

TRANSPORTATION RESEARCH  
**CIRCULAR**

Number E-C267

October 2020

**Summary of  
Transportation  
Research Needs  
Related to  
COVID-19**



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TRANSPORTATION RESEARCH CIRCULAR E-C267

# Summary of Transportation Research Needs Related to COVID-19

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The **Transportation Research Board** is one of seven major programs of the National Academies of Sciences, Engineering, and Medicine. The mission of the Transportation Research Board is to provide leadership in transportation improvements and innovation through trusted, timely, impartial, and evidence-based information exchange, research, and advice regarding all modes of transportation

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## Background

The novel coronavirus (COVID-19) has proven a formidable adversary worldwide, with tremendous impact on the United States. The transportation system is an essential element of our response to this pandemic but has also been significantly impacted across all modes, both passenger and goods movement. The term “pivot” has become popular to reflect that our typical response to anticipated crises does not apply to this threat. We must be innovative and quickly adapt to use available resources in new ways.

This environment is where research is needed most. Research will capture what we are learning in real time, how we have responded in individual circumstances, and, over the long term, what we can apply to be better prepared for events like this in the future. Even as we begin this research effort, however, the situation is changing. Areas that were hot spots 3 months ago are no longer the focus of today. Scientists are learning more about this virus and how it spreads every day. Research that is initiated now can take advantage of these immediate lessons learned.

Within this summary activity, the Transportation Research Board (TRB) is facilitating development of a high-level research agenda that can assist research funding agencies in prioritizing research activities and funding. The discussion that initiated this summary was correctly identified as a “brainstorming session,” where all ideas were on the table and participants were responding to what was top of mind. On April 29, 2020, the TRB held this online meeting to help identify potential issues that could be addressed in a research agenda for COVID-19–related transportation topics. In advance of the meeting, participants were given a list of discussion topic areas that would be followed to facilitate the conversation. These thought leaders identified the issues and challenges that are translated here into problem statements as the basis for prioritization and additional action.

Anticipated long-term changes throughout the country as a result of COVID-19 mean transportation issues are intertwined with broader societal needs, making difficult the separation of transportation needs from those of public health, emergency management, and the entire working population of the United States, most particularly, essential workers. The information that follows briefly identifies the approach used to synthesize the brainstorming information into individual problem statements with supporting information and an initial evaluation of the urgency of the research.

## Summary Approach

In preparation for the brainstorming session, TRB staff and volunteers developed a preliminary list of research topics. These topics have been used as an organizing framework for the summary. The topics are:

- A. Operations, Resilience, and Disaster Recovery;
- B. Supply Chain and Goods Movement;
- C. Changes in Demand, Transportation Planning, and Data;
- D. Social Justice, Access, and Mobility Equity;
- E. Effects on Economics, Revenues, and Costs (Including Stimulus);
- F. Governance and Roles During a Pandemic; and
- G. Public Health.

In addition to the brainstorming discussion detail, the TRB Research Needs Statements (RNS) Express, a survey instrument provided to the transportation community to contribute research ideas quickly and easily, was reviewed. See Table 1 for a comparison of RNS categories to the COVID-19 summary categories.

Because no direct relationship exists between all topic areas in these two categorizations, each RNS was considered independently and aligned with a COVID-19 summary category. The RNS provides strong support for the problem statements by illustrating the depth of information needed from the pandemic and the various ways in which that information can be useful. In considering the problem statement categories for future research, the individual RNS topics will provide a great deal of substance.

Problem statements generally represent a high-level explanation of the issue or need and are not mode-specific. Although the specific discussion of airports and marine ports was limited in the brainstorming session, many problem statements can be applied generally to these modes. In contrast, several of the RNSs apply only to airports, air travel, and ports. The RNS List presented at the end of the Appendix captures air and marine travel in a separate table.

**TABLE 1 Category Comparison Between Resources**

COVID-19 Summary	Research Needs Statements
Operations, resilience, and disaster recovery	Leadership and administration transportation system resilience
Supply chain and goods movement	Supply chain
Changes in demand, transportation planning, and data	Post-COVID-19 future system implications
Social justice, access, and mobility equity	Distributed throughout
Effects on economics, revenues, and costs	Distributed throughout
Governance and roles during a pandemic (including stimulus)	Leadership and administration
Public health	Transportation and health
Distributed throughout	Workforce; technology applications tracking data; reporting methods, and evaluations

Each topic covered in the brainstorming session produced a variety of research ideas. The additional sources reviewed, primarily from the RNS Express database, provided additional concepts, detail, and understanding for many of the brainstorming ideas. The topic categories of these two primary contributors to the summary were similar and therefore were cross-referenced and combined. It is important to note that while the brainstorming discussion may have occurred within one topic area, some research needs cross-cut multiple topics.

Staff at ICF Incorporated, LLC, provided subject matter expert review in several disciplines, namely emergency management, public health, and resiliency. The intent of this review was to identify where collaboration with these sectors might be beneficial for the transportation community and to include them based on mutual interests or the ability to share information and resources. The expert input has been incorporated into the relevant problem statements.

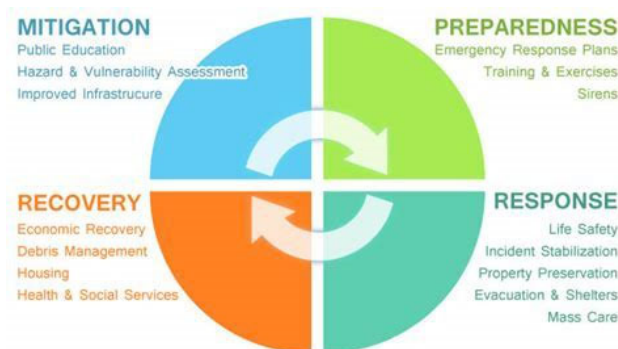


## Organization and Relationships

This report contains 38 problem statements to be considered as candidates for future research funding. Each problem statement is assigned to one primary category. Although individual problem statements often relate across more than one category, the category assignment is based on the category description provided by TRB staff to participants before the brainstorming session (even if the topic came up within a different category discussion during the brainstorming session).

As expected, there are crossover implications and supporting relationships to consider when developing each category of problem statements. To address this potential complexity, the summary approach was to categorize problem statements based on the primary relationship, using supporting documentation to identify other research needs or active research studies that might support the stated problem. Individual problem statements have the following structure.

- Category: corresponding to A through G.
- Objective/Purpose: short description of the purpose or intent of the research.
- Problem Statement Title: identifier.
- Description: more detailed description of the context or need.
- Research Questions: based on the description, initial questions that should be considered.
  - Relationship to Other Problems/Research: build on past or existing related research, as readily available, or associated problem statements and connections to other problem statement areas, if a logical sequence is present.
  - Outcome, Benefits, and Implementation: potential types of resulting products (e.g., research summary, case studies, guidebook, tool, or model) and benefits.
  - Urgency: based generally on the emergency management cycle as illustrated in Figure 1. Research needed during the COVID-19 pandemic response is identified as *immediate*. Research to address recovery is *short-term*, while research that addresses future changes needed such as developing plans and providing training is *mid-term*.



**FIGURE 1 Four phases of emergency management, Ottawa County, Michigan**  
([http://www.miottawa.org/Sheriff/emergency\\_management.htm](http://www.miottawa.org/Sheriff/emergency_management.htm)).

The information provided in Relationship to Other Problems/Research is based on an assessment of connections between the different problem statements, research knowledge, and a quick scan of the Transportation Research Information Database. Research topics within the last 2 years, or identified for future research, are identified if they relate strongly to a problem statement, but this is not a comprehensive list of other ongoing or planned research.

As a quick reference, each problem statement category is described in Table 2, along with a list of the individual problem statements in each category.

**TABLE 2 Categories and Problem Statements**

<b>Category A: Operations, Resilience, and Disaster Recovery</b>	
<b>What is included:</b> Planning for, responding to, and recovering from disruptions to the transportation system due to a pandemic or other emergency.	
<b>Problem Statement List</b>	
A.1	Ensuring the Health and Safety of Transportation System Operators and Others in the Transportation Workforce
A.2	Adjusting Transportation Services and Practices During Different Phases of a Pandemic to Maximize Safe, Efficient Access
A.3	Coordination and Collaborative Decision-Making During an Emergency to Respond to Rapidly Changing and Uncertain Situations
A.4	Approaches for Providing a Safe Environment for Transportation Passengers on Facilities that Serve Many People During a Pandemic and Recovery
A.5	Appropriate Ways of Applying Controls at Borders and Other Points of Entry
A.6	Handling Multiple Crises or Emergencies During a Pandemic
A.7	Creating a More Resilient Transportation System to Support Recovery and Preparation for Possible Future Pandemics
A.8	Applying Stress Tests to Transportation Agencies
<b>Category B: Supply Chain and Goods Movement</b>	
<b>What is included:</b> Impacts of supply chain disruptions. Effect of the pandemic on supply and demand for goods and implications of the post-pandemic economy on U.S. supply chains.	
<b>Problem Statement List</b>	
B.1	Maintaining an Open Supply Chain for Vital Goods and Products
B.2	Understand Cargo Fluidity as Non-Essential Businesses Shut Down
B.3	Alternative and Nontraditional Methods for Satisfying Product Demands During a Pandemic
B.4	The Role of Technologies Including Automation to Support More Resilient and Adaptable Goods Movement

*continued on next page*

**TABLE 2 (continued) Categories and Problem Statements**

Category C: Changes in Demand, Transportation Planning, and Data	
<b>What is included:</b> Short-term and long-term changes in passenger travel demand, trip patterns, and modal usage. Implications on transportation planning resulting from COVID-19 and the subsequent consequences.	
Problem Statement List	
C.1	Techniques for Planning in Uncertain Times
C.2	Understanding Factors That Influence Decisions to Resume Travel
C.3	Impacts of Short-Term and Long-Term Changes in Travel Behavior on Use of Public Transportation and Shared Mobility, as Well as Vehicle Ownership and Household Location Decisions
C.4	Impacts of Short-Term and Long-Term Changes in Long-Distance Leisure Travel and Business Travel
C.5	Understanding Ways to Make Desirable Behavior Changes Continue and Support Sustainable Travel Decisions
C.6	Using Better Data, Including Proprietary Data, for Near-Term and Long-Term Decision-Making
C.7	The Opportunities and Challenges Associated with Virtual Public Engagement in Transportation Decision-Making

Category D: Social Justice, Access, and Mobility Equity	
<b>What is included:</b> Ensure that essential transportation services are provided for low-income, transit-dependent, and other disadvantaged groups.	
Problem Statement List	
D.1	Addressing Disproportionate Share of Health, Economic, and Transportation Impacts For Lower-Income Households and Communities of Color
D.2	Shifts From Brick-And-Mortar Businesses to Home Delivery Services, Creating Challenges for Lower-Income and No-Car Households
D.3	Ensuring the Collection of Context-Specific Data, Particularly for Vulnerable Populations
D.4	Impacts on Transit Access and Mobility Post-Pandemic
D.5	Maintaining Transportation Services for People with Disabilities, Paratransit, and Other Service Needs During a Pandemic

Category E: Effects on Economics, Revenues, and Costs	
<b>What is included:</b> Economic impacts of COVID-19, including impacts on transportation agency costs and revenues; and the use of transportation system investments as an economic stimulus tool.	
Problem Statement List	
E.1	Impacts of the COVID-19 Pandemic on Transportation Revenues and Costs, Both Short Term and Long Term
E.2	Impacts of a Restructured Economy, Including Small Business Failures and Changes in Supply Chain, on Travel and Transportation Needs
E.3	Supporting Greater Resiliency in Private-Sector Partners with Less Dependency on Stimulus Funding
E.4	Understanding the Distribution of Economic Impacts Across Cities, Regions, States, and Countries
E.5	Benefits and Costs of Advancing Infrastructure Projects During a Pandemic

*continued on next page*

**TABLE 2 (continued) Categories and Problem Statements**

Category F: Governance and Roles During a Pandemic	
<b>What is included:</b> Roles and responsibilities of government agencies at all levels of government; communications among transportation officials and with other agencies; public involvement procedures and public interaction.	
Problem Statement List	
F.1	Effective Government Functions and Practices During the Pandemic
F.2	Understanding How the Complexity of Governmental Organizations Affects Ability to Respond to Complex Issues
F.3	Getting the Most Out of Economic Stimulus or Infrastructure Stimulus Packages

Category G: Public Health	
<b>What is included:</b> Roles various transportation and land use factors played in the spread of COVID-19; medical supply transportation issues and transportation for healthcare workers.	
Problem Statement List	
G.1	Understanding the Role of Transportation in the Spread of COVID-19 and What Could Be Done to Lessen that Role
G.2	Understanding the Role of Land Use Density in Relation to the Incidence of Infection, and Implications for Planning and Policy
G.3	Reconsider How Streets and Public Spaces Can Be Adapted to Facilitate Increased Biking and Walking
G.4 <sup>a</sup>	Engaging the Health Community in Protocols for Protecting Transportation Workers and System Users
G.5 <sup>a</sup>	Transportation Options for Essential Workers That Are Safe, Widely Available, and Where Cost Is Not a Factor
G.6 <sup>a</sup>	Recovery Phase: Providing Safe Access and Mobility During Pandemic Recovery

<sup>a</sup> These problem statements relate very closely to statements under Category A, and may be merged into those statements, rather than handled as stand-alone problem statements. However, these were called out due to specific relationships to health expertise and human behavior elements.

## Summary and Key Takeaways

The individual contributions from participants built upon one another and several themes emerged that were cross-cutting. These themes are offered as key takeaways to provide the context for the problem statements.

### **SAFETY**

Safety is always the first topic considered by transportation agencies, but in the pandemic safety is defined in a unique way that does not tie directly to our traditional concerns. Public health is the basis of safety in this context, and essential workers are the immediate concern. Providing safe travel options for those who are working and at risk during the pandemic, including transportation staff, is a primary responsibility of the transportation sector.

### **EQUITY**

The pandemic has brought into sharp focus the systemic inequities in our society and with which we have dealt ineffectively for many years. Brainstorming participants identified ways in which some responses would exacerbate some of these inequities. For example, technology is a key component to our response and will continue to enable us to move forward efficiently. However, technology is not universally available. We must identify the barriers that are embedded in proposed solutions, and overcome or at least work around them. The disproportionate impacts of the novel coronavirus on people of color is a fundamental lesson learned.

### **DATA**

It is essential to collect as much information, anecdotal or quantitative, on the behaviors, responses, challenges, and individual stories from the pandemic. Our traditional data sources will take years to catch up with the data from this crisis. We must find new ways to gather data—creative ways that require partnerships with private-sector companies that may only have been stakeholders previously. Collecting and warehousing this data for broad use is the first priority.

### **COLLABORATION**

From the first minutes of the brainstorming discussion, participants identified collaboration as a key support for these new ideas and approaches to problem solving. With individual states and even local areas working on independent problems, standard partnerships that had not been supported in an ongoing way did not prove as strong as expected or needed. The pandemic touches everything in our way of life. The problem statements illustrate the many connections to other sectors—health, emergency management, housing, education—where transportation has a role to support and be supported by actions that are necessary moving forward.

## **OPPORTUNITIES**

At the end of the session there was an eagerness to consider where the challenges we face as an industry may have a silver lining. There is so much to learn from this experience to inform our thinking in new ways. We are no longer defined or held back by the way things have always been. The pivot allows us to be creative, innovative, and advance things that may have seemed futuristic until now. Our underlying transportation decision-making processes are firmly established by law and regulation. This provides the foundation to launch from. By tackling the pandemic as a new dynamic that must be dealt with first as a discrete event and then, over time, as an influence on long-term decisions, we can return to doing business while adjusting to the new normal.

# Problem Statements

## Category A: Operations, Resilience, and Disaster Recovery

### Problem Statement A.1: Ensuring the Health and Safety of Transportation System Operators and Others in the Transportation Workforce<sup>a</sup>

#### *Objective/Purpose*

Identify effective practices to help ensure the health and safety of transportation system operators and the transportation workforce involved in construction, maintenance, and operations of the system.

#### *Description*

Transit operators, shared-mobility drivers, truck drivers making deliveries, roadside assistance operators, tow truck drivers, toll booth collectors, law enforcement, and first responders who address roadway crashes interact with the public who may be infected and therefore are at higher risk of contracting a virus during a pandemic. Beyond personal protective equipment (PPE), it is important to understand the range of issues faced, strategies that can be implemented, their effectiveness, costs, and implications. In some situations, such as emergency response, it is often required that people be in close proximity. While other transportation functions such as construction and maintenance may not interact directly with the public, employees typically work together in small teams or crews that may place workers at risk. Truck drivers need open rest stops or facilities to ensure their safe ability to travel. This research will focus on developing guidance on best practices to protect the safety of these employees.

#### *Research Questions*

- What are the risks/exposure possibilities for different transportation system functions (public and private sector, across all modes)?
- What are lessons learned in terms of what strategies are effective in keeping transportation employees safe during a pandemic? Are there different strategies that could be applied?
- What do transportation sector employees identify as important for their health and safety?
- What kinds of training, manuals, guidance, or communication are needed for employees in specific job types to support the effective implementation of strategies?
- To what extent are mental health and other employee supports needed for different types of roles, and in what ways are supports most effectively delivered?

#### *Relationship to Other Problems/Research*

- Clogston, F. TCRP Project F-26, “Improving the Health and Safety of Transit Workers with Corresponding Impacts on the Bottom Line.” <https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4293>.
- Puentes, R. *NCHRP Synthesis 543: Transportation Workforce Planning and Development Strategies*, 2019. <http://www.trb.org/Main/Blurbs/179878.aspx>.

#### *Outcome, Benefits, and Implementation*

- Guidance on effective practices for supporting the health and safety of the transportation workforce.

#### *Urgency*

- Immediate.

<sup>a</sup> This problem statement could be divided into separate projects addressing different types of worker needs across modes and functions (i.e., aviation crews, transit operators, truck drivers, construction/maintenance workers).

### Category A: Operations, Resilience, and Disaster Recovery

#### Problem Statement A.2: Adjusting Transportation Services and Practices During Different Phases of a Pandemic to Maximize Safe, Efficient Access<sup>a</sup>

##### *Objective/Purpose*

Identify effective practices for adjusting transportation services and practices to meet needs safely during different phases of a pandemic.

##### *Description*

Essential employees during a pandemic, as well as individuals requiring health care and other vital services, depend on transit to travel to and from work. At the same time, public transit agencies implement major reductions in service to reduce community spread and as demand dropped off significantly, making travel difficult for many frontline workers. This research would explore best practices for addressing decisions about the location, frequency, and hours for “lifeline services” during a pandemic, considering how users of services can travel safely, including options for providing substitute means of transportation when general services have been scaled back. This research would address effective practices for reorienting transit during a pandemic to focus on essential employees’ access, use of on-demand transit services, and options as a substitute for low-ridership routes, as well as essential services for truckers and other vital employees. Adjustments to service needs in ways that support efficient transit services and travel options during recovery as workers return to employment centers are also included.

##### *Research Questions*

- What are specific challenges that transportation options faced in the COVID-19 pandemic?
- What protocols, guidance, and/or training have assisted or may help in the future to maximize efficiency and minimize exposure?
- Is there a Business Continuity Plan or Continuity of Operations Plan that can be adapted to this risk? If not, what immediate steps are necessary to develop this?
- What actions can be taken now to make these systems more resilient in the future?
  - Will these strategies also help prepare for other risks to the transportation system?
  - What are the co-benefits, disbenefits, and costs to these strategies?
  - Do the strategies apply broadly and equitably to transportation users?

##### *Relationship to Other Problems/Research*

- Fletcher, K. NCHRP Project 20-59(44), “A Guide for Public Transportation Pandemic Planning and Response,” 2013. <https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3082>.

##### *Outcome, Benefits, and Implementation*

- Data from COVID-19 pandemic on changes to transportation services and needs during the pandemic.
- Case studies on the effectiveness of actions different agencies, states, or cities have implemented in regard to service changes and how to address needs for vital workers.

##### *Urgency*

- Immediate.

<sup>a</sup> Similar issues occur with other modes, such as when rest stops were closed, creating challenges for truck drivers. This problem statement could be divided into separate projects addressing modes such as transit and trucking.



### Category A: Operations, Resilience, and Disaster Recovery

#### Problem Statement A.3: Coordination and Collaborative Decision-Making During an Emergency to Respond to Rapidly Changing and Uncertain Situations

##### *Objective/Purpose*

Identify effective approaches to enhance coordination and collaborative decision-making among agencies during an emergency, in particular in response to rapidly changing travel demands and conditions in an environment with high levels of uncertainty.

##### *Description*

The COVID-19 pandemic showed the importance of communication and collaboration between agencies/cities around the country. Although transportation decision-making typically relies on a foundation of national leadership with the flexibility to respond uniquely in individual states, during the pandemic various cities and states have handled the pandemic differently based on the context within their geographies. Communication—across different levels of government (national, state, local), jurisdictions, modes of transportation, and across different functions (transportation, health, emergency response)—in developing effective plans is particularly critical in situations such as a pandemic during which radical changes in demand (e.g., immediate shelter-in-place) and critical needs on the transportation network may occur within a context of a high level of uncertainty and lack of data. At this point in the COVID-19 pandemic, lessons learned and best practices can be documented in order to support establishing procedures and guidance to help individual agencies communicate better even in a changed situation with future pandemics or emergencies with rapidly evolving conditions and limited data.

##### *Research Questions*

- Has a communication plan been established for use in a pandemic? What communication platforms are in place and broadly used for virtual collaboration?
- What have individual agencies done to enhance and support communication during the COVID-19 pandemic that may be broadly applicable?
- When relevant data is limited, what protocols can help support decision-making? Are roles and ongoing communication channels established outside of a pandemic helpful during the pandemic?
- What partnerships can be established or strengthened now to prepare for the future, including nontraditional partnerships that can represent community needs, specifically those of disadvantaged populations? Are there tools or methods that enhance this communication? Include qualitative approaches as well.

##### *Relationship to Other Problems/Research*

- This research can build on past research focused on enhancing system management and operations, emergency management, and effective decision-making.
- This problem statement is closely related to issues related to border crossings (A.5) and governance problem statements.

##### *Outcome, Benefits, and Implementation*

- Innovative or adaptive approaches to new and unexpected challenges.
- Better coordination may help prevent the spread of COVID-19 and help prepare for future crises.

##### *Urgency*

- Immediate.

**Category A: Operations, Resilience, and Disaster Recovery**

**Problem Statement A.4: Approaches for Providing a Safe Environment for Transportation Passengers on Facilities that Serve Many People During a Pandemic and Recovery**

***Objective/Purpose***

Define effective near-term ways to make public transit, intercity rail, transit–rail–airport terminals, and other transportation facilities that serve many people safer for essential workers and other customers; also consider shared-use options, including carpools, vanpools, on-demand ride services, and micromobility options.

***Description***

During the COVID-19 pandemic the need to social distance, use PPE and maintain a germ-free environment has resulted in less use of public transit or other shared transportation options by those with a personal vehicle, as well as a significant reduction in air travel and intercity rail. Those who depend on transit and shared options for essential jobs often do so at personal risk. And there is a desire during recovery to open up other types of facilities, such as rail stations, airports, and other facilities that serve many people in crowded conditions. This research would focus on best practices for keeping vehicles used for transporting multiple customers sanitary, including cleaning processes/frequencies for vehicles, and assess the costs of doing so. In addition to vehicles, it would consider changes to operations at terminals and stations, such as increasing automated ticketing and check-in, use of temperature sensors at check points, reducing touch points and increasing sanitation, and reducing funneling of people at one time into a limited number of entrances and exits. It would also address operating practices, such as social distancing guidelines and the effectiveness of different communications practices.

***Research Questions***

- What are the specific issues with transportation options that carry multiple riders (public transit, ride share, rail) that must be considered?
- What examples of actions taken during the COVID-19 pandemic offer lessons learned, both positive and negative?
- What public health information and/or operational approaches can help address this problem?
- What is the realistic role of PPE, cleaning, and training in addressing this problem? What supply and demand planning has been initiated? What are the means to get resources such as PPE to those in need?
- When solutions are identified, what is the most effective means to communicate the safety of public transit options?

***Relationship to Other Problems/Research***

- NCHRP Project 20-128, “Emergency Response: Organizational and Operational Models Used by State DOTs.” <https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4773>.

***Outcome, Benefits, and Implementation***

- Potential to bring customers back to public transit, shared mobility, and other options if considered safe and reliable.

***Urgency***

- Immediate.

### Category A: Operations, Resilience, and Disaster Recovery

#### Problem Statement A.5: Appropriate Ways of Applying Controls At Borders and Other Points of Entry

##### *Objective/Purpose*

Identify ways to control or direct state border crossings, and other points of entry, such as airports and rail, during a pandemic due to differing state responses. This research could also address national border crossings with Canada and Mexico and via aviation.

##### *Description*

States, and some cities and counties, have developed individual responses to movement of people and goods during the pandemic. Some states have implemented quarantine requirements for people coming from hot spot areas. While entry can more easily be identified via air and rail due to ticketing and screening procedures, the strategies and controls available for on-road travel are less well defined. Individual transportation agencies may have specific protocols that are not coordinated with surrounding states, making travel confusing at border crossings.

##### *Research Questions*

- What experiences during COVID-19 have been documented by transportation agencies concerning border crossings and points of entry?
- Are there some universal practices, best practices, or unsuccessful practices to build upon or learn from?
- Is it practical or desirable to implement a more unified response by states during a pandemic?
- What internal agency groups and external partners should be involved in these decisions?
- What disaster recovery, resiliency, or traffic operations strategies may be useful to consider?
- Is there a meaningful way to test options such as scenario planning, tabletop exercises, other options?

##### *Relationship to Other Problems/Research*

- This research can build on lessons learned from other hazards, as well as data being gathered. For instance, the American Transportation Research Institute (ATRI) vehicle probe data set can show how the movement of shipments across state lines has changed or to pinpoint changes geographically.

##### *Outcome, Benefits, and Implementation*

- Case studies that illustrate the effectiveness of controlling state borders can help identify options for individual states.
- Guidance, standard operating procedures, or other documented protocols can provide a quick response until more data becomes available.

##### *Urgency*

- Immediate.

### Category A: Operations, Resilience, and Disaster Recovery

#### Problem Statement A.6: Handling Multiple Crises or Emergencies During a Pandemic

##### *Objective/Purpose*

Provide guidance for transportation agencies on how to prepare for and address different types of emergency events (e.g., wildfires, snowstorms, hurricanes, power system failures) during a health pandemic.

##### *Description*

The COVID-19 pandemic is a unique event that has raised awareness on a global scale of what crisis means. However, some areas have ongoing threats such as hurricanes, wildfires, or other natural events that require mobilization of the emergency management community. It is not unreasonable to consider that manmade or natural disasters, severe weather, or other emergency events will occur during the pandemic or recovery phases, and could require responses that are handled in very different ways than traditional emergency response. Climate changes make these types of events increasingly more likely going into the future. Preparation for multiple hazard threats will help agencies be better prepared and make the transportation system more resilient.

##### *Research Questions*

- What can the emergency management community contribute to understanding a multi-hazard response?
- What areas are prone to specific hazards now and anticipated in the future?
- What are unique issues associated with response during a pandemic (e.g., challenges with evacuating masses of people, crowd control at rest facilities, maintenance of distancing between people)?
- What are the anticipated impacts of a pandemic plus other events?
- What preparations can be made to address this occurrence?

##### *Relationship to Other Problems/Research*

- This research can build on ongoing research related to climate resilience and severe weather. For the most recent information on future hazards through climate science (see *Fourth National Climate Assessment, Volume II: Impact, Risks, and Adaptation in the United States*).
- This research can also build on research related to emergency management and transportation. One recent study is published in *NCHRP Research Report 931: A Guide to Emergency Management at State Transportation Agencies*, 2019, <https://www.nap.edu/catalog/25557/a-guide-to-emergency-management-at-state-transportation-agencies>.

##### *Outcome, Benefits, and Implementation*

- Guidebook on successful practices used in dealing with other crises during a pandemic.
- Standard procedures, guidance, and training for individual and collective events.

##### *Urgency*

- Near-term.

### Category A: Operations, Resilience, and Disaster Recovery

#### Problem Statement A.7: Creating a More Resilient Transportation System to Support Recovery and Preparation for Possible Future Pandemics

##### *Objective/Purpose*

Going beyond immediate responses, provide information on changes to transportation infrastructure design, technology, and operations to support recovery and preparation for possible future pandemics.

##### *Description*

Beyond immediate changes to transportation service operations, explore possible longer-term changes to transportation infrastructure, such as design of transit and rail stations, and use of automation and other technology, such as automated transit vehicles, flexible transit services, and other innovations that provide benefits, and are adaptable for evolving situations, particularly as related to health concerns. This research could address both passenger and freight travel.

##### *Research Questions*

- What are the roles for autonomous transit or autonomous shared-mobility vehicles during a pandemic and for their deployment as part of future transportation system operations?
- What are the roles and opportunities for automated trucks and delivery vehicles to support goods movement during a pandemic and to support efficient freight movement?
- Should changes be made in terminal design (i.e., transit and rail stations and airports that serve many people in crowded conditions)? How would these changes relate to other aspects of system resiliency, such as in relation to other types of disasters?

##### *Relationship to Other Problems/Research*

- This research could build on the more immediate/near-term strategies covered under A.4.
- This research could build on significant work being conducted exploring automation in transportation, use of big data, and artificial intelligence.

##### *Outcome, Benefits, and Implementation*

- Information on possible technology, policy, and investment needs to strengthen transportation resiliency to support recovery and possible future pandemics.

##### *Urgency*

- Mid-term.

**Category A: Operations, Resilience, and Disaster Recovery**

**Problem Statement A.8: Applying Stress Tests to Transportation Agencies**

***Objective/Purpose***

Consider the appropriateness of testing transportation agency capacity to respond to disruptive scenarios, particularly in relation to financial resilience. If appropriate, identify an approach that might apply to all state DOTs.

***Description***

After the Great Recession of 2009, banks had to perform stress tests to analyze their capacity to survive disruption scenarios and make explicit decisions in terms of financial reserves and plans to try to address the issues identified. A similar type of test may be helpful for transportation agencies and organizations to understand their capacity to survive disruption scenarios, particularly in relation to future financial situations.

***Research Questions***

- What is the reasonableness of testing state DOTs and potentially partner organizations on preparedness for another pandemic or other disruption scenario? How likely are decision-makers to support such testing, either uniformly or on a widespread basis?
- Who would conduct the assessment? Is this a federal government action or a state DOT internal evaluation?
- What are the potential benefits?
- What partners and stakeholders should participate?
- What reporting or follow-on actions are meaningful to consider?

***Relationship to Other Problems/Research***

- This problem statement relates closely to Category E: Effects on Economics, Revenues, and Costs (Including Stimulus).
- This problem statement may relate to research on risk and capability maturity assessment, as well as testing continuity of operations or continuity of business planning.

***Outcome, Benefits, and Implementation***

- Identification of agency areas of weakness that may present a risk in certain circumstances.
- Identification of the similarities and unique qualities of these risks.

***Urgency***

- Mid-term.

## Category B: Supply Chain and Goods Movement

### Problem Statement B.1: Maintaining an Open Supply Chain for Vital Goods and Products

#### *Objective/Purpose*

Identify actions needed to prevent or lessen disruptions to the U.S. supply chain for vital goods as experienced during the COVID-19 pandemic. Consider actions that will prepare for any disruption during a future pandemic.

#### *Description*

The COVID-19 pandemic resulted in shortages of key products such as paper products, cleaning products, and some food products. Using data (as identified) from the COVID-19 pandemic, compare to pre-pandemic goods movement data, and identify where actions can be taken before or during a future pandemic to reduce disruptions. COVID-19 has illustrated in many cases the sub-industry level is important. For instance, with food, there was one supply chain for restaurants and another for groceries. These were completely different. Disruption of the supply chains from China and other countries for critical medical supplies has highlighted the need for more domestic sourcing of protective gear and other critical supplies. Understanding the dependence of public health authorities on supplies that are sourced internationally has become important. This study would collect data to provide an understanding of the supply chain interruptions, adaptations, successes, and failures during the COVID-19 pandemic.

#### *Research Questions*

- What have been the supply chain disruptions associated with the COVID-19 pandemic? What are the specific products and supply chain streams that have been most directly affected?
- How do international supply chains make the United States more or less resilient?
- What data exists at the appropriate level(s) for comparison? What recent studies of pre-pandemic goods movement are available as a logical comparison?
- How can these supply chains be made more resilient? What is the role of national and state policies (e.g., emphasis on U.S. manufacturing, move to electronic documentation)?

#### *Relationship to Other Problems/Research*

- This research can build on the Federal Highway Administration's (FHWA's) Freight Mobility Indicators tableau dashboard for reductions in traffic that have affected mobility of freight and the ATRI vehicle probe dataset that can show how the movement of shipments across state lines has changed.
- Recent research includes:
  - Meyer, M. D., et al. *NCFRP Research Report 39: Freight Transportation Resilience in Response to Supply Chain Disruptions*, 2019. <https://trid.trb.org/view/1606510>.
  - Christopher, M. *The Mitigation of Risk in Resilient Supply Chains*. International Transport Forum, 2018. <https://trid.trb.org/view/1574863>.
  - NCHRP Project 08-134, "Integrating Freight Movement into 21st Century Communities' Land Use, Design, and Transportation Systems." <https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4746>.

#### *Outcome, Benefits, and Implementation*

- Identify ways to make the U.S. freight system more resilient to disruptions. Identify how federal, state, or local agency actions can assist with responding.

#### *Urgency*

- Immediate (data), mid-term (implications).

### Category B: Supply Chain and Goods Movement

#### Problem Statement B.2: Understand Cargo Fluidity as Non-Essential Businesses Shut Down

##### *Objective/Purpose*

Understand issues related to storing cargo in the face of reduced or adjusted demand in response to a pandemic.

##### *Description*

The United States has been seeing a very real concern on the part of port authorities and intermodal terminals about where to put incoming cargo. As non-essential businesses and warehouses closed, they were not taking delivery of cargo, and retailers and manufacturers who faced a sudden drop in demand were not anxious to take possession of the cargo. Furthermore, because less cargo was moving inland, exporters in the middle of the country who needed chassis and containers to be able to ship their cargoes were not able to get the equipment they needed. Differences among states in defining essential businesses also made it difficult to manage the supply chain.

##### *Research Questions*

- What is considered “essential” in terms of maintaining the fluidity of the supply chain?
- What can state and local governments do to enable ports to handle containers and other cargo in excess of their handling and storage capacities?

##### *Relationship to Other Problems/Research*

- This research supports B.3: *Alternative and Nontraditional Methods for Satisfying Product Demands During a Pandemic*. This research can build on information from the Federal Motor Carrier Safety Administration (FMCSA) and American Trucking Association, and port operators.
- Future FHWA guidebook, *Emergency Routing of Interstate Vehicles*, for emergency managers and fleet operators in moving vehicles across state lines in the event of an emergency.
- Azad, N., and E. Hassini. A Benders Decomposition Method for Designing Reliable Supply Chain Networks Accounting for Multimitigation Strategies and Demand Losses. *Transportation Science*, Vol. 53, No. 5, 2019, pp. 1287–1312. <https://trid.trb.org/view/1653006>.

##### *Outcome, Benefits, and Implementation*

- Reduce future disruptions to the supply chain based on a better understanding of the issues associated with cargo fluidity.

##### *Urgency*

- Mid-term.



### Category B: Supply Chain and Goods Movement

#### Problem Statement B.3: Alternative and Nontraditional Methods for Satisfying Products Demands During a Pandemic

##### **Objective/Purpose**

Identify innovative approaches to meet unanticipated demand for essential goods and products due to a pandemic.

##### **Description**

The COVID-19 pandemic has impacted both supply and demand. Increases in online ordering have created challenges for distribution centers and last-mile delivery services. To effectively provide typical goods and services and meet new demands that have developed from the pandemic, alternative methods and resources need to be considered. Identifying these alternatives will help decision-makers plan for a more resilient supply chain in case of future crises. For instance, leveraging big data for routing and rerouting could be applied. This research would also address near-term changes in policies that could help to support rapid changes in demand or needs for vital products. For instance, the FMCSA published an emergency declaration to waive hours of service requirements for the transportation of essential supplies during specific periods of the COVID-19 pandemic.

##### **Research Questions**

- What are alternative methods of meeting demand for essential goods and services?
- What experience from the COVID-19 pandemic is relevant and informative? For example, fleet operators have had difficulty understanding the waivers that have been issued by different agencies and states.

##### **Relationship to Other Problems/Research**

- This research builds on B.2: *Understand Cargo Fluidity as Non-Essential Businesses Shut Down*. This research can build on information from the FMCSA and American Trucking Association.
- Future FHWA guidebook, *Emergency Routing of Interstate Vehicles*, for emergency managers and fleet operators in moving vehicles across state lines in the event of an emergency.
- Azad, N., and E. Hassini. A Benders Decomposition Method for Designing Reliable Supply Chain Networks Accounting for Multimitigation Strategies and Demand Losses. *Transportation Science*, Vol. 53, No. 5, 2019, pp. 1287–1312. <https://trid.trb.org/view/1653006>.

##### **Outcome, Benefits, and Implementation**

- Identification of innovative methods.

##### **Urgency**

- Mid-term.

### Category B: Supply Chain and Goods Movement

#### Problem Statement B.4: The Role of Technologies Including Automation to Support More Resilient and Adaptable Goods Movement.

##### *Objective/Purpose*

Identify the role of technologies, such as autonomous trucks and delivery vehicles, robotics, and machine learning to support more resilient freight–goods movement. Determine the impacts, vulnerabilities, and opportunities for these technologies in global logistics, commercial shipping, and local deliveries.

##### *Description*

The rapid increase in demand for contactless home delivery of products is likely to continue to increase the amount of goods and products, including groceries, that the public receives directly at home, resulting in changes in shipment needs. This study would explore a wide variety of technologies across the entire supply chain to support more efficient and direct delivery of goods. It would explore the potential impacts and vulnerabilities of increased automation and use of robotics and unmanned aerial systems in global logistics, commercial shipping, and local deliveries. In an urban–suburban context, it would examine ways to operate small automated delivery vehicles on existing rights of way to efficiently move goods. It also could explore broader questions such as how to best leverage significant advances in affordable, powerful, and compatible large-scale distributed computing, distributed networks, and intelligent and reasoning systems in the context of supply chain optimization.

##### *Research Questions*

- What are the opportunities for increased and improved use of automated delivery and other technologies within the supply chain? What are the risks?
- What policies or practices would support application of technologies, including issues related to right-of-way use, loading and unloading, and safety?

##### *Relationship to Other Problems/Research*

- This research builds on research focusing on automation in transportation and emerging technologies.

##### *Outcome, Benefits, and Implementation*

- Identification of key technology applications and associated policy needs to enhance the resiliency of goods movement and to meet increasing demand for home delivery.

##### *Urgency*

- Mid-term.

<b>Category C: Changes in Demand, Transportation Planning, and Data</b>
<b>Problem Statement C.1: Techniques for Planning in Uncertain Times</b>
<p><b><i>Objective/Purpose</i></b> Identify how planning decisions change in times of uncertainty, including methods that can be used when planning within the context of high levels of uncertainty regarding travel demands and needs in the near term and long term.</p> <p><b><i>Description</i></b> The COVID-19 pandemic has created a tremendous amount of uncertainty in regard to transportation planning, investment decision-making, and policy. There are both high levels of uncertainty regarding near-term transportation needs based on changes in demand due to stay-at-home orders and reduced demand, as well as long-term transportation needs based on continuing effects on the economy and patterns of travel including potential long-term implications of increased telework and e-commerce. This uncertainty raises questions about the needs for different types of transportation projects across all modes, how to prioritize projects, and what policies are needed regarding capacity across modes and parking. This research will explore possible planning approaches that work within a context of sustained uncertainty.</p> <p><b><i>Research Questions</i></b></p> <ul style="list-style-type: none"> <li>• How can approaches such as scenario planning, assumption-based planning, and dynamic adaptive pathways support planning during uncertainty?</li> <li>• What data and information are available to support these methods?</li> <li>• What examples can be used and shared with the transportation planning community?</li> <li>• What methods have been used in emergency management planning?</li> <li>• What partners and stakeholders should be engaged?</li> </ul> <p><b><i>Relationship to Other Problems/Research</i></b></p> <ul style="list-style-type: none"> <li>• This research can build on recent work focused on scenario planning for automated and connected vehicles and other technologies, as well as research on scenario-based modeling tools.</li> </ul> <p><b><i>Outcome, Benefits, and Implementation</i></b></p> <ul style="list-style-type: none"> <li>• Guidance and training materials to help transportation agencies understand and apply approaches that better account for uncertainty and risk in decision-making.</li> </ul> <p><b><i>Urgency</i></b></p> <ul style="list-style-type: none"> <li>• Short-term.</li> </ul>

**Category C: Changes in Demand, Transportation Planning, and Data**

**Problem Statement C.2: Understanding Factors That Influence Decisions to Resume Travel**

***Objective/Purpose***

Document the causes of changing travel behavior during the pandemic and the factors that influence decisions to resume travel.

***Description***

The COVID-19 pandemic has influenced travel behavior significantly in the near term and may have long-term implications as well. People have been traveling less due to stay-at-home orders, office closures, school closures, closures of theme parks and recreational and entertainment venues, and concerns about social distancing, etc. To better understand how transportation agencies should be planning, it is important to understand the true causes of changing travel behavior and whether they will continue in the long term. It is also important to understand what factors play a role in decisions to resume travel after the pandemic, and how opening up different kinds of businesses and services will affect travel. This information will be important to assist with adjustment of road construction times, traffic signal coordination, and other operations needs, and could help ascertain patterns and expectations that could be utilized in future crises or pandemics.

***Research Questions***

- What factors influence travel behavior during a pandemic or emergency?
- How do employers, schools, and business operations influence travel decisions?
- What other societal factors (e.g., health messages, public communications, community perceptions) influence travel behavior during a pandemic or emergency?
- What can we learn about the most effective ways to reduce community transmission while enabling economic activity to resume?

***Relationship to Other Problems/Research***

- This research relates to research focused on public health behaviors and economic impacts.

***Outcome, Benefits, and Implementation***

- Guidance to support communities in supporting behaviors that reduce community transmission of a virus or pathogen.

***Urgency***

- Immediate.

<b>Category C: Changes in Demand, Transportation Planning, and Data</b>
<b>Problem Statement C.3: Impacts of Short-Term and Long-Term Changes in Travel Behavior on Use of Public Transportation and Shared Mobility, as Well As Vehicle Ownership and Household Location Decisions</b>
<p><b><i>Objective/Purpose</i></b></p> <p>To understand the impact of short-term and long-term changes in household behavior regarding travel, use of public transportation, shared mobility, and personal vehicle use, as well as changes to consumer behavior, such as decisions about vehicle ownership and household location.</p> <p><b><i>Description</i></b></p> <p>The COVID-19 pandemic has changed the characteristics of personal travel. There has been a reduction in travel demand due to stay-at-home orders and social distancing. Fewer people are commuting to work, and more people are walking and biking. In the long term, there may be a shift to teleworking and remote learning. Shift in modes choice is also possible as people try to avoid options such as public transit and shared vehicles. Other things to consider could be changes in household behaviors, such as decisions about vehicle ownership and household location decisions (e.g., urban, suburban locations). These nontransportation decisions likely will have important implications on travel choices and decisions, specifically in relation to transit use. This research may involve surveys or other information to assess public perceptions and expectations regarding travel. Understanding the impacts these changes will have on travel is important for agencies to plan and prepare.</p> <p><b><i>Research Questions</i></b></p> <ul style="list-style-type: none"> <li>• What data are available to illustrate travel behavior changes during the COVID-19 pandemic?</li> <li>• What do short-term changes in travel volume and usage imply for the long term? What other factors will influence long-term potential changes in the amount of trip-making (i.e., more telework, e-commerce, and e-learning) and in mode choices (i.e., use of transit, ridesharing, bicycling, and walking)?</li> <li>• Will attitudes toward social distancing carry over after the pandemic, and what does that portend for public attitudes toward the use of rail and bus mass transit? How is the use of shared-ride services offered by ride-hailing companies likely to change? In the long-term, how it is likely to affect attitude toward automated services that would operate without a driver?</li> <li>• What do these changes imply in terms of possible future needs for transportation investments and policies? What changes in both funding and service may be needed to meet new market demand, specifically in relation to transit?</li> </ul> <p><b><i>Relationship to Other Problems/Research</i></b></p> <ul style="list-style-type: none"> <li>• This problem statement is related to C.1: <i>Techniques for Planning in Uncertain Times</i> but is intended to develop more specific information on likely travel pattern changes, potentially for different regions or contexts.</li> </ul> <p><b><i>Outcome, Benefits, and Implementation</i></b></p> <ul style="list-style-type: none"> <li>• New data to help assess changes in travel, and likely implications in terms of travel demand and future investment and policy needs.</li> </ul> <p><b><i>Urgency</i></b></p> <ul style="list-style-type: none"> <li>• Short-term.</li> </ul>

**Category C: Changes in Demand, Transportation Planning, and Data**

**Problem Statement C.4: Impacts of Short-Term and Long-Term Changes in Long-Distance Leisure Travel and Business Travel**

***Objective/Purpose***

To understand the impact of short-term and long-term changes in long-distance leisure travel and business travel demand.

***Description***

COVID-19 has temporarily disrupted long-haul passenger travel demand, both for leisure and business travel. There are questions about how much of the long-haul demand loss will be permanent, particularly for business travel, as businesses become more accustomed to holding meetings online rather than in person. A reduction in demand would have near-term and potentially long-term impacts across modes of long-distance travel, including aviation and intercity rail. Moreover, changes in demand could have ripple effects across the economy in the hospitality business, including effects on hotels, rental car industries, convention centers, and their associated impacts on businesses in their vicinity, as well as transportation systems in cities and recreational sites. This study would involve surveys or other information gathering to assess public and business expectations regarding travel, as well as analysis to understand the potential direct and indirect impacts (e.g., businesses closing in some locations). Understanding impacts these changes will have on travel is important for agencies to plan and prepare.

***Research Questions***

- What data are available to illustrate travel behavior changes during the COVID-19 pandemic?
- What do short-term changes in travel volume and usage imply for the long term? What factors will influence long-term potential changes in long-haul leisure and business travel? What are potential implications in different locations, such as major cities and recreational and tourist locations?
- What are potential implications on demand for transit, taxis, shared-mobility vehicles, and parking needs, etc.? What do these changes imply in terms of possible future needs for transportation investments and policies?

***Relationship to Other Problems/Research***

- This problem statement is related to [C.1: Techniques for Planning in Uncertain Times](#) but is intended to develop more specific information on likely travel pattern changes, potentially for different regions or contexts.

***Outcome, Benefits, and Implementation***

- New data to help assess changes in travel, and likely implications in terms of travel demand and future investment and policy needs.

***Urgency***

- Short-term.

### Category C: Changes in Demand, Transportation Planning, and Data

#### Problem Statement C.5: Understanding Ways to Make Desirable Behavior Changes Continue and Support Sustainable Travel Decisions

##### *Objective/Purpose*

Understand the extent to which behaviors developed due to the pandemic will remain and determine the extent to which policies and incentives can be created to encourage desirable behaviors' continuation. Specifically, determine ways to sustain behavioral changes that have resulted in reductions in greenhouse gas (GHG) emissions and air quality improvements.

##### *Description*

The COVID-19 pandemic has influenced the behaviors of people and businesses in ways that have in the near-term contributed to substantial reductions in GHG emissions and improved air quality. However, past experience with travel changes based on gas prices has shown that changes in behavior might be short-term (i.e., end when people have greater ability to travel) and may not be long-lasting with the reopening of non-essential businesses. However, even with businesses reopening, reduced vehicle trip-making may continue due to telework, telemedicine, and remote learning, and there could be significant benefits to transportation system performance and sustainability. Moreover, there has been an increase in bicycling and walking activity in many places, which has benefits for public health and sustainability. At the same time, there is a potential for personal vehicle travel to increase due to concerns about transit and shared rides. This study would focus on how to best support the positive impacts of changes in travel behavior, including consideration of policies and incentives that may be helpful in promoting the continuation of desirable pandemic-associated behaviors.

##### *Research Questions*

- To what extent are pandemic-associated behaviors likely to continue? Will there be a direct return to pre-pandemic behaviors or a “new normal?”
- What approaches may help sustain the reductions in vehicle travel, reductions in GHG emissions, and improvements to air quality post-pandemic? What transportation or societal policies (e.g., those of the business community) and incentives and disincentives may be appropriate in order to make the desirable behaviors continue?
- How should these policies/incentives be implemented or communicated?
- What might be the unintended consequences of these policies and continued travel behaviors (e.g., increased social isolation, loss of local businesses supporting business districts, loss of transit ridership), and what are the best approaches to support overall societal benefits?

##### *Relationship to Other Problems/Research*

- This research can build on past research on telework, shared mobility, and bicycling and walking.

##### *Outcome, Benefits, and Implementation*

- Guidance on policies or incentives that can be used to continue desirable behaviors.

##### *Urgency*

- Mid-term.

### Category C: Changes in Demand, Transportation Planning, and Data

#### Problem Statement C.6: Using Better Data, Including Proprietary Data, for Near-Term and Long-Term Decision-Making

##### *Objective/Purpose*

Determine how proprietary data may be more broadly accessible for planning within a pandemic and during recovery stages. Identify private-sector partners that may be willing to support this data sharing, while reconciling the need for better data with privacy concerns.

##### *Description*

Data plays an important role in understanding the effects and impacts of the COVID-19 pandemic. The private sector collects significant amounts of data that can be useful in understanding these impacts and effects on the transportation system. Transportation practitioners are purchasing data in many instances for planning purposes, but the cost of additional data during an economic crisis can be prohibitive. It is important to work with the private sector to encourage effective use of proprietary data and determine how to achieve a return on investment for the private sector in different ways. Some non-transportation data, such as information on online purchases of different products could also be helpful to develop leading indicators that could help to inform future transportation system demands, or needs. At the same time, vast use of data on the public's movement, purchasing decisions, online meetings, etc., may have privacy implications.

##### *Research Questions*

- What proprietary data is considered highly useful in pandemic planning? Who owns this data?
- What can the private sector gain by making proprietary data more broadly available?
- Is this a legitimate use of stimulus or other special funding?
- How can we reconcile the need for better data with privacy concerns? What data collection methods are available that allow for privacy while providing the most insights into likely travel behavior decisions and transportation system needs?

##### *Relationship to Other Problems/Research*

- This research can build on significant recent research related to big data and its applications as a leading indicator of trends.

##### *Outcome, Benefits, and Implementation*

- Efficient and effective use of data allows for a better understanding of COVID-19 impacts and to prepare for changes in travel demands and needs.

##### *Urgency*

- Short-term.



### Category C: Changes in Demand, Transportation Planning, and Data

#### Problem Statement C.7: The Opportunities and Challenges Associated with Virtual Public Engagement in Transportation Decision-Making

##### *Objective/Purpose*

Develop guidance to support virtual engagement of the public in transportation decision-making, considering effective practices to more broadly engage the public and recognize potential disparities in access to virtual engagement opportunities.

##### *Description*

Due to the stay-at-home orders and social distancing guidelines, many of the public hearings and meetings for transportation plans, projects, and policy discussions have shifted to online formats. These changes often required emergency authorizations to allow public meetings to be held via video conference, given requirements associated with publicly open meetings. The shift to virtual meetings offers both opportunities and challenges for transportation agencies. While online meetings can provide easy access for the public to view and participate in public decision-making, it may not be equitable and can be problematic for those in rural, low-income, and limited-English-proficiency communities, as well as the elderly or persons with disabilities. This research could delve into the data to inventory areas and communities with limited high-speed internet access and those where households need to share computers or do not have smartphones to understand where online participation is not possible or is challenging. It would identify best practices for engaging different communities online and identify public involvement tools and approaches that can serve as alternatives to online participation to provide equitable access.

##### *Research Questions*

- What online public engagement techniques are effective in engaging different audiences? What are best practices for their application?
- What communities have limited access to online engagement? And what public involvement tools and approaches can serve as effective alternatives?

##### *Relationship to Other Problems/Research*

- This research can build on significant recent research related to virtual public involvement, including the FHWA's Every Day Counts Initiative.
- This research is closely related to [Category D: Social Justice, Access, and Mobility Equity](#).

##### *Outcome, Benefits, and Implementation*

- Efficient and effective use of online techniques to engage the transportation community equitably.

##### *Urgency*

- Short-term.

<b>Category D: Social Justice, Access, and Mobility Equity</b>
<b>Problem Statement D.1: Addressing Disproportionate Share of Health, Economic, and Transportation Impacts for Lower-Income Households and Communities of Color</b>
<p><b><i>Objective/Purpose</i></b></p> <p>Examine the disproportionate share of COVID-19 impacts in lower-income households and communities of color, particularly in relation to transportation needs. Identify how to effectively address these needs during the pandemic, including balancing the supply of transit for essential workers when there is reduced overall transit demand.</p> <p><b><i>Description</i></b></p> <p>It is well documented that minority and low-income populations have had a significantly higher incidence of COVID-19 than other groups. Low-income households and communities of color represent a higher portion of frontline workers in grocery stores, healthcare providers, meat-processing industries, and other service industries where workers do not have the option for working from home. At the same time, many of these workers are transit-dependent, and may face challenges accessing their jobs, as well as vital needs such as access to food, due to cuts in transit service. Although the COVID-19 pandemic has caused a notable decrease in transit ridership and service, essential workers and those with limited transportation options will continue to need public transit for some travel. While ensuring that transit is available during a pandemic, agencies must identify reasonable levels of service and how to adjust from the typical service in a specific area. As a result, these groups are experiencing a disproportionate share of the impacts. This research would address ways for transportation agencies, service providers, and policy-makers to help address needs during the pandemic and into the future.</p> <p><b><i>Research Questions</i></b></p> <ul style="list-style-type: none"> <li>• What additional information can public health partners provide to better understand the disproportionate impacts on low-income and minority communities? How likely are COVID-19 impacts to continue or have residual effects?</li> <li>• What transportation options can be used to lessen this disproportionate share of impacts? How can transit services be most effectively designed to support their needs in the context of overall significant reductions in transit demand? What ongoing partnerships are supportive?</li> <li>• What is the most effective means to provide transit services that are vital to communities? What other transportation options might supplement or support the transit trip?</li> </ul> <p><b><i>Relationship to Other Problems/Research</i></b></p> <ul style="list-style-type: none"> <li>• This research can build on significant ongoing research on public health and COVID-19, as well as work at the intersection of health and transportation, such as NCHRP Project 25-25, Task 105, “A Guidebook for Communications between Transportation and Public Health Communities.” <a href="https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4101">https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4101</a>.</li> <li>• This research relates to problem statements A.2: Adjusting Transportation Services and Practices During Different Phases of a Pandemic to Maximize Safe, Efficient Access and D.2: Shifts from Brick-and-Mortar Businesses to Home Delivery Services, Creating Challenges for Lower-Income and No-Car Households, and others related to Category E: Effects on Economics, Revenues, and Costs (Including Stimulus).</li> </ul> <p><b><i>Outcome, Benefits, and Implementation</i></b></p> <ul style="list-style-type: none"> <li>• Understanding of effective practices to help meet the needs of vital workers and support their health and well-being.</li> </ul> <p><b><i>Urgency</i></b></p> <ul style="list-style-type: none"> <li>• Immediate.</li> </ul>

<b>Category D: Social Justice, Access, and Mobility Equity</b>
<b>Problem Statement D.2: Shifts from Brick-and-Mortar Businesses to Home Delivery Services, Creating Challenges for Lower-Income and No-Car Households</b>
<p><b><i>Objective/Purpose</i></b></p> <p>Identify how and to what extent shifts in the economy, including the rise of home delivery services during the pandemic, disproportionately impacts low-income workers and affects their travel options and costs, as a private vehicle is increasingly required for these jobs.</p> <p><b><i>Description</i></b></p> <p>Auto-ownership is less frequent in low-income households, with greater reliance on public transportation. Recently, brick-and-mortar retail businesses have been declining while online shopping and home delivery are becoming more popular. The COVID-19 pandemic has exacerbated this trend, with a dramatic increase in demand for home delivery services and resulting new “essential workers.” Although workers supporting this service are typically low-income, young, and have less job security, these populations also are less able to own and maintain a private vehicle, which is becoming more necessary in the delivery business and increasing “gig” economy.</p> <p><b><i>Research Questions</i></b></p> <ul style="list-style-type: none"> <li>• What data is available on home delivery workers? What additional data or data sources can provide supporting information?</li> <li>• What is the potential for this demand to remain long term?</li> <li>• What are the options to support these essential workers?</li> <li>• Is there a role for public transit in addressing this issue?</li> <li>• What partnerships may be necessary to fully understand the problem and jointly identify solutions?</li> </ul> <p><b><i>Relationship to Other Problems/Research</i></b></p> <ul style="list-style-type: none"> <li>• This research relates strongly to other essential worker problem statements.</li> </ul> <p><b><i>Outcome, Benefits, and Implementation</i></b></p> <ul style="list-style-type: none"> <li>• Identify how changes in the economy may affect transportation needs and economic opportunities for low-income communities.</li> </ul> <p><b><i>Urgency</i></b></p> <ul style="list-style-type: none"> <li>• Short-term.</li> </ul>

Category D: Social Justice, Access, and Mobility Equity
Problem Statement D. 3: Ensuring the Collection of Context-Specific Data, Particularly for Vulnerable Populations
<p><b><i>Objective/Purpose</i></b> Determine how to ensure that the data being collected and studied is context-specific data, particularly for the most vulnerable populations, for broad usability.</p> <p><b><i>Description</i></b> Data is an essential need to fully understand the impacts of the COVID-19 pandemic. The collection of context-specific data better captures the impacts, especially for vulnerable populations. Context can relate to specific populations, geographical or place types, demographic, economic, and trends. The degree to which data can be collected and disaggregated for many uses will be a significant benefit across sectors.</p> <p><b><i>Research Questions</i></b></p> <ul style="list-style-type: none"> <li>• What data types benefit from a context-specific approach? What groups or sectors can use the data?</li> <li>• What individual sector partnerships and key stakeholders that should be engaged for data collection, analysis, and use?</li> <li>• What analysis approaches and methods are needed/available?</li> </ul> <p><b><i>Relationship to Other Problems/Research</i></b></p> <ul style="list-style-type: none"> <li>• This problem statement supports C.6: Using Better Data, Including Proprietary Data, for Near-Term and Long-Term Decision-Making, but with a focus on exploring data by demographic group to understand equity issues.</li> </ul> <p><b><i>Outcome, Benefits, and Implementation</i></b></p> <ul style="list-style-type: none"> <li>• Improved context-specific data collection.</li> <li>• Data and analysis on the impacts COVID-19 has had on vulnerable populations.</li> </ul> <p><b><i>Urgency</i></b></p> <ul style="list-style-type: none"> <li>• Short-term.</li> </ul>

Category D: Social Justice, Access, and Mobility Equity
Problem Statement D.4: Impacts on Transit Access and Mobility Post-Pandemic
<p><b><i>Objective/Purpose</i></b></p> <p>Determine the long-term impacts of COVID-19 on transit services and opportunities for transit-dependent communities, with a specific focus on low-income, minority, and disabled patrons.</p> <p><b><i>Description</i></b></p> <p>The COVID-19 pandemic has caused a notable decrease in transit ridership due to reductions in commute travel, which is a basis for many transit trips. Although there are many causes of this decline, whether this trend will continue post-pandemic is unknown. A sustained reduction in transit travel will have important implications for transit system revenues and service provision, which is likely to impact low-income, minority, and disabled patrons disproportionately. It will be important to consider potential changes in mode choice post-pandemic is an important factor in transportation decision-making.</p> <p><b><i>Research Questions</i></b></p> <ul style="list-style-type: none"> <li>• Will the current declines in ridership continue post-pandemic? What are the implications for transit services long-term?</li> <li>• What are the implications for transit-dependent riders, in terms of access to destinations, travel time, and costs, if direct connections are reduced?</li> <li>• What are the implications of potential transit policies to support low-income communities, such as moving to a fare-free system? How would transit agencies recover fares? Would there be unintended consequences that could create challenges for social distancing and maintaining system cleanliness?</li> </ul> <p><b><i>Relationship to Other Problems/Research</i></b></p> <ul style="list-style-type: none"> <li>• This problem statement is closely related to C.3: Impacts of Short-Term and Long-Term Changes in Travel Behavior on Use of Public Transportation and Shared Mobility, as Well as Vehicle Ownership and Household Location Decisions, but with a focus on implications for low-income, minority, and other often transportation-disadvantaged communities.</li> </ul> <p><b><i>Urgency</i></b></p> <ul style="list-style-type: none"> <li>• Mid-term.</li> </ul>

### Category D: Social Justice, Access, and Mobility Equity

#### Problem Statement D.5: Maintaining Transportation Services for People with Disabilities, Paratransit, and Other Service Needs During a Pandemic

##### *Objective/Purpose*

Determine ways to maintain paratransit and other transportation services for people with disabilities or other special needs during the pandemic.

##### *Description*

The COVID-19 pandemic has greatly impacted public transportation service availability. Many people rely on public transportation, now seen as an unsafe option. Besides identifying the best approaches to maintain transportation services generally, specific consideration must be given to people with unique needs who rely on public transportation options. This group comprises those with disabilities, seniors who no longer drive, people to whom only demand-response transportation is available, and people with other unique needs.

##### *Research Questions*

- What information was collected during the COVID-19 pandemic concerning this population?
- How are data for these populations identified? This includes transportation needs and routine ways that these needs are addressed.
  - What data exists on these populations?
  - What is the nature of the transportation needs of these populations?
  - How has the COVID-19 pandemic changed the transportation needs?
- What challenges during the pandemic restrict or limit these routine transportation options? Is there research identified to address these challenges?
- How are transportation options generally available and supported during a pandemic? What stakeholder groups, agencies, or other entities typically support these populations in other ways? Is there potential for partnership to meet these needs?
- Do opportunities exist to bring certain services to these populations rather than require them to travel to the point of service?

##### *Relationship to Other Problems/Research*

- National Aging Network, Administration on Aging, Administration on Disabilities, or local nonprofit agencies' support.
- Sandt, L. *NCHRP Research Report 932: A Research Roadmap for Transportation and Public Health*, 2019. <http://www.trb.org/Main/Blurbs/179959.aspx>.
- Zmud, J. P. TCRP Project B-47, "Impact of Transformational Technologies on Underserved Populations." <https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4686>.

##### *Outcome, Benefits, and Implementation*

- Guidance on maintaining transportation services for people with disabilities and others with unique needs during a pandemic.
- Guidance on helping local authorities connect people to mobile services, thus reducing the need for transportation options.

##### *Urgency*

- Short-term.

### Category E: Effects on Economics, Revenues, and Costs (Including Stimulus)

#### Problem Statement E.1: Impacts of the COVID-19 Pandemic on Transportation Revenues and Costs, Both Short Term and Long Term

##### ***Objective/Purpose***

Determine the impacts on transportation revenues and the economic, financial, and health costs for the transportation sector due to the COVID-19 pandemic, both short term and long term.

##### ***Description***

COVID-19 will have significant impacts on transportation revenues both in the short term and the long term. Transportation revenues from gasoline taxes have dropped markedly, and transit fare box revenue and Amtrak have dropped dramatically. Port fees, toll collections, and parking revenues have also dropped. There also have been significant drops in revenues for private companies that provide transportation services, such as transportation network companies and private-sector toll road operators. At the same time, costs for many of these organizations have increased, due to increased needs for cleaning, social distancing protocols, signage, or technology to support touchless service. Some transit agencies also have switched to fare-free transit with back-door boarding. Research is needed to understand what the impacts will be on the ability to deliver services and capital programs, as well as pay off revenue bonds, both short term and long term.

##### ***Research Questions***

- What are anticipated changes in short-term and long-term transportation revenues for different transportation agencies?
- What are the anticipated changes in costs, including worker health costs?
- What effects will long-term changes in revenue and costs have on levels of service that can be provided, especially for transit?
- What does this data suggest for future pandemics? What are the remaining unknowns, and how can these be estimated or qualified?

##### ***Relationship to Other Problems/Research***

- This research can build off some previous research exploring changes in transportation infrastructure and service provision, such as *NCHRP Research Report 917: Right-Sizing Transportation Investments: A Guidebook for Planning and Programming* (<http://www.trb.org/Main/Blurbs/180145.aspx>).

##### ***Outcome, Benefits, and Implementation***

- An assessment of impacts on transportation revenues and costs.
- Forecasting tools or approaches to estimate revenue and financial implications.
- Guidance on approaches for how to deal with a dramatic decline in revenues.

##### ***Urgency***

- Immediate.

**Category E: Effects on Economics, Revenues, and Costs (Including Stimulus)**

**Problem Statement E.2: Impacts of a Restructured Economy, Including Small Business Failures and Changes in Supply Chain, on Travel and Transportation Needs**

***Objective/Purpose***

To determine what primary and secondary impacts will be associated with changes to the economy in the near term and long term in terms of travel demand and transportation needs.

***Description***

The COVID-19 pandemic has hurt the economy in many ways, one way being the failure of many small businesses. Closure of many small businesses, including restaurants, small retail, and shopping centers is anticipated due to increases in telework, increased use of e-commerce, and less overall travel activity. The economic ramifications suggest a symbiotic relationship between work, transportation, and small businesses. If more employees continue to work from home and fewer from offices, this will likely make it difficult for small businesses in business districts to survive. The shift to e-commerce also makes brick-and-mortar retail struggle further, which in turn may lead to fewer ancillary businesses such as restaurants. This research will explore how changes in the economy may occur and potential implications on transportation system demand. Understanding these impacts and issues will help transportation agencies plan and prepare for demand in a restructured economy.

***Research Questions***

- What will be the primary and secondary impacts of small business failures? Can something be done to help decrease small business failures or the impact of their failures?
- What will be the impact over a restructured economy on the transportation system demand? Are there ways transportation agencies can prepare for this impact?
- Will changes in the nature of employment (e.g., more gig economy, more delivery services) lead to more of different types of travel?

***Relationship to Other Problems/Research***

- This research relates to problem statements C.3: Impacts of Short-Term and Long-Term Changes in Travel Behavior on Use of Public Transportation and Shared Mobility, as Well as Vehicle Ownership and Household Location Decisions; C.4: Impacts of Short-Term and Long-Term Changes in Long-Distance Leisure Travel and Business Travel; and C.5: Understanding Ways to Make Desirable Behavior Changes Continue and Support Sustainable Travel Decisions related to changes in travel demand, as well as D.2: Shifts from Brick-and-Mortar Businesses to Home Delivery Services, Creating Challenges for Lower-Income and No-Car Households related to how changes in the economy, including a shift from brick-and-mortar businesses to home delivery will affect low-income workers.

***Outcome, Benefits, and Implementation***

- Information to help transportation agencies and governments at various levels understand policies that can support businesses and transportation needs.

***Urgency***

- Mid-term.



Category E: Effects on Economics, Revenues, and Costs (Including Stimulus)
<b>Problem Statement E.3: Supporting Greater Resiliency in Private-Sector Partners with Less Dependency on Stimulus Funding</b>
<p><b><i>Objective/Purpose</i></b>  Identify the extent to which private-sector transportation partners (suppliers, funding sources, contractors, etc.) can become more resilient and less likely to need future stimulus package funding.</p> <p><b><i>Description</i></b>  Many private businesses have relied on funding from stimulus packages during the COVID-19 pandemic. How widespread this reliance has been within transportation sector partners is unknown. This research would consider how partners can become more resilient and less dependent on funding from a future stimulus package.</p> <p><b><i>Research Questions</i></b></p> <ul style="list-style-type: none"> <li>• What is the impact of stimulus funding on the transportation sector, including partner businesses?</li> <li>• How can specific partners or groups become more resilient and less likely to need funding from a future stimulus package?</li> <li>• What data is currently freely available? Is data collection necessary and reasonable?</li> <li>• What is the economic risk and what are the potential impacts on transportation agencies?</li> </ul> <p><b><i>Relationship to Other Problems/Research</i></b></p> <ul style="list-style-type: none"> <li>• Unknown.</li> </ul> <p><b><i>Outcome, Benefits, and Implementation</i></b></p> <ul style="list-style-type: none"> <li>• Documentation of how stimulus funding has affected firms in the transportation industry.</li> <li>• Identification of ways that transportation partners can be more resilient to economic downturns.</li> </ul> <p><b><i>Urgency</i></b></p> <ul style="list-style-type: none"> <li>• Mid-term.</li> </ul>

**Category E: Effects on Economics, Revenues, and Costs (Including Stimulus)**

**Problem Statement E.4: Understanding the Distribution of Economic Impacts Across Cities, Regions, States, and Countries**

***Objective/Purpose***

Understand the uneven distribution of economic impacts from the pandemic across cities, regions, states, and countries.

***Description***

The COVID-19 pandemic has had a global impact, but the impacts range in severity across different places. It is important to understand how the impacts of this pandemic have been unevenly distributed across cities, regions, states, and countries.

***Research Questions***

- What geographies/place types are meaningful to consider from an economic (other) perspective?
- How are impacts reported at this scale?
- What contributes to the differences and similarities?
- What does this imply about different transportation response at various scales, locations, or other places?
- What partners and/or stakeholders should be engaged?
- Is a qualitative or quantitative response applicable? If quantitative, what data is available to inform?

***Relationship to Other Problems/Research***

- Impacts may be broadened to health impacts, social impacts, and other identified consequences to the COVID-19 pandemic.

***Outcome, Benefits, and Implementation***

- Case studies on various scale, geography, and other place characteristics that identify the types of impact from the pandemic and measures taken to address these.

***Urgency***

- Mid-term.

<b>Category E: Effects on Economics, Revenues, and Costs (Including Stimulus)</b>
<b>Problem Statement E.6: Benefits and Costs of Advancing Infrastructure Projects During a Pandemic</b>
<p><b><i>Objective/Purpose</i></b></p> <p>To understand the benefits and costs of keeping or advancing large infrastructure projects under construction during a pandemic.</p> <p><b><i>Description</i></b></p> <p>During the COVID-19 pandemic, some transportation agencies cut back on expenditures, recognizing the anticipated reductions in revenue, potential health concerns of having employees working on projects, and uncertainties about demand. At the same time, other agencies continued to advance or worked to accelerate infrastructure construction or reconstruction projects. Keeping these projects ongoing has the potential for multiple benefits, including providing economic stimulus by keeping workers employed and taking advantage of reduced traffic and transit demands, resulting in the ability to complete projects faster and with lower work zone traffic management costs. In some cases, these projects might also reduce construction costs due to faster project delivery times or lower bid prices. However, changes in petroleum demand have meant some challenges in terms of asphalt availability. This research would consider the various benefits and costs of moving projects forward during a pandemic.</p> <p><b><i>Research Questions</i></b></p> <ul style="list-style-type: none"> <li>• What are the additional costs and risks of working during a pandemic?</li> <li>• What are the benefits of working on projects during a pandemic?</li> <li>• How can agencies manage finances to advance projects during challenging fiscal times? How have different transportation agencies, both highway and transit, handled this?</li> </ul> <p><b><i>Relationship to Other Problems/Research</i></b></p> <ul style="list-style-type: none"> <li>• Unknown.</li> </ul> <p><b><i>Outcome, Benefits, and Implementation</i></b></p> <ul style="list-style-type: none"> <li>• Information on the benefits and costs of moving large infrastructure projects forward during a pandemic.</li> </ul> <p><b><i>Urgency</i></b></p> <ul style="list-style-type: none"> <li>• Short-term.</li> </ul>

### Category F: Governance and Roles During a Pandemic

#### Problem F.1: Effective Government Functions and Practices During the Pandemic

##### *Objective/Purpose*

Determine the ways government has functioned effectively during the pandemic and learn from best practices.

##### *Description*

There have been various actions and reactions to the COVID-19 pandemic from government officials at all levels of government. For example, FMCSA relaxed hours-of-service rules and states relaxed weight restrictions for public health supply and food deliveries. Other issues addressed by government agencies included flexibility for public meeting rules, including a shift to virtual meetings, and implementation of emergency procurement rules. Past emergency response research has shown that communication and pre-existing relationships are important for effective response to emergencies. Understanding the ways government has functioned effectively and what best practices have been observed will help guide agencies in their planning for future pandemics moving forward.

##### *Research Questions*

- Where did government, including transportation agencies, function effectively under these unprecedented conditions? What practices are noteworthy and are they broadly applicable?
- What comparisons can be made that are useful for future pandemics?
- What new partnerships were created, or existing ones strengthened?
- What are the best methods to communicate these success stories?

##### *Relationship to Other Problems/Research*

- This research can build on past research related to government policy and innovation. An example of recent work is NCHRP Project 19-16, "Federal Funding in State, Local, and Regional Departments of Transportation: Impacts, Responses, and Adaptation." <https://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4578>.

##### *Outcome, Benefits, and Implementation*

- Documentation of effective practices, which could be applied in future situations.
- Identification of potential future opportunities.

##### *Urgency*

- Mid-term.

<b>Category F: Governance and Roles During a Pandemic</b>
<b>Problem Statement F.2: Understanding How the Complexity of Governmental Organizations Affects Ability to Respond to Complex Issues</b>
<p><b><i>Objective/Purpose</i></b> Determine the relationship between nimble and immediate response that complex issues require and the complexity of governmental organizations.</p> <p><b><i>Description</i></b> Government organizations in the United States have many individual roles and responsibilities that result in a complex structure of decision-making. There is the potential for this complex structure to becoming an obstacle in the necessary rapid response to a pandemic.</p> <p><b><i>Research Questions</i></b></p> <ul style="list-style-type: none"> <li>• How do government agencies differ with respect to complexity? For example, how is one state DOT different in structure than another?</li> <li>• Do these differences correspond to population or geographical differences? Other differences?</li> <li>• Is there a difference in government response to the COVID-19 pandemic between agencies? Within a state? Between states?</li> <li>• What lessons learned and corresponding changes are implied by these differences?</li> </ul> <p><b><i>Relationship to Other Problems/Research</i></b></p> <ul style="list-style-type: none"> <li>• This research relates to Problem Statement A.3: Coordination and Collaborative Decision-Making During an Emergency to Respond to Rapidly Changing and Uncertain Situations on coordination and collaborative decision-making during an emergency.</li> </ul> <p><b><i>Outcome, Benefits, and Implementation</i></b></p> <ul style="list-style-type: none"> <li>• Guidance on how agencies can effectively respond to complex issues under different operating structures, including roles between federal, state, and local agencies.</li> </ul> <p><b><i>Urgency</i></b></p> <ul style="list-style-type: none"> <li>• Mid-term.</li> </ul>

### Category F: Governance and Roles During a Pandemic

#### Problem Statement F.3: Getting the Most Out of Economic Stimulus or Infrastructure Stimulus Packages

##### *Objective/Purpose*

Determine what processes or policies to put in place to achieve the best return on investment from any economic stimulus or infrastructure stimulus package.

##### *Description*

The COVID-19 pandemic has created a significant need for congressional support, including stimulus funding as well as infrastructure investment. To ensure that these emergency funds are used most efficiently, internal transportation agency business processes and policies may require specific adjustment. This will involve considering the use of stimulus funding to keep services operating, for new projects, and to address a backlog of maintenance needs.

##### *Research Questions*

- How does stimulus or short-term investment at the national level differ from typical funding streams? What policies or procedures are used to report and analyze this type of funding?
- How is the return on investment?
- What are the projects or processes to get the greatest bang for the buck? What are the projects or processes to get the most impact in supporting small businesses (including minority- and woman-owned businesses), and provide the biggest benefit to the community and local economy?
- What partners and stakeholders should be engaged?

##### *Relationship to Other Problems/Research*

- This problem statement has a relationship to [Category D: Social Justice, Access, and Mobility Equity](#) in regard to considering benefits to the community and particular to small businesses and disadvantaged communities, as well as [Category G: Effects on Economics, Revenues, and Costs \(Including Stimulus\)](#).

##### *Outcome, Benefits, and Implementation*

- Identification of effective policies and practices for use of economic stimulus and infrastructure stimulus packages.

##### *Urgency*

- Mid-term.

### Category G: Public Health

#### Problem G.1: Understanding the Role of Transportation in the Spread of COVID-19 and What Could Be Done to Lessen That Role

##### *Objective/Purpose*

Analyze the role of transportation in the spread of COVID-19 and what could be learned to lessen that role in a future pandemic.

##### *Description*

The coronavirus initially spread from Asia and Europe to the United States through travelers coming from these other parts of the world. Once it entered the United States, infected individuals traveled within their communities and throughout the country and spread the virus through participation in activities (e.g., work, conferences, religious services, events) and likely through travel itself, including on shared modes such as airplanes, intercity rail, and public transit. This research would address what role travel played, and these modes of transportation played in particular, to understand mitigation measures that could reduce the role these modes play in the spread of a virus, including understanding the effectiveness of travel restrictions.

##### *Research Questions*

- What role did aviation play in the spread of the virus? And what is the effectiveness of halting air travel through bans on travel from different countries, or hot spot locations?
- What role did intercity rail, intercity buses, and public transit play in the spread of the virus? And what strategies could be applied to reduce the spread of a virus?
- How effective are lockdowns and efforts to reduce travel in containing the spread of the virus, such as through temporarily limiting transit services to only essential travel, eliminating on- and off-street parking to deter people from congregating in public spaces, etc.? What other transportation strategies could help to reduce the spread of a virus?
- How effective are travel bans or other restrictions?

##### *Relationship to Other Problems/Research*

- This research is closely tied to public health research that is exploring the ways in which the coronavirus spreads from person to person, and in tracing where individuals may have come in contact with the virus. It would supplement that research with a focus on the role of transportation, and how strategies to reduce travel or make travel safer would reduce the spread.

##### *Outcome, Benefits, and Implementation*

- A research synthesis on the role of different transportation modes in the spread of COVID-19 across the United States, and potentially in individual communities.
- Analyses of the effectiveness of transportation strategies to contain virus spread that could be integrated into a guidebook or resource.

##### *Urgency*

- Mid-term.

**Category G: Category G: Public Health**

**Problem Statement G.2: Understanding the Role of Land Use Density in Relation to the Incidence of Infection, and Implications for Planning and Policy**

***Objective/Purpose***

Determine if there is a true correlation between incidences of infection in high-density versus low-density areas. If so, what does this imply for future transportation planning in specific areas? To what extent does public perception of this correlation influence behavior change?

***Description***

Many of the initial hot spots of infection during the COVID-19 pandemic have been in high-density areas, causing people to leave dense city environments. Some researchers think there may be a population resurgence in suburban areas due to the pandemic. Population density has been widely supported as the means to encourage transit and active transportation options as well as reduce the public health risk of obesity and support a more sustainable and resilient transportation system. It is important to determine if there is a true correlation between incidences of infection in high-density versus low-density areas for future decision-making, and based on the research to determine what factors in regard to development patterns, travel patterns, and other practices play a role in spread of the virus. Based on the initial COVID-19 experience, it may be difficult to change public perceptions.

***Research Questions***

- What is the rate of infection in high-density areas versus low-density areas as experienced during the COVID-19 pandemic? Has this changed over time?
- What factors may contribute to different levels of incidences?
- What immediate data is available? What data should be collected?
- How can the public health sector contribute to understanding the patterns of community spread in urban, suburban, and rural environments?
- What are the implications on land use and transportation planning and policy, recognizing the role of density in transportation system sustainability? And how should immediate health concerns be weighed in relation to long-term goals in terms of planning for and investments in a resilient system?
- What are effective transportation strategies that are applicable in different contexts, for instance, widening sidewalks in dense urban environments?

***Relationship to Other Problems/Research***

- Relates to public health, planning, and data.
- Other correlations may be important to add to this topic that are useful for transportation analysis.

***Outcome, Benefits, and Implementation***

- Data analysis of the role of density and other factors in the spread of COVID-19.
- Case studies for various high-density and low-density areas to understand differences across and within different types of land use/density patterns.

***Urgency***

- Mid-term.



### Category G: Public Health

#### Problem Statement G.3: Reconsider How Streets and Public Spaces Can Be Adapted to Facilitate Increased Biking and Walking

##### *Objective/Purpose*

Consider redesign or repurpose of some public spaces and streets to facilitate biking and walking that is more prevalent in a pandemic.

##### *Description*

The COVID-19 pandemic stay-at-home orders have resulted in additional walking and biking as a true transportation option, for recreation, and as a response to “cabin fever.” With the increased use of outdoor spaces coupled with the need to social distance, the use of trails, sidewalks, and even roadways for active transportation, exercise, and recreation might cause transportation infrastructure to become overcrowded and difficult to use. From a transportation and public health perspective, more walking, jogging, and biking is a positive outcome. What short-term and long-term adjustments can be made, however, to support safe active transportation?

##### *Research Questions*

- Which local areas have converted spaces to accommodate increased walking and biking? What are the lessons learned from this experience? What are best practice examples?
- How do the changes being made adhere to public health guidelines for the pandemic?
- How likely is this situation to represent a permanent change versus meeting a temporary need? What options are available for both/either?
- What benefits can be quantified, assumed, or forecast to use as communications to the public?
- What partners and stakeholders should be engaged?
- What data/analysis approaches are needed?

##### *Relationship to Other Problems/Research*

- In the public health sector, the built environment is of high interest as a way of promoting activity to address obesity and other health risks. Research on the built environment may be useful for consideration.
- Literature review and expert panel input can inform design, selection, and implementation.

##### *Outcome, Benefits, and Implementation*

- Case studies on local areas that have altered their streets and spaces for nonmotorized travel.
- A guidebook on how to reimagine streets for increased biking and walking.
- Communicate the benefits of more biking and walking, which can have a positive impact on mental and physical health.

##### *Urgency*

- Short-term.

### Category G: Public Health

#### Problem Statement G.4: Engaging the Health Community in Protocols for Protecting Transportation Workers and System Users

##### *Objective/Purpose*

To engage and maintain the Occupational Safety and Health Administration (OSHA) and the National Institute for Occupational Safety and Health (NIOSH) in discussion of transportation needs and communication on recommended protocols and guidance to protect transportation workers and transportation system users.

##### *Description*

The social distancing guidelines developed by the Centers for Disease Control and Prevention (CDC) during the COVID-19 pandemic have highlighted the potential for unsafe work environments. It is essential to understand how to make work environments safe for employees and system users. Initial understanding, established protocols, and general guidance will assist transportation agencies in responding during COVID-19 as well as in preparing for future pandemics.

##### *Research Questions*

- What existing policies and practices within individual transportation agencies may assist in responding to public health crises and pandemics?
- Given the potential for extreme demands on OSHA and the NIOSH, can transportation agencies/national leadership effectively engage these partners in discussion?
- What initial meaningful research/resources can educate and advise transportation agencies for this discussion?
- What data are available to support a sense of urgency?

##### *Relationship to Other Problems/Research*

- Consider a systematic review of existing literature and transportation policies related to influenza and the former Ebola pandemic to inform safety protocols for work environments.
- This project statement is directly tied to problem statements A.1: Ensuring the Health and Safety of Transportation System Operators and Others in the Transportation Workforce and A.2: Adjusting Transportation Services and Practices During Different Phases of a Pandemic to Maximize Safe, Efficient Access, which relate to the health and safety of transportation workers and the public. This problem statement could be merged into the other statements.

##### *Outcome, Benefits, and Implementation*

- Transportation procedures, guidelines, training, and similar actions can be in established prior to any future pandemic.
- Improved response during the COVID-19 pandemic.

##### *Urgency*

- Immediate.

### Category G: Public Health

#### Problem Statement G.5: Transportation Options for Essential Workers That Are Safe, Widely Available, and Where Cost Is Not a Factor

##### *Objective/Purpose*

Identify reasonable transportation options for essential workers to get where they are needed without placing additional burdens such as car ownership, extended travel time, and risking their own safety and health, including that of others (family, customers).

##### *Description*

For many workers identified as essential during the COVID-19 pandemic, using public transportation is the most feasible option for several reasons (car ownership, financial means). However, COVID-19 has made public transit a less desirable mode of transportation in many cases due to the health risks and the inability of riders to adequately protect themselves. Transit service responds to ridership, and fewer riders means reduced funding to operate the system. If this mode becomes less available due to service changes or interruptions, it is important that essential workers have other transportation options.

##### *Research Questions*

- What are the best ways to get essential workers where they need to go, recognizing that transit is going to be used less?
- Are there ways to make public transit safer for essential workers?
- What partners and stakeholders should be engaged?
- What data/analysis approaches are needed?

##### *Relationship to Other Problems/Research*

- This research is very closely related to Problem Statement A.1: Ensuring the Health and Safety of Transportation System Operators and Others in the Transportation Workforce and A.2: Adjusting Transportation Services and Practices During Different Phases of a Pandemic to Maximize Safe, Efficient Access. This problem statement could be merged into the other statements.

##### *Outcome, Benefits, and Implementation*

- Research on best opportunities for essential workers to commute during a pandemic.

##### *Urgency*

- Immediate.

### Category G: Public Health

#### Problem Statement G.6: Recovery Phase, Providing Safe Access and Mobility During Pandemic Recovery

##### *Objective/Purpose*

Identify actions allowing people to feel safe to return to work and those necessary to support their travel across all modes: air travel, public transit, biking, walking, personal-vehicle, and shared-ride options.

##### *Description*

During the COVID-19 pandemic the personal vehicle has become the preferred travel option when walking and/or biking cannot be used to reach a destination. However, transportation has long supported non-single-occupancy vehicular travel, and many people do not have the personal-vehicle option. Air travel is perceived to be the least safe option for transportation during the pandemic. To plan for the near future, when greater mobility is a reasonable option, transportation agencies need to identify when people will likely feel safe in returning to work places/work travel and what preparations and precautions can be taken to support safe and accessible travel.

##### *Research Questions*

- What is necessary to ensure that people feel comfortable returning to work?
- What factors will be key to identifying when broad return to travel can and should occur? This is an interface point between public health and transportation.
- What is necessary to make individual modes of transportation safe? What precautions and protocols should be initiated by transportation agencies, airports and airlines, transit operators, and others to ensure safe travel?
- How do we communicate these changes to the public to help them feel safe to travel?
- What partners and stakeholders should be engaged?

##### *Relationship to Other Problems/Research*

- This research is very closely related to problem statements A.2: Adjusting Transportation Services and Practices During Different Phases of a Pandemic to Maximize Safe, Efficient Access and A.4: Approaches for Providing a Safe Environment for Transportation Passengers on Facilities that Serve Many People During a Pandemic and Recovery. This problem statement could be merged into the other statements.
- Examples of research include: Wilhelmi, J. *TRB Conference Proceedings 55: Airport Roles in Reducing Transmission of Communicable Diseases*, 2019. <http://www.trb.org/Main/Blurbs/178666.aspx>.
- Research from other countries where return to work has been successful.

##### *Outcome, Benefits, and Implementation*

- Research on the level of fear and caution the public will have in both the short and long term due to the pandemic.
- Guidance on safety precautions transportation providers can implement.

##### *Urgency*

- Short-term.

## APPENDIX

### TRB Research Needs Statements

The tables below provide individual research needs from the TRB Research Needs Statements Express, which served as key inputs to the problem statements, along with input from the brainstorming session.

#### CATEGORY A: OPERATIONS, RESILIENCE, AND DISASTER RECOVERY

Operations, Resilience, and Disaster Recovery		
Topic	Research Needs Statement Title	Description
POST-COVID-19 Future System Implications	Impact of Social Distancing on Law Enforcement and Incident Management	The impact of social distancing on direct contact transportation services like law enforcement, safety service patrol, towing and recovery, and tolling personnel. To assist responders and other workers who are required to interact with or assist road users, guidance that details more than PPE is needed. It is often required that people be in close proximity or even inside vehicles together during the course of assisting disabled motorists, persons involved in collisions, or those arrested for driving infractions. A better understanding of the problem and guidance is needed.
Technology Applications	Coordinated Swarm Operations of Ultra-Small Automated Surface Vehicle for Public Works Purposes	Research to develop swarm operations in which such small vehicle platforms can be used to enable other missions on the public right-of-way, such as: <ul style="list-style-type: none"> <li>• Smart swarm work zone delineation,</li> <li>• Smart swarm asset management, and</li> <li>• Smart swarm street cleaning and sanitation.</li> </ul>
Technology Applications	Improved Physical Designs of Transportation and Related Infrastructure: Best Practices for Design of Drive-Through Pandemic Test and Evaluation Facilities	Transportation management agencies and major event centers are experienced in the processing of large volumes of vehicles. During a pandemic, by recipients remaining in their personal vehicles, social distancing of potential carriers can be effective. However, this can create extensive queues or confusion and anxiety among test recipients if wayfinding and ingress–egress facilities are poorly designed. This research will identify best practices for configuration of temporary pandemic test facilities to assist healthcare providers in providing efficient and safe testing of potential carriers.
Technology Applications	Overcoming Barriers to Providing Deliveries of Critical Goods	The dependability of existing delivery services has been strained and still endangers the delivery staff and customers by exposure to the virus. Current research and development is developing of autonomous delivery vehicles and drones, but research could be conducted to expedite this vehicle development. Include coordination that prioritizes personal travel that could potentially save lives with “x2x” technology and leveraging big data so essential services and supplies can be routed or re-routed in real time to respond to real-time needs.

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Operations, Resilience, and Disaster Recovery		
Topic	Research Needs Statement Title	Description
Technology Applications	Remote Inspections and Audits	Determine the effectiveness of the various forms of remote compliance methods and tools used during the pandemic. The marine industry generally continued operating throughout the period, but normal oversight was significantly curtailed. Workarounds included extensions of inspection and audit due dates as well as using remote inspection tools and analytics to verify compliance. The need for traditional human presence compliance checks should be validated or public policy should formally allow for remote compliance methodologies.
Technology Applications	Virtualization of Traffic and Incident Management During Pandemics	The Transportation Management Center (TMC) is a key asset in infrastructure owner–operators toolkit for traffic and incident management. In a pandemic with stay-at-home and social-distancing mandates, traffic may be lighter and require less management, but crashes and incidents will still occur. While most agencies provide virtual private network (VPN) access to critical software systems, TMC staff working from home may be challenged to be as effective as they could be while in the TMC. This research will explore mitigations and advanced information technology solutions that can support TMC staff in unusual operating conditions.
Tracking Data, Reporting Methods, and Evaluations	Evaluate Ways to Better Connect Transportation Infrastructure to Hospitals and Medical Facilities to Better Track Movement of Supplies and Movement of Those Infected	Using x2x technology and leveraging big data, essential services and supplies can be routed or re-routed in real time to respond to real-time needs. This could also include the use of automated vehicles for delivery of supplies and equipment to minimize the risk of infection to human delivery agents.
Tracking Data, Reporting Methods, and Evaluations	Expediting Data and Science to Inform Crisis Management Decisions and Risk Models	Transportation organizations are not well versed in epidemiology. The guidance from the governments is issued in the context of broad scenarios. Industries (like offshore oil and gas) require more finely tuned analyses of specific risks, applied to specific scenarios (e.g., cannot socially distance on helicopters). What risk framework should be used in deciding minimum manning requirements and distancing? How should organizations balance increasing the frequency of high-risk activities to provide social distancing against the risk of increased infection? A study that examines what competencies are needed going forward in high-risk industries, like offshore energy, in order to make organizational decisions during crisis given the lessons learned from COVID-19?

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Operations, Resilience, and Disaster Recovery		
Topic	Research Needs Statement Title	Description
Transportation System Resilience	All Hazards Resilience and the Marine Transportation System	In looking at the system through a resiliency lens, one can assess the interconnectivity of systems (landside, waterside, and the intermodal relationships as well as the supporting infrastructure, including rivers, dams, levees, dredging, etc.). What is inhibiting the system? Do we have adequate asset resilience and system resilience, are we sacrificing one for the other, creating a “lumpy” unreliable system especially in times of acute shocks (natural disaster, COVID-19, etc.) and chronic stressors (aging infrastructure, funding priorities, cyber threat, etc.). It is how our system does or does not perform, that bares itself in times of crisis. A truly resilient marine transportation system should mitigate issues to a manageable level, not exacerbate them. A study should consider the redundancy (exploring more shipping and intermodal partnerships, mutual aid compacts); robustness (analysis of supply chain alternatives and choke points); adaptability (ability to reconfigure port facilities, adapt vessel for different cargo or usage, or re-route); resistance (health and human safety, financial and economic preparations); and recovery (how quickly commerce can rebound and importance of maritime industry to support it).
Transportation System Resilience	Determining the Impacts of Global Disruptions and Vulnerability Threats on Transportation Infrastructure Elements, Nodes, and Modes	<p>Elements of a broad study could include:</p> <ul style="list-style-type: none"> <li>• Physical infrastructure and connective nodes (roads, bridges, ports, waterways, airports, railroads, space and their connective space/connecting nodes);</li> <li>• Commercial infrastructure (global supply chains, logistics, maritime shipping, last-mile connectivity, customer relationship management);</li> <li>• Communications and networking infrastructure (legacy, cloud, local versus remote technology support, bandwidth and last-mile challenges);</li> <li>• Human infrastructure including education, workforce development and training programs for national and global needs in commercial and government transportation, and for anticipated labor and economic shifts due to changes in on shoring, off shoring, buy–ship–build local efforts;</li> <li>• Biological infrastructure (predictive analytics for population health, testing/diagnostics, remediation and mitigation for human capital, their families and workforce continuity); and</li> <li>• Intellectual infrastructure (cybersecurity, intellectual property, innovation, and discovery).</li> </ul>

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Operations, Resilience, and Disaster Recovery		
Topic	Research Needs Statement Title	Description
Transportation System Resilience	Evaluate the Need and Benefits of Coordinating Essential Transportation Services During a National, Statewide, or Regional Emergency, Including Public and Private Transportation Services	A coordinated response that prioritizes essential travel when and where needed could potentially save lives. This could also include services such as package and food delivery.
Transportation System Resilience	Optimizing Operational Performance: Sharing Best Practices	Develop a synthesis of best practices on key operations that were implemented by transportation agencies, including strategies like guidelines on cost-effective redundant operations, such as operations centers; controlling corridor access; closure (or not) of rest areas and provisions for truckers; use of variable message sign (VMS) boards for communication to the traveling public; designating corridors for emergency operations or transit for health care workers; rear door boarding on transit; PPE practices and economically sanitizing facilities, from stations to fuel pumps, etc. A synthesis is needed of best practices of key operational initiatives, practices, and guidelines that were implemented by transportation agencies to improve operational performance during the COVID-19 crisis.
Transportation System Resilience	Supervised Automated Public Transit Vehicles	It is important to keep the public transit system running for critical service personnel who may be transit-dependent to get to/from home and work. However, we need to reduce the risk to the human operator in the pandemic environment. A solution is to have centralized supervision of the automated transit vehicles to allow rapid adaptation to operational changes, such as, <u>changing routes to service emergency medical facilities.</u>
Workforce	Managing Workforces Safely	What are the best practices for keeping people working regardless of “essential and non-essential” categories while protecting and communicating safety requirements timely and effectively? Many needs have arisen during the crisis that can use the skills of those deemed non-essential. What is the learned guidance on protocols and training to engage and/or reassign staff and to redeploy them with sufficient resources to minimize financial impacts and maximize operating efficiencies? The objective of this research is to summarize the learned guidance on protocols and training to engage or reassign staff and to redeploy them with sufficient resources to minimize financial impacts and maximize operating efficiencies.



**CATEGORY B: SUPPLY CHAIN AND GOODS MOVEMENT**

Supply Chain and Goods Movement		
Topic	Research Needs Statement Title	Description
POST-COVID-19 Future System Implications	Future Supply Chains Post-Pandemic	<p>Possible change drivers include:</p> <ul style="list-style-type: none"> <li>• More self-reliant U.S. (and other nations’) supply chains for some commodities, resources, products;</li> <li>• More distributed and non-transport consumption;</li> <li>• Entertainment online, more active experience-oriented consumption, etc.;</li> <li>• Urban and suburban changes in density, and personal mobility;</li> <li>• A shift (again) in demand for warehouse location, product prepositioning, etc.; and</li> <li>• More localized manufacturing (3D printing, remote vertical management of manufacturing), and onshoring or reshoring.</li> </ul> <p>Modeling approaches:</p> <ul style="list-style-type: none"> <li>• Infrastructure defines revision options for post-pandemic futures;</li> <li>• Current freight corridors are legacy corridors aligned with international supply chains;</li> <li>• Long-term consequences include re-rationalization of supply and demand; and</li> <li>• Multi-criteria measures of recovery, economic service, and environmental sustainability.</li> </ul> <p>Current tools may serve many research needs in the context of these new economic realities.</p> <ul style="list-style-type: none"> <li>• Commodity Flow Survey, the quinquennial survey conducted by the U.S. Census Bureau and its derivative products like the Freight Analysis Framework can be adapted for modeling potential futures.</li> <li>• These tools can be coupled with new means of tracking and developing new freight data products as needed (e.g., geofencing, real-time observation by GIS units and satellites).</li> <li>• E-commerce techniques that afford greater network connectivity, remote management and transparency will be integrated into these operational, planning and decision policy tools.</li> </ul>

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Supply Chain and Goods Movement		
Topic	Research Needs Statement Title	Description
Supply Chain	Understand Cargo Fluidity as Non-Essential Businesses Shut Down	We are seeing a very real concern on the part of port authorities and intermodal terminals about where they are going to put incoming cargo. Non-essential warehouses are closed, so they are not taking delivery of the cargo, and retailers and manufacturers (who have faced a sudden drop in demand) are not anxious to take possession of the cargo. Furthermore, because less cargo is moving inland, exporters in the interior of the county who need chassis and containers to be able to ship their cargoes are not able to get the equipment they need. There also seems to be a disparity among the states and between the states and federal government concerning the definition of an essential business. This makes it very difficult to manage the supply chain. A study could address the following research questions: How can we assess what is essential or non-essential in terms of maintaining the fluidity of the supply chain? What can state and local governments do to enable ports to handle containers and other cargoes in excess of their handling and storage capacities?
Supply Chain	Freight Planning for Service Corridors During a Pandemic	How do local, state, and federal agency laws and actions impact freight movement on critical corridors? For example, what is the impact on freight movement of states closing highway rest areas? How do truck drivers meet basic needs in those circumstances? Research is needed to identify the resources and methods for implementing innovative changes and findings related to these freight corridor actions arising from the COVID-19 experience. What operational practices should states consider when deciding how to manage and clean all types and sizes of rest areas and full-service-center facilities? How do you maintain rest area and service center facilities so that freight operators can get adequate services and rest during their workday? How do you implement, execute, and oversee PPE services to ensure adequate PPE standards are maintained for the traveling public? The objective of this research is to identify the resources and methods for implementing innovative changes and findings related to these freight corridor actions arising from the COVID-19 experience.
Supply Chain	Impacts of International Supply Chain Sourcing Changes in the Post-Pandemic Environment	The COVID-19 pandemic showed the vulnerabilities of the domestic industries due to high dependence of Asian sources of intermediate and final products. Most likely, the domestic industries will realign current sourcing patterns, bringing changes freight flows and transportation infrastructure requirements. Research question: How can the national transportation system prepare for changes in international trade flows due to adjustments to current supply chain operations?

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Supply Chain and Goods Movement		
Topic	Research Needs Statement Title	Description
Supply Chain	New Freight Corridors Arising from Recovery–Stimulus–Emphasis on Domestic Supply Chain Sources	Would new freight corridors be generated as a result of a combination of economic stimulus packages developed in response to COVID-19 and simultaneously renewed emphasis on developing enhanced domestic supply chains? Any new corridors that would be generated because of these policies would require some investments in order to meet enhanced freight demands in a recovering economic environment. This research would identify the new corridors, freight flows under previous economic conditions, and expected freight flows in the new economic supply chain environment, as well as related potential infrastructure requirements.
Supply Chain	Short and Intermediate Term Impact on Freight Transportation and Ports of Policy Moves (in reaction to COVID-19 related issues) to Bring the Supply Chain for Specified Commodities Back into the Country	What could happen to the freight and marine transportation systems if the supply chain disruptions the nation is currently confronting are affected in some manner by policy moves designed to reduce reliance on foreign sources for several commodities. These policy proposals could change the freight flows coming into specified ports, and at the same time (at the extreme) reduce export activity for “critical materials” as well. What would these policy initiatives do to domestic freight flow movements and possibly infrastructure requirements?
Supply Chain	Supply Chain Impacts Related to COVID-19	A NASEM study could collect valid data and provide a comprehensive understanding of the supply chain interruptions, adaptations, successes and failures, and their extended economic and societal impacts. This would be particularly beneficial if it included how local, state, and federal laws and agency actions assisted or interfered with response, adaptation and recovery, and lessons learned for future improvements. The quick increase in use of electronic systems and documentation may have enabled smoother flow and adaptation. Should the move to electronic documentation be a national objective, and if so, what cybersecurity would be needed? What changes in training for agency personnel and practices would be required to enable this? Cargo flow disruptions and the resulting impacts on the origin–destination country activities and economies should also be included (e.g., retail shutdowns in the United States and resulting cargo congestion). How might this influence national policies (e.g., should there be an emphasis on U.S. manufacturing of some goods)? Will so many businesses in the supply chain shut down permanently that it will not be possible to handle the post-COVID-19 demand for goods and services? Will enough employees who were furloughed or laid off decide not to return to their former employment that it will not be possible for businesses to conduct operations at a “normal” level?

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Supply Chain and Goods Movement		
Topic	Research Needs Statement Title	Description
Supply Chain	The Implications of the Post-Pandemic Economy on U.S. Supply Chains	Recent prognostications of the post-pandemic economy suggest that only 80% of previous businesses—industries will recover. Some, like airlines and cruise liners, are predicted to see significant headwinds even in a post-COVID-19 recovery. As transportation agencies plan for a different future, a post-pandemic economy, they will be doing so with pre-pandemic freight flow and commodity data. The Commodity Flow Survey, the quinquennial survey conducted by the U.S. Census Bureau, and its derivative products like the Freight Analysis Framework do not serve the just-in-time needs of new economic realities. Research is needed on new means of tracking and developing new freight data products.
Supply Chain	Transportation and Supply Chains in a “Millions of Markets” Future	Several years ago, <i>NCHRP Report 750: Strategic Issues Facing Transportation</i> (the six-volume <i>Foresight Series</i> ) reported on what freight transportation might look like under a number of plausible futures. One of those futures (Millions of Markets) presumes that the U.S. becomes highly self-reliant in terms of energy, agriculture, and manufacturing through technology adoption. The population begins to migrate toward smaller urban areas that are supported by regional innovation hubs that can manufacture population needs on a localized scale via 3D printing and agile manufacturing. COVID-19 has unexpectedly navigated U.S. manufacturing of PPE in this direction. Will this trend continue post-pandemic, and what are the implications for transportation networks, supply chains, and funding?
Technology Applications	COVID-19: Preliminary Implications for Freight Autonomous Vehicles	The COVID-19 pandemic will likely lead planners, developers, operators, and the public to rethink the role and use of freight AVs. As of early 2020, there is of course, no literature or research on the subject. A NASEM study could set a research baseline in this topic area. Significant issues likely to emerge include: <ul style="list-style-type: none"> <li>• Potential surging demand for “no touch” transactions and deliveries to minimize human contact.</li> <li>• Concern over access to needed supplies for those quarantined, self-quarantined, or sheltering in place.</li> <li>• Concern over the sanitation of transit vehicles and delivered goods or meals.</li> <li>• The long-term impacts of social isolation and dependence on delivered goods.</li> <li>• Fragility of the “gig economy” and impacts on supply chain employment.</li> </ul>

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Supply Chain and Goods Movement		
Topic	Research Needs Statement Title	Description
Technology Applications	Developing Real-Time Predictive Analytics and Actionable Decision Support at Scale: Identifying and Addressing Vulnerabilities and Opportunities in the Systems of Systems that Comprise Global Logistics, Commercial Shipping and Supply Chains	A study could explore how best to leverage significant advances in affordable, powerful and compatible large-scale distributed computing, distributed networks, intelligent and reasoning systems providing massively parallel analytics in real time in the context of supply chain optimization.
Technology Applications	Potential Benefits in Light of COVID-19: Autonomous and Automated Technologies, AI, and Machine Learning Applications for Global Logistics	Determine the impacts and vulnerabilities of, and opportunities for improved autonomy, embedded intelligence—machine learning, and robotic process automation in global logistics, commercial shipping, government transportation, and worldwide supply chains.
Technology Applications	Swarm Operations of Ultra-Small Automated Delivery Vehicle on Existing Right-of-Way.	Examine ways to operate small automated delivery vehicles on existing right of ways to efficiency move 1/5- or 1/4-sized vehicles in mixed traffic to safely enable automated delivery of goods.
Transportation System Resilience	Short-Term Infrastructure Requirements Related to Surges in Economic Activity	The COVID-19 shutdown is expected to lead to a significant recession in 2020. However, most forecasts show a dramatic recovery in 2021, with gross domestic product (GDP) growth expected to exceed 6%, possibly followed by growth of 4% or more in 2022. With the surge in economic activity, and a substantial bounce-back in related freight flows, are there some short-term infrastructure investments that need to be undertaken in order to avoid some serious bottlenecks or disruptions that under other circumstances could be deferred under normal growth conditions. Would these potential disruptions lead to possible shortages, even with the economy recovering? Needed research would estimate the surge in selected routes and the impact on freight transportation systems.
Workforce	The Linchpin of U.S. Logistics: Truck Drivers—How Vulnerable Are They?	As the saying goes, “If you bought it, a truck brought it.” It is estimated that trucks in the United States carry 67% of the nation’s freight by weight and 73% by value. As the nation responds to an unprecedented pandemic supply chains have become even more dependent upon the flexibility and reliability of trucking. By the nature of their jobs (considered essential in the current environment), drivers maybe at higher risk in a pandemic due to customer contacts and reliance on public facilities. Drivers also rely on restaurants and rest areas for basic nutrition and hygiene, yet many states have responded to the pandemic by closing rest areas and dine-in restaurants. This research could examine, post-pandemic, the COVID-19 infection among truck drivers as compared to the general population. The research could also examine actions that state and local agencies could take to support driver rest and wellness needs.

**CATEGORY C: CHANGES IN DEMAND,  
TRANSPORTATION PLANNING, AND DATA**

<b>Changes in Demand, Transportation Planning, and Data</b>		
<b>Topic</b>	<b>Research Needs Statement Title</b>	<b>Description</b>
Leadership and Administration	Going Virtual: The New World Order	Virtual meetings are here to stay. The new world order for engagement of the public will use some form of virtual meetings today and in the future. Virtual meetings have broken down barriers to engagement but may have failed to address lagging equity problems. Research is needed to identify and synthesize the best practices that engage and provide more accessible interaction with the public for required public involvement. COVID-19 has required fundamental changes to public meetings and and likely will continue to affect such interactions into the future. This is a synthesis to gather best practices from states for modifying the required public participation processes as a result of the pandemic for highway, rail, transit, and aviation. The silver lining of the pandemic is the realization that what virtual does for us is it eliminates three obstacles: time constraints, geographic constraints, and who we can access. Are we getting more robust meetings since people can access meetings virtually more easily? The quality, quantity, and types of engagement have greatly improved but we still have accessibility problems. The objective of this research is to identify and synthesize the best practices that engage and provide more accessible interaction with the public for public involvement.
POST-COVID-19 Future System Implications	Assessment of Advanced Vehicle Technology Solutions for Mobility Disadvantaged Populations During a Pandemic	Connected and automated vehicles have the potential to offer tailor-made solutions to individual user needs, which is critical in case of the mobility-disadvantaged populations. These groups were previously viewed as monolithic; however, each user group has specific and unique needs (medical, mobility, etc.), and typical solutions are not readily available. As a result, communities have come up with ad-hoc solutions to support these populations during the pandemic, but a systematic assessment of technology solutions is needed for future preparedness. This research will support identification of these user groups against available technology solutions, identify potential feasible solutions, and support conducting a benefits assessment.

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Changes in Demand, Transportation Planning, and Data		
Topic	Research Needs Statement Title	Description
POST-COVID-19 Future System Implications	Better Understanding of Travel Demand and Behavior for Future Crises	State DOTs have been collecting and assessing data on changes to travel behavior and demand since the COVID-19 crisis. The data are being used to inform community and department decision-makers about changes in travel patterns including traffic volume, speed, and classification, modes versus population classes, and access. Respondents indicated that these data can assist with the measurement of government stay-at-home order compliance, adjustment of road construction times, forecasting revenue effects, and the allocation of first responders. A synthesis of practice might help ascertain patterns and expectations that could be repeated in future crises/pandemics and/or inform longer-term public policy to mitigate the effects to transportation services, infrastructure and projects in the future. To what extent are these changes temporary versus permanent, and what does that imply for the needs for all forms of urban transportation during the coming decades? How much of the prior demand for commute travel will return, and over how long a period? How much of the prior demand for shopping and leisure activity travel will return, and over how long a period? How will public transit services and roadway infrastructure need to change in response to the demand-side changes? This study would need to include both surveys of traveler attitudes and hard data on trips actually made.
POST-COVID-19 Future System Implications	COVID-19: Mid-Range Scenario Planning	While there is a wealth of information about what transit agencies are doing in the moment to respond to COVID-19 challenges, finding information about various mid-range scenario-based planning for COVID-19 recovery has been quite evasive. For the purposes of this study, mid-range can be defined as April 2020 to September 2020. The ideal research outcome would be a comprehensive set of scenario-based considerations and potential corresponding mitigation actions that transit agencies are taking to address mid-range recovery (the next 6 months) for challenges stemming from COVID-19.
POST-COVID-19 Future System Implications	Environmental Impacts of COVID-19	A study could be proposed to fully understand the environmental impacts of COVID-19. There will be many claims on air, water, and climate impacts, and the causes (reduced vehicle miles traveled, retail and manufacturing shutdowns, etc.). These claims could be collated, peer-reviewed and verified, and assembled into a national resource for researchers.
POST-COVID-19 Future System Implications	Impacts of Pandemics on the Future of Automated Vehicles	The current global COVID-19 pandemic is causing significant impacts on travel and transportation systems. Policies such as social distancing, shelter-in-place, and restrictions on business and government services have brought to light how transportation modes exacerbate or mitigate the spread of infectious diseases. This project will analyze the possible actions (policy, planning, infrastructure, IT/data) that state and local agencies might undertake to use driverless vehicles to mitigate future pandemics and synthesize the findings in a report.

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Changes in Demand, Transportation Planning, and Data		
Topic	Research Needs Statement Title	Description
POST-COVID-19 Future System Implications	Impacts on Public Transportation from the COVID-19 Pandemic	For planning for possible future events, determine what the impacts on public transportation have been related to ridership and operator health and safety. Determine the role that public transit should play during future pandemics and its ability to serve the demand for public transportation or the adaptability for assisting in the movement of goods and services.
POST-COVID-19 Future System Implications	Implications of COVID-19 on Public Attitudes Toward Shared-Ride Services	To what extent will the current attitudes toward social distancing carry over after the pandemic is past, and what does that portend for public attitudes toward use of conventional rail and bus mass transit services? How is that likely to affect usage of the shared-ride services offered by ride-hailing companies today? In the longer term, how is that likely to affect attitudes toward automated taxi services that would operate without a driver, for both individual and shared rides? Surveys of public attitudes toward these questions at several time intervals post-pandemic would be very useful to show how enduring the effects of the pandemic are going to be.
POST-COVID-19 Future System Implications	Managing Traffic Control and Transportation Facilities	The COVID-19 pandemic and the social distancing countermeasure have impacted the way to manage traffic control and transportation facilities. We need to reconsider and develop new strategies, approaches, and infrastructure usage when it comes to traffic signal, bus, and transit operations, and the associated impacts. To that end, we would need to research, study, and explore: <ul style="list-style-type: none"> <li>• Pedestrian-related traffic signal retiming parameters (Walk, flashing Don't Walk, Don't Walk, and associated parameters in the context of this pandemic that facilitate social distancing;</li> <li>• Design guidelines for pedestrian sidewalks (one-way versus two-way versus Barnes Dance intersections) to minimize person-to-person contact, maintain social distance effectively; and</li> <li>• Dynamic bus-transit seat arrangements based on the intended destinations while providing the best social distancing and minimizing person-to-person interactions.</li> </ul> These strategies will call for strategy and guideline development, and pedestrian-related simulation studies, and decision-support tools for emergency management agencies and policy- and decision-makers.
POST-COVID-19 Future System Implications	Preliminary Implications for Freight Autonomous Vehicles	The COVID-19 pandemic will likely lead planners, developers, operators, and the public to rethink the role and use of freight autonomous vehicles. As of early 2020, there is of course, no literature or research on the subject. A NASEM study could set a research baseline in this topic area. Significant issues likely to emerge include: potential surging demand for "no touch" transactions and deliveries to minimize human contact; concern over access to needed supplies for those quarantined, self-quarantined, or sheltering in place; concern over the sanitation of transit vehicles and delivered goods or meals; long-term impacts of social isolation and dependence on delivered goods; and fragility of the "gig economy" and impacts on supply chain employment.

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Changes in Demand, Transportation Planning, and Data		
Topic	Research Needs Statement Title	Description
POST-COVID-19 Future System Implications	Shared Mobility in a Post-COVID-19 World	What are the potential short-term and long-term impacts of the COVID-19 pandemic on shared mobility? How will the willingness to use shared-mobility services be impacted by fears of infection, availability of a vaccine, apprehensions of using public transit, telecommuting, and driverless vehicles? What changes can be expected to provide trusted networks, touchless travel, and rider protocols? What changes will be temporary, and which will be enduring?
POST-COVID-19 Future System Implications	Societal Benefits Resulting from the Required Social Distancing and Teleworking	The mandated social distancing and travel restrictions have resulted in a magnitude increase in teleworking. In the short length of time this has been in effect, traffic congestion on our nation's roadways has almost been eliminated. As a result, there may be significant societal benefits. These benefits include reduced traffic congestion leading to improved safety through crash reductions and improved air quality. It is important to identify and model these benefits so that the cost/benefit can be factored into future discussions and decisions on the viability of this transportation demand management technique for when we return to more a normal situation after the pandemic has ended.
POST-COVID-19 Future System Implications	Strategies to Encourage Safe Ridership Regrowth Following COVID-19	Ridership for public transit has plummeted in the immediate response to COVID-19 as stay-at-home orders and restrictions on travel reduce demand for all transportation services. However, there is broad concern that people will continue to avoid public transit when they resume other travel for fear of the social mixing that occurs while waiting and onboard. Technical fixes will be one part of the solution (e.g., changing seating arrangements), but the marketing and public communications aspects will be just as important. What are strategies to encourage safe ridership regrowth as countries emerge from the COVID-19 pandemic? How can more forms of contact-free payment and incentives be made available to riders? What kinds of incentives can agencies provide, and are there policy changes or tools provided as needed to support this? How can this be done in ways that are equitable across the ridership of each agency?
POST-COVID-19 Future System Implications	Study the Implications of COVID-19 on Public Attitudes Toward Shared-Ride Services	To what extent will the current attitudes toward social distancing carry over after the pandemic is past, and what does that portend for public attitudes toward use of conventional rail and bus mass transit services? How is that likely to affect usage of the shared-ride services offered by ride-hailing companies today? In the longer term, how is that likely to affect attitudes toward automated taxi services that would operate without a driver, for both individual and shared rides? Surveys of public attitudes toward these questions at several time intervals post-pandemic would be very useful to show how enduring the effects of the pandemic are going to be.

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Changes in Demand, Transportation Planning, and Data		
Topic	Research Needs Statement Title	Description
POST-COVID-19 Future System Implications	Study the Implications of the COVID-19 Travel Disruptions for Longer-Term Changes in Long-Haul Passenger Travel Demand	COVID-19 has temporarily destroyed long-haul passenger travel demand, for both business and leisure travel. How much of the long-haul business travel demand loss will be permanent, as businesses become more accustomed to holding meetings online rather than in person? What are the implications for the air travel, hotel and rental car industries, as well as the convention centers and their associated impacts on transportation systems in their vicinity? This study would need to include both surveys of business attitudes and policies and hard data on business travel post-pandemic.
POST-COVID-19 Future System Implications	Study the Implications of the COVID-19 Travel Disruptions for Longer-Term Changes in Urban Trip-Making Behaviors	The COVID-19 restrictions on travel have forced people into telecommuting and online shopping to an unprecedented extent and have severely disrupted public transit services in most cities. To what extent are these changes temporary versus permanent, and what does that imply for the needs for all forms of urban transportation during the coming decade? How much of the prior demand for commute travel will return, and over how long a period? How much of the prior demand for shopping and leisure activity travel will return, and over how long a period? How will public transit services and roadway infrastructure need to change in response to the demand-side changes? This study would need to include both surveys of traveler attitudes and hard data on trips actually made.
POST-COVID-19 Future System Implications	Transit after COVID-19	Transit will be different after COVID-19, funding will be different, demand will likely be different, and possibly the types of services provided. Differences to consider include: <ul style="list-style-type: none"> <li>• What the demand for transit will be, both in terms of types of types and amounts of transit;</li> <li>• Through surveys and market research, how to find transit's market; and</li> <li>• The changes in both funding and transit regulation to meet the new market demands and the changes in the economy which affect transit funding.</li> </ul>
Technology Applications	Automated Contactless Refueling–Recharging of Vehicles	Refueling traditional vehicles and recharging of electric vehicles (and paying for such supplies) is a manual task typically done by the driver or a passenger. In days past, it was more common that an attendant would provide such services. While careful use of PPE (gloves, sanitizer) can largely address such situations during pandemics, not all users may comply. This research would explore robotic methods by which vehicles can be refueled without the need for a human to exit the vehicle. The research is also germane to a future of driverless vehicles, which will need refueling but may not be in proximity to a refueling station with an attendant.

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Changes in Demand, Transportation Planning, and Data		
Topic	Research Needs Statement Title	Description
Technology Applications	Deploying Autonomous Vehicles in Neighborhoods and in Urban and Campus Environments	Public transit's lack of agility in responding to this virus indicates that the era of fixed-route, fixed-schedule transit service may be over. We simply do not have the funds to continue business as usual. Investing in high-capacity transit from major nodes while providing low-cost local access using on-demand autonomous shuttles on low-speed streets will connect people in suburbs to transit. There is the need to study last-mile services and the possible elimination of underperforming routes. This has been accomplished in other parts of the world, such as, Doha, Dubai, and Singapore, where driverless high-capacity trains operate and many community areas already feature internal on-demand links to transit, shortening trip times while increasing reliability.
Technology Applications	Shared Mobility in a Post-COVID-19 World	The COVID-19 pandemic has changed the landscape for shared-mobility services and companies. The willingness to use shared-mobility services in the future can be expected to be impacted by fears of infection, availability of a vaccine, apprehensions of using public transit, and other factors. Transportation agencies need to know what to expect from these services in a post-COVID-19 world, and how this might affect the future of transportation systems and services. What are the potential short-term and long-term impacts of the COVID-19 pandemic on shared mobility? How will the willingness to use shared-mobility services be impacted by fears of infection, availability of a vaccine, apprehensions of using public transit, telecommuting, and driverless vehicles? What changes can be expected to provide trusted networks, touchless travel, and rider protocols? What changes will be temporary, and which will be enduring?
Technology Applications	Supervised Automated Public Transit Vehicles	It is important to keep the public transit system running for critical service personnel who may be transit-dependent to get to—from home and work. However, we need to reduce the risk to the human operator in the pandemic environment. A solution is to have centralized supervision of the automated transit vehicles to allow rapid adaptation to operational changes, such as changing routes to service emergency medical facilities.
Technology Applications	Using Automated Vehicles to Mitigate the Impacts of Pandemics	The global COVID-19 pandemic has caused significant impacts on travel and transportation systems. Policies such as social distancing, shelter-in-place, and restrictions on business and government services have brought to light how transportation modes exacerbate or mitigate the spread of infectious diseases. This project will analyze the possible services that automated vehicles could provide (e.g., freight deliveries, transportation for essential workers) and state and local actions (policy, planning, infrastructure, IT/data) that could be undertaken to use driverless vehicles to mitigate the impacts of future pandemics.

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Changes in Demand, Transportation Planning, and Data		
Topic	Research Needs Statement Title	Description
Tracking Data, Reporting Methods, and Evaluations	Accounting for Gender Dimensions in Commuting and Activity Patterns	Our mobility has been disrupted by stay-at-home orders during the COVID-19 pandemic response. Those able to work remotely have been obliged to do so, although our working behaviors have changed our normal home behaviors. For instance, in-home activities such as childcare, errands, and family care have replaced the time normally spent on commuting to the office or other in-office work functions. This change in working-at-home behavior has added extra pressure on (working-at-home) women. As a result, they are facing time and space constraints to organize their in-home and out-of-home activities (unpaid trips). Hence it is very important to explore how the intra-household attributes affect the out-of-home activities in the context of working from home. A study is needed to analyze the intra-household attributes: socioeconomic, demographic, household attributes, partner attributes, gender roles and responsibilities, and preferences. The research could explore the association between working from home (or absence of commuting) and intra-household attributes in order to provide sustainable and suitable strategies within gender-transport nexus during response phases to a pandemic that benefits gender groups.
Tracking Data, Reporting Methods, and Evaluations	Correlation of Early 2020 Pandemic Transmission Patterns to Regional Travel Model Outputs Based on Live, Work, Shop, and School Patterns	What can we learn about the dispersal patterns of COVID-19 infections from existing regional travel demand models? Metropolitan planning organizations (MPOs) develop and maintain macro travel models to understand flows of people and goods at the regional level. These models are based on well-documented patterns of where people live, work, shop, and go to school, as well as core household and socioeconomic characteristics of the population. They are the foundation of the MPO toolkit, and their analyses cover most of the urban areas of the United States. What can be learned by mapping the January–April pandemic outbreaks across the country on the base-year travel pattern outputs of the nation’s regional travel demand models? Are there any patterns that can be useful in anticipating how future outbreaks might spread spatially within a region based on where the eruption occurred? There are 408 MPOs across the United States, and the vast majority maintain a travel demand model calibrated to a relatively contemporary base year. Highly functioning MPOs, especially in major metropolitan areas, collect their own data and so have finely tuned models that reflect their regions’ land use patterns integrated with detailed socioeconomic household characteristics. Many also model multiple modes of travel and a wider range of trip purposes. A relatively quick assessment will help determine whether or not outbreaks correspond to any discernible travel patterns generated by regional travel demand models. If there is a correlation in patterns, the research could evaluate how these regional models can be used to better anticipate the trajectory of future outbreaks to help better predict, isolate, and target flare-ups. The objective is to determine whether the observed patterns

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Changes in Demand, Transportation Planning, and Data		
Topic	Research Needs Statement Title	Description
		of dispersal of COVID-19 between January–April 2020 correspond to base-year travel patterns generated by regional travel demand models. If there are correlations, what can be deduced about the value of these models in understanding the spread of future outbreaks? The products are likely to be data fusions bringing together public health data records and regional model outputs for a select number of regions around the country with documentation of the analyses and a brief on the findings.
Tracking Data, Reporting Methods, and Evaluations	How Travel Behavior Changed as Shifting Priorities Changed Throughout the Pandemic	Did certain modes prove to be more essential and by which population classes? Were certain travel characteristics valued for certain activities, such as managed lanes offering reliability and transit providing lifeline transportation to those who needed it? How much of an impact did the shutdown–slowdown of public transit, micro-transit, TNC, etc. have on populations that do not own vehicles or have easy access to them?
Transportation System Resilience	How Travel Behavior Changed as Shifting Priorities Changed Throughout the Pandemic.	Did certain modes prove to be more essential and by which population classes? Were certain travel characteristics valued for certain activities, such as managed lanes offering reliability and transit providing lifeline transportation to those who needed it? How much of an impact did the shutdown–slowdown of public transit, micro-transit, TNC, etc., have on populations that do not own vehicles or have easy access to them?
Transportation System Resilience	Deploying Autonomous Vehicles in Neighborhoods and in Urban and Campus Environments	Public transit’s lack of agility in responding to this virus indicates that the era of fixed-route, fixed-schedule transit service may be over. We simply do not have the funds to continue business as usual. Investing in high-capacity transit from major nodes while providing low-cost local access using on-demand autonomous shuttles on low-speed streets will connect people in suburbs to transit. There is the need to study last-mile services and the possible elimination of underperforming routes. This has been accomplished in other parts of the world, such as, Doha, Dubai, and Singapore, where driverless high-capacity trains operate and many community areas already feature internal on-demand links to transit, shortening trip times while increasing reliability.

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Changes in Demand, Transportation Planning, and Data		
Topic	Research Needs Statement Title	Description
Transportation System Resilience	Rethinking Emergency Corridors: All Modes and User Focused	<p>Transportation corridors must be evaluated not just for cars evacuating out of an area but for all modes to access areas of critical services and suppliers in and out of an area. This evaluation must include redesign and modification of operations to effectively address new needs revealed during the pandemic, as well as strong consideration and integration of transit and freight into corridor designations and planning. Research is needed to support identification of key corridors to transport essential employees to and from work using multiple modes, such as transit, rail, cars, and bicyclists–pedestrians. We have well-developed transportation systems to evacuate people out of business centers, but the new challenge is returning people to work and school whether the challenge be medical, financial, etc. Bus schedules are not designed for dynamic scheduling or communications. Research is needed to support the effort to plan, model, and operate emergency corridors to service critical facilities during the emergency and in the recovery phase. In the past, corridor scenario planning did not consider access to serve the community needs during a pandemic. Evacuation corridors were originally planned to get residents out of areas when natural disasters were about to happen. In the past, typical planning didn't consider transit and rail, how to get people serving the sick and dying to work and/or get the sick to the hospital using transit, or how we get PPE and goods to hospitals. Emergency corridors that can be used during a pandemic should consider two-way traffic and need to be transit accessible. We need to plan corridors to serve hospitals and essential businesses. Are we serving those basic needs properly with our current evacuation corridors? How do we learn from our COVID-19 experience in the design of corridors, use of transit, flexibility in fares and services to actually prioritize corridor access for those who need it during a pandemic? Should we consider a reclassification of a one-way evacuation corridor as a two-way emergency corridor? Should we include transit in this modified emergency corridor planning? The objective of this research is to identify how we can learn from our COVID-19 experience in the design of two-way emergency corridors, use of transit and rail, and flexibility in fares and services to actually prioritize corridor access for those who need it to provide critical services or essential supplies during a pandemic.</p>
Workforce	IT/Virtual Meetings and Engagement: Best Practices on Virtual Meetings	<p>As social distancing has significantly increased teleworking, there are more virtual meetings. Research is needed for security safeguards as well as Internet and bandwidth constraints to conduct large volumes of work remotely. Some agencies have modified their policies regarding remote VPN and use of personal equipment in very short time periods. There was very little guidance on this pre-COVID-19. A synthesis is needed of IT/virtual meetings and engagement best practices during COVID-19 so agencies can benchmark against their peers.</p>

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Changes in Demand, Transportation Planning, and Data		
Topic	Research Needs Statement Title	Description
Workforce	Impact on Businesses from Increased Telework	This pandemic is providing a unique opportunity for evaluating various businesses–industries to determine the impact of this increased telecommuting. Many businesses in the past have opposed telework because they worry about the productivity of their staff working remotely versus their typical working pattern. Thus, an extensive survey of various types of businesses–industries analyzing if their fears are unfounded or confirming they are right for their particular business–industry.

**CATEGORY D: SOCIAL JUSTICE, ACCESS, AND MOBILITY EQUITY**

<b>Social Justice, Access, and Mobility Equity</b>		
<b>Topic</b>	<b>Research Needs Statement Title</b>	<b>Description</b>
Leadership and Administration	Equitable Public Participation in the Time of Social Distancing and Zoom	Public involvement and community outreach have been significantly altered due to the COVID-19 global pandemic. Stay-at-home orders and social distancing guidelines prohibited traditional in-person events and quickly moved most public participation opportunities online. Though moving everything online can be an “easy” solution, it’s not an equitable one and has the potential to disenfranchise those in rural, low-income, limited English proficiency, and environmental justice communities. This research topic will gather data so transportation professional can better understand areas and communities that are disproportionately impacted by online public involvement. With 2020 Census data available in the coming year, this research will delve into data to inventory areas and communities with no or limited high-speed Internet access, smartphone, tablet, and computer access, and households that have to share computers. In addition to a national inventory research should also include public involvement tools that are more equitable than online participation and meet the needs of the various populations challenged by online access. The objective of this research topic is to inventory the country regarding areas where online participation is not possible or challenging and provide public involvement tools that can serve as alternatives to online participation. The research and information will assist transportation professional in facilitating more equitable public involvement.
Transportation System Resilience	Americans with Disabilities and Travel Navigating in a Pandemic Environment Requiring Social Distancing	Many retail establishments have placed tape on the ground to indicate distances 6 ft apart, especially for customers waiting in line. However, tape, rope, or plastic chain strung between devices are not detectable by those with visual impairments and do not comply with the design standards in the Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities, and should not be used as a control for pedestrian movements. How do we mitigate potential harm to vulnerable populations and provide equitable accessibility options during a pandemic?



**CATEGORY E: EFFECTS ON ECONOMICS, REVENUES,  
AND COSTS (INCLUDING STIMULUS)**

Effects on Economics, Revenues, and Costs (Including Stimulus)		
Topic	Research Needs Statement Title	Description
Transportation System Resilience	Evaluate the Benefits of Keeping Ongoing, Large, Infrastructure Projects Under Construction During Pandemic or Similar Events	This research would have twofold benefits, providing necessary economic stimulus by keeping large numbers of workers employed and realizing the cost-saving benefits of utilizing construction methods by taking advantage of reduced traffic demands in corridors resulting in lower work zone traffic management costs. In addition, construction time may be reduced due to this reduced traffic.
Transportation System Resilience	Provide Immediate Grants and Matches to Local Agencies and State DOTs for Maintenance of Roadways	These projects are sorely needed and can be delivered quickly using workers with minimal training. Examples include pavement resurfacing, bridge patching, drainage and slope improvements, and a variety of other projects that typically employ workers with family-wage jobs. Such projects will get people working outside where the risk of virus transmission is lower while at the same time allowing public agencies to catch up on a huge backlog of deferred investment in roads.

**CATEGORY F: GOVERNANCE AND ROLES DURING A PANDEMIC**

<b>Governance and Roles During a Pandemic</b>		
<b>Topic</b>	<b>Research Needs Statement Title</b>	<b>Description</b>
Leadership and Administration	Customer-Facing Innovations: Implementing Changes Post-Pandemic	Research is needed to support agencies as they seek to institutionalize the many changes to organizations, operations and service improvements post-pandemic. For example, rear-door transit boarding, transit routes, providing DMV–RMV services (licenses, registrations, hearings) online, virtual public engagement, etc. We need a synthesis to document what agencies are doing to institutionalize these changes. The objective of this research is to support agencies as they seek to institutionalize the many changes to organizations, operations, and service improvements post-pandemic.
Leadership and Administration	Implement and Sustain Workforce-Facing Innovations Post-Pandemic	The COVID-19 crisis has created an amazing body of experience and practice enabling flexibility in workforce location and capabilities implemented during COVID-19. Research is needed to identify and synthesize best practices to support policies and practices that encouraged innovation ensuring the beneficial changes used during the pandemic are institutionalized. These crisis-inspired legal, legislative, and policy innovations now in place will enable lasting benefits. Some areas of research include changes to physical location and layout of offices, use of meeting space with requirements of social distancing, and remote working. Are we going back to private offices? Do we need to modify our bathrooms? Will more staff be able to work from home on a regular basis? A synthesis of best practices is needed to support workforce policies and practices that encourage innovation, ensuring the beneficial changes used during the pandemic are institutionalized.
Workforce	Addressing Aging Marine Transportation Infrastructure Within Post-Pandemic Infrastructure-Jobs-Stimulus-Recovery Bill	Addressing aging infrastructure will be one of the key factors in putting America back to work. Ports, inland waterways infrastructure, and coastal waterways are often not included in the aging infrastructure discussion—planning at the federal level despite the economic benefits they provide. Inclusion of this vital infrastructure specifically in related recovery legislation would be of great benefit to the nation.
Workforce	3-Day Work Week: An Alternative Solution for Reopening the Economy	The initial idea was developed to solve travel congestion problems: most transportation facilities are overwhelmed during peak periods, a.m. and/or p.m., when people go to work and come home around the same time. If only half of the commuters go to work on the earlier part of the week and the other half go to work during the latter half of the week, the travel demand during peak periods will decrease by 50%, which will solve the traffic congestion problem for most locations. The 3-day work week will shorten the working time for most workers but may not decrease the productivity, as has been supported by many studies. The increased free time not only provides opportunities to rest, enjoy recreation, and pursue leisure, community, and innovative activities, but also to redistribute the spatial and temporal patterns of activities of most urban dwellers, which is made urgently necessary by the social distancing, no-gathering, and lower capacity of even essential businesses during the unprecedented COVID-19 pandemic.

**CATEGORY G: PUBLIC HEALTH**

Public Health		
Topic	Research Needs Statement Title	Description
POST-COVID-19 Future System Implications	Adjusting to the “New Normal” to Protect the Traveling Public and Transportation Professionals	The traveling public may find it difficult to return to mass transportation options (public transit, aviation, marine, etc.). Their safety must be ensured and confidence must be instilled before we can get to any semblance of a normal situation. Looking at what happened because of September 11, 2001, after which security protocols throughout the transportation industry, especially airports, were drastically changed to address concerns and protect the traveling public, some inference can be made that similar drastic changes will be needed to ensure the safety of public health (e.g., routine or required health screenings). We need to learn from procedures that already exist (primarily in Asia) and determine what works, along with the implications for implementation on infrastructure, policies, and procedures, particularly at major ports (air, marine, borders).
Transportation and Health	Carpooling During a Respiratory Pandemic	Should carpooling be encouraged during the COVID-19 pandemic response and recovery? If yes, what are the safest ways to carpool? What precautions should carpoolers take? Who would communicate precautions and good practices to carpool companies and drivers? Would the practices needed be mandatory or voluntary? If no, how should we best meet the travel needs of carpool users? Although little data is available on the common practice in normal times of giving relatives, friends, neighbors, and community members’ rides to services, events, and appointments, in 2018, 9% of Americans commuted to work via carpool or vanpool, as compared to only 4.5% via mass transit. (Note: The CDC releases and updates advice for drivers for-hire, but as of May 6, 2020, had not addressed carpooling or giving rides within a community.) In the short-term, the research should produce a best practices brief that can inform decision-makers in public health, community development, transportation demand management, etc. In the long-term, research on the impacts of carpooling and ride-giving should inform pandemic response and recovery planning.
Transportation and Health	COVID-19 Locality Vulnerability Assessment	As COVID-19 restrictions are lifted, and before they are reimposed with a second wave, we need a statistical assessment of local population vulnerability to COVID-19. We know which health conditions leave people especially vulnerable, and we know from CDC and United States Renal Data System data sets by locality where these people live. We need an index using predictive analytics determining which of these statistics correlate with clusters of hospitalization and death due to COVID-19. This index would be used by elected officials to assess risk in each county, city, and township–parish. An index to be used by elected officials in imposing or lifting restrictions is necessitated by COVID-19.

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Public Health		
Topic	Research Needs Statement Title	Description
Transportation and Health	Reducing the Risk to Passengers and Operators by Designing Easily Disinfected Transit Interiors	Research transit vehicle interior design to simplify frequent (e.g., the end of each run or more) cleaning and sanitization of interior. The choice of material that can influence the balance between cost, maintenance, and effectiveness.
Transportation and Health	Understanding Pollution's Role in the Spread of COVID-19	There have been studies (limited) to show the potential linkage between air pollution level (e.g., PM <sub>2.5</sub> ) and the spread of virus. Specifically, virus may become aerosolized with particulate matter particles in the air and transport longer distances as aerosols in the air. In other words, higher air pollution may contribute to wider spread of COVID-19. Virtually no study has looked at this linkage in the indoor environment (e.g., in aircraft cabin, cruise ship, subway station, transit vehicle, nursing home, or even our residential homes). On a daily basis average, people spend about 80% of their time indoors. There is a great need to fill that void and the research has tremendous public health implications.

### AIR TRAVEL AND PORTS<sup>a</sup>

Air Travel and Ports		
Topic	Research Needs Statement Title	Description
Leadership and Administration	Aircraft Parking Communication and Management	TRB has excellent publications on the importance of this (see <i>Transportation Research Circular E-C266: Transportation Asset Management in a COVID-19 World: A TRB Webinar</i> ). As has been realized during the pandemic, guidance on effective internal communication from leadership to rank-and-file workers is needed. Also, guidance is needed for agency external communications with partners and businesses that are mutually dependent. As agencies expend significant time and effort on issuing new directives on a daily basis to address new and changing data and lessons learned from the pandemic, more guidance and best practices on how to effectively and efficiently communicate while optimizing resources such as time of managers would be useful. What are the best practices for coordinated communications among political jurisdictions? Often it looks as if every crisis recreates this wheel. The objective of this research is to provide guidance and best practices on how to effectively and efficiently communicate internally with the rank and file and externally with partners and businesses while optimizing resources such as time of managers.
Leadership and Administration	Communications: Best Practices During a Pandemic	During the COVID-19 pandemic, airlines scrambled to park aircraft as air traffic declined rapidly. Unlike regular flight operations requests, which may be communicated through IATA SSIM messages, no organized messaging system exists for aircraft parking requests across multiple airports. The research would focus on failings of the current system brought to light by COVID-19 and propose solutions.
Leadership and Administration	Effects of Lease Agreements and Rates and Charges Policies on COVID-19 Responses	U.S. airports operate under myriad lease agreements, none of which were designed to accommodate an event on the scale of the COVID-19 pandemic. The research would focus on how different airport-airline leases affected the efficiency with which airports and airlines could adapt to changing conditions, the financial stability or uncertainty experienced by each party, and the effects of lease and charging policies on airline recovery strategies.
Leadership and Administration	Improving Airline-Airport Communication During Crises	In the United States, airlines rarely communicate advance schedules to airports. In the absence of this information, airports must rely on third-party schedule aggregators like the <i>Official Airline Guide</i> , which were not designed for rapid updates. The research would focus on the role of timely, structured schedule sharing in the efficient operation of airports and airlines during a crisis.

<sup>a</sup> As discussed in the Summary Approach section of this E-Circular, discussion of problem statements specific to air travel and ports was limited during the brainstorming session. Consequently, the RNS list provided in this table has not been presented as a category within the main body of this report.

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Air Travel and Ports		
Topic	Research Needs Statement Title	Description
POST-COVID-19 Future System Implications	Changing Behavior of the Rich Because of COVID-19 and the Impact on Their Air Travel Mode Selection	With COVID-19 there is something unfamiliar that may provide a downside for the airlines and upside for business aviation. There is an emerging theory that the wealthy and Fortune 500 companies will not want to expose their seniors to the risk of infection from the general population. Traveling on business aircraft feels safer and will enable mobility sooner. Wealth inequality is a reality, and much of the air transportation business is reliant on rich peoples' and global companies' spending. The small proportion of passengers who sit in first and business class provide a disproportional profit contribution to the airlines. It could be argued that the price-inelastic rich enable low-cost flying for the masses. Separately, rich individuals and corporations support the business aircraft industry, which employs over 250,000 people in the United States and directly contributes \$40 billion to the economy. Will price-inelastic rich people and global corporations change their mode of air travel due to safety concerns from COVID-19 and future pandemics? Is this phenomenon structural or temporary? Is the impact enough to change the airlines' business model?
POST-COVID-19 Future System Implications	Efficacy of Facility Closures Due to COVID-19	Due to a lack of demand, several airports are closing gates, concourses, and whole terminals. A study would determine the efficacy of these closures, accounting for reductions in staffing, operations, and maintenance costs and acceleration of construction projects, where appropriate.
POST-COVID-19 Future System Implications	Study the Implications of the COVID-19 Travel Disruptions for Longer-Term Changes in Long-Haul Passenger Travel Demand	COVID-19 has temporarily destroyed long-haul passenger travel demand for both business and leisure travel. How much of the long-haul business travel demand loss will be permanent, as businesses become more accustomed to holding meetings online rather than in person? What are the implications for the air travel, hotel and rental car industries, as well as the convention centers and their associated impacts on transportation systems in their vicinity? This study would need to include both surveys of business attitudes and policies and hard data on business travel post-pandemic.
Technology Applications	The Role of Surface Collaborative Decision-Making (S-CDM) in Crisis Management	Over the next few years, Federal Aviation Administration will roll out S-CDM tools to select airports in the National Airspace System. In Europe, a similar CDM process, Airports CDM, has existed for several years. This research would focus on the role of S-CDM in managing airports and airlines during a crisis.

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Air Travel and Ports		
Topic	Research Needs Statement Title	Description
Technology Applications	What Are Best Practices for Ensuring Quick Recovery for Airlines	Hypothesis: grounding fleets—at this magnitude—has rippling effects on airline operations. From retraining pilots, to ensuring gas in engines does not go moldy to getting customers comfortable with flying again, COVID-19 provides a unique opportunity to compile and synthesize best practices for ensuring quick return to operations. [Side Note: AGIFORS, the airline professional organization, is attempting to host an online conference in June to address this issue; this could be a potential co-sponsored event with the National Academy of Engineering for expanding scope.] Hypothesis: some of the practices currently being implemented, like deep cleaning—fogging aircraft or minimizing contact with passengers may continue after COVID-19. It would be good to get a sense of what the costs/benefits are of continuing some of these practices (such as deep cleaning).
Tracking Data, Reporting Methods, and Evaluations	Effects of the COVID-19 Pandemic on Small, Medium, and Large Hub Airports	This research would study the effects of the pandemic on groups of airports by size to determine whether hardships were distributed evenly or unevenly.
Tracking Data, Reporting Methods, and Evaluations	How Did Schedule Reductions Evolve Among the Carriers, and Were There Differential Impacts on Profitability Across Different Carrier Types?	Hypothesis: There will likely be structural changes to the airline industry post-COVID-19, with a loss in ultra-low-cost carriers, small airline carriers, and potentially even large airline carriers. What are the consequences on future airline competition given these forecasted restructurings? What distinctions exist between the impacts for passenger aviation and air cargo?
Tracking Data, Reporting Methods, and Evaluations	Predicting Future Airline Demand	Predicting when customers will return to airline service after the COVID-19 event is difficult, yet important to understand for getting a perspective on the sustainability of airline operations. There will likely be structural changes in demand that occur. For example, will businesses reduce overall travel? Will leisure customers delay trips? Through customer surveys conducted over time, we can build a model of how customer and business sentiment is influencing demand for air travel and get a better picture of recovery.
Transportation System Resilience	Organizational Resiliency Planning for Airports	A study should identify which functions or services are critical and essential to continue. It also should determine what systems are needed to support those critical or essential functions; what suppliers we rely on to support or provide those services; if the suppliers would be available to assist during a crisis; who is needed to support those essential functions and systems; where they can do this from; how to communicate, coordinate, and collaborate with stakeholders; and if we have financial resources to survive without pax/air service, etc.
Transportation System Resilience	Prepare a National Aviation Pandemic Preparedness Plan	Have airports prepare plans that supplement local- or state-level plans. This could be integrated into climate change—resilience preparedness and adaptation into airport development and operations.

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Air Travel and Ports		
Topic	Research Needs Statement Title	Description
Workforce	Effects of Labor Agreements on Airline Responses to COVID-19	This research would study the effects of various airline-employee labor agreements on their reactions to the COVID-19 pandemic, including the roles of unions, scope clauses, and offers of paid and unpaid leave.
Workforce	Crew Safety Risk Management Framework	The current safety framework gives organizations a process and decision support tools to systematically analyze their ships and offshore assets and their associated work areas to determine their workforce's risks so that controls can be implemented to mitigate the risks to an acceptable level. This may or may not have been used successfully or optimally within the marine industry for the COVID-19 event. A study could be proposed to determine the applicability of existing risk management concepts to deal with contagious infections.
Workforce	Impact of Pandemics on Mariners	Some countries' travel restrictions have prevented crew changes, resulting in tours onboard international commercial vessels being extended 30 to 60 days or more, at a time when crews' families are in lockdown or at risk of infection at home. How did this impact our mariners mentally and in performance? Does this vary by vessel type or by command-management structure or approach? How could this be handled more effectively, and how can it be coordinated internationally in the future? A NASEM study could explore how the current international governance structures facilitate or impede movement of the mariners and goods. What protective practices and policies were most effective in preventing crew infection, and what helped support crew morale and mental health? How might education and training, for officer and crew be improved to address future health emergencies?
Workforce	The Effects of the COVID-19 Pandemic on Defense Readiness	On vessels and in close quarters, COVID-19 is spreading rapidly on Navy and Coast Guard ships. There is a need for developing further protocols where social distancing is largely not feasible. In addition, vendor closures in the U.S. Department of Defense (DOD) supply chain are continuing to degrade military readiness. Production line employees are choosing paid leave and voluntary layoffs rather than risk exposure to COVID-19. The armed services are limiting transfers and recruit training, which will affect workforce levels and readiness into the future. DOD civilian leadership were not prepared or manned appropriately to handle the current crisis. A study related to COVID-19's effect on defense readiness could be executed by NASEM.

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Air Travel and Ports		
Topic	Research Needs Statement Title	Description
Leadership and Administration	Aircraft Parking Communication and Management	TRB has excellent publications on the importance of this (see <i>Transportation Research Circular E-C266: Transportation Asset Management in a COVID-19 World: A TRB Webinar</i> ). As has been realized during the pandemic, guidance on effective internal communication from leadership to rank-and-file workers is needed. Also, guidance is needed for agency external communications with partners and businesses that are mutually dependent. As agencies expend significant time and effort on issuing new directives on a daily basis to address new and changing data and lessons learned from the pandemic, more guidance and best practices on how to effectively and efficiently communicate while optimizing resources such as time of managers would be useful. What are the best practices for coordinated communications among political jurisdictions? Often it looks as if every crisis recreates this wheel. The objective of this research is to provide guidance and best practices on how to effectively and efficiently communicate internally with the rank and file, and externally with partners and businesses while optimizing resources such as time of managers.

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