conclusions

A Wide Range of Global, Domestic, and Local Factors Could Impact NJDOT

As indicated in the NCHRP's Foresight 750 Series and translated into NJ-specific briefing books, NJDOT will be influenced by a wide range of factors. At the global level, innovations in energy production and the unrenowned characteristics of gasoline will affect revenue tied to New Jersey's conventional gasoline tax. Locally within New Jersey, population growth is increasingly occurring within the urbanized portions of the state, leading to increased public transit demand.

Talent and Knowledge Management Are Key Organizational Issues Faced by NJDOT

Based on internal surveying and focus group efforts, talent and knowledge management are significant issues that will affect NJDOT. Stemming from a wide variety of issues, NJDOT faces significant competition from the private sector and DOTs of other states in recruiting and retaining staff. Knowledge transfer capabilities are affected by this given that a large number of staff are eligible for, and actually retiring, without a formalized process for sharing key knowledge and insight with new and existing staff.

Key Research Needs Include Technology and Staffing

The gap assessment revealed a number of research needs, with the most notable being technology and staffing needs. Moving forward, additional research will be needed that considers the implementation of new technology and software at NJDOT, concurrent with user guidance, staff training, and changes to organizational structures and business processes. Staffing research will need to focus on attracting and retaining staff amidst competition from other state DOTs and the private sector. Staffing research should also focus on relevant training programs and the topic of knowledge transfer.

BACKGROUND

The NJDOT is responsible for the complex task of managing and maintaining New Jersey's multi-modal transportation system. Simultaneously, the Department needs to accurately forecast and plan for shifting travel demand, new technologies, funding, external factors such as severe weather, and internal factors such as talent acquisition, retention and knowledge transfer. While these various factors add a further layer of complexity, they are also necessary to best positioning NJDOT to perform its core functions. The purpose of this project is to develop a strategic research plan, based on a foundation of insight into national best practices and internal agency employee insight, in order for NJDOT to best understand constantly shifting needs and travel demand. Ultimately, this strategic research plan will lay out priorities for future research.

OBJECTIVES

The goal of this research was to provide NJDOT with a strategic research plan that lays out priorities for future research. The strategic research plan is based on the following elements:

- Briefing books identifying major global, domestic, and local trends that may affect NJDOT currently and in the future.
- Research Needs & Technology Transfer survey distributed to NJDOT, MPO, and select other state agency staff.
- Focus groups conducted with a senior staff from NJDOT, local MPOs, and New Jersey Transit.
- Research gap assessment based on the previous elements and previously conducted research by the NJDOT Bureau of Research.

INTRODUCTION

This research was designed to provide the NJDOT Bureau of Research with a strategic plan that lays out priorities for future research. The strategic plan consists of a gap assessment of previously conducted research at NJDOT, insight from surveying and focus group efforts with NJDOT, MPO, New Jersey Transit, and other public agency staff, and global, domestic, and local trends, identified from the NCHRP Foresight 750 Series.

SUMMARY OF THE LITERATURE REVIEW

The Research Team performed a review of the NCHRP's Foresight 750 Series, a series of white papers developed by the Transportation Research Board of the National Academies of Sciences, Engineering, and Medicine that examine global and domestic strategic issues and their implications for state DOTs. The Foresight 750 Series consists of six volumes, related to freight, climate change, technology, sustainability, energy, and socio-demographics.

The following reports from the NCHRP Foresight 750 Series were reviewed:

Volume 1: Economic Changes Driving Future Freight Transportation (2013). The Freight volume of the Foresight 750 Series considers scenario planning as a means to predict future freight traffic across the United States. Assuming that statewide and local freight traffic is largely influenced by macroeconomic and global factors, a total of four scenarios are considered:

- High global trade and high resource availability
- High global trade and restricted or low resource availability
- Low global trade and high resource availability
- Low global trade and restricted or low resource availability

Using these scenarios the report goes onto describe results of roundtable workshops hosted by multiple MPOs and DOTs to identify likely future scenarios and the corresponding impacts to freight traffic and required infrastructure investments.

New Jersey Statewide Freight Plan (2017). The New Jersey Statewide Freight plan presents a comprehensive update to the 2007 version in which e-commerce was not nearly as significant. The Freight Plan provides general goals and objectives for the statewide freight system, statewide freight activity and trends including relationships with other states and commodity flows, multi-modal network performance, innovative technologies and strategies, and project prioritization recommendations. Innovative technologies discussed include connected and autonomous vehicles, truck platoons, intelligent transportation systems, and 3d printing.

Volume 2: Climate Change, Extreme Weather Events, and the Highway System: Practitioner's Guide and Research Report (2014). The Climate Change volume of the Foresight 750 Series considers the effects of climate change on multi-modal and highway systems. In particular, the report considers what climate change will consist of in 2050 and the expected effects on design project delivery, transportation system management and operations, and maintenance. Estimated effects from climate change stem from increases in temperature, changes in precipitation and precipitation intensity, sea-level rise, and combinations of threats from coastal storms (e.g., storm surge combined with sea level rise). The report also outlines a framework for incorporating risk assessment into asset management and broader performance management activities.

New Jersey Climate and Health Profile Report (2017). Developed by the New Jersey Climate Adaptation Alliance of Rutgers University, this report delves into detail on climate change issues affecting New Jersey. In particular, climate trends, climate projections, and threats to the environment and vulnerable populations are discussed. In particular, New Jersey is seeing a rise in average annual temperature and precipitation, as well as sea level rise. These trends are expected to accelerate in the foreseeable future.

Volume 3: Expediting Future Technologies for Enhancing Transportation System Performance (2013). The Technology volume of the Foresight 750 Series identifies a process that transportation agencies can use to identify, assess, shape, and adopt new and emerging technologies to achieve long-term system performance objectives. The process reflects relevant trends in technologies and their applications and helps transportation agencies anticipate, adapt to, and shape the future. Known as STREAM (Systematic Technology Reconnaissance, Evaluation, and Adoption Methodology), the methodology is applied to a number of technologies, including within a bridge monitoring system case study.

Volume 4: Sustainability as an Organizing Principle for Transportation Agencies (2014). The Sustainability volume of the Foresight 750 Series identifies an analytical framework and implementation approaches to assist DOTs and other state agencies with evaluating their current and future capacity to support a sustainable society. Sustainability is considered within the context of transportation in a rapidly changing social, economic, and environmental setting within the next 30 to 50 years. The report additionally considers key sustainability-related challenges in urban and suburban environments.

Volume 5: Preparing State Transportation Agencies for an Uncertain Energy Future (2014). The Energy volume of the Foresight 750 Series considers a number of trends and implications in relation to transportation and energy. This includes the historical, current, and predicted roles of DOTs in relation to energy policy, including implications of funding tied to gasoline taxes. The report also introduces and analyzes multiple emerging fuel and vehicle technologies and the application to light and heavy duty vehicles. Finally, population, economic, land use, and policy factors are considered, along with an overall scenario planning framework for DOTs.

2017 Pocket Guide to Transportation (2017). Updated annually, the FTA's Pocket Guide to Transportation illustrates key transportation statistics, trends, and implications of various major topics including personal travel, energy, infrastructure, and freight.

Volume 6: The Effects of Socio-Demographics on Future Travel Demand (2014). The Socio-Demographics volume of the Foresight 750 Series identifies eight socio-demographic trends that are expected to influence travel patterns and overall DOT operations. Those trends and their application to transportation planning include the following:

- Decline in population growth rates
- Increase in average population age
- Increase in ethnic diversity
- A more diverse workforce
- Increasing similarities between cities and suburbs

- Slower growth in households
- Increased reliance on technology
- Increased consideration for environmental issues

SUMMARY OF WORK PERFORMED

The research team divided the work effort into three tasks, as follows:

1. Briefing Books on National Research Areas
2. NJDOT Staff Survey and Focus Groups
3. Gap Assessment of Existing Research Areas

The following sections of this report include detailed analyses of each category.

Task 1 – Briefing Books on National Research Areas

The research team began the project with the development of six briefing books, consisting of text and graphics, and based on the NCHRP's Foresight 750 Series consisting of Freight, Climate Change, Technology, Sustainability, Energy, and Socio-Demographic volumes. Each briefing was divided into the following sections:

- Introduction: General introduction of each topic and important considerations for the provision of transportation.
- Where Are We Now? Trends & Conditions: A brief history of each trend, especially within the context of New Jersey, leading up to current trends and existing conditions.
- What Does the Future Hold? Possible Trends: Based on current trends and existing conditions, a number of future trends and scenarios are identified, including specific implications for New Jersey.
- What Does this Mean for New Jersey? Impact of Scenarios: Specific travel demand, fiscal, and policy consideration for New Jersey and NJDOT based on the possible trends identified.

In developing the six briefing guides, the Research Team originally aimed to summarize each of the Foresight 750 Series volumes, with a specific application to New Jersey. Given that many of the volumes were developed at the national level, the Research Team decided to additionally incorporate research and insight from local sources including NJDOT itself and Rutgers University. This allowed for a more insightful analysis and development of New Jersey-specific trends and scenarios. A brief summary of each of the six briefing books is as follows. The full briefing books, including graphs, maps, and visuals can be found in Appendix 1.

Freight Briefing Book

The Freight Briefing Book considers the continued growth in freight traffic, which was significantly influenced by the development of the standard shipping container and the continued growth in capacity of shipping vessels. Today, freight traffic is being influenced by the rise of internet-based shopping and demand for expedited home delivery and shipping by consumers. Owing to its position within the center of the Northeast Corridor and within direct adjacency to New York and Philadelphia, New Jersey is especially impacted by the growth of freight traffic, with distribution and fulfillment centers being constructed throughout the state. Based on this insight, the following trends are expected to impact New Jersey and NJDOT:

- Trend 1: Continued E-Commerce and Mobile-Commerce (M-) Growth
- Trend 2: 286,000lb Rail Track Capacity Standardization
- Trend 3: Reductions in Truck Parking Availability
- Trend 4: The Rise of Driverless Trucks

Climate Change Briefing Book

Based on research conducted by Rutgers University, the Climate Change Briefing Book documents strong statistical evidence of climate change in New Jersey and especially along coastal portions of the state. In particular, evidence of increased average annual temperatures, increased precipitation, and increased sea level rise are documented. Issues of climate change within New Jersey are more significant given the immediate proximity to the growing urban centers of New York and Philadelphia. Based on this insight for projections of increased climate-change related phenomena, the following trends are expected to impact New Jersey and NJDOT:

- Trend 1: Increased Duration, Intensity and Frequency of Summer Heatwaves & Warmer, Wetter Winters
- Trend 2: Increased Frequency of Coastal Storms and Intense Rain Storms
- Trend 3: Continued Sea-Level Rise

Technology Briefing Book

The Technology Briefing Book considers the impacts of various new technologies on the provision of transportation. Intelligent Transportation Systems (ITS) are highlighted as an efficient means of managing traffic and travel demand, increasing safety, and communicating with transportation users. In addition, the rise of TNCs is also discussed which is proving to be a major disruptor to taxis and public transit. Lastly, connected and autonomous vehicles are discussed. Unlike some of the other briefing books, the Technology version is somewhat more broad in that such related trends have largely come about at the national level. Based on this insight, trends expected to impact New

Jersey and NJDOT are divided into Individual Mobility, Mass Transit, and Freight categories as follows:

Individual Mobility:

- Trend 1: Continued Market Penetration of TNCs
- Trend 2: Rise of Connected and Autonomous Vehicles

Mass Transit:

- Trend 1: Continued Embrace of Mobile Applications
- Trend 2: Vehicle Driver Automation
- Trend 3: Big Data & its Increasing Role in Decision Making

Freight:

- Trend 1: Shared Freight 'Mobility'
- Trend 2: The Rise of Driverless Trucks

Sustainability Briefing Book

The Sustainability Briefing Book considers the role of transportation in sustainability in historical, current, and future contexts. Within the context of New Jersey, automobile dependency is a significant influencer on travel patterns dating back to the mid-20th century when DOTs placed emphasis on construction, including through existing urban neighborhoods. Given a combination of finite funding for capital construction and a growing propensity towards urban living by younger and older generations, there is now increasing demand for public transit expenditure and bicycle/pedestrian accommodation. Based on this insight, the following trends are expected to impact New Jersey and NJDOT:

- Trend 1: Continued Dominance of the Automobile & Dispersed Development
- Trend 2: Continued Embrace of Sustainability Initiatives at the Local & Municipal Level
- Trend 3: Increased Attention to Public Health Initiatives
- Trend 4: Increased Awareness of the Role of Food Systems in New Jersey Municipalities
- Trend 5: Increased Housing & Transportation Costs

Energy Briefing Book

The Energy Briefing Book considers the role of energy in transportation planning. This includes from an emissions standpoint, given that transportation is a major source of pollutant emissions. Much of these emissions largely originate from private automobiles which comprise the majority of travel within New Jersey. The complex relationship of energy, transportation, and funding is also discussed. On one hand, vehicles are becoming more efficient and emitting less pollutants, especially by means of greater fuel economy. In addition, cleaner, electric-based vehicles are growing in popularity. However, many of New Jersey's capital transportation projects are tied to the gasoline tax which is funded on a per-gallon basis. While greater fuel efficiency and reduced reliance leads to less pollutants, it also means reduced funding by means of the gasoline tax. Given the characteristics of New Jersey's dense and heavily-used multi-modal infrastructure system, NJDOT faces a particularly significant dilemma based on this topic of energy. Based on this insight, the following trends are expected to impact New Jersey and NJDOT:

- Trend 1: Continued Volatility in Petroleum Prices
- Trend 2: Potential Growth in Alternative Fuel Vehicles & Technologies
- Trend 3: Stagnant Gasoline Tax Revenue

Socio-Demographics Briefing Book

The Socio-Demographics Briefing Book considers the effects of multiple socio-demographic variables on travel demand in New Jersey. Broadly, the Briefing Book considers the rise of suburban development which significantly influenced land use patterns in New Jersey given its proximity to New York City and Philadelphia. While suburbia reigned dominant through the end of the 20th century, the 2000s and especially 2010s have been characterized by a propensity towards denser and urbanized neighborhoods, which carries multiple implications for NJDOT. Based on this insight, the following trends are expected to impact New Jersey and NJDOT:

- Trend 1: Reduced Population Growth Due to Declining Fertility Rates
- Trend 2: The Graying of America
- Trend 3: The 'Browning' of America – Increased Diversity
- Trend 4: The Changing American Workforce
- Trend 5: The Blurring of the City and Suburbs
- Trend 6: Slowing Growth of Households
- Trend 7: The Growing Role of Technology in Everyday Life

- Trend 8: Saliency of Environmental Concerns

Task 2 – NJDOT Staff Survey and Focus Groups

In order to gain further insight internally from NJDOT staff and other agency transportation practitioners in New Jersey, the Research Team developed an online survey and hosted a number of focus groups. These efforts aimed to target seasoned staff, including Deputy and Assistant Commissioners to gather specific input on long-term trends, issues, and potential future scenarios that will need to be considered by NJDOT, including knowledge transfer from seasoned staff to newer hires.

The Research Team began by developing the online survey, known as the ‘NJDOT Research Needs & Technology Transfer Survey’. The survey was distributed to NJDOT Assistant Commissioners, as well as select Directors from DVRPC, NJTPA, SJTPO, and the Motor Vehicles Commission (MVC), via Survey Gizmo, an online surveying platform. The survey was released on February 15, 2018 with respondents given three weeks to complete it. On March 8, 2018, the survey link was closed, with a total of 25 responses received.

Survey Design

The survey contained the following elements. A full version of the surveying instrument can be found in Appendix 2.

Respondent Information

Respondents were asked to provide basic contact information including names, titles, organization, division/bureau, job title, description of duties, and length of employment.

Office/Division Priorities, Needs, & Challenges

Next, respondents were asked to elaborate on the priorities, issues, needs, and challenges facing their office/division. First, respondents were asked to identify and describe the top 1-3 priorities facing their division.

Respondents were then asked to identify whether a variety of transportation-related topics are current, near-term, and/or long-term challenges facing their division. Those topics included for this survey were the following:

- Changing transportation and communications technology
- Extreme weather impact, vulnerabilities, and risks
- Economic changes
- Transportation funding and finance
- Cost to provide and maintain transportation infrastructure and services

- Loss of institutional funding at my agency
- Internal agency organizational issues
- Problems with internal processes and procedures
- Intergovernmental relationships and partnerships
- Ability to gather and use data and information to make better decisions
- Changing roles of public and private sectors in providing transportation infrastructure and services
- Ability to recruit, retain, and train workers with the knowledge, skills, and abilities to address the agency's needs
- Aging, diverse, and growing populations
- Global trade, migration, and economic security
- Access to multi-modal transportation options
- Energy supply/demand
- Environmental stewardship
- Any other topics as identified by the respondent

Peer Agency/Innovative Ideas

The next set of questions asked respondents about their familiarity with innovative technologies, initiatives, and ideas that NJDOT and specifically the Bureau of Research could be supporting, including those at peer agencies.

Agree-Disagree Statements

Respondents were then asked to evaluate whether they agree or disagree, on a 4-point scale, with a number of statements related to the functionality of their division. Those statements that respondents were asked to evaluate were the following:

- My division has the right people with the right skills to accomplish our goals.
- My division has the right data, models, tools, and other technologies to help us do our daily job in a way that produces desired outcomes.
- My division has well-defined and well-understood policies and processes in place to produce consistent results that help us achieve our goals.

- My division has the information and knowledge needed to be effective and serve customers with excellence.
- Knowledge is at risk of being lost in my office or division due to turnover.
- Isolated workgroups or employees are not receiving available sources of information and knowledge.

General Research and Division Functionality Questions

Based on what was indicated in the previous portions of the survey, respondents were asked a number of general questions to conclude the survey. Those questions included the following:

- What information or knowledge would you like to have to do your job better?
- Does the passage of the FAST Act or other legislation impact how you conduct business?
- What areas of research are needed to help you respond to new legislation and/or regulations?
- Please share any additional ideas for research topics and/or technology transfer activities that the NJDOT Bureau of Research could support to address the transportation needs of New Jersey.

Survey Results

As previously indicated, a total of 25 respondents completed the survey during the 3-week period that the survey was open. Once the surveying period ended, the Research Team compiled and analyzed the results. These results are summarized as follows, with the complete results available in Appendix 3.

Respondent Information Results

Of the 25 responses received, the majority stemmed from NJDOT staff, with the remaining responses stemming from DVRPC, SJTPO, and MVC. Within NJDOT itself, a number of divisions were represented. These divisions include Aeronautics, Capital Planning, Construction & Materials, Civil Rights, Environmental Resources, Executive, Highway & Traffic Design, Information Technology, Local Aid, Multi-Modal, Operations, Permits, Planning, Procurement, and Safety & Outreach. This indicates that despite being a large organization, most divisions of NJDOT were well-represented through this survey.

The general make-up of the respondents consisted of a mix of directors, managers, assistant directors, assistant commissioners, planners, and engineers. As shown in Figure 1, these respondents tend to be very familiar with their organization and current role. In fact, over 50% have been with their organization for over 20 years, with approximately 20% having been in their current position for over 6 years. This indicates

that in addition to representing a large portion of NJDOT, the survey was also able to capture personnel who potentially possess significant knowledge and ideas.

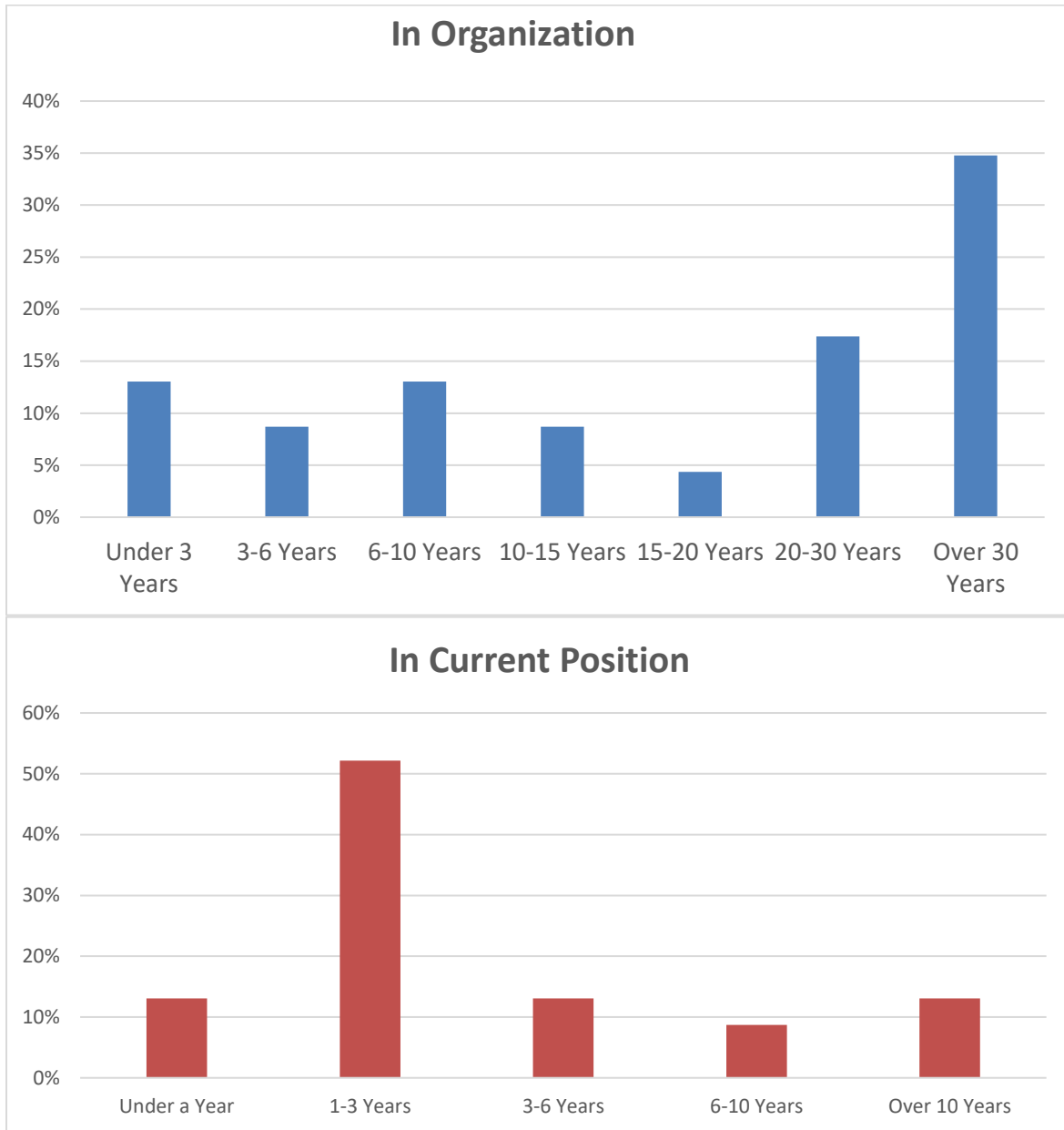


Figure 1. Length of Employment

Office/Division Priorities, Needs, & Challenges Results

Results for the office/division priorities, needs, & challenges section, as displayed in Figures 2-4, were sorted based on proportions of immediate (current), long-term, and irrelevant tallies. It should be noted that for this section, respondents were allowed to check off more than one answer. For example, if a certain topic was found to be

relevant both in the near- and long-term, respondents would be allowed to check off both time periods. As such the results indicated in Figures 2-4 represent the proportion of 'checks' received for each time period (current, near-term, long-term, and irrelevant).

As displayed in *Figure 2*, respondents indicated a relative diverse group of challenges as those immediately relevant to their division. Likely driven by the rise of 'big data' and the availability of large quantities of insightful, yet raw data, respondents (over 50 percent of which) most indicated the use of data and information in decision making as the most immediate challenge. This was followed by risks from extreme weather, intergovernmental relationships, and talent acquisition, retention & management. With over 40 percent of responses indicated as a challenge, changing transportation and communications technology was also noted as a significant current challenge. Given the parallels of data and decision making with evolving technologies, respondents may have considered the merit in better aligning these two themes moving forward.

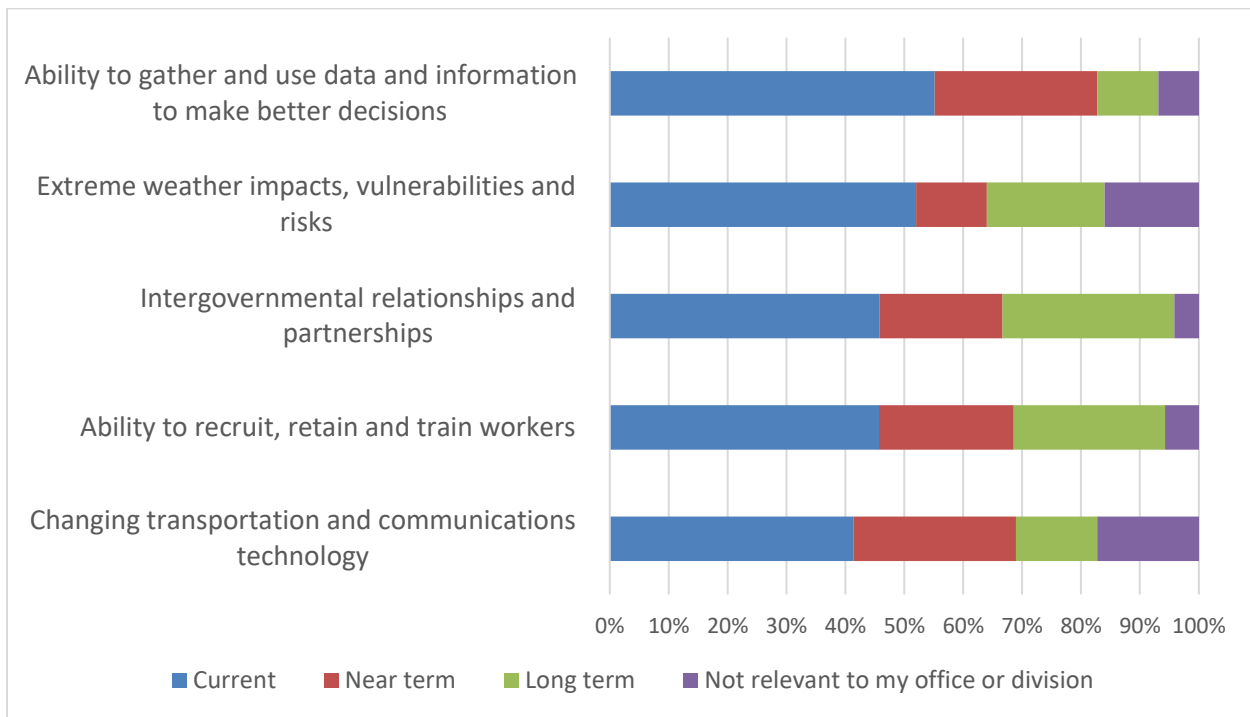


Figure 2. Immediate Challenges

Long-term challenges, are indicated in Figure 3. The changing roles of public and private sectors in providing transportation infrastructure and services, was indicated as the most significant long-term challenge with approximately 35 percent of responses indicated as such. This was followed by intergovernmental relationships, energy, funding, and talent acquisition, retention & management. These responses may reflect macro-scale organizational challenges and evolving transportation needs within the long-term. Respondents indicated a potentially growing private sector role in transportation provision alongside intergovernmental partnerships, and perhaps most significantly, funding, as long-term challenges. Broadly, this may indicate that respondents believe that other organizations, and even companies, besides NJDOT will

have significant stakes in transportation funding, especially given finite funding stemming from state and federal sources.

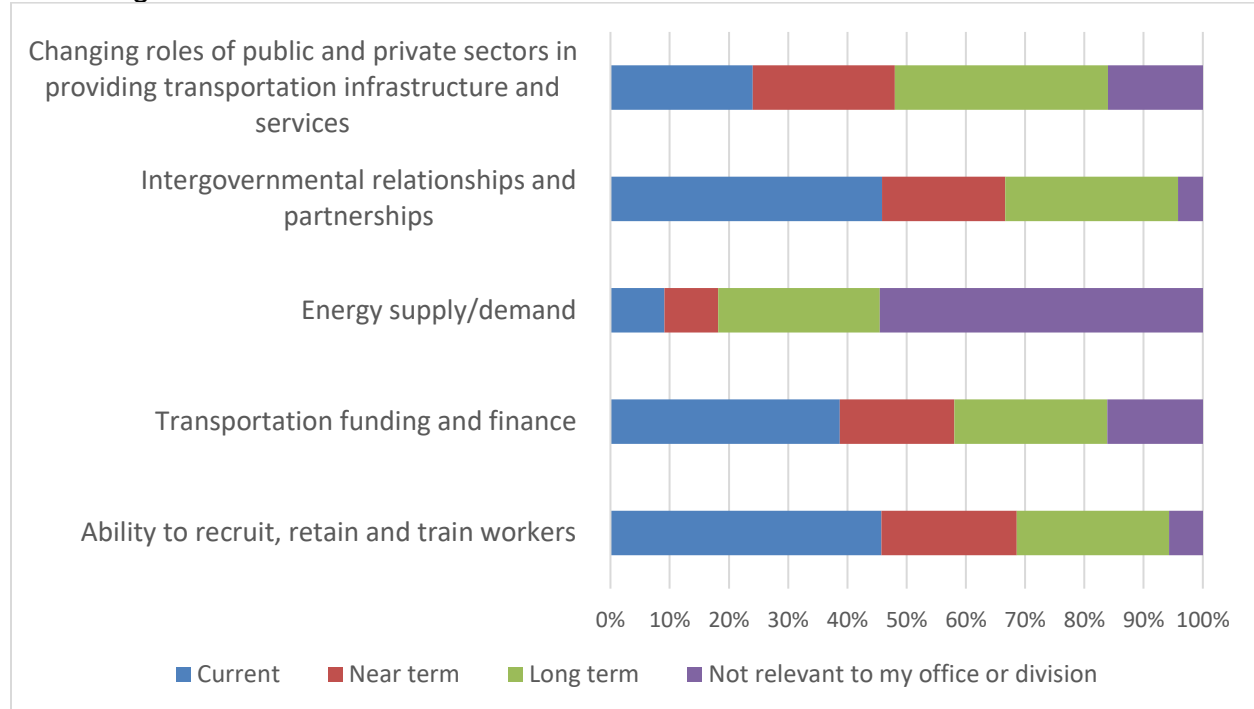


Figure 3. Long-Term Challenges

Lastly, those challenges largely deemed irrelevant are displayed in Figure 4. Multiple inferences can be made from these results. First, global trends such as trade, migration, and economic security was deemed to be the most irrelevant challenge, based on over 70 percent of the results. This is largely in contrast to the NCHRP’s Foresight 750 Series Freight volume which considers global trade to be a major predictor of nationwide freight traffic in the years to come. Within the survey, global trade was followed by energy and environmental stewardship. It should also be noted that energy was indicated by other respondents as a long-term challenge, meaning there is not yet a consensus as to whether or not energy will significantly impact NJDOT.

Access to multimodal transportation options was also indicated as irrelevant based on a proportion of approximately 40 percent of responses, which could indicate that respondents are primarily concerned with maintaining their assigned single modes of transport, and not as much with prioritizing multi-modal connections. Lastly, with a similar proportion of responses, respondents indicated loss of agency institutional funding as an irrelevant challenge. This may indicate that while respondents are concerned about transportation funding figures in general, as indicated as a long-term challenge in Figure 3, they are not concerned that such funding will completely disappear.

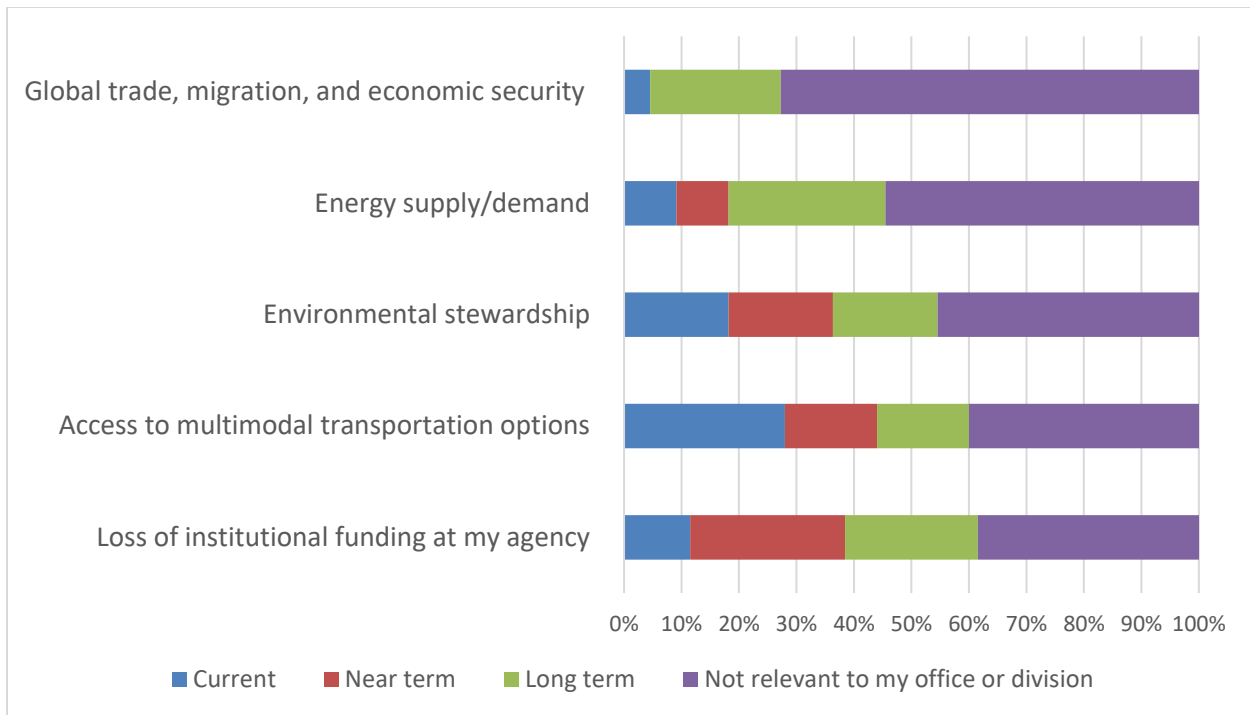


Figure 4. Challenges Deemed Irrelevant

Key takeaways from the Office/Division Priorities, Needs, & Challenges questions are as follows:

- Current challenges include the ability to keep pace with new and evolving transportation and communication technologies, as well as the ability to incorporate data and information in decision making processes.
- Long-term challenges are largely organizational based, including relationships with other agencies and the private sector, based on finite funding.
- Broader themes of global trade, environmental stewardship, and multi-modal connectivity are not considered to be major challenges.
- The ability to attract, train, and retain staff is considered to be a significant challenge throughout all time horizons.

Peer Agency/Innovative Ideas Results

Approximately 40 percent of respondents indicated awareness of innovative ideas, currently being considered, tested, or utilized at peer agencies. Those ideas indicated by respondents include the following:

- Connected and Autonomous Vehicles research: This was the most popular response, and was noted as being actively considered at multiple peer agencies.

- Use of Light Detection and Ranging (LiDAR) for field data collection: Currently being considered at multiple peer agencies and indicated by multiple respondents.
- Unmanned aerial vehicles (UAVs) for field data collection: Currently being considered at multiple agencies and indicated by multiple respondents.
- PennDOT Connects: An interactive initiative at PennDOT that considers community needs and input throughout all portions of the planning and project delivery process.
- ArcGIS-based open data sharing platform.
- Data analytics software (Probe Data Analytics Suite developed at the University of Maryland Center for Advanced Transportation Technology (CATT) Laboratory).

Agree-Disagree Statements Results

The results of the agree-disagree statement portion of the survey are shown in Figure 5. As indicated by Figure 5, there is general agreement that the various divisions have the right knowledge, information, policies, and staff in place to accomplish agency goals. However, there appears to be less of a consensus in place regarding technology, including models that could further expedite decision making. In fact, 40 percent of respondents disagreed or strongly disagreed with the related statement.

There was additional concern and lack of consensus regarding isolated workgroups/employees and risks of knowledge loss during staff turnover. With regards to the risks associated with isolated workgroups/employees, respondents were almost evenly split as to whether they thought this was or wasn't an issue. On the other hand, about 75 percent of respondents indicated that knowledge is at risk of being lost due to staff turnover. Of this 75 percent, approximately half strongly agreed with the related statement.

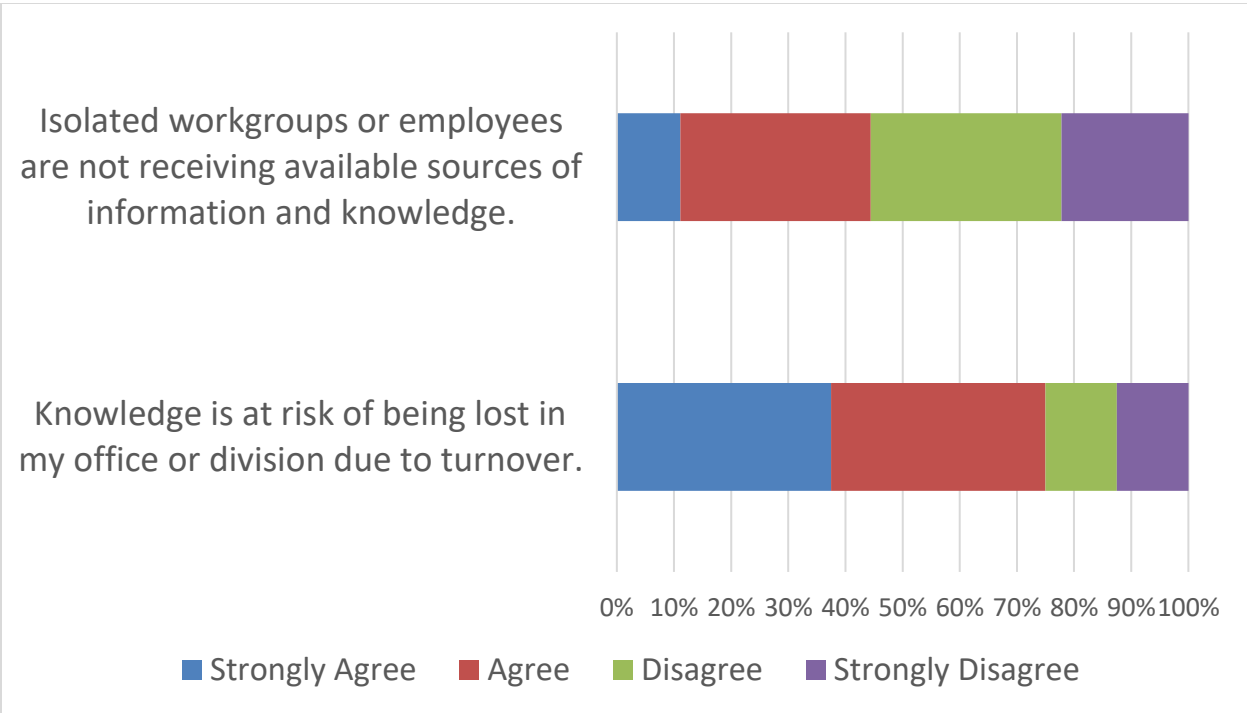
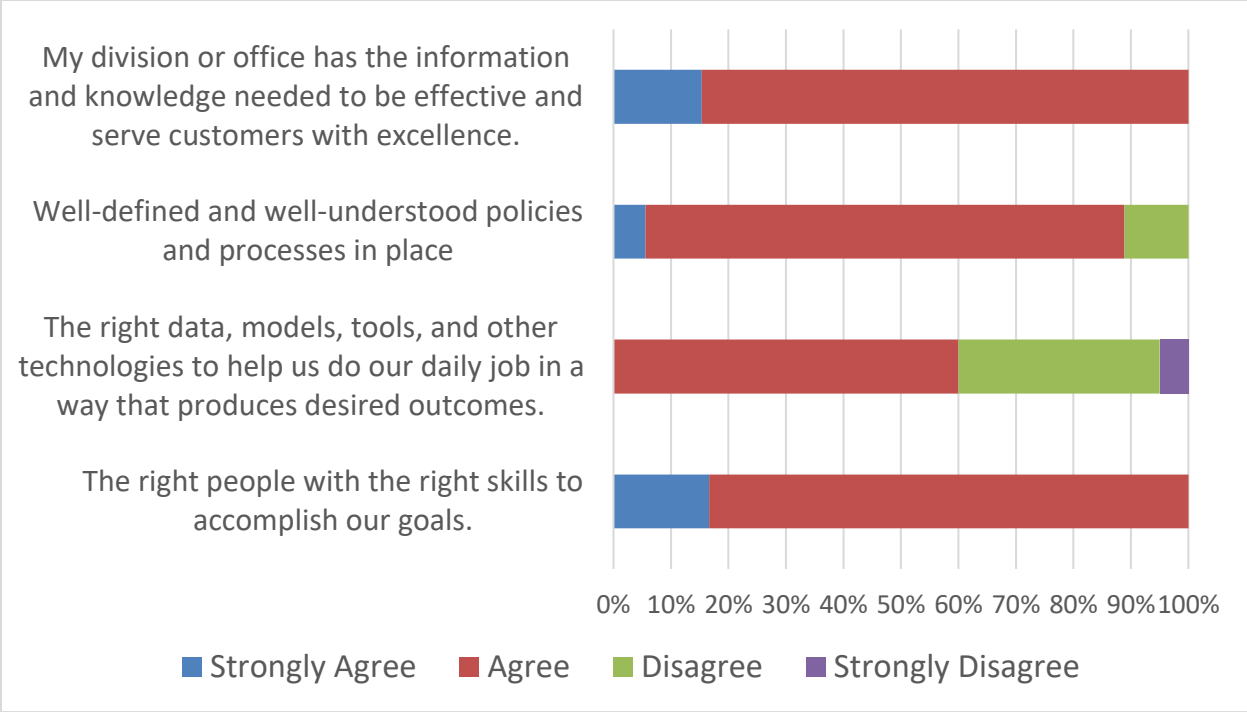


Figure 5. Agree-Disagree Statements

General Research and Division Functionality Results

A number of unique and individual responses were provided to the mostly open-ended questions of this section of the survey. These responses were likely influenced by passage of the FAST Act, which was deemed as a significant influencer on everyday

operations by 65 percent of respondents. The responses to the open-ended questions of this section are elaborated on as follows:

When asked about what additional information respondents would need to better carry out their duties at the divisional level, respondents indicated the following:

- Succession planning efforts and additional means of preserving institutional knowledge.
- Information on businesses that generate freight traffic.

When asked the same question at the individual level, respondents indicated the following:

- Exposure to the newest technology and trends, including ArcGIS, connected and autonomous vehicles, machine learning, UAV, forecasting tools, and mobile applications.
- Increased communication between NJDOT, local MPOs, and subregional stakeholders.
- Peer exchange between other states and certain large corporations.
- Technical and regulatory environmental knowledge.

When asked about potential areas of new research in order to respond to new regulations and legislations, respondents indicated the following:

- UAV technology
- Freight-related technology advances
- Environmentally friendly alternatives to highway de-icing salt.
- Extreme weather impacts, performance measure targets, mitigation, and adaptation, driven as a result of the FAST Act's emphasis on stormwater resiliency.

Additional research technology topics and transfer activities indicated include the following:

- Better leveraging of NJDOT's Data Warehouse
- Potential benefits and applications of blockchain technology.
- Electrically conducive pavement
- Effects of centerline rumble strips on roadway conditions

- Comparison of emission rates between alternative and conventional fuels
- Bicycle/pedestrian near-miss crash data analysis

Round-Table Focus Group Sessions Description

Following presentation of the Research Needs & Technology Transfer survey to the NJDOT Bureau of Research, the Research Team moved to develop and conduct focus group sessions. The purpose of these focus groups was to further engage with those senior staff from NJDOT and other state transportation agencies and organizations, based on those needs, trends, and ideas identified through the previous surveying efforts. A total of six focus groups were conducted on-site at NJDOT Headquarters between June 25 and June 28, 2018, each of which lasting for approximately two hours. Each focus group consisted of a moderator leading the discussion, a scribe recording the conversation (with specific responses kept anonymous), and the participants. Each focus group garnered approximately five participants, with formal invitations sent out by the Bureau of Research. The titles and descriptions of the focus groups, as included within the invitations, are as follows:

1. New Jersey's Economy: Implications for People and Freight – Monday, June 25th at 9:00 AM

Evidence of New Jersey's booming industrial economy is visible in many parts of the state, especially along the Northeast Corridor. Distribution and fulfillment centers, sometimes upwards of 1 million square feet, are constantly being constructed, driven largely by New Jersey's location between New York and Philadelphia. The result is an increase in multi-modal freight traffic that produces unique and added burdens to the entire transportation system. How should NJDOT strategically invest in the transportation system in a manner that accommodates and continues to grow the statewide economy?

2. Resilience to Climate Change and Other Threats – Tuesday, June 26th at 9:00 AM

A coastal setting, high population, and dense concentration of multi-modal infrastructure all combine to make New Jersey one of the most vulnerable states to climate change and other severe weather threats. Only 6 years ago, Superstorm Sandy came ashore here, completely washing away a portion of the Barnegat Peninsula in Mantoloking, and causing severe damage to multiple components of the statewide multi-modal transportation system. With almost all indicators pointing to increased risk from severe weather and other natural disasters, how should NJDOT move forward in protecting vulnerable assets and developing a more adaptive and sustainable transportation system? What role does FAST Act legislation play in shaping these decisions?

3. Organizing, Staffing, and Sustaining the New Jersey DOT of the Future – Tuesday, June 26th at 1:00 PM

Like many other public agencies, NJDOT is at a crossroads. Highly skilled and seasoned veteran employees are retiring at a rapid rate, and not being replaced quickly enough by new hires due to a number of factors, putting NJDOT at risk for knowledge drain. What steps can NJDOT take to best position the agency, market itself to new hires, all while facilitating effective knowledge transfer?

4. New Technologies: Opportunities and Challenges – Wednesday, June 27th at 9:00 AM

TNCs, UAVs, LIDAR, PTC, and CAVs are more than just abbreviations. In many cases, they're also the future of transportation. These technologies are evolving rapidly. Whether it be through vehicles that communicate with other vehicles and infrastructure systems, or the ability to survey bridges for structural integrity using drones, NJDOT needs to be at the forefront of harnessing these technologies. How can NJDOT best integrate new technologies into its business processes in a manner that produces tangible results and in a cost effective manner?

5. Improving Project Delivery to Achieve Better Outcomes – Wednesday, June 27th at 1:00 PM

The project delivery process is a core function of NJDOT. This includes everything from project inception to final product delivery and every process in between and even including communication across different divisions. What is working well with the current process at NJDOT? What can be improved? How can NJDOT facilitate dialogue, communication, and collaboration across division boundaries?

6. Managing and Maintaining a 21st Century Transportation System – Thursday, June 28th at 9:00 AM

The turn of the 21st century has largely marked a transition from the aggregate construction of new transportation infrastructure, to the complex task of maintaining it for long-term use. This task is even more complex for NJDOT, given New Jersey's dense development and population density which puts added strain on the transportation system. Maintenance costs and demands are all growing, along with population, while revenues and funding sources remain stagnant at best. In this era of growing costs and limited funding, how can NJDOT best manage New Jersey's multi-modal transportation system in a safe and efficient manner?

Round-Table Focus Group Sessions Results

A brief summary of each of the focus groups, including research needs identified, is as follows. A full version of each focus group summary can be found in Appendix 4.

New Jersey's Economy: Implications for People and Freight

The economy-based focus group was essentially divided into two sections: freight, and general economic development and fluidity. On the topic of freight, participants discussed NJDOT's role in trucking-related topics such as the ongoing truck parking shortage, permitting, navigation, municipal restrictions, and the eventual implications of driverless trucks. A sizable amount of conversation was also devoted to the need for better datasets and information related to freight generators, given the challenges of engaging with the private sector which is the essential driver of freight traffic. On the topic of general economic trends, the participants spoke of the differ travel and lifestyle patterns of millennials, increases in telecommuting, and the need to analyze the effects of these trends on travel demand.

Through the dialogue, participants identified the following research needs and topics:

- Methods of expediting truck/freight fluidity including by means of improving permitting processes and managing hours of service (HOS) regulations.
- Better coordination of municipal regulations and restrictions on trucks.
- Impacts of driverless trucks.
- Identifying accurate origin-destination and freight generators, including implications for data accuracy.
- Identification of up-to-date and future travel demand habits, including effects of TNCs and technological advances.
- Determination of effects of reduced reliance on conventional fuel.

Resilience to Climate Change and Other Threats

With regards to the relationship between climate change and transportation infrastructure resiliency, the participants spoke about the means in which each organization/division/county considers risk, and immediate, as opposed to long-term needs. The participants additionally identified some specific needs and desires regarding resiliency. These include the need for a single, definitive predictive flood plain map for statewide decision making purposes, greater emphasis on nuisance and 'sunny day' flooding decision making, and data-based decision making.

Through the dialogue, participants identified the following research needs and topics:

- Effective scientific data for climate change-based decision making.
- Identification of cost-effective solutions that can be used to adapt transportation assets and networks to the impacts of climate change and other threats.
- Understand tradeoffs between repair, rehabilitation, and reconstruction strategies suggested by a life-cycle planning approach (corridor, network and system-scale)

informed by climate change, and investments to support other strategic goals (such as safety, economic development, and environmental conservation).

- Modeling asset and system-level vulnerability to various climate stressors.
- Additional communication between various state agencies on issues of climate impacts to transportation, water, communications, housing, schools, social services, and other infrastructure and services.
- Staff capabilities to support climate vulnerability and risk assessment, asset management, and design decisions, including data modeling and centralized database practices.
- Integrating climate risk (damage and disruption costs) into cost-benefit analysis of capital investment strategies, life-cycle cost analysis for specific assets, and life cycle planning for corridors, networks, and systems.

Organizing, Staffing, and Sustaining the New Jersey DOT of the Future

During this focus group, the participants elaborated on the challenges that NJDOT faces related to staffing. According to a participant, approximately two-thirds of NJDOT staff is eligible for retirement within the next ten years. At the same time, NJDOT struggles to remain competitive for new hires compared to other state DOTs and private sector transportation firms. Amongst other recommendations, participants recommended reinstating a new-hire mentoring program that was recently cut, reducing silos, and encouraging inter-departmental interaction. Participants also spoke of extraneous civil service restrictions that can create further challenges in the hiring and talent management process.

Through the dialogue, participants identified the following research needs and topics:

- Methods of expediting knowledge transfer in preparation for oncoming waves of experienced staff retirements.
- Increased training and collaboration so that staff have a strong understanding of their roles with respect to the broader mission of NJDOT
- Knowledge sharing and summaries of best practices to help staff gain practical understanding of the application of their jobs to the real world.
- Methods of coordinating staffing with general needs, including data collection and modeling and consistency in carrying out business processes.
- Identification and understanding of the consequences of reduced staffing availability.

New Technologies: Opportunities and Challenges

On the topic of new technologies, the participants discussed key challenges regarding use of technology at NJDOT. In the near-term, data processing/analytics remains a significant challenge, while long-term challenges include possessing both the right tools and staffs for sound decision making. In addition to possessing the right tools and technology, the participants additionally spoke on the need for the right support and guidance systems. In particular, there is a need for effective training that dictates the right technology to use at the right times in support of NJDOT's core business processes. The topic of connected and autonomous vehicles was also discussed, with participants agreeing on a realistic time frame of at least 20 years until significant market penetration. Despite this relatively long time frame, the participants also discussed the need to understand what the effects of this evolving technology on travel and traffic patterns.

Through the dialogue, participants identified the following research needs and topics:

- Methods of connecting various data/project management software, along with analysis of best practices from other DOTs.
- Methods of leveraging technology to better integrate real-time data.
- Determination of how UAVs can best be integrated into NJDOT's maintenance and operations activities.
- Determination of how to keep track of different travel patterns and respond accordingly, including different ways of reporting and updating such patterns.
- Scenario planning of connected and automated vehicle market penetration.
- Analysis of declining public transit ridership and potential mitigations.

Improving Project Delivery to Achieve Better Outcomes

The project delivery focus group was essentially divided into two sections: managing federal mandates, and internal project scoping. On the topic of dealing with federal mandates, the participants spoke of issues in complying with Buy America and Americans with Disabilities (ADA) regulations. While both regulations were created with good intentions and produce notable benefits, they can also have negative impacts on project delivery, including costs, specifications, and time components. On the topic of project scoping, the participants debated the pros and cons of partial- as opposed to full-scope projects with regards to factors of time, cost, and incorporation of sustainability and multi-modal components.

Through the dialogue, participants identified the following research needs and topics:

- Ability of NJDOT to cope with federal regulations, most notably ADA and Buy America requirements.

- Development and structure of full- as opposed to partial-scope projects, including dynamics/interactions between project managers, engineers, and planners.
- Incorporation of multi-modal components into relevant projects.
- Development of effective methods of project management, including software, and means of communication during early phases.

Managing and Maintaining a 21st Century Transportation System

The final focus group aimed to broadly cover a number of topics, including those discussed during the previous focus groups. As such, multiple topics were revisited, including the need for improved knowledge of travel demand patterns, and technology-based decision making. The topic of project management, including project scoping was also revisited, particularly based on the need for an improved evaluation system for ranking and scoring projects for funding eligibility. Also owing to its significance, the issue of staffing and knowledge transfer was also revisited, including a need for more effective training system for new hires.

Through the dialogue, participants identified the following research needs and topics:

- Allocation of funding between statewide and local projects, including with considerations for federal requirements.
- Allocation of funding for multi-modal projects, as opposed to surface transportation, and implications for increasing this.
- Improving methods of acquiring and training new staff/talent as a result of increased retirements.
- Methods of positioning NJDOT to respond to modern travel patterns and transportation needs.

Task 3 – Gap Assessment of Existing Research Areas

Following the efforts from Tasks 1 and 2 to gather knowledge and insight at the national and internal organizational levels, the Research Team moved to prepare a gap assessment of existing research conducted by the Bureau of Research. The purpose of this gap assessment was to compare the depth and breadth of this research to those needs identified by NJDOT, MPO, and other related transportation practitioners in New Jersey, as well as those national trends that could affect NJDOT.

The gap assessment considers all research conducted by the Bureau of Research between 2013 and 2017. A listing of all research pieces conducted during this time period, along with accompanying abstracts, lead researchers, and key words identified by the researcher, is provided in Appendix 5. Each research piece is also sorted into eight categories:

- **Department Management:** Research and analysis of internal departmental issues, goals, and affairs.
- **Environmental:** Research on air quality, water quality, soil, topography, as well as climate change-related analyses.
- **Freight:** Research involving freight systems within New Jersey, including general trends and infrastructure needs.
- **Infrastructure:** Research involving infrastructure and material management and degradation.
- **Mobility:** Research related to public transit, TNCs, and other multi-modal methods of transportation, including safety.
- **Project Delivery:** Research related to project management, communications, and interactions internally within NJDOT and with other organizations.
- **Staffing:** Research involving talent acquisition and retention, as well as knowledge transfer and workforce training.
- **Technology:** Research on new technologies, including implementation, models, and pilot testing.

It should be noted that each research piece could be sorted into more than one research theme. For example, a research piece detailing the use of UAVs for infrastructure monitoring would be considered to be both an 'Infrastructure' and 'Technology' piece. A research piece describing a modern project management software for implementation would be considered to be both a 'Project Delivery' and 'Technology' piece.

General Research Trends

Based on the compilation of research between 2013 and 2017, the Research Team compiled statistics on lead researchers, as well as research themes. Figure 6 summarizes completed research based on the lead researcher. As Figure 6 shows, the majority of research completed has been conducted by a university. The New Jersey Institute of Technology (NJIT), Rowan University, as well as the Voorhees Transportation Center and Center for Advanced Infrastructure and Transportation of Rutgers University comprise a large majority of the lead agencies conducting research for NJDOT. To a lesser extent, the private sector, led by Cambridge Systematics has also led a number of research pieces (11).

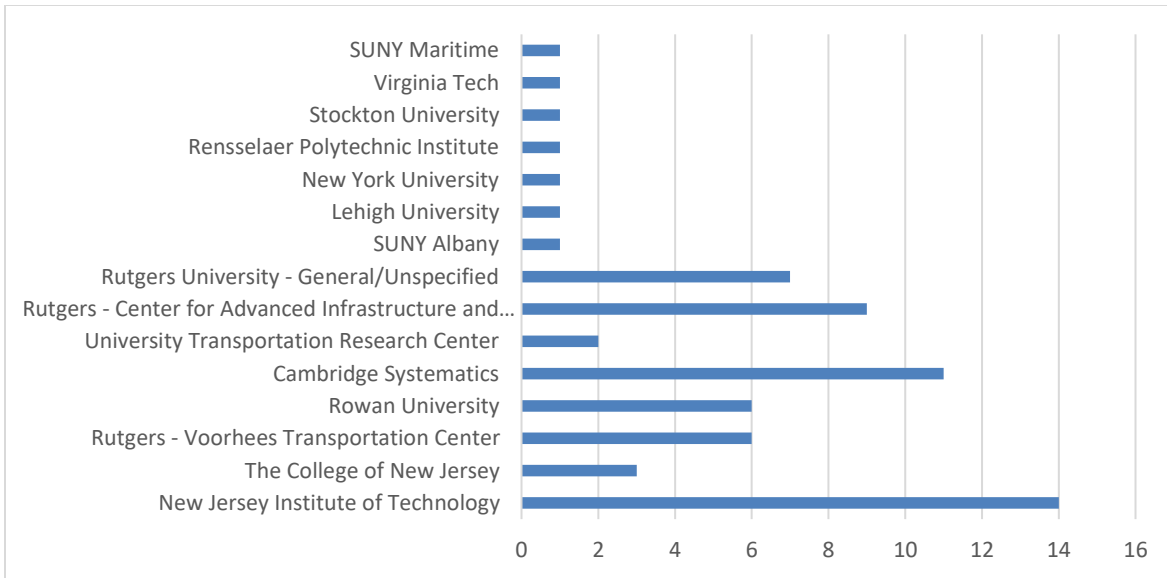


Figure 6. 2013-2017 Completed Research by Lead Agency

Figure 7 below summarizes completed research based on the eight research themes previously identified. As Figure 7 shows, research in the last five years has focused most on technology and infrastructure. Together, these two themes comprise almost half of all research. On the other hand, staffing, project delivery, and freight themes have comprised under 15 percent of all research. As previously indicated, research pieces could be grouped into more than one research theme.

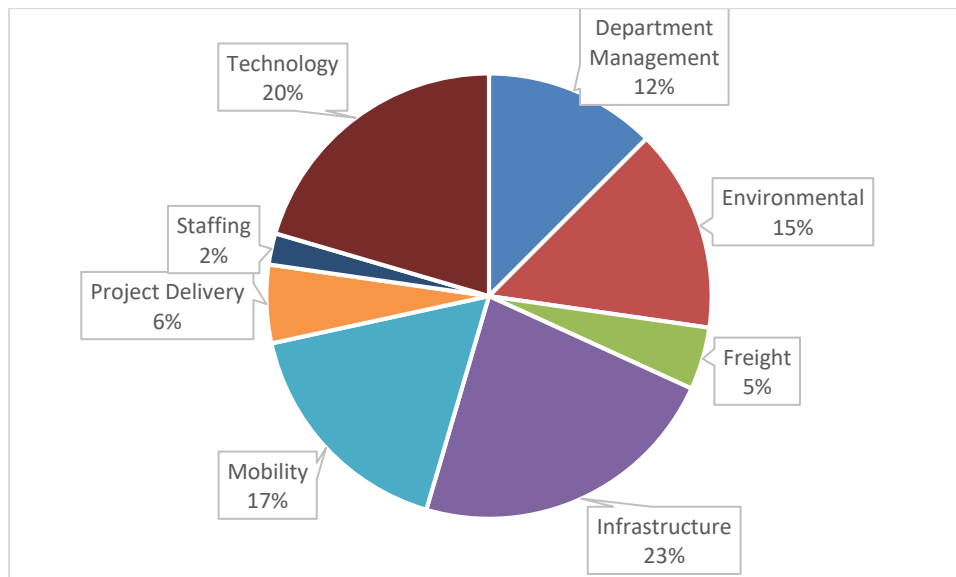


Figure 7. 2013-2017 Completed Research by Research Theme

Gap Assessment

Through Tasks 1 and 2, the Research Team broadly identified the following primary and secondary research needs to be undertaken by the Bureau of Research. For the purposes of this gap assessment, primary research needs can be defined as the most pressing research needs, especially those identified on one or more occasion during the focus groups and surveying process. These research needs are already impacting or are expected to impact NJDOT very soon. Identified primary research needs include the following:

- **Staffing:** How can NJDOT continue to attract, retain, and effectively train new staff? This takes into account factors such as compensation, inter-departmental training, and perhaps most importantly, knowledge transfer. Through the surveying and focus group efforts, staff indicated that NJDOT is having a difficult time remaining competitive against the private sector and other state DOTs.
- **Project Delivery:** Issues of compliance and effects on departmental operations took up a large portion of the Project Delivery focus group, given what appears to be significant issues in efficiently integrating Buy America requirements and Americans with Disabilities Act mandates into operations.
- **Technology Access & Guidance:** Survey takers and focus group participants often indicated the need for better access to new technologies given the potential implications for NJDOT. However, the issue of providing guidance and accurate decision making processes to accompany new technologies was considered to be as important.
- **Information on Freight Generators:** Freight is an important yet complex subject given that such operations are carried out almost exclusively by the private sector which is often reluctant to release valuable data. Survey takers and focus group participants were especially eager to determine the best methods of acquiring such data for improved freight- and multi-modal-based decision making.
- **Streamlined Methods of Infrastructure Management:** A number of focus group participants discussed the need for improved and efficient decision making support systems for managing infrastructure. Such systems should be able to determine the best allocation of funding, and effectively predict the degradation of infrastructure.

Secondary research needs are those which may have been come up to a somewhat lesser extent than those primary research needs. However, these needs are still likely to impact NJDOT throughout all timespans. Identified secondary research needs include the following:

- **Declining Public Transit Use/Impacts of TNCs:** Public transit use has largely stagnated in recent years, alongside the rapid rise of TNCs. Given these trends, multiple focus group participants explained the importance of understanding these trends and predicting future impacts on statewide travel demand and NJDOT.
- **Connected and Autonomous Vehicles:** Research into connected and autonomous vehicles continues to be significant for all DOTs, given the potential

impacts on statewide travel demand and corresponding operations. This topic was identified through multiple focus groups and via the online surveying process.

- **Truck Parking:** Research into truck parking shortages continues to be important, especially as e-commerce continues to drive freight traffic. Given a number of factors, truck parking shortages are increasing which also has significant implications for safety.
- **Impacts of Climate Change:** Given New Jersey's coastal setting, climate change has a number of implications for NJDOT, which is why the subject was assigned its own focus group. Additional research continues to be needed.

A number of trends are evident based on the research conducted within the last five years at NJDOT, and those research needs identified through this particular planning process. The first of these trends is related to the theme of technology. Although technology accounted for 20 percent of all research pieces assembled by the Bureau of Research, the second-most only behind infrastructure, it was also determined to be one of the most significant primary research needs on the part of NJDOT staff. This may be attributed to a number of reasons. The first could be that even with the significant amount of research being conducted, the amount of and implications of new technologies and related processes may be so large that it requires even more research. The second reason may be attributed to the need for better implementation. Focus group participants and survey takers highlighted the issue of not only acquiring new technologies, but also having strong guidance on how to best apply these technologies in the context of NJDOT's organizational structure and current staffing. Third, there may be a disconnect between the types of technologies being studied and those technologies that NJDOT staff determine to be most important.

On the other hand, there appears to be a lack of research involving staffing, especially compared to how often the topic was brought up. Despite being extensively brought up during the online surveying process and in multiple focus groups, staffing and related knowledge transfer activities were the subject of only two research pieces. Those include the following:

- *Increasing Representation of Minorities, Females and Underrepresented Individuals in Journey Level Jobs on Highway Construction Projects (2017)*
- *Streamlining the Project Management Process at NJDOT's Bureau of Research (2014)*

The two identified staffing research pieces do provide NJDOT with valuable insight related to staffing, including on topics of minorities interacting within a highly unionized industry, and on inter-departmental information sharing which has become an important component of knowledge transfer. However, additional information appears to be needed that directly answers the following questions:

- How can NJDOT compete with other state DOTs and the private sector in attracting and retaining staff?

- How can NJDOT directly facilitate knowledge transfer from more experienced to newer staff?
- How can NJDOT best go about training new staff?

Despite its importance and relevance to the entire multi-modal transportation system, freight also comprised a small portion (5 percent) of research. Those research pieces focusing on freight include the following:

- *Impact of Freight on Highway Infrastructure in New Jersey (2016)*
- *Oversize/Overweight Public Documentation Benchmarking and Effectiveness Study (2015)*
- *Impact of the Rail Grants Program (2015)*
- *Oversize/Overweight Permitting Practices Review (2013)*

Each of the research pieces involving freight produces strong merit in that they attempt to understand the patterns, trends, and details associated with New Jersey's growing freight and industrial economy. At the same time however, based on this planning process, such research into statewide freight systems could strongly benefit from insight on how to acquire more data and insight on the most influential freight generators across the state. This may eventually spur other freight-related research topics, including further analysis on the effects of large vehicles on highway infrastructure and the development of a solid framework for a mitigating compensatory fee-based system.

The topic of Project Delivery (and, specifically, Buy America & ADA compliance) proved to be the narrowest scope of all of the identified primary research topics. This is attributed to the significant and unintended implications of such policies on NJDOT as summarized in the project delivery focus group results (Task 2). While direct research is needed to address compliance with these policies, this primary research need could also be expanded to address compliance and implications with and for other policies as they arise, given what can often be a lack of guidance at the federal level.

Lastly, infrastructure and the use of relevant decision making processes remains an important primary research need despite accounting for 23 percent of all research (the most out of any of the eight identified research themes). Similar to the case with technology-based research, this may be attributed to a number of reasons. First, since infrastructure management is one of NJDOT's primary duties, infrastructure research will likely always be needed. However, this may also be attributed to a direct need for more decision support tools that can assist practitioners, as opposed to infrastructure and material modeling efforts that have comprised a large portion of conducted infrastructure research. As such integration of infrastructure research with other themes such as environmental (climate change) and technology may generate significant merit for advancing NJDOT's mission.

CONCLUSION AND RECOMMENDATIONS

In summary, this report aimed to provide the NJDOT Bureau of Research with the framework for a strategic plan that lays out priorities for future research.

This research effort was guided by the following key questions:

What are the global, domestic, and local trends that could impact NJDOT?

Based on the NCHRP Foresight 750 Series, consisting of six theme volumes, a number of global, domestic, and local trends could impact NJDOT currently and in the future. These major themes include freight, climate change, technology, sustainability, energy, and socio-demographics.

- Key freight-related trends include the continued growth in e-commerce and the corresponding demand for fulfillment center space, as well as the need to accordingly upgrade New Jersey's multi-modal infrastructure system.
- Key climate change trends include increased threats from sea level rise, extreme temperatures, and severe weather, especially in and around coastal and low-lying areas of New Jersey.
- Key technology trends include the continued growth of transportation network companies (TNCs) and connected and automated vehicles.
- Key sustainability trends include increased demand for bicycle and pedestrian modes of transportation, driven by growing desire, especially by millennials, for walkable, urban neighborhoods.
- Key national energy trends include improved vehicle fuel efficiency standards and the growth of alternative fuels, which may have implications for the funding of transportation projects that are tied to New Jersey's gasoline tax.
- Key socio-demographic trends within New Jersey include growth in and around major rail corridors and urban areas, increased ethnic diversity, and the aging of baby boomers who have traditionally been accustomed to lower density, suburban neighborhoods.

What are the key organizational challenges that NJDOT faces?

Based on the 'Research Needs and Technology Transfer' survey distributed to NJDOT staff, as well as certain staff at member metropolitan planning organizations (MPOs), and New Jersey public agencies, the Research Team identified multiple immediate and long-term challenges.

Key immediate challenges include the data-based decision making capabilities, extreme weather risks, intergovernmental relationships and partnerships, talent acquisition and retention, and changing transportation and communications technology.

Key long-term challenges include the changing roles of the public and private sectors in managing transportation infrastructure, intergovernmental relationships and partnerships, energy supply and demand, transportation funding and finance, and talent acquisition and retention.

What are NJDOT's key research needs?

NJDOT's key research needs can be divided into primary and secondary research needs as identified through this strategic planning process. Primary research needs include the following:

- **Staffing:** How can NJDOT continue to attract, retain, and effectively train new staff? This takes into account factors such as compensation, inter-departmental training, and perhaps most importantly, knowledge transfer.
- **Project Delivery:** Including issues of compliance with Buy America requirements and the Americans with Disabilities Act and effects on NJDOT.
- **Technology Access & Guidance:** Including the need for better access to new technologies and corresponding guidance and accurate decision making processes to accompany new technologies.
- **Information on Freight Generators:** Freight is an important yet complex subject given that such operations are carried out almost exclusively by the private sector which is often reluctant to release valuable data.
- **Streamlined Methods of Infrastructure Management:** Including the need for improved and efficient decision making support systems for managing infrastructure. Such systems should be able to determine the best allocation of funding, and effectively predict the degradation of infrastructure.

Secondary research needs include the following:

- **Declining Public Transit Use/Impacts of TNCs:** Public transit use has largely stagnated in recent years, alongside the rapid rise of TNCs. Given these trends, what are the implications for statewide travel demand and NJDOT?
- **Connected and Autonomous Vehicles:** Research into connected and autonomous vehicles continues to be significant for all DOTs, given the potential impacts on statewide travel demand and corresponding operations.
- **Truck Parking:** Research into truck parking shortages continues to be important, especially as e-commerce continues to drive freight traffic. Given a number of factors, truck parking shortages are increasing which also has significant implications for safety.

- **Impacts of Climate Change:** Given New Jersey's coastal setting, climate change has a number of implications for NJDOT.

Research Conclusions

NJDOT will be Influenced by a Wide Range of Global, Domestic, and Local Factors

As indicated in the NCHRP's Foresight 750 Series and translated into visual-based briefing books, NJDOT will be influenced by a wide range of factors. At the global level, innovations in energy production and the unrenowable characteristics of gasoline will affect revenue tied to New Jersey's conventional gasoline tax. Locally within New Jersey, population growth is increasingly occurring within the urbanized portions of the state, leading to increased public transit demand.

Talent and Knowledge Management are Key Organizational Issues faced by NJDOT

Based on internal surveying and focus group efforts, talent and knowledge management are significant issues that will affect NJDOT. Stemming from a wide variety of issues, NJDOT faces significant competition from the private sector and DOTs of other states in recruiting and retaining staff. Knowledge transfer capabilities are affected by this given that a large number of staff are eligible for, and actually retiring, without a formalized process for sharing key knowledge and insight with new and existing staff.

Infrastructure and Technology have Comprised the Largest Proportions of Recently Conducted Research

An examination of previously conducted research between 2013 and 2017 revealed that technology and infrastructure have comprised the largest proportions of undertaken research. Infrastructure accounted for 23 percent of such research, while technology accounted for 20 percent of such research.

Research is Lacking on Freight

An examination of previously conducted research between 2013 and 2017 revealed that freight has comprised only 3 percent of undertaken research. Moving forward, additional research is needed that particularly considers how to acquire data and information from private sector freight generators.

Key Research Needs Include Technology and Staffing

The gap assessment revealed a number of research needs, with the most notable being technology and staffing needs. Moving forward, additional research will be needed that considers the implementation of new technology and software at NJDOT concurrent with user guidance, staff training, and changes to organizational structures and business processes. Staffing research will need to focus on attracting and retaining staff

amidst competition from other state DOTs and the private sector. Staffing research should also focus on relevant training programs and the topic of knowledge transfer.

Research Recommendations

Expedite Primary Research Needs. The Research Team recommends that the Bureau of Research prioritizes those primary research needs identified through this strategic planning process. Those research needs include:

- Staffing,
- Project Delivery (focusing specifically on Buy America & ADA compliance),
- Technology,
- Freight, and
- Infrastructure management.

The Bureau of Research should also continue to prioritize those secondary research needs that are also significant for NJDOT. Those secondary research needs include:

- TNCs and their impact on public transit/overall travel demand,
- Connected and autonomous vehicles,
- Truck parking, and
- Impacts of climate change

Development of a Formalized Implementation Plan. The Research Teams that the Bureau of Research places a greater focus on the implementation of research, primary through the development of a formalized implementation plan. A suggested framework for an implementation strategy follows and includes considerations for addressing those primary and secondary research needs. It also includes recommendations for a technology-specific implementation plan, and an improved outreach process with other NJDOT departments.

IMPLEMENTATION

The implementation strategy provides recommendations on how NJDOT should prioritize future research based on this overall planning process. In particular, the primary and secondary research needs and corresponding gap assessment provide the basis for this strategy.

Primary Research Topics

Based on the gap assessment, the most significant primary research needs relate to the topics of staffing and technology. Other primary research needs include Buy America & ADA compliance, freight, and infrastructure decision making.

Staffing Research

Given that staffing research has comprised such a small portion of completed research within the last five years, the Bureau of Research should expedite research that considers those research questions highlighted in the gap assessment and through the staffing focus group. When designing a formalized scope of work (SOW), the Bureau of Research should also place a particular focus on training programs, and the feasibility of reinstating former programs. In addition, the Bureau of Research should consider developing a formalized plan/process for addressing knowledge transfer needs.

Technology Research

The topic of technology provides multiple options for moving forward. As indicated in the gap assessment, there is still significant demand for research on technology, despite it comprising a significant portion of existing recently completed research. Moving forward, the Bureau of Research should use the following strategy to ensure that future technology research directly responds to the needs of NJDOT staff:

1. Conduct further outreach across multiple NJDOT departments to develop a clear picture of what NJDOT's specific technology needs are.
2. Identify where and how technology can be integrated into other important components of NJDOT operations including infrastructure management, and climate change modeling/mitigation actions.
3. When designing a formal SOW, provide considerations for implementing new technologies and guiding NJDOT staff on when and how to use these technologies.
4. Develop a continuing check-in system that monitors how NJDOT staff are interacting with new technologies, and considers evolving technology needs.

Project Delivery Research

On the topic of Buy America & ADA compliance, the Bureau of Research should move to implement an SOW that directly considers how other state DOTs are coping with these federal mandates. Given the significant dialogue dedicated to this topic during the project delivery focus group, other state DOTs are likely to be in the same position as NJDOT, and may have already developed coping strategies. Similar to the

recommendations for instituting technology research, the Bureau of Research should develop a process of reaching out to NJDOT departments about any other policies, developed at both the state and federal levels, that could have both intended and unintended consequences on NJDOT.

Freight Research

As indicated within the gap assessment, NJDOT should also expedite research that considers how to acquire freight data from the private sectors, including key freight generators and distribution/fulfillment centers. As previous research has indicated, NJDOT may be considering a fee-based system for overweight vehicles, based on the accelerated damage they cause to existing infrastructure. This research would significantly be strengthened through an improved understanding of freight travel demand patterns, much in the way that NJDOT and public transit agencies attempt to understand personal travel demand patterns. Research into private sector freight generators and data acquisition would also go a long way to understanding the specific transportation and infrastructure needs of New Jersey's freight and industrial economy. For such research, the Bureau of Research could consider partnering with the New Jersey Economic Development Authority, given its experience with the private sector. Overall, this research should consider best practices and methods for engaging and reaching out to the private sector.

Infrastructure Research

Lastly, infrastructure management and decision making remains an important primary research topic, even with infrastructure comprising the largest proportion of research topics. Moving forward, the Bureau of Research should place a strong emphasis on the implementation of the methodologies, processes, and conclusions highlighted in such research, with a particular focus on risk-based decision making. There is likely additional strong merit in developing technology/identifying software that will further enhance NJDOT's infrastructure management operations.

Secondary Research Topics

The secondary research needs highlighted in the gap assessment include TNCs and their impact on public transit/overall travel demand, connected and autonomous vehicles, truck parking, and impacts of climate change. While somewhat broader themes, research into these topics remains extremely important to NJDOT. As such, they should be prioritized accordingly.

Within the past five years, no research has been conducted on the truck parking shortage within New Jersey. Moving forward, the Bureau of Research should collaborate with relevant NJDOT departments to consider whether New Jersey-specific research, or research conducted by other states/organizations would be adequate to address the issue. The Bureau of Research may find that additional research will be needed with a New Jersey context, including the economics that may inhibit truck parking expansion. On the topic of climate change, while additional research will

continue to be needed for the foreseeable future, such research will likely be most effective when integrated into other components of NJDOT's core business processes, including infrastructure management, technology, and staff support.

Prioritizing Research

Overall, when prioritizing future research, including both the primary and secondary research needs identified through this strategic planning process, the Bureau of Research should aim to place an increased emphasis on implementation. This will be important so that new research undertaken by NJDOT is effectively able to build off of recommendations and conclusions put forth under previous works. This will also help strengthen the connection between NJDOT staff-identified research needs, and undertaken research/research conclusions. Additionally, this will also help to minimize any 'journal effects' where published research remains available for citation and use in future research, but is rarely actively engaged with. In order to place a stronger emphasis on implementation, the Bureau of Research should strongly consider the following actions:

- Development of formalized and expanded implementation guidelines for future SOWs. A specific implementation plan template should be developed for research that focus on new technologies and software that could potentially benefit NJDOT.
- Development of a formalized surveying process that identifies NJDOT's technology needs.
- Ensure that where applicable, relevant NJDOT staff have input and collaborate with researchers.
- Instituting a process of continuing communication with other NJDOT departments following the conclusion of conducted research that impacts those departments.

By following this implementation strategy, the Bureau of Research will be able to ensure that undertaken research directly and significantly advances NJDOT's mission and operations.