



NCFRP 48: Freight Research to Support MAP-21 Implementation

Final Report (Draft)

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1 Introduction

1.1 Background

The National Cooperative Freight Research Program (NCFRP) was authorized in SAFETEA-LU in 2005. An Oversight Committee was formed in 2007, followed by the development of a Strategic Plan. The NCFRP mission is to “conduct research and disseminate timely findings that will inform investment and operations decisions affecting the performance of the freight transportation system.” The first NCFRP projects were initiated in the fall of 2007, with the first projects completed in 2009. Approximately 50 NCFRP projects have been funded; a full list of NCFRP projects and published reports is included as Appendix A. NCFRP was not re-authorized in the MAP-21 or FAST Act legislation, so the program will end when the currently active projects are completed.

The NCFRP research has spanned a wide range of topics, including improvements in data and tools for freight analysis, methods to identify and evaluate freight system improvement, and opportunities to strengthen the institutional framework for the freight system. Other projects have focused on describing some of the complex behaviors and business relationships in freight transportation that may not be well understood by public agency practitioners.

MAP-21 contained freight provisions that went significantly beyond previous surface transportation authorizations; many of these requirements have been continued in the FAST Act. While most of these provisions apply to the U.S. DOT, some resulted in new requirements for state DOTs and MPOs. Among other provisions, MAP-21 called for:

- Establishment of a national freight network
- Development of a national freight strategic plan
- Improvements in data and tools to support the evaluation of freight transportation projects
- A biennial freight conditions and performance report
- State freight plans and freight advisory councils
- Setting of state and MPO performance targets for freight

Planners and other practitioners at state DOTs, MPOs, and local agencies can face difficulty incorporating freight into their decision making, and the provisions in surface transportation legislation can exacerbate these challenges. The findings from NCFRP can help practitioners overcome some of the difficulties when incorporating freight into transportation planning and programming. However, like all the TRB cooperative research programs, NCFRP faces the

challenge of making practitioners aware of its research products so that the findings can be put to use. Transportation agency staff today are inundated with information, often being able to access hundreds of documents on a given topic, but not knowing which are the most relevant for a particular question or activity. Thus, for anyone charged with implementing the MAP-21 or FAST Act freight provisions, there is a need for a web tool for locating relevant research findings that are tailored to the specific needs of practitioners engaged in freight policy, planning, and programming.

1.2 Project Purpose and Overview

The primary purpose of this project was to create a web-based tool customized to the needs of freight transportation practitioners to facilitate improved access to NCFRP products and findings. The tool allows users to search for NCFRP research products related to specific freight policy, planning, and programming activities, and returns research findings that can assist with these activities. A beta version of the website is available at the following web address: <https://ncfrp48-stage.icfwebservices.com/NCFRP48/reports/>. A final host for the website had not been determined at the time of this writing.

A secondary purpose of the project was to develop a better understanding of how NCFRP products are being used and by whom, and to identify additional freight transportation research needs. This information can be used to structure a new freight transportation research program. The research team gathered information on the current use of NCFRP products through an on-line survey followed by interviews.

To help identify research needs and to solicit feedback on the draft website, the research team held a peer exchange workshop on October 2, 2015 at the TRB headquarters in Washington, DC. Approximately 40 people attended the workshop, including staff from the U.S. Department of Transportation (DOT), state DOTs, metropolitan planning organizations (MPOs), ports, research institutions, and the private sector.

In advance of the workshop, the research team prepared five white papers to document the contributions of NCFRP to specific freight research areas, provide examples of how NCFRP research in these areas has been used, and present recommendations on future research needs. These white papers, included as Appendix C, were organized around the following topic areas:

- Freight Economic Analysis
- Freight Modeling and Forecasting
- Freight Data and Performance Measurement

- Urban Freight Mobility
- Ports and Waterways

1.3 Report Organization

The remainder of this report is organized in three sections and five appendices. Section 2 contains a short description of the website development process. Section 3 discusses our findings on the use of NCFRP products, based on the survey and interviews. Section 4 contains a discussion of research needs.

Appendix A lists all the NCFRP projects and corresponding published reports. Appendix B contains full results of the survey. Appendix C contains the five white papers that were prepared as background material for the peer exchange workshop. Appendix D includes the peer exchange agenda and a list of participants. Appendix E is the website User Guide.

2 Website Development Process

This section summarizes the process used to develop the project website. A *User Guide* for the website is contained in Appendix E.

The development of the website followed a user-centered design process, which ensures that the ultimate product is based on a thorough understanding of the website users and their unique needs. As a first step, we secured the participation of a User Group, consisting of 11 public agency freight practitioners and researchers.

We conducted a needs assessment to gather information on the user needs for a searchable web-based tool for accessing NCFRP research products. We conducted one-on-one user interviews with participants from the User Group using a prepared script. During the interview sessions, a list of structured questions were discussed with individual participants to understand their roles, their goals, interests, freight transportation related activities, current pain points, preferences, resources, and tools. Web conferences were set up to facilitate remote participation and enable the moderator to observe participants interacting with the existing NCFRP website and reports. A total of seven user interviews were conducted – three with freight transportation planners/practitioners and four with researchers.

Based upon the user interviews, we identified the needs of the web-based tool. These needs were aggregated from user interviews and grouped into content needs and functional needs.

In parallel with the user needs assessment, the research team developed a taxonomy for categorizing NCFRP report content along three dimensions:

- **Topic** – Topics covered by NCFRP reports reflect the subject of the research using terminology familiar to practitioners.
- **Mode** – It is expected that some users may be interested in research that is focused on a single freight mode.
- **Geographic scale** – The intended users of the NCFRP 48 tool include freight practitioners working at different governmental levels (e.g., federal, state, MPO, local), so the tool is intended to give users the ability to search for NCFRP research by geographic scale.

The draft taxonomy was shared with the User Group interviewees, which largely validated the taxonomy, with some suggestions for minor modifications. Table 1 lists the 18 Topics, 7 Modes, and 7 Geographic Scales that are available to search for NCFRP reports.

Table 1. Website Topics, Modes, and Geographic Scales

Topics		Modes	Geographic Scales
Air quality impacts	Other environmental and community impacts	Air	International
Data	Performance measurement	Inland waterway	National
Economics/benefit-cost analysis	Regulatory issues	Intermodal	Port
Economics development impacts	Resiliency	Marine/ocean	State or multi-state
Institutional/organizational arrangements	Revenue/finance	Pipeline	Corridor
Land use impacts	Safety	Rail	Terminal or facility
Modeling/forecasting	Security	Truck	Urban or metropolitan
Operations - current practices	Stakeholder involvement		
Operations - efficiency improvements	Technology (new)		

Using the taxonomy, the research team reviewed 41 completed NCFRP products. Each chapter of each NCFRP report was categorized using one or more Topics, one or more Modes, and one or more Geographic Scales. Report appendices were also reviewed and categorized – either individually or in aggregate.

Using the chapter-level categorization, we then assigned each Topic, Mode, and Geographic Scale as covered by:

- The Majority of the Report
- A Portion of the Report
- Not Covered in the Report

Based on the user needs assessment and the report review, the research team developed a preliminary site map and a set of preliminary screen mockups (“wireframes”) for the web tool.

These products were intended to stimulate ideas and comment from the NCFRP 48 panel and User Group.

The web site includes a Home Page, which will be the starting point for most visitors to the site. From the Home Page, the site allows users access to NCFRP products in multiple ways:

- 1) **Select a report by name and number.** From the Home Page, the user can open a page that lists all the NCFRP reports (or projects) in numerical order. By clicking on a report, the report's "landing page" appears, which displays an abstract, other publication details (date, number of pages, author, etc.), and a link to the report PDF (housed on the TRB site).
- 2) **Keyword search.** An additional option to locate relevant results is to search by any word or phrase. The web tool searches the body of completed NCFRP reports (in PDF) and displays research results.
- 3) **Identify research by category.** An alternative search method allow the user to select a research Topic, Mode, or Geographic Scale – consistent with the taxonomy discussed above. By selecting a Topic, Mode, or Geographic Scale, the web site displays the associated report, ranked by relevance. A user can then select an individual report to proceed to the details page. This search feature enables the selection of multiple Topics, Modes, and Geographic Scales.

It was expected that some users may wish to first view the freight provisions of MAP-21, and use this to identify relevant NCFRP products. For these users, a link on the Home Page brings users to a listing of the MAP-21 freight provisions and corresponding NCFRP research Topics. By clicking on a Topic, the user sees ranked results similar to those describe above for a Topic search.

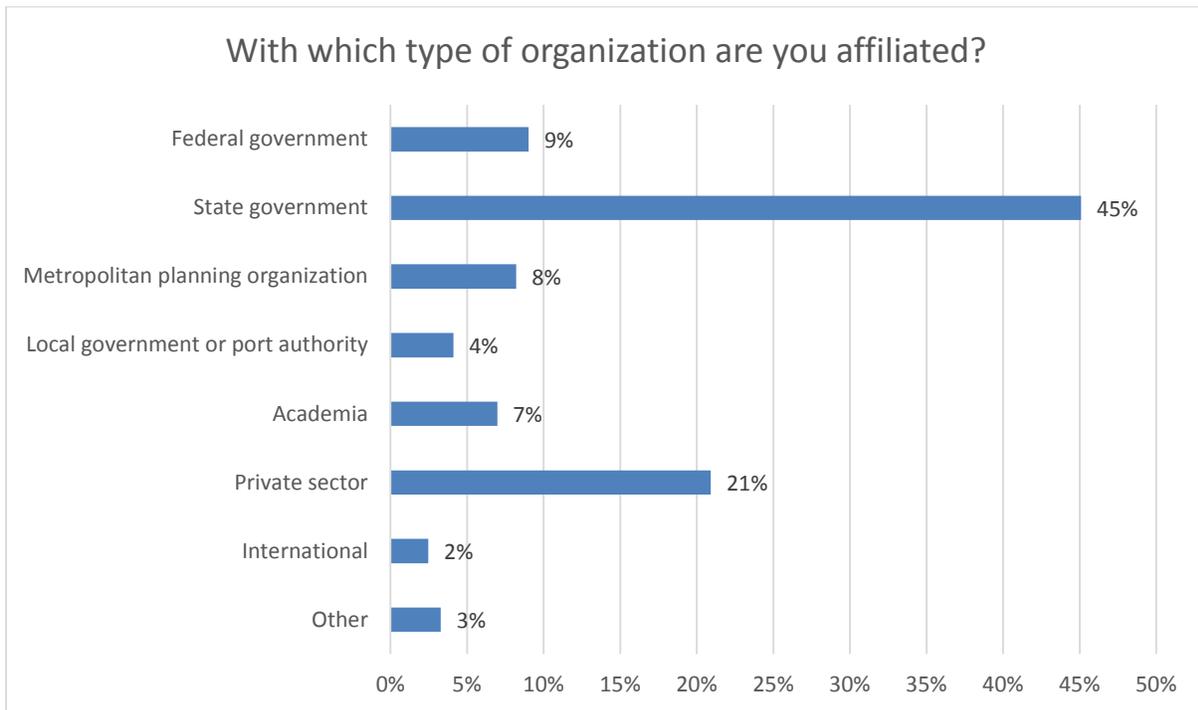
3 Use of NCFRP Products

3.1 Survey Results

In coordination with the project oversight panel, the research team developed and implemented an online survey to determine how NCFRP products are currently being used and to identify future research needs. The survey was conducted from November 2014 through January 2015. We recruited survey respondents via emails to the project’s User Group, AASHTO’s freight distribution list, chairs of TRB’s freight committees (with a request to forward on to committee members and friends), and to the research team’s own professional networks. A full summary of the survey results is available in Appendix B.

A total of 244 participants responded to at least some of the survey. As shown in Figure 1, nearly half of respondents were affiliated with a state agency, which is likely due in part to the use of AASHTO to advertise the survey and the participation of state DOT representatives on TRB’s freight committees. More than one-fifth were from the private sector – many of these consultants as well some freight carriers.

Figure 1. Organizational Affiliation of Survey Participants



Survey participants were asked to indicate which of the completed NCFRP research products they have used in the course of their professional duties. Of the 244 total participants, 133 answered this question. Table shows the NCFRP reports most frequently cited by the survey respondents. Given the emphasis on performance measurement in MAP-21 and more broadly

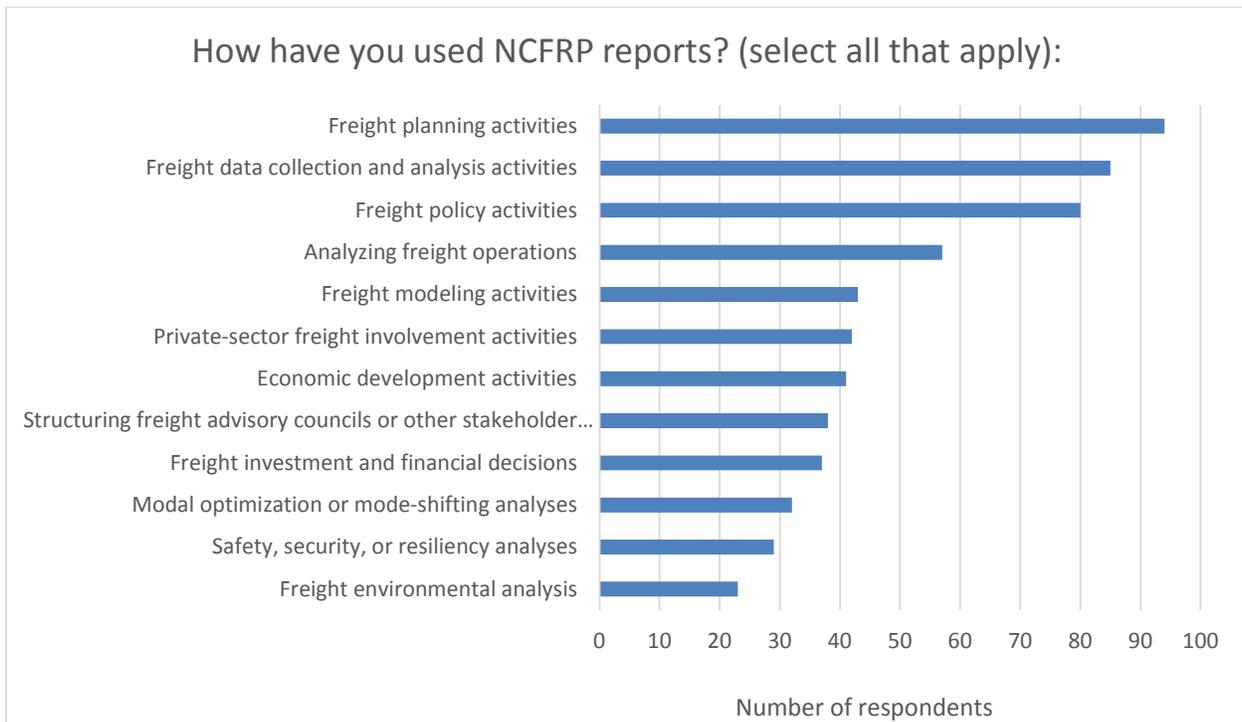
in the transportation community, it is not surprising that NCFRP Report 10 is at the top of the list. Overall, 11 reports were identified by at least 25 percent of the respondents as being used. Note that because the survey was completed in January 2015, a number of NCFRP reports had not yet been released at that time.

Table 2. NCFRP Reports Most Frequently Used by Survey Respondents

Report Number and Title	Year Published	Response Percent
Report 10: Performance Measures for Freight Transportation	2011	64%
Report 8: Freight-Demand Modeling to Support Public-Sector Decision Making	2010	45%
Report 14: Guidebook for Understanding Urban Goods Movements	2012	44%
Report 6: Impacts of Public Policy on the Freight Transportation System	2011	44%
Report 19: Freight Trip Generation and Land Use	2013	38%
Report 24: Smart Growth and Urban Goods Movement	2013	31%
Report 25: Freight Data Sharing Guidebook	2013	31%
Report 5: North American Marine Highway Operations	2010	26%
Report 22: Freight Transportation Cost Data Elements	2013	26%
Report 23: Synthesis of Freight Research in Urban Transportation Planning	2013	25%
Web-Only Doc. 2: Multistate Freight Corridor Organizations	2011	25%

The survey also asked participants to indicate how they have used NCFRP reports by selecting from among a pre-defined list of activities. Of all survey participants, 127 answered this particular question. Figure 2 lists the activities by the percentage of respondents that selected them. “Freight planning activities” was most frequently chosen activity; this broad category could encompass many of the other options provided to survey participants. “Freight data collection and analysis” and “freight policy” were the other two categories most cited.

Figure 2. Activities for Which NCFRP Reports Were Used by Survey Respondents



Survey respondents were provided an opportunity to provide a text response describing how they used the NCFRP report (or reports) that they found to be the most useful. Fifty-five respondents provided text responses, a sample of which are shown in Table .

Table 3. Sample Responses Describing Examples of Use of NCFRP Research

Type of Respondent	Sample Responses
State DOT	<ul style="list-style-type: none"> ▪ Report 10 was very helpful in developing a draft list of freight performance measures for our State Freight Plan. ▪ Helped with the initial planning for the DOT freight program. We are moving into the implementation of the program. ▪ Provided Report 14 to state's MPO's to help them incorporate freight planning in their planning processes.
MPO	<ul style="list-style-type: none"> ▪ Identifying the total extent of truck and rail based commodity movement. ▪ Background information, strategies, and best practice examples for better integrating freight transportation considerations into the transportation planning process. ▪ Needed to review existing or new analysis and evaluation methods.

Type of Respondent	Sample Responses
Port authority	<ul style="list-style-type: none"> ▪ Report 20 helped with development of chassis pool study. ▪ Economic and business benefits of freight investments. ▪ Project investment prioritization.
Federal	<ul style="list-style-type: none"> ▪ Identify prior research efforts and connect with those most knowledgeable about a topic (Volpe).
Academia	<ul style="list-style-type: none"> ▪ Development of corridor performance measures. ▪ Network disruption costs and recovery responses. ▪ Estimation of freight demands (esp. trucking demands) and costs. ▪ NCFRP 23 was desperately needed. We haven't had a synthesis of freight planning research in at least two decades. This report... measurably advanced the research and literature on freight planning.
Private sector	<ul style="list-style-type: none"> ▪ Reports have supported analysis of safety data issues and marine highways studies. ▪ Use the reports as either background to, or checks on, our own freight analyses.

3.2 Interview Results

Through interviews with practitioners and the survey discussed above, the research team identified a variety of examples of how NCFRP reports have contributed to freight planning, programming, and project development. This section highlights these contributions in five topic areas that span the bulk of completed research:

- Freight Economic Analysis
- Freight Data and Performance Measurement
- Freight Modeling and Forecasting
- Urban Freight Mobility
- Ports and Waterways

The research team conducted 20 interviews, by telephone and in-person, with most lasting one hour. The interviewees included five federal agencies, three state DOTs, four MPOs, three ports, five research organizations and industry associations, and three consultants.

Freight Economic Analysis

Our interviews confirmed the importance of NCFRP and other TRB-sponsored research for continuing to expand the understanding of freight transportation economic issues, improve the methods and tools for analyzing proposed freight system investments, and make these research findings accessible to practitioners, especially those without an economics background.

Freight staff at the U.S. DOT pointed out that NCFRP has been particularly effective in addressing economics and other issues that cut across freight modes, due in part to the diversity of the NCFRP oversight board. Given the increasingly multimodal nature of freight transportation, this perspective is critical for understanding and improving the freight system, since other freight research has often focused on singular modes.

NCFRP has been instrumental in providing practitioners examples of how plans, projects, performance measures, data programs, and economic analyses have been implemented by other organizations. One MPO practitioner noted that NCFRP:

“provides case studies or examples of how it has been done. We are constantly looking at what others are doing. These reports provide estimates of economic benefits ... they allow us to compare what the benefits of these programs might be and source it.”

NCFRP Report 3, Separation of Vehicles—CMV-Only Lanes, has been used as part of the analysis of proposed improvements to the I-710 corridor in Los Angeles County. A Major Corridor Study and subsequent environmental impact report for this project considered alternatives that involve a separated, four-lane, truck-only corridor. The same NCFRP report also has been used for consideration of truck-only lanes in other locations.

Another practitioner noted the usefulness of *NCFRP Report 13, Economic and Transportation Drivers for Siting Freight Intermodal and Warehouse Distribution Facilities*. “The problem was understanding the factors that influence industrial location decisions. NCFRP 13 outlined both the transportation and non-transportation factors.”

In our survey on the use of NCFRP research and future freight research needs, respondents were asked to identify individual NCFRP reports that have proved useful. Although the economics-related reports were not among the most used NCFRP products, several were cited by a significant number of respondents. For example:

- Of the 133 survey responses, 31 (23 percent) identified *NCFRP Report 12, Framework and Tools for Estimating Benefits of Specific Freight Network Investment Needs*, as a report that had been used.

- Eighteen respondents (14 percent) indicated making use of *NCFRP 22: Benefit-Cost Analysis to Freight Project Selection: Lessons from the Corps of Engineers*.

Note that the largest NCFRP study on economic impacts (*NCFRP Project 46, Benefit-Cost Methodologies for Evaluating Multimodal Freight Corridor Investments*) had not yet been completed at the time of the interviews and survey. Based on our interviews, we expect this report to be used extensively when it is released in 2016.

Freight Data and Performance Measurement

Our interviews identified many ways that NCFRP research products have been useful for transportation agency practitioners and researchers involved in the collection and analysis of freight data. For example, the reports have helped inform stakeholders about the activities of other agencies. Several agencies noted using NCFRP products to help write requests for proposals. By defining the scope of existing knowledge, agency officials can target such requests to specific research needs. One freight planner found practical value in using these reports to help his MPO participate in the I-95 corridor coalition. Several NCFRP reports were used to develop a freight scope of work for a contractor.

Freight practitioners noted that NCFRP products were targeted toward areas where research was needed. They found these products to have practical application to the problems they face daily. A freight planner with an MPO noted, “It is a great program – a great resource – planners need this information and they may not always know what is being done around the country ... it is useful.” Practitioners reported having respect for the practical applicability of NCFRP products. One planner noted that NCFRP products are “all relevant and practical research reports ... not things that are abstract – not academic – many NCFRP projects have real world applications.”

The educational value of NCFRP products lies in the fact that so many different variables in freight transportation challenge agency staff to stay current on all topics that might arise. As one state DOT official noted,

“My background is in planning; I may not have a background in supply chain management; these reports help us to be proactive in educating ourselves ... they are easy flowing ... the research is done for you in a one stop ... the reports keep up with developing freight trends and a report pops out not too long after a trend emerges.”

NCFRP products have enabled agency staff to quickly become familiar with new topics for writing grant applications. One state DOT official noted, “since we are a DOT, we are highway-heavy ... we use NCFRP reports to do some homework on other modes.” A state DOT noted that NCFRP projects helped them obtain designation of the waterway north of St. Louis as a Marine

Highway. They assembled a TIGER (Transportation Investment Generating Economic Recovery) grant application for Upper Mississippi River Planning, to raise funds for approving this designation. NCFRP reports also were used to obtain background knowledge in the marine freight area for this application.

NCFRP products were instrumental in summarizing the existing body of knowledge through literature reviews. A researcher at the American Transportation Research Institute noted, NCFRP “is the first thing we look to ... we look to NCFRP for a literature review ... especially for TRB papers ... a lot of literature isn’t easily accessible ... NCFRP research is accessible.”

In our survey of practitioners, *NCFRP Report 10, Performance Measures for Freight Transportation*, was the NCFRP product cited most often as being used by survey respondents. Several practitioners we interviewed also noted the value of NCFRP Report 10. They found this report useful in helping them think about the MAP 21 requirements to develop freight, safety, and mobility performance measures. They noted a push within their agencies to make performance measures more robust, and this report informed their efforts.

The Iowa DOT used NCFRP Report 10 to help the agency select performance measures for their freight plan. They used the report for background knowledge and examples. Iowa DOT has a Freight Advisory Council, which they consult to determine what is important; NCFRP Report 10 provided ideas and good examples for starting a conversation with the Freight Advisory Council.

One interviewee noted that state DOTs use NCFRP Report 10 as a starting point to define the performance measures they should use. State DOTs ensure their actions align with the contents of Report 10. “People call saying they need a map similar to what was in that report, a measurement that is similar ... how would you do the reliability measurement?”

NCFRP products, such as *Report 9: Guidance for Developing a Freight Transportation Data Architecture*, have been useful for helping planners integrate data and solve real-world challenges. The Baltimore Metropolitan Council noted that they have been gathering freight datasets from many different groups—including the state highway data, data from economic development agencies, commodity flows—and assembling them in a hub. Report 9 has been useful in conceptualizing this effort.

Washington State DOT noted that they have referenced NCFRP Report 9 in their work, including the development of a freight library. NCFRP Report 9 provided the agency with information on what data sources are available. Washington State DOT has also been interested in developing a freight data tool useful for various user groups; NCFRP Report 9 served as a starting point for identifying approaches to storing and sharing freight data.

Our survey also identified two other data-related reports (Reports 22 and 25) as being among the top ten NCFRP reports that survey respondents use most frequently. Our interviews with practitioners identified examples of how these reports were used. One MPO used *NCFRP Report 22, Freight Transportation Cost Data Elements* to help identify freight projects for their long-range plan and estimate the cost impacts for freight projects.

A freight planner at the Baltimore Metropolitan Council noted the practical value of *NCFRP Report 25, Freight Data Sharing Guidebook*. The MPO used this document in preparing for a data-sharing working group that included both private- and public-sector members. They used the examples of data-sharing agreements to inform their efforts and help them obtain data from railroads. Collecting these data was part of a project to create a freight finder app, which pulls together data from both public and private sources. The agency found Report 25 useful to ensure that private-sector data are protected and to ensure consistency in reporting standards with its public- and private-sector partners. Washington State DOT also noted using NCFRP Report 25 when preparing their freight data library.

Several practitioners noted *NCFRP Report 29, Making Trucks Count: Innovative Strategies for Obtaining Comprehensive Truck Activity Data* was useful for considering data gaps and their remedy. One planner noted “we look at freight routes – we look at the percentage of trucks on the route, but we want to make it commodity based – we know we have 100 trucks, but what do they carry ... we want to make this more of an economic analysis.” This agency was seeking to understand how the value of the commodities carried affects the benefit-cost calculation for different types of investments. The Iowa DOT used NCFRP Report 29 to help identify freight bottlenecks. In general, the DOT has found many NCFRP reports useful for background research and literature reviews, and for identifying options for new analytical efforts.

Washington State DOT also has used *NCFRP Report 26, Guidebook for Developing Subnational Commodity Flow Data*, to develop a data collection program. The DOT was studying urban food distribution and was interested in understanding commodity flows in the face of natural disasters. Washington State DOT has also been studying the rural wheat supply chain and developing an understanding of other supply chains in their state. The agency has a statewide geographic information system-based tool to support the freight network. This research is informing a larger statewide model development project being conducted as a pilot study.

Freight Modeling and Forecasting

NCFRP products have proven useful for advancing the state of practice in freight modeling and forecasting, helping with understanding the scope of available knowledge, designing new research projects, ensuring that research dollars are spent effectively, educating professionals, obtaining expertise in niche topic areas, providing technical information for improving agency

models, and documenting that the methods used are state of the practice for federal certification reviews.

One common use of NCFRP reports has been to serve as the basis for additional research efforts. For instance, agency officials frequently discussed referencing NCFRP reports in request for proposals to ensure that contractors write reports and proposals reflecting the latest knowledge. Request for proposals have included references to NCFRP reports that contractors were ask to review. One agency official noted,

“In some areas we have deep expertise, but we need to rely on the existing body of knowledge to make our work more efficient, we need to have our research dollars add to the base of knowledge, we don’t want to waste time and dollars finding out what is already there.”

In our survey on the use of NCFRP research, several respondents commented on the use of NCFRP reports to support their modeling activities. Examples of these comments include:

- “Have used NCFRP projects to get information about urban goods movement supply chains, freight data collection suggestions and actual data, and examining different freight modeling approaches.”
- Used an NCFRP report to analyze "multi-modal commodity flows, intra-state or multi-state commodity flows, contribution of freight transportation to air emissions.”
- “The report helped me to prepare for specifically addressing freight planning as a part of a comprehensive planning process.”

NCFRP reports have been used as a starting point to compile internal literature reviews. For example, when the Coast Guard was compiling available studies and literature on commodity flows and supply chains around ports, they used *NCFRP Report 26, Guidebook for Developing Sub-national Commodity Flow Data* as source material.

Agency officials often have used NCFRP products to educate themselves on specific topics. As one agency official noted, “The scope of our activity is so broad, it becomes hard to develop expertise in a particular niche.” Another agency official noted that because their agency was focused mostly on highway transportation, they used NCFRP research to learn more about other freight modes such as rail and marine. NCFRP products were useful resources to enable busy agency officials to become current quickly on new topics.

NCFRP products also have served as the basis for making technical improvements to existing models. The Atlanta Regional Commission used *Report 4, Representing Freight in Air Quality and Greenhouse Gas Models* to integrate environmental analysis more fully into their planning

process. For example, the agency developed multiclass truck trip tables, which enabled them to analyze air emissions with greater precision.

Among respondents to our survey of practitioners, *NCFRP Report 8, Freight-Demand Modeling to Support Public-Sector Decision Making* ranked second in terms of the percentage of respondents who had used the report; 60 of 133 respondents identified this report as useful. This report also was mentioned by the interviewees. The Atlanta Regional Commission used this product to understand the state of the practice and to adjust their own methodologies to keep them updated.

MPOs also noted using NCFRP products in documenting that their practices were up to date for the U.S. DOT planning certification review. The primary purpose of a certification review is to formalize the continuing oversight and day-to-day evaluation of the planning process, and to ensure that legally mandated planning requirements are satisfactorily implemented. One MPO identified NCFRP products as useful resources to ensure that the MPO was using the most appropriate and advanced planning methods and to document this for the certification review.

NCFRP products also have helped transportation agencies understand the supply chain better and to integrate supply chain concepts more fully into their modeling. One consultant involved in freight modeling noted:

“The freight trip generation [NCFRP] products and sub national data are useful. There is a clear need to do accurate disaggregation and a need to get it down to a county and sub county level, but planners should also be pressing hard to tackle the problem from a supply chain perspective. What are the market dynamics for freight movement? The commodity flow approach was a good approach in the 1970s. In the 1990s, you needed a supply chain based approach. Today it is absolutely critical to consider the supply chain.”

Several NCFRP reports have contributed to improving knowledge of the supply chain. For instance, *NCFRP Report 14, Guidebook for Understanding Urban Goods Movement* includes a typology of supply chains in urban markets. It provides information on how goods are delivered in particular supply chains – information that is needed to model urban freight markets more accurately. Both state DOTs and MPOs noted the usefulness of Report 14.

Another NCFRP document that has been applied to evaluate how carriers and shippers make decisions about location is *NCFRP Report 13, Freight Facility Location Selection: A Guide for Public Officials*. Report 13 provides information about the factors that businesses consider when evaluating freight facilities site location. Planners have used Report 13 to consider the issue of regional competitiveness. For example, the Iowa Freight Plan focuses on how to attract businesses. In developing this plan, Iowa DOT planners considered how they can link their

freight plan with economic development – specifically how to accurately assess the factors that will make the state competitive and promote the growth of business. NCFRP Report 13 has helped transportation agencies think about the factors that affect business location and informed their forecasts of business development that might flow from improvements in freight transportation systems.

Urban Freight Mobility

As noted previously, our survey of the use of NCFRP research found that three of the top ten most used reports are focused on urban freight issues. Note that Report 33 had not been released at the time of the survey.

Report 14, Guidebook for Understanding Urban Goods Movements, was identified as useful by 58 of 133 survey respondents (44 percent). Regarding this report, one respondent commented:

“I was challenged to get my state’s MPOs to incorporate freight planning in their planning processes. I was able to share the Report 14: Guidebook for Understanding Urban Goods Movements with MPOs as well as others in attendance at a state chapter conference of the American Planning Association.”

Another respondent noted, “I needed to better understand urban goods movements, and [Report 14] helped educate me.”

Report 23, Synthesis of Freight Research in Urban Transportation Planning, has also been well received. It was identified as useful by 25 percent of the survey respondents. One respondent provided this comment:

“NCFRP 23 was desperately needed. We haven’t had a synthesis of freight planning research in at least two decades. This report has become required reading in transportation planning classes I lecture in and has measurably advanced the research and literature on freight planning.”

Others provided more general comments regarding these reports, such as:

“From an international perspective, the NCFRP has produced important lessons about and designs for outreach from government to the public and to private stakeholders. Also, for purposes of international comparison, reports on urban freight and modeling were very useful.”

North Central Texas Council of Governments (NCTCOG) offered a specific example of using an NCFRP report. In 2010, NCTCOG began a comprehensive review of the freight transportation system in the Dallas-Ft. Worth region. In addition to assessing the current state of the system, this process included a needs assessment for future policies, programs, projects, and studies to

improve freight planning and operations in the region. NCTCOG staff indicated that *NCFRP Report 7, Identifying and Using Low-Cost and Quickly Implementable Ways to Address Freight-System Mobility Constraints*, was particularly useful to the agency during this study process. The MPO used NCFRP reports to help write the *North Central Texas Regional Freight System* report. NCTCOG also used NCFRP products to help make the case for more fully considering freight needs during the project prioritization process. The agency asserts that many projects intended to enhance freight mobility can be implemented quickly and at low cost. The NCTCOG report included a table of “Quickly Implementable Freight Projects” that was obtained from Report 7.

Another MPO reported using *Report 19, Freight Trip Generation and Land Use* to improve the modeling of urban truck trips. The report helped the agency review specific corridors and identify the special trip generators. The MPO’s planners identified more than a dozen special trip generators and included them in their model. The updated model provided a better treatment of truck traffic to and from these areas and improved how these trips were assigned to network, which resulted in a more accurate model at the local level.

Ports and Waterways

Interviewees engaged in ports and waterways issues noted using NCFRP reports as important reference documents. Two of the interviewees noted that reports were referenced in congressional testimony and cited as a reference with a state’s air quality review board. Graduate students were urged to review the reports as critical resource tools in their research, although the interviewee also noted that the students would not have known about the NCFRP reports otherwise because they often did not appear in Internet searches.

Some specific characterizations of the importance of these products as reference tools included:

- “Solid defensible references.”
- “Not many other objective research reports exist.”
- “Scholarly and intellectually valuable reports are hard to find with freight.”

With so many recent major disruptions, *NCFRP Report 30, Making U.S. Ports Resilient as Part of Extended Intermodal Supply Chains*, was the report most often cited by the port-related interviewees as being useful. Interviewees used this report to familiarize themselves with best practices related to resiliency. The report was used to disseminate examples, lessons learned, and best practices to private maritime terminal operators.

NCFRP Report 5, North American Marine Highway Operations, was cited as useful by more than half the port-related interviewees, reflecting the importance of this subject. In our survey on

the use of NCFRP research and future freight research needs, 31 respondents (23 percent) identified this report as useful.

One port executive, who teaches a class at a local university, noted that his students relied heavily on *NCFRP Report 20, Guidebook for Assessing Evolving International Container Chassis Supply Models*, to produce several research papers on truck drayage.

Port experts interviewed for this paper also identified as useful several reports that are not focused primarily on ports. For example, *NCFRP Report 28, Public-Sector Sustainability Strategies Addressing Supply Chain Air Emissions*, was cited by a port as helpful in discussing an air quality matter with the state environmental agency. Interviewees noted that ports are located in urban areas, and therefore *NCFRP Report 14, Understanding Urban Goods Movement*, was cited as useful by three of the port-related interviewees. *NCFRP Report 10, Performance Measures for Freight Transportation*, was cited by a port interviewee whose organization is creating such metrics.

4 Future Freight Research Topics

Freight transportation is continuously evolving in response to technology developments, economic forces, regulatory changes, and numerous other factors. The government agencies that plan, finance, or operate portions of the freight system must understand (and, ideally, anticipate) these changes to ensure high levels of system performance and safety while minimizing negative impacts on communities and the environment. This section summarizes trends and future challenges facing government agencies in freight transportation. Future research topics that can address these challenges are also discussed. The discussion is organized under six subject areas:

- Technology and Innovation
- Funding and Finance
- Planning and Operations
- Forecasting and Modeling
- Data and Performance Measures
- Safety, the Environment, and Public Health

Material in this section is drawn primarily from interviews, a review of documents, and the project peer exchange workshop held in October 2014.

4.1 Technology and Innovation

Trends and Challenges

The role of telematics in trucking continues to grow, with the continued diffusion of new mobile technologies, sensors, vehicle tracking, and vehicle management systems in the market. Numerous startup companies are seeking to become “Uber for freight.” These operations are fundamentally altering how trucking services are provided – increasing utilization levels of drivers, trailers, and other equipment, and potentially reducing truck vehicle miles traveled (VMT). The incorporation of “geo-fencing” technologies to ensure that trucks and loads remain moving on the designated route has increased security and enabled shippers to more carefully monitor for potential delays. Such geo-fencing is also now being used by cities, such as London, in restricting trucks during portions of the day. The emerging companies are also including free features for truck drivers, such as mobile apps to check for available truck parking, that mesh with public sector goals.

The development of connected and autonomous vehicle (CV/AV) technologies has the potential to fundamentally alter freight trucking in the future. Demonstration and pilot projects involving

CV technologies for trucks are already occurring. For example, the U.S. DOT has funded a commercial vehicle-focused pilot project on the I-80 corridor in Wyoming that will create a suite of CV applications to improve safety and reliability for truckers. As another example, under the Exploratory Advanced Research Project, FHWA is working with partners, including Volvo Trucks, to develop and test partially automated truck platooning using cooperative adaptive cruise control (CACC). The emphasis of these tests is on near-term deployment, with drivers retaining steering control and operating in mixed traffic in the I-710 corridor in California. FHWA has also announced a program with up to \$40 million in funding for a mid-sized city to conduct a “Smart City Demonstration,” which can include elements such as implementing automated trucks, connected vehicles, vehicle-to-infrastructure communication, and data driven smart logistics.

Concern about the environmental impacts of freight has led to experimentation with and deployment of new engine, vehicle, and vessel types with significantly lower emissions. Alternatives to diesel fuels include electricity, natural gas, and other alternative fuels; other strategies provide more effective use of fuel and reduced idling. The widespread implementation of these technologies has implications for operations and fueling requirements for all segments of the supply chain and freight movements. As many of these movements involve public sector facilities, knowledge of the changes are crucial. The most significant changes would be electrification of freight movement, particularly in heavily congested urban freight corridors where there is a critical need to reduce air emissions. Several ports have demonstrated the operation of battery electric drayage trucks and yard hostlers. Electric trucks using an overhead catenary system are being tested, and planning is underway to consider and potentially implement elevated and electrified freight shuttles that automate the transportation of containers and trailers at border crossings, ports, and specifically along I-35 between Dallas and San Antonio.

Innovation and new technology will also drive the need for additional workforce development. In the future, an aging workforce and the diffusion of new technologies will require that new employees possess a new set of skills. Investments in the skills of the existing workforce will also be needed.

Technology also promises to increase the effectiveness of enforcement. While weigh-in-motion and license plate reader technologies have existed for some time, new applications of these and similar technologies for enforcement in urban environments are possible. For instance, municipal officials in London are using cameras staffed in real-time to issue tickets related to truck parking. Cameras can measure how long trucks are parked and if they have overstayed their times in loading zones. Other technologies, such as the introduction of new bridge and roadway sensors, may better help to manage infrastructure.

Research Topics

Assessing the impacts of new technology on freight transportation is an important area of research, given the rapid pace of technological development. Creating a scan of freight technology trends and their impact on the future freight system could help policy makers obtain a broad understanding of technology driven changes that are coming. Additional research is also needed that is targeted to specific areas such as autonomous trucks in freight transportation and connected vehicle applications for freight. Preparing intermodal facilities for ITS, CV, AV, and general automation is another technology area that will likely see significant growth in the near future. Understanding the potential impacts of drones on the future freight delivery system was mentioned by many interviewees and attendees at the peer exchange workshop.

The role of technology in improving the operations of the current freight system is another important research area. Research is needed to facilitate the use of intelligent transportation systems to improve freight routing. There is also an opportunity for advanced technologies and data to improve freight system efficiencies through load consolidation and the coordination of pickups and deliveries. Optimizing information systems across all modes so that they can communicate with each other could unlock new efficiencies in the movement of cargo across all modes. The impacts of mobile technology on the freight market (e.g., Roadie) is another technological possibility that should be considered for additional research.

Further research is needed to understand how technology can enable new enforcement methods, such as the use of cameras and license plate readers to enforce truck parking restrictions in urban environments. Technology may play a role in improving operations through understanding changes in the peak times for truck and other vehicle trips and the impacts of traffic peaking on system performance. Research in each of these areas could help planners and policymakers understand a rapidly changing technology landscape.

4.2 Funding and Finance

Trends and Challenges

Funding and finance for freight transportation infrastructure will continue to be a challenge. The growth of the U.S. economy and population is outpacing the level of investment in the nation's surface transportation infrastructure, creating a situation that could affect U.S. economic competitiveness and also degrade safety, environmental quality, and livability. The Federal Highway Trust Fund, along with state motor fuel taxes, have historically been the primary revenue source for highway investment. Most gasoline and diesel taxes are collected as a fixed amount per gallon, and their purchasing power has been eroded by inflation. Improvements in vehicle fuel economy and increased use of alternative fuels will also diminish

traditional revenues to support highway investment. Many states are relying more heavily on alternative financing methods for highway infrastructure, including public-private partnerships, which introduce new challenges.

Some trucking companies, shippers, and their representative organizations have voiced support for additional fuel taxes provided that the additional revenue is dedicated to highway infrastructure. One challenge has been using this base of support to achieve a policy outcome. Better communicating the economic benefits of freight transportation infrastructure improvements could help to enhance political support for increasing investment.

Other components of the freight system also face funding and financing challenges. A greater level of investment will be needed in port infrastructure to maintain and improve existing infrastructure. Historic periods of high investment in port infrastructure in the 1920s and 1970s have created infrastructure that is now reaching the end of its natural life in many places. Some port terminals need investment to accommodate larger containerships. While a large portion of port terminal improvements are funded through user fees, public investment has historically been used for projects with port- or region-wide benefits, such as channel dredging.

There is also a need to improve inland waterway systems so that they can continue serve the transportation needs of bulk shippers and provide an alternative to shipment by truck or rail. Vessel operators on most of the inland waterway system pay a fuel tax that provides revenue to the Inland Waterways Trust Fund and is used to pay for improvements to locks and dams. Existing levels of investment in lock and dam infrastructure are currently inadequate to maintain the condition of the system, minimize wait times, and ensure against future lock and dam failures.

While the operation, maintenance, and expansion of the nation's freight rail system is funded almost entirely by the railroad companies, the public sector can play a key role in funding critical improvement projects such as intermodal connectors, roadway grade separations, and vertical clearance in select locations. As congestion grows in metropolitan areas, the public sector role in freight rail improvements will become more important. There are significant capital needs in the rail sector as well. Regulatory requirements, such as positive train control, will require increasing investment. Some have estimated that positive train control will cost the Class 1 railroads \$10 billion. How these large investments will be financed is a significant challenge and may impact the capital available to maintain or improve existing rail infrastructure. Class 2 and Class 3 railroads also have significant capital needs. The rail network is losing rail right of way with the closure of poor performing railways.

Some have argued that because of the significant public benefits from diverting freight shipments from highways to rail, additional public support for rail investments, such as loan

guarantees other subsidies, are warranted. The recently passed FAST Act demonstrates some additional political support for providing public financing for freight rail projects. The FAST Act creates a new National Freight Program with \$6.2 billion in funding over five years. Under this program, states will be allowed to allocate as much as 10 percent of these funds to rail or port projects. If additional public dollars will be invested in rail, there also needs to be better approaches to estimating public benefits. Better methodologies for estimating public benefits would help rail projects to compete for TIGER grants as well.

Changes in the outlook for where investments are needed can pose a challenge for securing funding. For instance, the future growth of intermodal freight may no longer be focused only around the ports, which have harnessed user fees as a source of funding for new investments. Federal money has typically played a relatively small role in investing in intermodal freight infrastructure. The changing geographic focus of intermodal investments may require new approaches to securing sources of funding.

Research Topics

The research team identified a number of potential research topics relating to freight infrastructure finance. Interviewees identified a need to better understand the impact of shortfalls in the Highway Trust Fund on freight transportation projects. How to fix the current system of highway finance and evaluate potential alternatives was often mentioned as issue that should be high on any transportation research agenda. A related research topic would focus on alternatives for funding intermodal system improvements.

Considering how operational improvements can complement (or impact) capital improvements may be important for understanding future finance and investment needs. For instance, will the adoption of autonomous vehicles allow for more efficient use of existing road capacity and reduced levels of investment in new infrastructure? Or will these vehicles require new or enhanced infrastructure, such as dedicated lanes? Will congestion pricing reduce peak traffic loads and congestion, reducing the need to expand lane miles to accommodate these peak periods? Or will roadway pricing, if it happens at all on a broad scale, be focused in dedicated high occupancy toll lanes that require additional investment?

Some interviewees voiced interest in research to understand the investment needs of U.S. ports, particularly in light of the Panama Canal expansion and the increase in the size of vessels calling at U.S. ports. Maintaining investment in shortline railways and the impact of declining coal volumes on the ability of railroads to maintain and finance the existing network were also considered important research topics.

4.3 Planning and Operations

Trends and Challenges

The integration of freight into long range transportation planning has improved tremendously since the passage of ISTEA 25 years ago. Most states have now created statewide freight plans, which will now be required under the FAST Act. And many states and MPOs have freight advisory committees that provide input on project selection and, in some cases, operational programs. Despite this progress, applying a multimodal perspective will remain a key challenge for freight planning. Some of the most critical investments in the freight system are those that link transportation modes together and improve the functioning of multimodal supply chains. Carriers, shippers, planners, policymakers, and other stakeholders need to work together to ensure that investments enhance the development of seamless freight transportation networks. Providing a data-driven multimodal planning and project prioritization process could help to target investments to where they are most needed.

The growing prominence of port clusters has made regional port coordination a growing area of interest as well. There is a need to understand how ports can work together better, identifying situations in which individual ports can benefit from better regional cooperation and strategy development. Landside access is a growing challenge facing ports and transportation agencies. Many major seaports are located in large metropolitan areas that are highly congested and cannot easily expand highway and rail capacity. Some ports have successfully used incentives to shift some truck access trips to off-peak periods.

Port planners have also been challenged by the difficulty of making long term investments when demand can be influenced by short term dynamic changes in marine freight markets. At some ports, existing investments in capacity may be underutilized when shipping lines discontinue container service. Labor disputes and the use of larger container ships have affected which ports shipping lines choose to call on. The expansion of the Panama Canal will likely affect further changes in the provision of container service by shipping lines.

Freight traffic on the nation's railroad system is also likely to see significant shifts. Intermodal rail traffic has grown significantly over the last several decades. In contrast, coal has declined more than 30 percent in four years. The decline of coal may require railroads to rationalize their networks, with important implications for the entire freight system.

The growth in freight traffic has made planning particularly important in urban areas. The core of most major U.S. cities was built before the dominance of motor vehicles, with roadways, bridges, and other infrastructure that was not designed for the trucks that move most urban freight today. Trucks compete with passenger vehicles for roadway space and parking. Many urban areas have dense populations of residents and workers, leading to conflicts between

freight transport and the movement pedestrians, bicyclists, and public transit vehicles. In some cities, warehouse and industrial districts are experiencing redevelopment with infill housing, creating new challenges. Air pollution, noise, and other environmental challenges are also prevalent in many urban areas; freight and equipment can exacerbate these problems.

Maintaining urban freight mobility is made more challenging by the explosive growth of e-commerce, which is reconfiguring the urban freight needs of the retail sector. Part of what underpins the rapid growth in e-commerce is fast, low-cost order delivery that makes the Internet competitive with brick-and-mortar stores. This growth is evident in the surging volume of parcel delivery trucks. Planning and designing for urban freight operations is thus an important challenge.

Another challenge for freight planning is limited understanding among planners and policy makers about the freight economy. The freight economy is composed of many different sectors, and demand is driven by a number of complex business decisions by different stakeholders. Since local industries often have unique supply chains and transportation issues, establishing relationships with individual companies may be needed to understand regional transportation and logistics issues. There is a need to develop a new professional cadre with a profound understanding of “how the freight system works”. The challenge of hiring and retaining skilled freight professionals is compounded by the fact that the planning workforce is aging and the baby boom generation is reaching retirement. Most universities don’t teach freight as an integral component of transportation planning.

Research Topics

Strategies to balance the needs of the freight transportation system against other planning goals, particularly in an urban environment, will be an important area for research. Truck parking in urban areas was a research topic mentioned by many study participants. One suggestion was to develop design guidelines for truck parking facilities and freight-centric designs that can coexist with planning for complete streets. Additional guidance on using private-sector facilities to solve the truck parking problem is also needed. A model that estimates the impact of FMCSA’s Hours of Service Rule on truck parking would also help planners understand this issue.

Development of guidance on how best to communicate the importance of maintaining freight routes to advocates of “Complete Streets” treatments (and similar capacity reductions) was identified as a research need. Others noted the need for research on freight policies to protect freight gateways and port areas from gentrification. Updating *NCHRP Synthesis 320, Integrating Freight Facilities and Operations with Community Goals*, was identified as a research need. Another suggested topic was a compendium of best practices regarding rail freight bridges in

urban areas. In order to minimize the impacts of urban freight movement, a better understanding of how to achieve widespread adoption of deliveries during off-peak hours is needed – including studying the appropriate type and level of incentives for program participants.

Freight planners and policymakers are frequently challenged to communicate the benefits of investments in freight transportation infrastructure. Freight projects are often controversial because the impacts are localized and highly visible. Citizens may experience congestion due to more trucks on the road. Residents may resist the construction of major new infrastructure or large freight facilities in their communities due to concerns about property values, air quality, noise, and other environmental impacts. The largest benefits of freight projects often accrue to stakeholders outside the region where the freight infrastructure is being constructed and where the negative impacts are being experienced. This is particularly the case where the freight infrastructure serves as a link in major international supply chains. Improving freight transportation can have significant impacts on productivity and economic growth. In many cases national economic benefits are largely invisible to the local community.

Improved approaches to communicating the costs and benefits of freight projects would be useful for freight planners and policymakers. Freight projects can produce direct local benefits such as jobs, and longer term benefits, such as business expansion in related local industries; better approaches to understanding and communicating these benefits are needed. In addition, identifying and implementing practices to allow freight to be a “good neighbor” can reduce resistance to new or expanded freight facilities. This could include practices that are being used by private-sector freight companies and public transportation agencies in siting freight facilities, modifying operations, managing community relations, and mitigation practices.

Improving the resilience of urban freight transportation systems in the face of extreme weather events and other natural and manmade disasters was identified as a priority research area. Planners and policymakers also need new resources to address freight transportation issues associated with the growth of the U.S. oil and gas market. This includes new research and guidance related to the impact of freight on rural counties, including policy and planning issues associated with the impacts truck traffic from drilling and fracking of oil and gas wells.

In general, public agency planners need a better understanding of freight transportation issues, and the differences in the freight system between states and regions. Surveying logistics professionals across the country on a regular basis to identify their most salient concerns could provide a useful window for planners and policymakers into industry concerns. In addition, freight professional educational resources are needed for those entering the field. It would be useful to define the criteria for the transportation workforce of the future and identify ways to provide this workforce.

Planners and policymakers would benefit from more research on best practices for implementing low-cost freight improvements. This could include updating *NCFRP Report 7, Identifying and Using Low-Cost and Quickly Implementable Ways to Address Freight-System Mobility Constraints*.

More research is needed to improve analytical methods to define and measure the benefits of freight projects. This could include understanding the impact of investments in freight corridors, including multimodal corridors (rail vs. highway vs. marine) and risk management in a multi-modal context. A better understanding of the economic impacts of highway and bridge preservation projects is needed. In a broader context, NCFRP research could promote closer coordination between transportation and economic policy. Guidance is needed to assist transportation agencies in working with economic development agencies.

There were a number of research projects identified related to marine transportation and ports, and their integration with the freight system. There is a need for research to identify best practices for advancing the marine highway concept. In addition, guidance on how to improve integration of ports with rail and highway movements is needed. Research into best practices to assess freight flows both on corridors and in freight bottlenecks— particularly including ports and maritime facilities – would also support policymaking.

Research on issues that affect port operations specifically are also important. Studying ports that are operating within a footprint constrained by other land uses would be useful to many ports that face this issue. Improving multimodal analyses across a number of areas would benefit planning and policy analysis. Additional work is needed to improve asset management for rail and marine sectors. One suggestion was to study the impacts of providing dual-class I service to ports (inland and sea) as a way to eliminate captive shippers.

Lastly, there were suggestions for better information on innovative freight transportation practices and policies outside the United States. There is a perception that innovations from foreign countries tend to diffuse to the U.S. at a slow pace due to distance, language barriers, and other factors. Mining foreign experience can thus serve a resource for new ideas. Workshop participants suggested that each NCFRP project should include a chapter or section on best practices in other countries. In some cases these practices could be adopted in the U.S.; in other cases, there may be regulatory, market, or other barriers that prevent them from being widely implemented. Even when there are barriers, highlighting differences between the U.S. and other nations can help to highlight the regulations, policies, or other factors that could be changed, and the benefits from adopting these changes.

4.4 Forecasting and Modeling

Trends and Challenges

Freight modeling and forecasting is a critical element of long-range transportation planning and investment decisions. Yet transportation agencies often struggle to integrate freight fully into their decision-making processes because the models and tools needed to forecast freight movements are less well developed than those used for passenger travel. In some cases, transportation agencies lack in-house expertise in freight transportation modeling. Smaller MPOs, in particular, might not have the resources to support a dedicated professional with expertise in freight transportation. In addition, the data sources needed to support freight modeling have significant gaps. Often, significant effort and resources are required to develop custom data and tools to forecast freight demand. Conducting the modeling of freight trips that is required for infrastructure planning and policy analysis can thus be a substantial undertaking.

Freight transportation often is more difficult to forecast because it is influenced by changes in global supply chains. Unlike passenger travel, the factors that affect freight demand often are located outside the geographic boundaries of the state or region conducting the analysis. Freight transportation is driven by shifts in global markets, commodity prices, exchange rates, the relative cost of production in different locations, the cost of transportation, changes in technology, natural resource scarcity, and other factors. Private-sector supply chains are constantly adjusting their decisions about the sourcing of supplies, mode choice, transportation, inventory practices, warehousing, and distribution to respond to changes in global markets. The challenge in freight forecasting is to reflect this complex market adequately in a model that planners and policymakers can use.

Establishing a fundamentally new and different paradigm for modeling and forecasting freight flows may be necessary in order capture the complexity of freight movement. One approach to this would be to develop agent-based or activity-based models that can model how businesses use transportation, including supply chain decisions on warehousing and distribution of freight.

Better freight modeling and forecasting requires an understanding of how a myriad of factors can influence the freight transportation system. For instance, large swings in fuel prices have an impact on the price and demand for truck freight transportation, although these effects can also be mediated by negotiated contracts, hedging, and other strategies to manage the price of freight transport and fuel. For international trade, fuel prices and excess capacity are likely to continue to lower ocean freight costs. The future of these trends on international supply chains is uncertain.

Congestion is a top concern of logistics professionals, and the level of congestion ultimately has a significant impact on how businesses use transportation. Congested roadways affect how

supply chains are managed, how much inventory is held, and how much transportation is used. Longer transit times and unpredictable delays can encourage firms to hold more inventory and position supplies closer to the market. Other factors may run counter to these trends. For instance, neighborhood-specific merchandising seeks to tailor the mix of products in stores based on demographics and other market characteristics. This has resulted in more items in stores and less shelf space per item. These stores require more frequent on-time deliveries that are spaced across the day to keep items in stock.

Freight forecasting and modeling also needs to account for differences in regional economic activity, which can affect the need for investment in freight infrastructure. For example, in some regions with significant oil and gas resources, drilling activity has increased truck traffic. A single fracked gas well can generate 1,500 truck trips. Vehicles hauling fracking fluids, drilling equipment, or waste water can cause spikes in truck traffic and significant wear and tear on rural roads.

Research Topics

Significant research is needed to improve the freight modeling and forecasting tools available to public agencies. Workshop participants suggested development of a research strategy to better incorporate supply chains into freight forecasting and modeling. This could include developing and improving agent-based forecasting and microsimulation models. A study surveying the current state of practice in agent-based and microsimulation modeling of freight flows would be useful. The diffusion of agent-based and microsimulation modeling of freight flows could be expedited by making the necessary input data available and providing more user friendly tools.

Our interviews identified a range of other needed improvements to freight modeling. For instance, guidance for nesting/integrating MPO travel demand models with state freight models would be helpful to practitioners. There is a need for “scalable” freight analysis tools that can be used by smaller, as well as larger, MPOs. Better information and models to address mode shifts and improved freight routing models are needed.

Improved economic methods and approaches are needed to estimate the economic benefits of investments in freight. More research is needed to link freight system improvements and regional economic competitiveness. In addition, the larger and related linkage of freight system improvements, trade, and global competitiveness could be improved with additional research. Methods for measuring and valuing improvements in travel-time reliability are important to assessing the productivity benefits of freight investments. A deeper understanding of freight transportation and the supply chain is also needed to improve economic analyses. The

development of additional information on a typology of supply chains by industry and geography would help to further this understanding.

Interviewees noted the need for additional research on a variety of supply chain issues. Public agency staff noted that it would be useful to identify emerging trends in supply chain organization and operation. A better understanding of truck distribution centers, as well as a characterization of truck movements and truck tours, would be useful to improve modeling. New approaches for obtaining commodity flow data could help to improve the underlying data for modeling and forecasting. New approaches and data are needed to improve corridor analysis of commodity flows.

More research is also needed to improve multimodal forecasting of freight movements. A better understanding of the effect of changes in investment in one freight mode on other modes (e.g., how new investment in rail might impact waterways and truck freight) is needed. In general, freight modeling needs to better incorporate interaction between modal networks (truck, rail, others). Research into the impacts of maintaining efficient landside road and rail access to port facilities is needed. Freight forecasts would be improved by comparing increases in forecast maritime cargo volumes with available freight rail capacity.

4.5 Data and Performance Measures

Trends and Challenges

Over the past decade, a data explosion has occurred, as the cost of collecting and storing data has dropped steadily. Data from cell phones, vehicle probes, sensors, and other sources are revolutionizing the field of transportation data collection. Individual companies can now collect and store vast databases that characterize the movement of each of their vehicles in detail. Global positioning system (GPS) data from vehicle-based equipment and cell phones have provided a means to geo-locate and map these data with great temporal and geographical detail. However, concerns about privacy and maintaining the confidentiality of sensitive business information present a barrier to the full use of this data. Transportation planners are still determining the best way to work with private-sector organizations to use these data securely. In the field of transportation, the promise of big data to fundamentally improve the usage of equipment and infrastructure is significant.

The increase in data availability coincides with growing interest in using performance measures to inform transportation planning and programming decisions. FHWA has advanced the state of the art in highway performance measurement by funding the development of the National Performance Management Research Data Set (NPMRDS). The NPMRDS makes available an unprecedented amount of data on truck speeds, by time of day and location, making possible the development of detailed measurements of highway freight transportation system

performance. The data is obtained from vehicle probes. One challenge is that the NPMRDS and other existing datasets have gaps. Practitioners are still conceptualizing the potential applications of the new data, and additional tools are needed to take full advantage of the NPMRDS.

Assessing the quality and validity of the data is important for performance measurement. The frequency of the data must match the frequency of reporting required for performance measures. The same data needs to be collected on an annual or biannual basis so that historical comparisons can be made.

There is also a disconnect between public and private sector performance measures. Public agencies often use metrics like level of service to measure the performance of individual roadway segments or facilities. Private sector carriers and shippers typically are more focused on metrics of shipment transit time or transit time variability, which reflect how they experience the supply chain. There is interest in developing a more expansive set of national performance measures that would measure overall freight transit time in specific corridors, including the transit time associated with other modes and time spent waiting at ports, rail yards, or other trans-shipment points.

In the past several years, transportation agencies and their research partners have expressed interest in the development of “freight fluidity” metrics to assess the performance of transportation supply chains and freight networks. The concept of measuring freight fluidity was first advanced by Transport Canada and has since been the focus of several TRB-sponsored workshops. In practical terms, freight fluidity involves the measurement of travel time, travel-time reliability, and cost of moving freight shipments from beginning to end of a supply chain. However, developing such freight fluidity measures is challenging because coordination with private sector partners is needed to access some of the data.

Different approaches to performance measurement may be appropriate depending on the level of government, data availability, or other factors. Data from traffic management systems may be used at a regional or local level to measure performance. There is a large quantity of data available, particularly from robust traffic management systems in large metropolitan areas. Understanding how this data can be applied, its geographic limitations, and how it can be connected to the rest of the state is an area of interest for some transportation agencies. Integrating data from private sector services, such as Google/Waze, could provide a new and rich source of data for public sector planning.

Significant data gaps still exist in freight transportation. The most recent FHWA truck size and weight study concluded that more data are needed to evaluate this important issue adequately. Data on the weight of vehicles in crashes would help address one gap. Some data sources that

have been available historically to understand freight movements have not been updated in recent years. The Vehicle Inventory and Use Survey, which collects data on the nation's on-road truck fleet, truck activity, and operations, was most recently conducted in 2002. The U.S. DOT is currently evaluating options for conducting this survey again, including using vehicle probes and other approaches to collecting some of the data. Designing the next Commodity Flow Survey to better meet the needs of practitioners and take advantage of new methods and technology is another area of significant interest.

Overall, an important challenge is to understand the next generation of freight data available to MPOs and state DOTs. Freight data collection and compilation has often been a low priority for public sector programs and projects, in part because of the cost. Public sector planners and policymakers need to fine tune what information is collected and understand more fully why it is needed. In addition to collecting new data, a better vision of how the data can be used is critical. Overall, the technology to collect new data is running ahead of our understanding of how to use it.

Research Topics

The rapidly changing field of transportation data is opening up numerous opportunities for new transportation research. Tapping into data available from the private sector could provide new sources of data for public agencies. Research on how best to partner with private sector data providers, such as Google/Waze, to improve data for performance measures and planning was considered by workshop attendees as a productive area for investment. Many noted a need for guidance on leveraging private-sector data. This guidance could include best practices in maintaining freight data privacy, since often ensuring confidentiality and building trust with private sector partners poses a high barrier to using this data.

The use of very large datasets and innovative analytics, often referred to as "Big Data", will likely grow in importance and warrants further research. Approaches to using very large datasets are still being developed and would likely see greater progress if additional research funding were made available. In particular, new approaches to integrating passive data, and other ITS data, for real time key performance indicators warrants further development.

Workshop participants noted the need for additional research into the best way to use existing resources, such as the NPMRDS data. The NPMRDS data or other similar vehicle probe data could be used for a wide range of applications, including serving as a source to improve data available on truck trips and freight flows. Creating standardized methods to use this new data to create truck trip tables or other resources would be useful. Existing NCFRP products could be updated to account for the new data resources that are available. For instance, an update to *NCFRP Report 29, Making Trucks Count: Innovative Strategies for Obtaining Comprehensive*

Truck Activity Data, is needed to account for new truck GPS data. Interviewees also suggested a need to update *NCFRP Report 9, Guidance for Developing a Freight Transportation Data Architecture*.

Improving national freight datasets was identified as an important priority. A revival of the Vehicle Inventory and Use Survey was a priority noted by many stakeholders. Others suggested that more work is needed to create a disaggregation methodology for the Freight Analysis Framework (FAF) data, particularly for the latest version (FAF 4.0). Freight planners have also expressed interest in developing better ways to convert data from the FAF to determine truck tonnage and truck trips in smaller geographies. This includes developing better approaches for estimating trucks trips for use in state-wide models and analyses down to the project level. Interviewees also expressed interest in expanding the FAF, including broadening the data to cover additional commodities and expanding the O-D data to make it more comprehensive so that smaller geographies can be addressed.

Better approaches to collecting the data for freight performance measures across all modes would be useful. In particular, more work is needed to develop approaches and data to create a freight fluidity index. This index would measure the performance of the supply chain from the perspective of the shipper and include transit time and reliability at each link in multimodal supply chains.

Other identified research topics related to data and performance measures include the following:

- Improving the data available on freight transportation cost for all modes, which would help practitioners conduct policy analysis and make comparisons between modes
- Additional guidance developing state or metropolitan freight data clearinghouses
- Publishing a new North American transportation map
- Collecting data to provide better inputs to freight models, including advanced agent and activity based models
- Improving data on trade gateways, congestion at the border, and trade corridors

Participants in the NCFRP 48 workshop determined that a priority research topic is a study to create a national freight data policy. This research could produce a tiered list of data needs – identifying data needs in different areas of freight transportation policy and planning, identifying where missing data reside, and developing strategies to obtain it. The following issues could be included in a single national freight data policy project or addressed in a portfolio of related projects:

- Standardization of data for collection and reporting
- Using new technology to address data gaps, including identifying ways to leverage passive data collection
- Determine best practices for collecting and using data from the private sector while also maintaining confidentiality and security for the data
- Improving data on commodity flows
- Bridging the economic development/transportation divide in the use of data

4.6 Safety, the Environment, and Public Health

Trends and Challenges

The relationship between transportation and public health will continue to be a high priority in the future. Vehicle safety and truck crashes loom large in this area. For the population group between the ages of 4 and 34, vehicle crashes are the number one cause of death. The long term trend in heavy-duty truck fatalities per mile has been falling, although in recent years it has been flat or increased slightly. New technologies, such as automatic braking, hold the promise of significantly reducing crashes further. But increasing highway congestion, growth of shared use rail corridors, and redevelopment of land in freight-intensive urban districts could create new freight safety challenges.

The impacts of freight movement on air quality will continue to be a source of concern. Over the last several decades, air quality has improved significantly in nearly every metropolitan area, and new trucks, locomotives, and ships emit far less pollution than they did ten years ago. At the same time, scientific understanding of the health impacts of air pollution has grown. In October 2015, EPA strengthened the National Ambient Air Quality Standards (NAAQS) for ground-level ozone, based on extensive scientific evidence about ozone's effects on public health and welfare. Diesel engines are a major source of nitrogen oxide (NOx) emissions that contribute to ozone formation. The revised ozone standard is expected to result in approximately 25 counties outside California being in non-attainment, which triggers new planning requirements and heightened interest in diesel emission control measures. Separate from ozone, research is shedding light on the connection between diesel particulate matter and cancer. Both the World Health Organization and the State of California have classified diesel exhaust as a human carcinogen. The effects of diesel particulate matter are likely to spur additional efforts to control freight emissions even in places that meet the new ozone standard.

Freight transportation also contributes significantly to greenhouse gas (GHG) emissions. Freight transportation (truck, rail, marine, air, pipeline) is currently responsible for 29 percent of U.S. transportation GHG emissions, and 8 percent of total U.S. GHG emissions (all sources).

Emissions from freight transportation have grown faster than the transportation sector as a whole. From 1990 to 2013, while total transportation emissions rose by 17 percent, emissions from freight transportation rose by 50 percent. Since 2009, GHG emissions from the entire transportation sector (including the passenger vehicle segment) have declined, while emissions from freight transportation have risen by five percent. In 2011, the U.S. EPA and DOT adopted the first-ever standards to reduce GHG emissions and improve the fuel efficiency of medium- and heavy-duty trucks; a second phase of these standards has now been proposed.

The impacts of climate change, including rising sea levels and extreme weather, could also significantly affect the freight transportation system. Freight transportation infrastructure across all modes is vulnerable to the impacts of climate change. Concern about these issues has raised the importance of incorporating resiliency into freight planning. This issue is challenging because the timing and exact nature of future impacts are uncertain, yet delaying action increases the risk of severe freight system disruptions due to extreme weather events.

Businesses have struggled to understand the impacts of environmental and safety regulations on their operations. Some transportation agencies have suggested that the long time needed for environmental review and permitting can serve as a barrier to some worthy freight infrastructure projects, and that expedited environmental reviews should be applied in some cases.

Research Topics

The impact of freight transportation on public health is an important area for future research. This includes environmental and safety impacts across all modes. The large increase in oil moving by rail has raised the need for research in this area. Studying the safety of rail shipments of petroleum products and other hazardous materials, particularly through cities, has become an important issue for many policy makers. Research into truck size, weight, and vehicle configurations issues continues to be important. The rise of a variety of autonomous vehicle technologies has made it important that policymakers understand what challenges and opportunities these technologies hold for improving safety and the environment. Connected vehicle technology also continues to be an important area of research, as noted in Section 4.1.

More research is needed to understand the environmental benefits of operational strategies that improve freight system efficiency. Studying how information systems can optimize freight movements across all modes involved in port and maritime cargo movements specifically, and the associated environmental and safety impacts, is a research area with much possibility. A study providing a vision for a sustainable freight transportation system could help guide the discussion of how to improve the safety and environmental performance of freight transportation.

Appendix A. List of NCFRP Projects and Reports

Project No.	Name	Report
NCFRP 01	Public and Private Sector Interdependence in Freight Transportation Markets	NCFRP Report 1
NCFRP 02	Impacts of Public Policy on the Freight Transportation System	NCFRP Report 6
NCFRP 03	Performance Measures for Freight Transportation	NCFRP Report 10
NCFRP 04	Identifying and Using Low-Cost and Quickly Implementable Ways to Address Freight-System Mobility Constraints	NCFRP Report 7
NCFRP 05	Framework and Tools for Estimating Benefits of Specific Freight Network Investment Needs	NCFRP Report 12
NCFRP 06	Freight-Demand Modeling to Support Public-Sector Decision Making	NCFRP Report 8
NCFRP 09	Institutional Arrangements in the Freight Transportation System	NCFRP Report 2
NCFRP 10	Separation of Vehicles---CMV Only Lanes	NCFRP Report 3/ NCHRP Report 649
NCFRP 11	Identification and Evaluation of Freight Demand Factors	NCFRP Web-Only Document 4
NCFRP 12	Specifications for Freight Transportation Data Architecture	NCFRP Report 9
NCFRP 14	Truck Drayage Practices	NCFRP Report 11
NCFRP 15	Understanding Urban Goods Movements	NCFRP Report 14
NCFRP 16	Representing Freight in Air Quality and Greenhouse Gas Models	NCFRP Report 4
NCFRP 17	North American Marine Highway Operations	NCFRP Report 5
NCFRP 17(001)	Marine Highway Transport of Toxic Inhalation Hazard (TIH) Materials	NCFRP Report 18
NCFRP 18	Synthesis of International Freight Scans	N/A (available by request)
NCFRP 19	Truck Tolling--Understanding Industry Tradeoffs When Using or Avoiding Toll Facilities (Jointly funded as NCHRP Project 19-09)	NCFRP Web-Only Document 3
NCFRP 20	Guidebook for Developing Sub-national Commodity Flow Data	NCFRP Report 26

NCFRP 22	Applying Benefit-Cost Analysis (BCA) to Freight Project Selection: Lessons from the Corps of Engineers	N/A (available on-line)
NCFRP 23	Economic and Transportation Drivers for Siting Freight Intermodal and Warehouse Distribution Facilities	NCFRP Report 13
NCFRP 24	Preserving and Protecting Freight Infrastructure and Routes	NCFRP Report 16
NCFRP 25	Freight Trip Generation and Land Use (Jointly Funded as NCHRP 08-80)	NCFRP Report 19/ NCHRP Report 739
NCFRP 25(01)	Estimating Freight Generation Using Commodity Flow Survey Microdata	in publication
NCFRP 26	Freight Transportation Cost Data Elements	NCFRP Report 22
NCFRP 27	Promoting Environmental Goals in Freight Transportation through Industry Benchmarking	NCFRP Report 21
NCFRP 28	Truck Idling Scoping Study	N/A (available on-line)
NCFRP 29	New Dedicated Revenue Mechanisms for Freight Transportation Investment	NCFRP Report 15
NCFRP 30	Web-Based Screening Tool for Shared-Use Rail Corridors	NCFRP Report 27
NCFRP 31	Guidebook for Sharing Freight Transportation Data	NCFRP Report 25
NCFRP 32	Impact of Smart Growth on Metropolitan Goods Movement	NCFRP Report 24
NCFRP 33	Public-Sector Sustainability Strategies Addressing Supply Chain Air Emissions	NCFRP Report 28
NCFRP 34	Evaluating Alternatives for Landside Transport of Ocean Containers	NCFRP Report 34
NCFRP 35	Multimodal Freight Transportation Within the Great Lakes-Saint Lawrence Basin	NCFRP Report 17
NCFRP 36(01)	National Multi-Modal Freight Transportation Strategy	N/A (available by request)
NCFRP 36(02)	Harbor Maintenance Tax Impacts on Freight	N/A (added to NCFRP 35)
NCFRP 36(03)	Multistate Freight Corridor Organizations	NCFRP Web-Only Document 2
NCFRP 36(04)	Carbon Footprint of Supply Chains: A Scoping Study	NCFRP Web-Only Document 5
NCFRP 36(05)	Synthesis of Freight Research in Urban Transportation Planning	NCFRP Report 23
NCFRP 37	Making U.S. Ports Resilient as Part of Extended Intermodal Supply Chains	NCFRP Report 30

NCFRP 38	Improving Freight System Performance in Metropolitan Areas	NCFRP Report 33
NCFRP 39	Making Trucks Count: Innovative Strategies for Obtaining Comprehensive Truck Activity Data	NCFRP Report 29
NCFRP 40	Improving Export Freight Logistics	in publication
NCFRP 41	Incorporating Truck Analysis into the Highway Capacity Manual	NCFRP Report 31
NCFRP 42	Integrating MTS Commerce Data with Multimodal Freight Transportation Performance Measures to Support MTS Maintenance Investment Decision Making	NCFRP Report 32
NCFRP 43	Guidebook for Assessing Evolving International Container Chassis Supply Models	NCFRP Report 20
NCFRP 44	Factors Influencing Freight Modal Shifts	in publication
NCFRP 45	Enhancing Sleep Efficiency on Towboats in the U.S. Inland Waterway Industry	NCFRP Report 36
NCFRP 46	Benefit-Cost Methodologies for Evaluating Multimodal Freight Corridor Investments	in publication
NCFRP 47	Freight Transportation Data Architecture: Data Element Dictionary	NCFRP Report 35
NCFRP 48	Freight Research to Support MAP-21 Implementation	in publication
NCFRP 49	Understanding and Using New Data Sources to Address Urban and Metropolitan Freight Challenges	active
NCFRP 50	Improving Freight Transportation Resilience in Response to Supply Chain Disruptions	active

Appendix B. Full Survey Results

Q1. With which type of organization are you affiliated?		
Answer Options	Response Percent	Response Count
Federal government	9.3%	22
State government	46.6%	110
Metropolitan planning organization	8.5%	20
Local government or port authority	4.2%	10
Academia	7.2%	17
Private sector	21.6%	51
International (outside the United States)	2.5%	6
Other (please specify)		8
<i>answered question</i>		236
<i>skipped question</i>		0

Q2. Please indicate your past or current involvement (if any) in the NCFRP Program (select all that apply):		
Answer Options	Response Percent	Response Count
Served on the NCFRP Oversight Committee	5.9%	14
Served on an NCFRP project oversight panel	16.5%	39
Conducted NCFRP research as a contractor	8.5%	20
Was interviewed for an NCFRP research project	15.7%	37
Other involvement in the NCFRP program	18.6%	44
No involvement	56.4%	133
<i>answered question</i>		236
<i>skipped question</i>		0

Q3. Please indicate the research sources that you have used in support of freight planning, programming, and policy decisions (select all that apply):		
Answer Options	Response Percent	Response Count
National Cooperative Highway Research Program reports	56.9%	132
National Cooperative Freight Research Program reports	62.1%	144
Airport Cooperative Research Program reports	6.0%	14
U.S. Government reports (e.g., published by FHWA, FRA, GAO)	70.3%	163
Research reports published by industry associations (e.g., ATRI, ATA, AAPA, AAR, CSCMP)	62.1%	144
Research reports published by independent organizations (e.g., Brookings Institute)	49.1%	114
Research reports by universities	61.6%	143

Research reports by state departments of transportation or economic development	65.9%	153
Research reports by metropolitan planning organizations	45.7%	106
Research conducted by or for your organization	63.4%	147
None of the above	10.8%	25
Other (please specify)		9
<i>answered question</i>		232
<i>skipped question</i>		4

#	Q3. Other (please specify)
1	I'm not directly involved in freight-specific planning, programming or policy decisions.
2	Research and reports from other countries, specifically Mexico
3	Transit Cooperative Research Program (TCRP)
4	TRB
5	Imo and ciao research
6	National Transportation Research Board--Standing committee on freight
7	xxxx
8	TRB Research and Reports
9	Conversations with freight carriers directly.

Q4. Have you ever used (read or referred to) any NCFRP research products in the course of your professional or academic duties, including implementation of MAP-21?

Answer Options	Response Percent	Response Count
Yes	66.5%	155
No	33.5%	78
<i>answered question</i>		233
<i>skipped question</i>		3

Q5. Below is a list of NCFRP publications that have been released to date. Please select the NCFRP report(s) that you have read or to which you have referred for professional or academic purposes.

Answer Options	Response Percent	Response Count
Report 1: Public and Private Sector Interdependence in Freight Transportation Markets	22.6%	30
Report 2: Institutional Arrangements in the Freight Transportation System	19.5%	26
Report 3: Separation of Vehicles-CMV Only Lanes	12.8%	17
Report 4: Representing Freight in Air Quality and Greenhouse Gas Models	20.3%	27
Report 5: North American Marine Highway Operations	26.3%	35
Report 6: Impacts of Public Policy on the Freight Transportation System	43.6%	58
Report 7: Low-Cost and Quickly Implementable Ways to Address Freight-System Mobility Constraints	17.3%	23
Report 8: Freight-Demand Modeling to Support Public-Sector Decision Making	45.1%	60
Report 9: Specifications for Freight Transportation Data Architecture	22.6%	30
Report 10: Performance Measures for Freight Transportation	63.9%	85

Report 11: Truck Drayage Productivity Guide	16.5%	22
Report 12: Framework and Tools for Estimating Benefits of Specific Freight Network Investment Needs	23.3%	31
Report 13: Econ. & Transp. Drivers for Siting Freight Intermodal and Warehouse Distribution Facilities	18.8%	25
Report 14: Guidebook for Understanding Urban Goods Movements	43.6%	58
Report 15: New Dedicated Revenue Mechanisms for Freight Transportation Investment	16.5%	22
Report 16: Preserving and Protecting Freight Infrastructure and Routes	19.5%	26
Report 17: Multimodal Freight Transportation within the Great Lakes-Saint Lawrence Basin	15.0%	20
Report 18: Marine Highway Transport of Toxic Inhalation Hazard Materials	4.5%	6
Report 19: Freight Trip Generation and Land Use	37.6%	50
Report 20: Guidebook for Assessing Evolving International Container Chassis Supply Models	6.8%	9
Report 21: Handbook on Applying Environmental Benchmarking in Freight Transportation	9.8%	13
Report 22: Freight Transportation Cost Data Elements	25.6%	34
Report 23: Synthesis of Freight Research in Urban Transportation Planning	24.8%	33
Report 24: Smart Growth and Urban Goods Movement	30.8%	41
Report 25: Freight Data Sharing Guidebook	30.8%	41
Report 26: Guidebook for Developing Sub-national Commodity Flow Data	21.1%	28
Report 27: Web-Based Screening Tool for Shared-Use Rail Corridors	1.5%	2
Report 28: Sustainability Strategies Addressing Supply-Chain Air Emissions	7.5%	10
Report 29: Making Trucks Count: Innovative Strategies for Obtaining Truck Activity Data	20.3%	27
Report 30 Making U.S. Ports Resilient as Part of Extended Intermodal Supply Chains	12.0%	16
Report 31: Incorporating Truck Analysis into the Highway Capacity Manual	18.0%	24
Web-Only Doc. 2: Multistate Freight Corridor Organizations	24.8%	33
Web-Only Doc. 3: Truck Tolling-Understanding Industry Tradeoffs When Using or Avoiding Toll Facilities	12.0%	16
Web-Only Doc. 4: Identification and Evaluation of Freight Demand Factors	9.8%	13
Web-Only Doc. 5: Carbon Footprint of Supply Chains: A Scoping Study	4.5%	6
NCFRP 22: Benefit-Cost Analysis to Freight Project Selection: Lessons from the Corps of Engineers	13.5%	18
NCFRP 28: Truck Idling Scoping Study	5.3%	7
Don't remember specific report(s)	6.8%	9
Other (please specify)		1
	answered question	133
	skipped question	103

Q6. Please indicate how you have used NCFRP reports (select all that apply):

Answer Options	Response Percent	Response Count
Support of freight planning activities	74.0%	94
Support of freight data collection and analysis activities	66.9%	85
Support of freight modeling activities	33.9%	43
Support of freight investment and financial decisions	29.1%	37

Support of freight policy activities	63.0%	80
Support of analyzing freight operations	44.9%	57
Support of economic development activities	32.3%	41
Support of freight environmental analysis	18.1%	23
Support of modal optimization or mode-shifting analyses	25.2%	32
Support of safety, security, or resiliency analyses	22.8%	29
Support of structuring freight advisory councils or other stakeholder outreach	29.9%	38
Support of private-sector freight involvement activities	33.1%	42
Other (please specify)		7
	answered question	127
	skipped question	109

#	Q6. Other (please specify)
1	Mobile source emission inventories for trucks
2	Benefit-cost analyses of proposed regulations
3	Transportation asset management activities
4	Support of additional research
5	Academic research projects on urban and metropolitan freight planning
6	State Rail Planning
7	Freight used to support economic competitiveness

Q7. For the NCFRP research product or products that you found to be the most useful, please briefly describe how you used that NCFRP report. What was the issue or problem you or your organization was facing when you consulted this report? How did the report help you address the issue or problem?

Answer Options	Response Count
	55
answered question	55
skipped question	181

#	Q7. Responses
1	Development of corridor performance measures. Network disruption costs and recovery responses. Estimation of freight demands (esp. Trucking demands) and costs.
2	Long range planning process: helped to gain an understanding of the topic, help process discussion to help guide the long range freight planning effort.
3	access to freight data
4	We do general freight research. How we use the NCFRP reports relates to the problem our research addresses.
5	We needed to identify performance measures specific to trucks, their methodologies, and data sources.
6	The problem was understanding the factors that influence industrial location decisions. NCFRP 13 outlined both the transportation and non-transportation factors.
7	Value in all products was to support understanding of other problem and data analysis solutions and development. Provides good peer reviewed/supported fundamentals on related issues to our work product.

8	Being new to freight planning, NCFRP reports have been very beneficial in understanding lessons learned from other countries, states, and local entities.
9	Report 10 was very helpful in developing a draft list of Freight Performance Measures for our State Freight Plan. This document, as well as other related reports, helped us put together a starting point that we could revise and make additions to.
10	Multi-modal commodity flows, intra-state or multi-state commodity flows, contribution of freight transportation to air emissions
11	Building up our freight program and knowledge
12	These reports are usually disconnected from the business realities out in the field. They reinforce the status quo and since it is not popular to express understandings that run counter to the prevailing dynamics in the private- sector these reports have limited validity. Effective business and policy depends on 100% whole-system accounting, as all the work for an entire year is intended to produce a 5% or less profit. If the accounting for costs and impacts is not 100% accurate, it is easy to see how profits or advances of any sort can be constantly out of reach.
13	Information was used to educate the meeting participants
14	I don't recall the specifics, but it was good context to learn more about investment decisions in the context of freight.
15	I needed to better understand urban goods movements, and this report helped educate me.
16	Best practices research in port and waterway planning, funding and policy. The report presented key best practices used elsewhere and provided a point of departure for further research.
17	Long range planning process: helped to gain an understanding of the topic, help process discussion to help guide the long-range freight planning effort.
18	Development of state freight plan. Gathering ideas for implementation and analysis.
19	How to project future costs for additional truck usage and fix rutting issues caused by trucks on our highways.
20	Preparation of FRA-required State Freight & Passenger Rail Plan Consideration of passenger rail - freight rail interests, sometimes conflicting, sometimes shared
21	NCFRP reports are an excellent way to develop knowledge and skills for supporting state and local long-range planning.
22	Many times the reports serve to help keep one up to date and current with the latest subject knowledge. I find that I often forward reports to others in the DOT that may have an interest or connection to the subject. In so many ways and times, the reports have helped to provide data, documentation or guidance: from legislative requests, support for dept. initiatives, requests for funding, etc.
23	* Identify prior research efforts * Connect with those most knowledgeable about the topic * Understand cutting- edge issues
24	Interested in analyzing proposed freight investment. Research products were used to inform the analysis and/or provide guidance.
25	NCFRP 23 was desperately needed. We haven't had a synthesis of freight planning research in at least two decades. This report has become required reading in transportation planning classes I lecture in and had measurably advanced the research and literature on freight planning
26	Safety and efficiency of marine operations and avoidance of accidents is the main focus of my activities. Data sources and their utility for analysis and development of policy recommendations are my primary focus. The ongoing project on operator fatigue on the inland waterways is a particularly focused and useful TRB project effort as it addresses specific research gaps in a series of industry developed research efforts into operational safety and sleep effectiveness. Other reports have supported analysis of safety data issues and marine highways studies I have been leading or a participant in. There are many areas of collaborative research efforts needed in these areas where TRB can play a leading role in facilitating highly useful studies.
27	Multimodal planning and prioritizing fixing bottlenecks

28	NCFRP Report 20 helps our current development of chassis pool study at Port of Long Beach.
29	The NCFRP reports provide outstanding background information, strategies, and best practice examples for better integrating freight transportation considerations into the transportation planning process.
30	We use the reports as either background to, or checks on, our own freight analyses.
31	Issues: lack of knowledge on the topic. help: it developed a knowledge base on the topic and provided noteworthy practices.
32	Primarily as reference material for freight planning and data issues. Often cite NCFRP research findings relevant to planning topics being addressed in reports that I write.
33	Conducting research on freight transportation, particularly freight transportation and good movement nationally, regionally and locally.
34	Used to create literature reviews and guide research frameworks
35	From an international perspective, the NCFRP has produced important lessons about and designs for outreach from gov to the public and to private stakeholders. Also, for purposes of international comparison, reports on urban freight and modelling were very useful.
36	To support State and MPO Freight plans
37	What I have used the most were the actionable results found in some of the reports. Particularly performance measures and the supply chain illustrations in NCFRP 14
38	Have used NCFRP projects to get information about urban goods movement supply chains, freight data collection suggestions and actual data, and examining different freight modeling approaches. Used in assessment of urban goods movement strategies for MPO freight plans and developing freight data surveys for a variety of different public sector clients.
39	Helped with the initial planning for the DOT freight program. We are moving into the implementation of the program.
40	One quick example: I was challenged to get my state's MPO's to incorporate freight planning in their planning processes. I was able to share the Report 14: Guidebook for Understanding Urban Goods Movements with MPOs as well as others in attendance at a state chapter conference of the American Planning Association.
41	We have developed a Transportation Action Process that addresses the many disconnects between research, policy, planning, and actual private-sector business plans that typically are not in alignment with public policy goals. Therefore the intended results of all of these activities are only being forwarded at the project-level, not the systemwide level which is where we have to get to.
42	Looking for best practices nationwide.
43	In planning and roadway capacity analyses we typically use all vehicles. We have not previously had a means for separating out truck performance - the NCFRP research provided guidance on evaluating highway capacity for trucks, specifically.
44	The report helped me to prepare for specifically addressing freight planning as a part of a comprehensive planning process.
45	They serve as base line for what has been done to date and are used to support further analysis
46	Studied the documents as background for developing and supporting State and Federal policy and appropriation objectives for my employers.
47	The report provide good structural foundation to support varies freight issue, otherwise not studied
48	Identifying the total extent of truck and rail based commodity movement.
49	Issues in surface transportation reauthorization. Background information and references to other work.
50	Environmental concerns around freight movement Mode shift

51	Getting the private sector more involved, types of data and ways to collect it, etc.
52	Project investment prioritization, freight policy within a climate change strategy, advocacy for freight investments, economic benefits and business benefits of freight investments, identification of low cost and timely freight improvements
53	investment prioritization decisions, freight model improvements, modifying regional, local and state policy, rationale for advocacy for freight investments, economic value of freight improvements
54	Needed to review existing or new analysis and evaluation methods.
55	Writing the State Freight Plan

Q8. How do you typically identify that an NCFRP report may be relevant to your work? (Select all that apply.)

Answer Options	Response Percent	Response Count
Do a general Web search (e.g., Google, Bing)	56.9%	74
Do a search on the TRB website	46.9%	61
Browse the list of NCFRP reports on the TRB website	47.7%	62
Subscribe to TRB email newsletter that announces newly published NCFRP reports	49.2%	64
Download interesting NCFRP reports as I learn about them and save them for later use	50.8%	66
Other (please describe)		9
<i>answered question</i>		130
<i>skipped question</i>		106

#	Q8. Other (please describe)
1	Suggested by colleagues
2	also learn about them from conferences as well as references from research articles, books and reports
3	TRIS and copernica
4	Receive printed copies of the final reports.
5	Colleagues who have become aware of the research will let me know about new reports. Sometimes hear about new reports that are of interest at TRB annual meeting. Our company also frequently bids on NCFRP projects and we will review reports on projects that we did not win if the topics remain of interest to us.
6	Thru our librarian
7	Word of mouth. TRB methods of notification are ineffective. TRB website is impossible to understand.
8	Contact the Librarian, Ken Winter, at the Virginia Center for Transportation and Innovation Research.
9	They are mailed to me.

Q9. Please provide reasons why you have not utilized NCFRP research products in the course of your professional or academic duties (select all that apply).

Answer Options	Response Percent	Response Count
Did not know about NCFRP program until now	46.9%	30

NCFRP research products are not relevant to me	15.6%	10
Too difficult to find relevant NCFRP research products	14.1%	9
Timeliness of NCFRP publications	9.4%	6
No time to read NCFRP research products	15.6%	10
Prefer to use other sources	4.7%	3
Don't use research reports	12.5%	8
Other (please specify)		10
	answered question	64
	skipped question	172

#	Q9. Other (please describe)
1	I'm new in my position and haven't used them yet.
2	While I appreciate the reports since they indicate future policy direction, my daily work in environmental planning is several steps removed from freight planning.
3	Quality has not been good enough. The NCFRP projects typically have been somewhat special interest oriented and performed by contractors who know the formula. Oversight committees seem to have insufficient scientific background. The strong practitioner oversight tends to make them good for the specific purpose they are written but limits their overall influence.
4	No particular reason, just haven't happened to use them.
5	Access to data
6	I don't avoid them or anything, but I can't recall seeing one that grabbed my attention. I usually look at the title of the report, not necessarily who was conducting the research. I don't spend a lot of time reading research products in general though.
7	Have not taken time know research products
8	Don't have the need.
9	we move loads that are not covered by NCFRP reports
10	Nothing against NCFRP, but I've found adequate information from other sources.

Q10. Below is a list of topic areas that could be the subject of future freight research. For each topic, indicate the degree to which you feel new research is needed. (1 = No need for new research; 5 = Critical need for new research)

Answer Options	1	2	3	4	5	Rating Average	Response Count
Economics of freight transport or infrastructure investment	1	13	25	62	70	4.09	171
Operational improvements for freight	1	14	41	79	29	3.74	164
Data issues for freight	2	12	47	53	53	3.86	167
Finance and revenue for freight	4	27	43	50	42	3.60	166
Forecasting and modeling for freight	2	12	46	59	44	3.80	163
Safety of freight systems	3	21	58	53	28	3.50	163
Security and resiliency of freight systems	2	24	59	52	27	3.48	164

Environmental and community impacts related to freight	1	27	48	62	29	3.54	167
Institutional and organizational arrangements for freight	5	31	60	41	25	3.31	162
Other							6
<i>answered question</i>							177
<i>skipped question</i>							59

#	Q10. Other
1	Technology for freight -- autonomous vehicles
2	none
3	standardize local, state and federal data
4	Technology - The Impact of Automated and Connected Vehicle Technologies
5	Strategies for managing urban goods movement.
6	1) economic benefits of freight investments and linkage to region, state economy, 2) last mile improvements within an urban area, 3) the role of freight system improvements to meeting national trade agenda

Q11. Do you have suggestions for specific freight research topics that will be needed in the next several years? If so, please describe.

Answer Options	Response Count
	58
<i>answered question</i>	58
<i>skipped question</i>	178

#	Q11. Responses
1	Impacts of 3-D printing. Impacts of network disruptions leading to surges in demand. Agent-based and microsimulation modeling of freight flows and costs.
2	More on intermodal market analysis and/or multimodal corridor planning.
3	no
4	Oversize infrastructure and revenue impacts and regional harmonization of permitting
5	leveraging private sector freight data for public sector decision-making process
6	Projected growth in inland waterborne freight traffic.
7	Intuitively there is a large unused freight capacity on the waterways of the United States. What will it take to accomplish a modal shift and reduce highway congestion
8	I would suggest a program for Federal Tax credits for shippers who elect to move from Highways onto the Inland waterways and other non-highway modes.
9	Efficiency and safety on inland navigation (barging). Available capacity on inland waterway systems.
10	Freight routes (specifically truck routes) and their importance to the economy and movement of freight.
11	Opportunities to increase size and weight; velocity of movements with truck only lanes; rail car transload/unload centers
12	Successful alignment of DOT freight plans and other planning documents, including the transportation asset management plan.

13	Potential impacts on emerging technologies on freight, both directly related to freight (V2V, V2I, feasibility of new energy sources for freight movements) and adjacent to freight (drones as delivery devices, same-day delivery roll-outs by Amazon and others, 3D printing as a potential to localize product creation)
14	Yes, the role of autonomous vehicles in freight transportation -- efficiency, environmental, social, economic and other implications
15	No
16	Will, or should, the use of rail increase?
17	keep exploring the development of freight corridors including construction funding
18	I think a report on the subject of intermodal markets / multimodal corridors would be a hugely helpful resource.
19	Weather related delay and the associated costs to freight on roadways.
20	Include car radars, anti-collision tools, Daimler, European green union and a new third generation industry creating new fuels, jobs and civil, human rights.
21	System Management and Operations for freight related planning
22	How changes of investment in one freight mode impacts others. ie, if no new investment in rail, how does that impact waterways, truck, vice versa
23	no
24	Understanding of the key factors that influence freight practitioners to seek out, evaluate and fully implement new ways of doing business, so that those factors can be explicitly taken into account when identifying and promoting innovations that seem likely to improve the freight transportation system.
25	1. The use of automated delivery vehicles for freight transportation 2. Funding for the inland waterway system 3. America's dependence on imported goods. Can we afford it? Will geopolitical events severely affect it?
26	Possible new freight corridors: NSR, TransAsia rail, Africa - US trade (efficiency, what should be done etc.)
27	National overweight permitting and fee structure to provide National freight corridors where permitting fees are structured to pay for consumption of infrastructure
28	truck parking
29	How 3-D printing will impact freight transportation demand.
30	best practices and case studies have the most real world impact
31	Standardize local, state and federal data examples.
32	Research can be done on Dedicated short-range communications and trucks. Currently a lot of research is being done for cars but more should and can be directed to tractor trailers. This research should include how DSRC can improve the movement of oversized loads as well.
33	Methodology for identifying "hotspots" of freight diesel emissions where the health of communities are disproportionately affected, and strategies for addressing those local challenges; Developing methodology for assessing the economic impacts of highway and bridge preservation projects.
34	I would like to see some research quantifying the relative safety (or lack thereof) of the various freight modes in transporting 1) non-hazmat commodities, 2) hazmat commodities, especially 2a) crude and ethanol, and 2b) PIH/TIH and 3) nuke material. Safety should consider transport end-to-end in terms of spills per ton-miles and at points of intersection with other modes, particularly highway-rail crossings (probability of collision, collision with a derailment, and collision with a derailment with a release of HM.
35	Impact on passenger rail.
36	Freight routing models.
37	Changes in spatial and functional demand characteristics of freight due to new technologies. Importance of freight network service quality for reshoring of national industry.

38	Economics of intermodal facilitates, economic impact. Intermodal in relation to ports.
39	West Coast port capacities and infrastructure restrictions relative to the influx of 15,000 teu capacity container vessels.
40	We need better and more accessible freight movement and cost data for all modes.
41	Technology - The Impact of Automated and Connected Vehicle Technologies
42	Railroad capacity in light of shifting global freight corridors
43	Preemptive economic growth strategies
44	1) Innovations in bridge height clearance notifications. To many bridges are being hit. Many of these loads were too high because of improper load securement or drivers that were unaware of their actual vehicle height. There is a need for better advanced warning signals. 2) Regional permitting for OS/OW loads. Obtaining special hauling permits can be a time consuming confusing process. Automated systems should do a better job of talking to each other so haulers don't have to duplicate similar functions for each state of travel.
45	Connect freight research with actual public-private sector business planning processes.
46	Land use and freight--especially tied to the protection of industrial lands supporting freight-intensive land uses. Better ways to explain the importance of maintaining freight routes in the face of increasing pressure from bike, ped and transit advocates for complete streets treatments and similar capacity reductions.
47	Disaggregation methodology for FAF data, particularly with FAF 4.0.
48	Transload facility and congestion mitigation
49	Identifying which transportation investments for freight have the most significant return on investment - from a public standpoint
50	Over-dimensional corridors and establish national infrastructure requirements for highway design. Example - eliminate roundabouts on over-dimensional corridors routes.
51	More of how the public and private sectors and evaluate the freight system
52	How to pay for freight infrastructure with declining gas tax revenue...intermodal optimization; leveraging private funds for freight infrastructure, determining/dedicating freight corridors and routes in urban environments.
53	Impact of freight movement to states via new infrastructure in another country e.g. Quebec Autoroute 35 development and its impact to freight movement on I-87 (NY) and I-89 (VT).
54	Development of interactive, google maps based system of tracking truck and rail based freight movements.
55	improving freight efficiencies
56	The positive and negative impacts of heavier weight and longer trucks. Tandem 53' trailers, 97,000# GVW, etc
57	How to institute freight policies that preserve freight gateways and ports from gentrification. Development of Guidance on how to address freight needs and issues in the Regional Transportation Plans on how to address freight issues.
58	freight investment and increasing exports and foreign direct investment trade, freight and climate change, increasing public/private investments in the freight systems

Q12. Do you have any suggestions for improving the dissemination of NCFRP research products?

Answer Options	Response Count
	34
<i>answered question</i>	34
<i>skipped question</i>	202

#	Q12. Responses
1	No
2	no
3	online dissemination
4	no
5	Utilize national modal network groups of new research products that have relevance so they may alert membership. As a private sector member of such groups this would add product distribution value. (Maritime Freight Sector; IRPT, AAPA, WCI, etc.)
6	Specific NCFRP quarterly email to interested parties detailing new products.
7	The reports need to be designed and advanced in direct connection with the development of a new Transportation Action Planning process that generates actual plans, with metrics, benchmarks, specific targets, action steps, and commitments.
8	no
9	No new suggestions at this time.
10	No
11	No
12	Presentations at national meetings where management of freight is important.
13	No.
14	Market with UN global compact, Clinton Foundation and Gates Foundation.
15	No
16	no
17	a lot more publicity - using social media - to reach folks who aren't necessarily able to attend NCFRP, TRB or AASHTO events.
18	Summary of results from research projects organized by subject area would help in the research community to permit quickly finding the key studies for finding useful background or cutting edge advances.
19	Need to do more webinars.
20	no
21	In the future, invite at least one representative from a broad range of groups (e.g., NARC, APA, and ULI) to sit on a project panel.
22	Not at this time.
23	no.
24	Ncfrp newsletter, overview presentations and special sessions on international conferences beyond TRB (WCTR, TRA, ETC).
25	Work more closely with state dots.
26	Continue dissemination as you have done
27	Use LinkedIn. Do something differently. Research products are unknown upon completion.
28	Webinars are great. Talking Freight has been a huge success
29	n/a
30	Monthly Web based news letter.
31	Additional webinars
32	better utilization of media and other research organizations
33	summarize key findings of reports for easy reference, link work to earlier work if new findings, e-blasts to all TRB freight committees, link to all freight committee websites
34	Converting them to an open "wikipedia" format to permit easier crosslinking, discussion and updates.

Q13. The NCFRP 48 research team will be conducting follow-up interviews with a small number of survey respondents to better understand the use of NCFRP products and to discuss responses regarding future freight research needs. If you are willing to speak with the research team, please provide your contact information below:

Answer Options	Response Percent	Response Count
Name:	100.0%	80
Title:	97.5%	78
Organization:	98.8%	79
Email Address:	100.0%	80
Phone Number:	97.5%	78
	<i>answered question</i>	80
	<i>skipped question</i>	156

Appendix C. White Papers

White Paper

Freight Economic Analysis: NCFRP Contributions and Future Research Needs

1. Introduction

This white paper is one of five that document the contributions of the National Cooperative Freight Research Program (NCFRP) to a specific freight research area, provides examples of how NCFRP research in these areas has been used, and present recommendations on future research needs. The paper was prepared as part of NCFRP Project 48. This white paper covers the topic of freight economic analysis.

This topic was selected based on an analysis of the research areas addressed by the current body of NCFRP research and on the results of a survey of freight practitioners at state departments of transportation (DOTs), metropolitan planning organizations (MPOs), federal agencies, academia, and the private sector. Survey participants were asked to indicate which (if any) of the NCFRP reports they had used and how they had used them. They were also asked to identify future research needs in the fields of freight policy and planning. In addition to the online survey, the research team interviewed several freight practitioners to obtain additional input on how NCFRP research has been used and what are the priority topics for freight research.

2. Role and Importance of Freight Economic Analysis

The economic impacts of the freight transportation system and freight system improvements are among the most important questions facing transportation agencies at all levels. Economic development in the United States has been shaped by freight transportation improvements since the early days of our nation, from investment in canal infrastructure in the early 1800s, to the spread of railroads in the latter half of that century, to the development of the Interstate highway system beginning in the 1950s. More recently, containerization and other improvements in freight transportation have continued to lower barriers to domestic and international trade.



Source: Port of Los Angeles

The contributions of freight infrastructure to productivity are critical to the performance of the economy. Because transportation serves as an input into every other sector of the economy, efficient transportation infrastructure investments can have an impact that ripples throughout

the economy. Reduced transportation costs enable firms to deliver more products and services for the same price. Investments in freight transportation infrastructure can thus serve to stimulate economic growth in all economic sectors, with the greatest impacts on those sectors that are most reliant on freight transport, such as manufacturing industries and retail.

Economists have been able to measure the benefits of freight transportation investments at the national level using data on infrastructure spending and private-sector productivity growth. Macroeconomic studies have shown a strong relationship between infrastructure investment and economic growth, with the greatest returns occurring during the 1950s and 1960s and more modest returns in recent years. Even with recent advancements in information technologies and growth of the services sector, transportation infrastructure investments continue to play a critical role in stimulating improvements in productivity growth in the economy at large.

When considering an individual project, benefit-cost analysis (BCA) is an important tool for planners to determine whether an investment in transportation infrastructure is economically and socially beneficial. BCA provides a standardized method for policy-makers to assess the value of different types of benefits occurring at different points in time. It has been used to evaluate planned investments resulting from the passage of the American Reinvestment and Recovery Act (ARRA) and the Transportation Improvement Generating Economic Recovery (TIGER) discretionary grant program. A BCA involves identifying and quantifying all the benefits and costs that will accrue to society if a project is undertaken. For freight transportation projects, this analysis involves estimating a dollar value for benefits to users of the facility such as reduced travel time, lower operating costs, and fewer crashes. Other societal benefits could result, for example, reductions in air pollutant emissions or noise. Benefits are compared to project costs such as construction, operations, and maintenance expenditures.

Traditional BCA has considered only the “first-order” benefits described above. The rise of the logistics sector, however, has led to the recognition that additional benefits can accrue when a reduction in the cost of freight carriage leads to “reorganization effects.” As the cost of shipping drops, supply areas and market areas increase in size. Reliability gains allow smaller buffer stocks, further reducing logistics costs. Businesses reorganize to take advantage of these gains, which results in greater economic benefits than captured in a typical BCA. The Federal Highway Administration has sponsored research to quantify these additional benefits and apply them in the BCA approach.¹

Economic impact analysis is another approach to evaluating freight system improvements. The purpose of economic impact analysis typically is to forecast personal income, employment, regional property values, and business impacts for a defined project. The results of an economic impact analysis are useful for understanding how and in what form the benefits and costs of a project will be distributed among industries, both regionally and within the economy as a whole. It provides policy-makers and the public with an important way to understand the effects on job creation and economic output, and can tell policy-makers what percentage of these impacts will flow into the regional economy and what percentage will accrue to other

¹ See http://www.ops.fhwa.dot.gov/Freight/freight_analysis/cba/index.htm

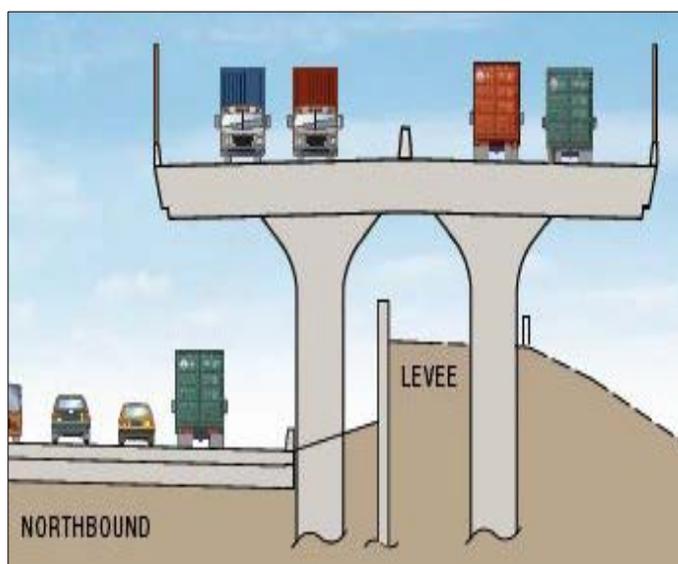
regions. For state and local policymakers, the ability to understand how benefits will affect a local region can provide an important justification for policymaking.

Although both BCA and economic impact analysis have been applied extensively in the transportation sector, numerous opportunities exist to improve these methods for freight transportation and make the methods more accessible to public agencies. With flat or declining revenues and growing funding needs, that public agencies have access to reliable estimates of the benefits and costs of the investments they are considering is more important than ever.

3. Contributions of NCFRP to Advancing the State of the Practice

Four NCFRP projects have focused on improving economic analysis for freight transportation projects. One of the first to focus on freight economic impacts is documented in *NCFRP Report 12, Framework and Tools for Estimating Benefits of Specific Freight Network Investment Needs*. This report introduces a comprehensive analytical framework and related tools to estimate both private and public benefits when evaluating potential freight infrastructure investments. The framework has three main functions: (1) to enhance public planning and decision-making processes regarding freight; (2) to supplement benefit/cost assessment with distributional impact measures; and (3) to advance public-private cooperation. The framework is capable of handling projects that span all the different modes and can assess benefits from a variety of project types, including capacity expansion and operational improvements. The research supports public-private agency discussions by helping all parties understand the wide range of perspectives and interests in potential freight investments.

Two reports address BCA for specific types of freight projects. *NCFRP Report 3, Separation of Vehicles—CMV-Only Lanes*, examines major issues and concepts that should be understood in developing new applications of commercial motor vehicle-only (CMV-only) lanes as a potential method for easing congestion and reducing the number of traffic accidents on highways. The report lays out how to conduct a BCA for a CMV-only proposal. Appendices to this report include performance evaluation criteria, benefits monetization factors and unit costs, and net present value calculations for BCA.



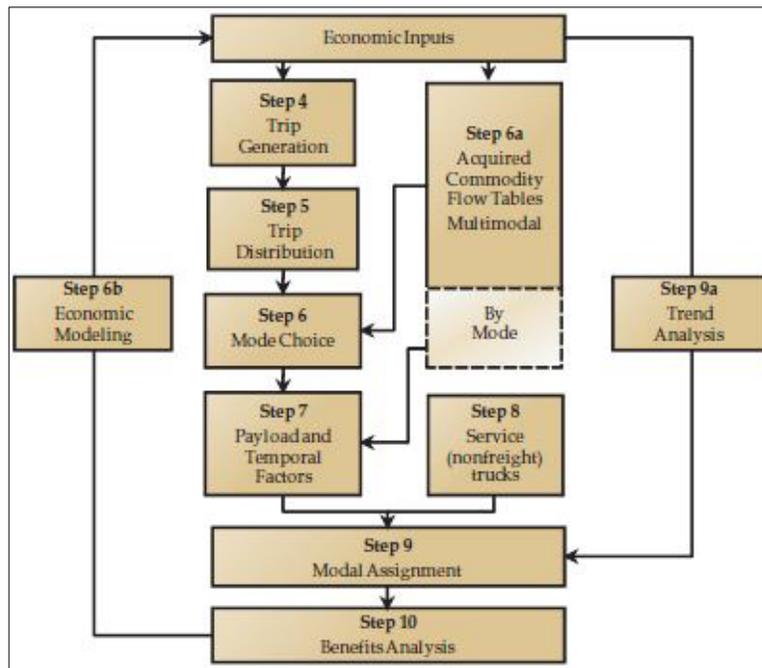
Source: I-710 Corridor Project, Draft Environmental Impact Report/Environmental Impact Statement and Section 4(f) Evaluation, California Department of Transportation and Los Angeles County Metropolitan Transportation Authority, June 2012

The second report, *NCFRP Project 22, Applying Benefit-Cost Analysis (BCA) to Freight Project Selection: Lessons from the Corps of Engineers*, examines transportation infrastructure evaluation based on the experiences and methodologies the U.S. Army Corps of Engineers uses in its selection, construction,

maintenance, and operation of both coastal and inland navigation projects. Special attention is given to the estimation of project benefits and the treatment of market externalities. The report contrasts the Corps of Engineers methodologies with similar processes used by the federal agencies that administer infrastructure development for other transport modes. The report found that variations in evaluation criteria lead to systematic differences in transportation infrastructure outcomes and the evaluation criteria are inconsistent with the development of truly multimodal freight transportation networks. The research concludes with suggested measures intended to remedy these outcomes.

NCFRP Report 13, Economic and Transportation Drivers for Siting Freight Intermodal and Warehouse Distribution Facilities, describes the criteria that the private sector considers when making decisions on where to build new logistics facilities. The intent of this study was to provide public-sector agencies with a fuller understanding of the dynamics of freight movement and the factors affecting private-sector location decisions. With this insight, public-sector agencies can successfully plan for, attract, locate, and partner with freight-related activities in their jurisdictions.

Several other NCFRP reports, although not focused primarily on economic analysis, contain information related to the understanding and quantification of the economic impacts of freight transportation decisions.



Source: NCFRP Report 8, *Freight Demand Modeling to Support Public-Sector Decision Making*

4. How NCFRP Research Has Been Used for Improving Freight Economic Impact Analysis

Interviews were conducted for the development of this white paper, involving individuals from the following organizations:

- U.S. Federal Highway Administration,
- U.S. Maritime Administration,
- U.S. Federal Railroad Administration,
- U.S. Bureau of Transportation Statistics,
- North Central Texas Council of Governments,
- Baltimore Metropolitan Council,
- California Department of Transportation,
- John A. Volpe National Transportation Systems Center, and
- Several transportation consultants.

Interviews conducted for this white paper confirmed the importance of the NCFRP and other Transportation Research Board-sponsored research for continuing to expand our understanding of freight transportation economic issues, improve the method and tools for analyzing proposed freight investments, and make these research findings accessible to practitioners, especially those without an economics background.

Freight staff at the U.S. DOT pointed out that NCFRP has been particularly effective in addressing economics and other issues that cut across freight modes, due in part to the diversity of the NCFRP oversight board. Given the increasingly multimodal nature of freight transportation, this perspective is critical for understanding and improving the freight system. Other freight research has often focused on singular modes.

NCFRP has been instrumental in providing practitioners examples of how plans, projects, performance measures, data programs, and economic analyses have been implemented by other organizations. One MPO practitioner noted that NCFRP

“provides case studies or examples of how it has been done – we are constantly looking at what others are doing – what is DVRPC [Delaware Valley Regional Planning Commission] doing? These reports provide estimates of economic benefits ... they allow us to compare what the benefits of these programs might be and source it.”

NCFRP Report 3, Separation of Vehicles—CMV-Only Lanes, has been used as part of the analysis of proposed improvements to the I-710 corridor in Los Angeles County. A Major Corridor Study and subsequent environmental impact report for this project considered alternatives that involve a separated, four-lane, truck-only corridor. The same NCFRP report also has been used for consideration of truck-only lanes in other locations.

Another practitioner noted the usefulness of *NCFRP Report 13, Economic and Transportation Drivers for Siting Freight Intermodal and Warehouse Distribution Facilities*: “The problem was

understanding the factors that influence industrial location decisions. NCFRP 13 outlined both the transportation and non-transportation factors.”

In ICF’s survey on the use of NCFRP research and future freight research needs, respondents were asked to identify individual NCFRP reports that have proved useful. Although the economics-related reports were not among the most used NCFRP products, several were cited by a significant number of respondents. For example:

- Of the 133 survey responses, 31 (23 percent) identified *NCFRP Report 12, Framework and Tools for Estimating Benefits of Specific Freight Network Investment Needs*, as a report that had been used.
- Eighteen respondents (14 percent) indicated making use of *NCFRP 22: Benefit-Cost Analysis to Freight Project Selection: Lessons from the Corps of Engineers*.

Note that the largest NCFRP study on economic impacts (*NCFRP Project 46, Benefit-Cost Methodologies for Evaluating Multimodal Freight Corridor Investments*) has not yet been completed. Based on ICF’s interviews, we expect this report to be used extensively when it is released in 2016.

5. Future Research Needs

In ICF’s survey on the use of NCFRP research and future freight research needs, respondents were asked to indicate the degree to which new research is needed in nine topic areas, on a scale of 1 (no need for new research) to 5 (critical for new research). The topic that received the highest average score (4.09) was “Economics of freight transport or infrastructure investment.” State DOTs in particular indicated the importance of this topic, with 40 percent rating this topic at 5. These results confirmed the finding of ICF’s interviews: There is a strong, continuing interest in additional freight economic impact research.

Freight System Improvements and Regional Economic Competitiveness. Although past studies have examined regional economic development impacts, much of this research has not been freight specific. More research is needed to link investments in freight transportation infrastructure with regional competitiveness and economic development. Practitioners noted the need to answer questions such as how can state and regional freight planners forecast the business development impacts of transportation system investments. How can the freight-planning world be better integrated with economic development planning? At the executive level of state and local agencies, there is great interest in understanding how transportation investments can drive the attraction, retention, and expansion of local businesses.

Working with Economic Development Agencies. On a practical level, state and local agencies want to know what actions they need to take to attract businesses and promote economic development. To facilitate this effort, enhancing the interaction of state DOTs with economic development agencies and local businesses would be critical. The perspectives of freight planners, economists, and the local business community can vary greatly. Public and private-sector silos can make coordination difficult. A research project could provide practical guidance on advancing this effort.

Freight Corridor Impacts. Several interviewees highlighted the need for new research to understand the impact of investments in freight corridors, including multimodal corridors (rail vs. highway vs. marine). This research could include analyzing freight routes (specifically truck routes) and its value to the economy and to movement of freight. Note that this research need might be addressed by NCFRP Project 46 (described in Section 2), which is currently underway.

Economic Impacts of Highway and Bridge Preservation Projects. Most studies of economic impacts focus on major capital projects that expand capacity. Yet much of the critical freight system investment in coming years will be for maintenance projects that preserve and extend the life of existing systems. The loss of critical highway and bridge links due to asset degradation can have serious economic repercussions for freight industry, making the case for these improvements on economic grounds can be challenging. The need to better understand and quantify the economic benefits of projects for preserving freight infrastructure is essential.

Freight System Improvements, Trade, and Global Competitiveness. Freight system efficiency is critical for maintaining the competitive advantage of many U.S. industries. Improvements to trade gateways and intermodal connectors can be particularly significant for businesses that deal with imports and exports. Interviewees identified the need for research on how freight system investment can help stimulate exports. A related research topic is the importance of service quality in the freight network to encourage the reshoring of manufacturing jobs.

How Can Governments Affect the Freight System. One interviewee, a transportation economist, believes existing reports can exaggerate the role of the public sector in planning and managing the nation's freight transportation system, particularly non-highway modes. He noted that such a focus can divert the public sector from the infrastructure investment and pricing decisions that actually affects the freight system. He recommended the freight research agenda focus on improving government agencies' ability to evaluate alternatives to freight infrastructure projects, to better understand the impacts of infrastructure investments on the performance of the freight system. A specific example is the need to enhance methods for measuring and valuing improvements in travel-time reliability for freight actors.

White Paper

Freight Modeling and Forecasting: NCFRP Contributions and Future Research Needs

1. Introduction

This white paper is one of five that document the contribution of the National Cooperative Freight Research Program (NCFRP) to a specific freight research area, provide examples of how NCFRP research in these areas has been used, and present recommendations on future research needs. The paper was prepared as part of NCFRP Project 48. This white paper covers the topic of freight forecasting and modeling.

The paper considers freight forecasting and modeling at the federal, regional, state, and local levels. Specific topics include commodity flow analysis, freight demand forecasting, the development of truck trip tables, models to estimate air emissions, models to characterize the supply chain, and other tools and approaches. This paper was informed by interviews with staff at federal, state, and local agencies, research institutions, and consultants engaged in freight modeling and forecasting. Additional information came from a survey of staff at public agencies and the private sector who are engaged in freight transportation planning and policy. Survey participants were asked to indicate which (if any) of the NCFRP reports they had used and how they had used them. They were also asked to identify future research needs in the fields of freight policy and planning.

2. Role and Importance of Freight Modeling and Forecasting

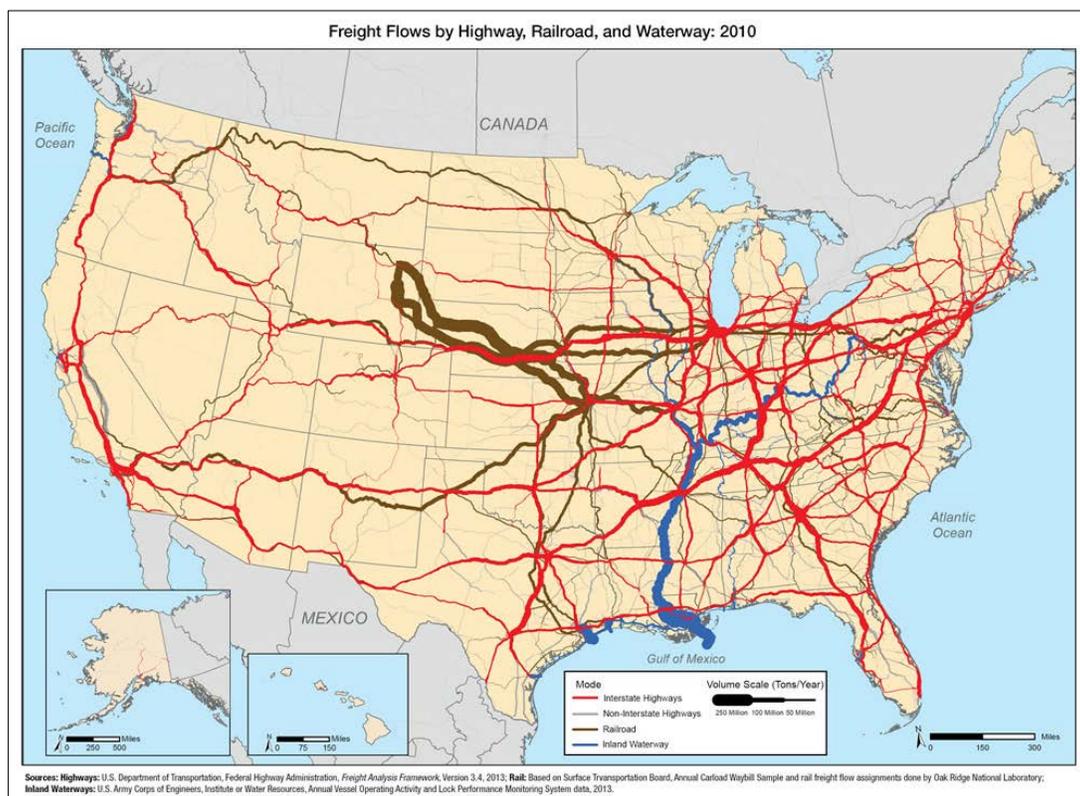
Freight modeling and forecasting is a critical element of long-range transportation planning and investment decisions. It also supports analyses related to the environment, energy, safety, land development, trade, and other issues. Yet transportation agencies often are limited by the inability of their planners to integrate freight fully into their decision-making processes because the models and tools needed to forecast freight movements are less well developed than those used for passenger travel. In addition, the data sources needed to support freight modeling have significant gaps. Often, significant effort and resources are required to develop custom data and tools to forecast freight demand. Conducting the modeling of freight trips that is required for infrastructure planning and policy analysis can thus be a substantial undertaking.

In some cases, transportation agencies lack in-house expertise in freight transportation. Expertise and modeling tools often are focused on passenger transportation, which tends to be higher on the agenda of policymakers and comprises most of the on-road vehicle trips. Smaller metropolitan planning organizations (MPOs), in particular, might not have the resources to support a dedicated professional with expertise in freight transportation. Even larger

transportation agencies might focus their resources toward on-road transportation and thus have less expertise in other modes of transportation.

Part of the problem is that freight transportation often is more difficult to forecast because changes in global supply chains influence it. The factors that affect freight demand often are located outside the geographic boundaries of the state or region conducting the analysis. Unlike passenger travel, which can be forecast accurately based on the characteristics of households in a region, the factors affecting freight demand are much more diverse and can be subject to global economic influences. Freight transportation is driven by shifts in global markets, commodity prices, exchange rates, the relative cost of production in different locations, the cost of transportation, changes in technology, natural resource scarcity, and other factors. Private-sector supply chains are constantly adjusting their decisions about the sourcing of supplies, mode choice, transportation, inventory practices, warehousing, and distribution to respond to changes in global markets. The challenge in freight forecasting is to reflect this complex market adequately in a model that can planners and policymakers can use.

Despite these challenges, freight modeling and forecasting has improved significantly over the past two decades and is now routinely part of the long-range transportation planning process for states and MPOs. Freight modeling and forecasting helps public agencies maximize the economic benefits of efficient movement of goods and capture the jobs and private-sector investment that accompany a thriving freight industry. Freight forecasting also is critical to understanding future adverse impacts that can be associated with freight—such as congestion, roadway safety problems, and air pollution—and then taking steps to mitigate these impacts.



Looking ahead, transportation agencies will continue to depend on accurate freight transportation modeling and forecasting, particularly given limited public resources for infrastructure investment and the growing need for regions to compete in the national and global markets. Freight modeling will need to reflect the continuous changes in freight logistics and take advantage of the explosion in available private-sector data. Finally, the freight modeling tools and techniques need to be made accessible to smaller transportation agencies with limited resources, while still providing the necessary granularity and accuracy.

Transportation planning agencies at all levels of government can benefit from improved modeling tools and forecasting methods to incorporate freight into transportation planning more fully. NCFRP has contributed to serving this need by funding research projects on key issues.

3. Contributions of NCFRP to Advancing the State of the Practice

Freight demand modeling is complex, and historical forecasts have not always had a high level of accuracy. During the 1970s, planners significantly underestimated future freight demand. They failed to foresee that the deregulation of transportation industries (trucking, rail, air) and the growth of international trade would significantly increase the volume of freight and number of shipments moving on the transportation network.

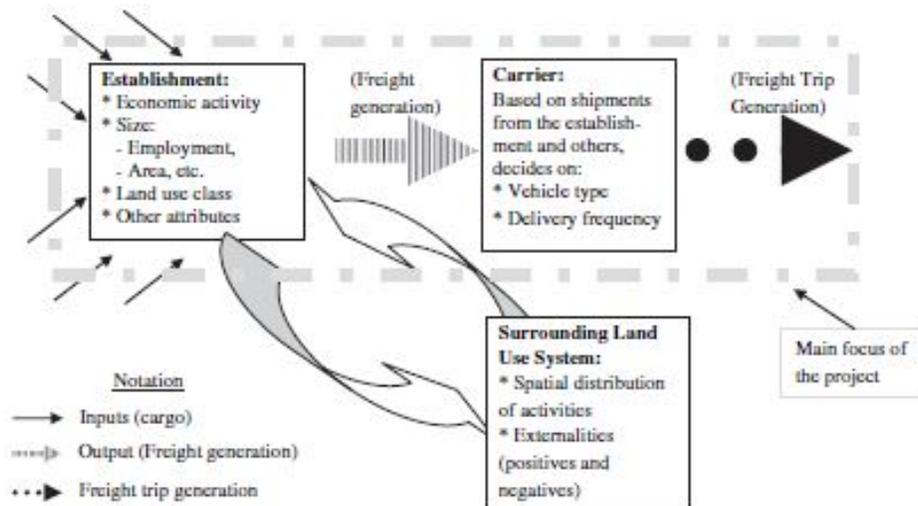
Today, most forecasts project a significant increase in freight demand over the next 20 years, suggesting that significant new investments in infrastructure will be needed. Given the mediocre track record of forecasters in predicting future demand, NCFRP funded *NCFRP Web-Only Document 4: Identification and Evaluation of Freight Demand Factors*. This report sought to identify economic, policy, or other variables that could provide early indicators of change in the demand for freight transport. This report focuses on publicly available data with the aim of improving the quality of freight demand forecasts and models. Because of the length of time required to build infrastructure, transportation planning typically considers a time horizon of 20 years or more. Improved freight modeling and forecasting methods can help improve planning, determine necessary investment levels, and target these investments more efficiently.

NCFRP funded *Report 8, Freight-Demand Modeling to Support Public-Sector Decision Making*, also to improve the quality of freight demand forecasts. This report reviews existing freight demand models and provides guidance to address gaps and incorporate the latest thinking into freight demand modeling. NCFRP Report 8 provided a roadmap for practitioners to improve the available freight demand modeling tools.

NCFRP also has funded reports that address very specific planning needs. Freight planners have a well-defined need to disaggregate freight flows accurately to a county and sub-county level. Although the Federal Highway Administration's Freight Analysis Framework provides a good resource for freight flows between states and major metropolitan regions, many transportation planners at the regional or local levels work with smaller geographies. In response, NCFRP funded *Report 26, Guidebook for Developing Subnational Commodity Flow Data*. This report

provides techniques for disaggregating national-level data to obtain commodity flows that can be used for freight planning in regions and localities.

NCFRP also has invested strategically in methods to develop truck trip tables. Creating a trip table that estimates truck movements between traffic analysis zones is a first step in incorporating freight into travel demand models. Various methods are available to create truck trip tables, and many planners have expressed a need to improve technical knowledge in this area. NCFRP addressed this need by funding *Report 19, Freight Trip Generation and Land Use*. NCFRP research in this area has provided guidance to planners and reduced technical barriers to the inclusion of trucks in travel demand models.



Source: NCFRP Report 19, *Freight Trip Generation and Land Use*

Another significant way that NCFRP has advanced the state of the practice is to create useful compilations of methods and tools for planners to use. An example is in the area of air emissions analysis for freight. Freight transportation is diverse, and no single air quality model covers all modes and all equipment types. Knowledge of the tools, techniques, and approaches for analyzing air emissions from freight is somewhat fragmented. NCFRP addressed this issue in *Report 4, Representing Freight in Air Quality and Greenhouse Gas Models*. The report covers all freight modes, including heavy-duty trucks, rail, ocean-going vessels, harbor craft, cargo handling equipment, and airfreight. For each mode, three geographic scales were analyzed: national, regional, and local/projects. This report provides an important resource for even experienced environmental professionals, by systematically compiling and evaluating the approaches available for air emissions analysis.

The practitioners interviewed also view NCFRP as contributing to research more generally by involving diverse stakeholders and identifying research gaps. NCFRP creates a mechanism to obtain input from diverse states and regions and to learn from the experience of other practitioners. Interviewees noted that NCFRP research has filled a gap that has endured in the freight research landscape. Research funding has shrunk over the past five years in many

agencies. As one federal agency practitioner noted, NCFRP has “leveraged their funds to tackle problems at a national, or multi-state, or multi-regional level. ... MPOs are just worried about their region. ... NCFRP involves everyone, including the national players ... and provides cooperative research.”

Practitioners have noted the important role NCFRP products provide in summarizing existing knowledge. An interviewee from the U.S. Coast Guard noted that NCFRP products “are going to be thoroughly researched. They have outstanding bibliographies. If I am in the literature search process, I can start there.” Another freight expert noted that NCFRP products “are high quality, peer reviewed,” with the work “presented in annual conference meetings.” “The value proposition of NCFRP research is that it is open access, available to everyone, and serves national needs.”

4. How NCFRP Research Has Been Used for Freight Modeling and Forecasting

This section discusses some concrete examples of how practitioners have used NCFRP research. NCFRP products have proven useful for a variety of specific purposes, including understanding the scope of available knowledge, designing new research projects, ensuring that research dollars are spent effectively, educating professionals, obtaining expertise in niche topic areas, providing technical information for improving agency models, and documenting that the methods used are state of the practice for federal certification reviews.

One common use of NCFRP reports has been to serve as the basis for additional research efforts. For instance, agency officials frequently discussed referencing NCFRP reports in request for proposals to ensure that contractors write reports and proposals reflecting the latest knowledge. Request for proposals have included references to NCFRP reports that contractors were ask to review. One agency official noted,

“In some areas we have deep expertise, but we need to rely on the existing body of knowledge to make our work more efficient, we need to have our research dollars add to the base of knowledge, we don’t want to waste time and dollars finding out what is already there.”

In ICF’s survey on the use of NCFRP research, several respondents commented on the use of NCFRP reports to support their modeling activities. Examples of these comments include:

- “Have used NCFRP projects to get information about urban goods movement supply chains, freight data collection suggestions and actual data, and examining different freight modeling approaches.”
- Used an NCFRP report to analyze “multi-modal commodity flows, intra-state or multi-state commodity flows, contribution of freight transportation to air emissions.”
- “The report helped me to prepare for specifically addressing freight planning as a part of a comprehensive planning process.”

NCFRP reports have been used as a starting point to compile internal literature reviews. For example, when the Coast Guard was compiling available studies and literature on commodity flows and supply chains around ports, they used *NCFRP Report 26, Guidebook for Developing Sub-national Commodity Flow Data* as source material.

Agency officials often have used NCFRP products to educate themselves on specific topics. As one agency official noted, “The scope of our activity is so broad, it becomes hard to develop expertise in a particular niche.” Another agency official noted that because their agency was focused mostly on highway transportation, they used NCFRP research to learn more about other freight modes such as rail and marine. NCFRP products were useful resources to enable busy agency officials to become current quickly on new topics.

NCFRP products also have served as the basis for making technical improvements to existing models. The Atlanta Regional Commission used *Report 4, Representing Freight in Air Quality and Greenhouse Gas Models* to integrate environmental analysis more fully into their planning process. They developed multiclass truck trip tables, which enabled them to analyze air emissions with greater precision.

Among respondents to ICF’s survey of practitioners, *NCFRP Report 8, Freight-Demand Modeling to Support Public-Sector Decision Making* ranked second in terms of the percentage of respondents who had used the report; 60 of 133 respondents identified this report as useful. This report also was mentioned by the interviewees. The Atlanta Regional Commission used this product to understand the state of the practice and to adjust their own methodologies to keep them updated.

The Atlanta Regional Commission also found NCFRP products to be useful in documenting that their practices were up to date for the U.S. Department of Transportation planning certification review. The primary purpose of a certification review is to formalize the continuing oversight and day-to-day evaluation of the planning process. The certification review process ensures that legally mandated planning requirements are satisfactorily implemented. For the Atlanta Regional Commission, Federal certification reviews occur every three years. Typically, the U.S. Department of Transportation will spend several days reviewing the tools and techniques and then make recommendations or request corrective action. The Commission identified NCFRP products as useful resources to ensure that the MPO was using the most appropriate and advanced planning methods and to document this for the U.S. Department of Transportation’s certification review process.

NCFRP products also have helped transportation agencies understand the supply chain better and to integrate supply chain concepts more fully into their modeling. A leading freight consultant noted,

“The freight trip generation [NCFRP] products and sub national data are useful. There is a clear need to do accurate disaggregation and a need to get it down to a county and sub county level, but planners should also be pressing hard to tackle the problem from a supply chain perspective. What are the market

dynamics for freight movement? The commodity flow approach was a good approach in the 1970s. In the 1990s, you needed a supply chain based approach. Today it is absolutely critical to consider the supply chain.”

Several NCFRP reports have contributed to improving knowledge of the supply chain. For instance, *NCFRP Report 14, Guidebook for Understanding Urban Goods Movement* includes a typology of supply chains in urban markets. It provides information on how goods are delivered in particular supply chains. This information is needed to model urban freight markets more accurately. This report has been useful at the state and regional levels.

Another NCFRP document that has been applied to evaluate how carriers and shippers make decisions about location is *NCFRP Report 13, Freight Facility Location Selection: A Guide for Public Officials*. Report 13 provides information about the factors that businesses consider when evaluating freight facilities site location. Planners have used Report 13 to consider the issue of regional competitiveness. For example, the Iowa Freight Plan focuses on how to attract businesses. A key issue Iowa planners addressed was how they can link their freight plan with economic development. How do they accurately assess the factors that will make their region competitive and promote the growth of business? NCFRP Report 13 helped transportation agencies think about the factors that affect business location and informed their forecasts of business development that might flow from improvements in freight transportation systems.

5. Future Research Needs

Interviewees, and the freight community more broadly, are interested in additional research in the area of freight modeling and forecasting. In ICF’s survey of practitioners, freight modeling and forecasting was rated as the third-highest in terms of the need for additional research. The research ideas identified in the interviews and a survey of the literature can be grouped generally into six categories:

1. understanding of the supply chain,
2. incorporation of supply chain concepts into freight demand modeling,
3. improved data for freight modeling and forecasting,
4. competitiveness,
5. multimodal freight analyses, and
6. other projects.

Overall, one of the top research items mentioned was the need for additional research on supply chains. Concern was expressed that supply chain research was only being undertaken on an ad hoc basis. Some interviewees argued that research focused on the supply chain should be an orientation that is part of all future NCFRP programs. ICF provides some examples of research that fall under each agenda item.

1. Improved Understanding of the Supply Chain

A research agenda focused on an improved understanding of the supply chains could include the following items:

- development of additional information on a typology of supply chains by industry and geography,
- development of freight fluidity indexes to measure the performance of the supply chain from an industry perspective, and
- identifying emerging trends in supply chain organization and operation.

2. Incorporating Supply Chain Concepts into Freight Demand Modeling

Much interest was shown in incorporating the supply chain more directly into freight modeling. In general, practitioners expressed a need for additional information about the available tools and tools that are more user friendly. Potential items for a research agenda include

- surveying agent-based and microsimulation modeling of freight flows and costs,
- promoting the diffusion of agent-based and microsimulation modeling of freight flows by making necessary input data available and providing more user friendly tools, and
- developing a research strategy to incorporate the supply chain in freight planning.

3. Improved Data for Freight Modeling and Forecasting

Substantial data needs are related to freight modeling and forecasting. A key area for further research that was highlighted was the need to tap into private-sector data and develop other, new sources of data on the supply chain. Potential items to include in this research agenda were

- perspectives from supply chain practitioners on “big” data,
- understanding of truck distribution centers,
- characterization of truck movements and truck tours,
- approaches for obtaining better commodity flow data,
- corridor analysis of commodity flows,
- data for activity-based modeling,
- improved passive data collection efforts such as the American Transportation Research data,
- upgrade of the Freight Analysis Framework, and
- revival of the Vehicle Inventory and Use Survey.

4. Understanding Freight Movement Across Modes

A significant need was indicated to incorporate and enhance a multimodal perspective in freight demand modeling. In many cases, transportation agencies do not use an integrated freight demand model that allows mode shifts to be modeled. Research agenda items could include the following:

- effect of changes in investment in one freight mode on other modes (e.g., how no new investment in rail might impact waterways and truck freight);
- research into better interaction between model networks (truck, rail, others);
- better information on mode shifts;
- freight routing models;
- projected growth in inland waterborne freight traffic; and
- impact of freight movement on states via new infrastructure in another country.

5. Other Projects

ICF identified assorted additional projects, some of which were only tangentially related to freight forecasting and modeling. These items included

- method of organizing a freight plan,
- institutional approaches to freight, and
- truck-only toll lanes.

White Paper

Freight Data and Performance Measurement: NCFRP Contributions and Future Research Needs

1. Introduction

This white paper is one of five that document the contribution of the National Cooperative Freight Research Program (NCFRP) to a specific freight research area, provide examples of how NCFRP research in these areas has been used, and present recommendations on future research needs. The paper was prepared as part of NCFRP Project 48. This paper covers the topic of freight data and performance measurement.

The topic area of freight data and performance measurement includes data and performance measures used at the federal, state, and local levels. This area is broad, covering subjects such as commodity flow analysis, truck trip tables, architecture of freight transportation data, development of cost elements for freight transportation, and sharing of freight transportation data. Interviews with staff at federal, state, and local agencies, research institutions, and consultants who are engaged with freight data and performance measures informed the discussion in this paper.

2. Role and Importance of Freight Data and Performance Measurement

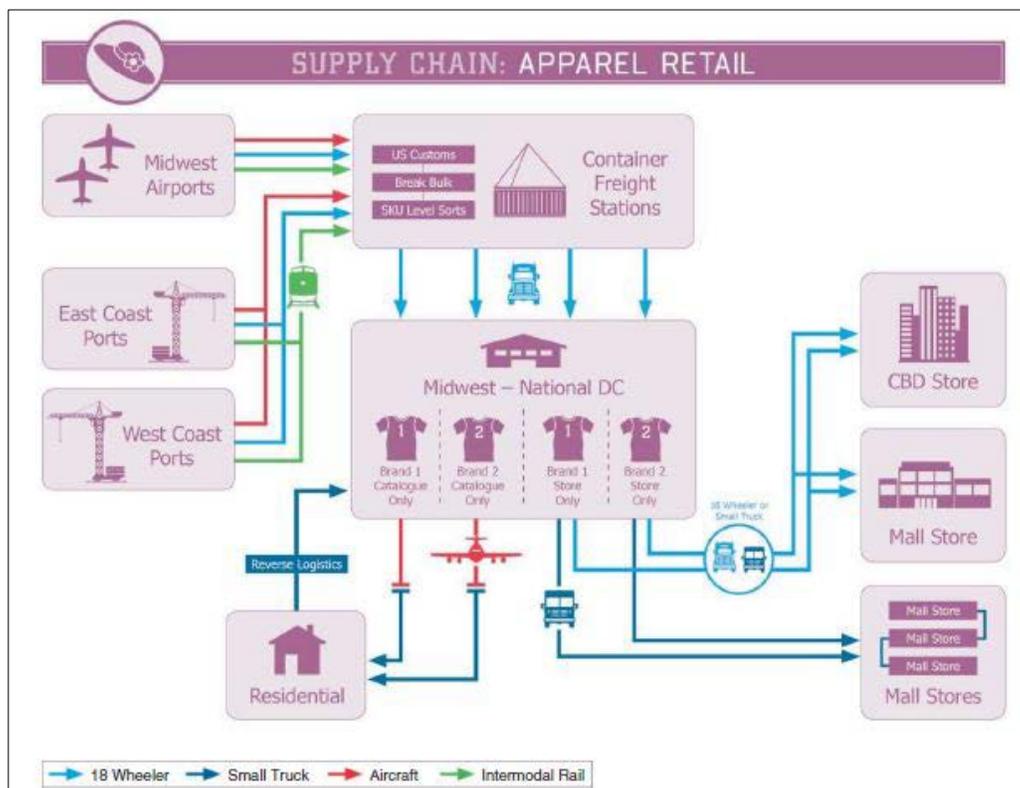
Freight data and performance measurement is an area of great significance to freight practitioners. Emphasis has been increasing at all levels of government on performance-based management of transportation networks and the accompanying data needs. State agencies are particularly interested in understanding what freight data and approaches to performance measurement will be needed to satisfy the requirements of MAP 21. The need also exists for accurate, comprehensive, and timely freight transportation data to understand freight demand, target transportation investments, and analyze freight transportation policy.

Obtaining comprehensive freight data can be challenging because the sources of data are diverse. This diversity reflects the numerous entities involved in freight transport and the heterogeneous nature of the industry. The collection and control of freight data are distributed across different modes and collected by different public agencies. Because of the fragmented nature of the data collection process, data definitions differ between data sources. Data is collected for different reasons, through diverse processes, and the definitions used in separate databases are often not easily integrated with each other.

In several areas, insufficient data are available to characterize freight movements. Lack of data on freight movements is an important barrier to integrating freight into the planning process. For instance, states and regions need to synthesize truck trip tables to include freight in the travel demand modeling process. The methods and tools used for modeling freight

transportation demand are not as well developed as they are for passenger transportation. Limited resources and insufficient data have thus served as barriers to more comprehensive modeling of both freight and passenger trips together. Gaps in freight transportation data also pose a barrier to the effective evaluation of policy issues. For example, the most recent FHWA truck size and weight study concluded more data are needed to evaluate this important issue adequately. Due to budget cuts, some data sources that have been available historically to understand freight movements have not been updated in recent years. One example is the Vehicle Inventory and Use Survey, which collects data on the nation’s on-road truck fleet, truck activity, and operations, was most recently conducted in 2002. The U.S. Department of Transportation (DOT) is currently evaluating options for conducting this survey again.

More comprehensive data on supply chains are needed. Planners and policymakers need to understand supply chains to characterize the dynamics that drive freight movement. Although public agencies have invested in developing commodity flow databases and forecasts, such as the Freight Analysis Framework (FAF), information on how industry supply chains are organized and might change in the future is more difficult to obtain. The organization of industry supply chains affects freight movement through decisions about sourcing, transportation, mode choice, warehousing, inventory management, and distribution. Many different global economic factors affect all these supply chain decisions, including the relative cost of production in different countries, resource scarcity, fuel prices, monetary exchange rates, and others. New approaches to characterizing and collecting data on industry supply chains would be of great use to transportation planners.



Source: NCFRP Report 14, Guidebook for Understanding Urban Goods Movement

A freight fluidity index, which measures the end-to-end performance (or shipment transit time) across the supply chain, is an example of a supply-chain measurement that will require new data. This performance measure includes dwell time at ports and intermodal yards, and transit times across the multiple modes of transportation used to move a shipment. This performance measure is essential because it captures the performance of the freight transportation system that shippers and receivers experience. Much of the data needed for a freight fluidity index are held privately, so new approaches for collaborating and sharing data with the private sector could be required to develop this performance measure.

Another issue with which freight planners have struggled is understanding the costs associated with freight transportation. Data on freight transportation cost often is considered proprietary and is not readily shared by carriers. Following the deregulation of transportation, many of the public sources of data on transportation cost are no longer available. Obtaining or estimating such data is often important for conducting cost-benefit analyses of freight system improvements or evaluating the potential for freight mode shifts.

Although many freight data needs exist, new technology presents opportunities to address them. Over the past decade, a data explosion has occurred, as the cost of collecting and storing data has dropped steadily. Data from cell phones, vehicle probes, sensors, and other sources are revolutionizing the field of transportation data collection. Individual companies can now collect and store vast databases that characterize the movement of each of their vehicles in detail. Global positioning system (GPS) data from vehicle-based equipment and cell phones have provided a means to geolocate and map these data with great temporal and geographical detail. Concerns about privacy and maintaining the confidentiality of sensitive business information have presented a barrier to the full use of this data. Transportation planners are still determining the best way to work with private-sector organizations to use these data securely.

FHWA has advanced the state of the art in highway performance measurement by funding the development of the National Performance Management Research Data Set (NPMRDS) to provide performance measures for truck freight movements. The NPMRDS makes available an unprecedented amount of data on truck speeds, by time of day and location, making possible the development of very detailed and real-time measurements of freight transportation system performance. One challenge is that the NPMRDS and other existing datasets have gaps. Practitioners are still conceptualizing the potential applications of the new data.

The field of freight data and performance measurement appears to be on the verge of significant evolution. Transportation planners have significant data needs. New requirements for performance measurement from MAP 21 and other mandates create a demand for more extensive use of performance measures. New technologies for collecting freight transportation data are offering the transportation planning community new tools to address these requirements.

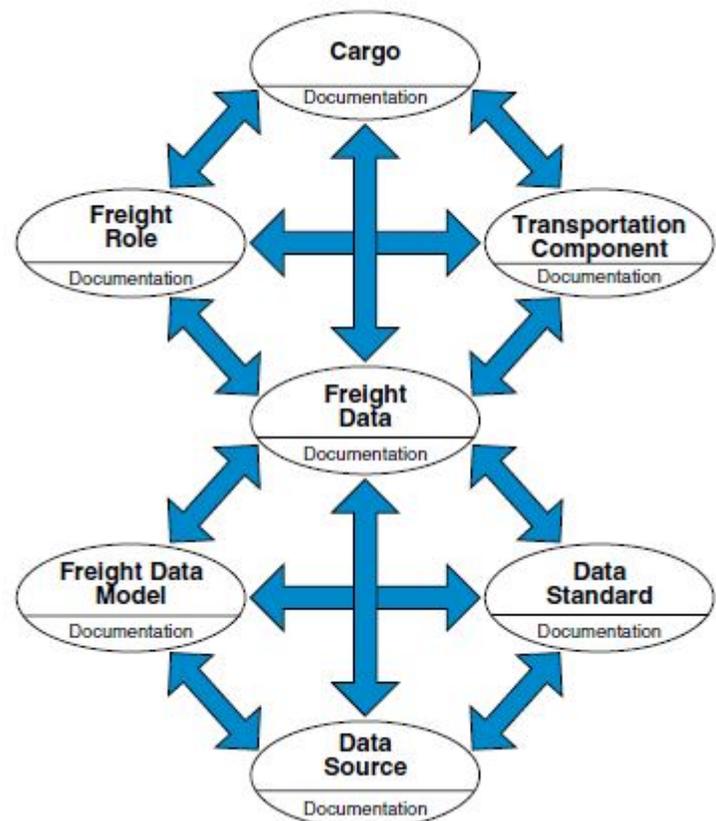
3. Contributions of NCFRP to Advancing the State of the Practice

NCFRP has invested significantly in the area of freight data and performance measures. Data and performance measurement have been relatively frequent topics of NCFRP research. NCFRP has funded research that has compiled information on freight performance measures and provided methods to integrate freight data from many sources. NCFRP products have also identified data gaps, provided strategies for collecting data that are more comprehensive, and produced guidance on how improve the sharing of freight transportation data. NCFRP investments have advanced the state of the practice in this area substantially.

NCFRP funded *Report 10, Performance Measures for Freight Transportation*, which provided a compilation of performance measures and associated data sources for freight transportation. The report presents performance measures across modes of freight transportation and includes measures of efficiency, effectiveness, capacity, safety, security, infrastructure condition, congestion, energy, and the environment. This product contributed to the literature by compiling information on performance measures and making them available in a single place and providing examples of the types of measures that could be used.

Comprehensive freight planning requires a multimodal perspective that requires integrating data from many different sources and modes of transport. NCFRP funded *Report 9, Guidance for Developing a Freight Transportation Data Architecture*, which presents guidance on integrating freight data from multiple, sometimes disparate, sources.

NCFRP has invested research funds to develop an agenda to improve freight data. *Report 29, Making Trucks Count: Innovative Strategies for Obtaining Comprehensive Truck Activity Data*, examined innovative ways to collect data on truck activity, including the use of cell phone probes, license plate readers, expanded vehicle and warehouse surveys, and agent-based models. *NCFRP Report 22, Freight Data Cost Elements*, reviewed many data sources across all modes of transportation to identify the availability and quality of cost data. Both documents contribute to the freight research



Source: NCFRP Report 9: *Guidance for Developing a Freight Transportation Data Architecture*

literature by identifying the gaps in data coverage and identifying potential solutions to address them.

One way to address significant data gaps in existing freight data is to obtain access to private sector data. *NCFRP Report 25, Freight Data Sharing Guidebook*, is intended to help transportation agencies work with private-sector partners to make new data available for planning and policy development. Many state and local agencies have a clear need to develop freight flows and truck trip tables at levels of the county, local, or even traffic analysis zone. *NCFRP Report 26, Guidebook for Developing Subnational Commodity Flow Data*, addressed this need, by helping transportation planners use the FAF or other national freight flow databases to conduct research at county level or local geographies.

These studies collectively have provided a framework that has facilitated the advancement of the state of the art. NCFRP research has helped clearly define the scope of existing data and methods and identification of approaches for addressing practitioners' needs for new sources of data and improved performance measures.

4. How NCFRP Research Has Contributed to Freight Data and Performance Measurement

Through interviews with practitioners and a large survey, ICF identified a variety of examples of NCFRP reports that contribute to freight data collection, data analysis, and performance measurement. Interviewees for this paper included:

- Baltimore Metropolitan Council,
- Iowa DOT,
- Washington State DOT,
- American Transportation Research Institute, and
- Several consultants.

NCFRP research products were essential for practitioners in many ways. They helped inform stakeholders about the activities of other agencies. Several agencies used NCFRP products to help write requests for proposals. By defining the scope of existing knowledge, agency officials could target such requests to specific research needs. One freight planner found practical value in using these reports to help their metropolitan planning organization (MPO) participate in the I-95 corridor coalition. Several NCFRP reports were used to develop a freight scope of work for a contractor.

Freight practitioners noted that NCFRP products were targeted toward areas where research was needed. They found these products to have practical application to the problems they face daily. Staff at the Baltimore Metropolitan Council noted, "It is a great program – a great resource – planners need this information and they may not always know what is being done around the country ... it is useful." Practitioners have great respect for the practical applicability of NCFRP products. One planner noted that NCFRP products are "All relevant and practical

research reports ... not things that are abstract – not academic – many NCFRP projects have real world applications.”

The educational value of NCFRP products lies in the fact that so many different variables in freight transportation challenge agency staff to stay current on all topics that might arise. One state DOT official noted,

“my background is in planning, I may not have a background in supply chain management, these reports help us to be proactive in educating ourselves ... they are easy flowing ... the research is done for you in a one stop ... the reports keep up with developing freight trends and a report pops out not too long after a trend emerges.”

NCFRP products enabled agency staff to quickly become familiar with new topics for writing grant applications. One state DOT official noted, “since we are a DOT we are highway heavy ... we use NCFRP reports to do some homework on other modes.” The Iowa DOT noted that NCFRP projects helped them obtain designation of the waterway north of St. Louis as a Marine Highway. They assembled a TIGER (Transportation Investment Generating Economic Recovery) grant application for Upper Mississippi River Planning, to raise funds for approving this designation. NCFRP reports also were used to obtain background knowledge in the marine freight area for this application.

NCFRP products were instrumental in summarizing the existing body of knowledge through literature reviews. A researcher at the American Transportation Research Institute noted, NCFRP “is the first thing we look to ... we look to NCFRP for a literature review ... especially for TRB papers ... a lot of literature isn’t easily accessible ... NCFRP research is accessible.”

In ICF’s survey of practitioners, *NCFRP Report 10, Performance Measures for Freight Transportation*, was the NCFRP product cited most often as being used by survey respondents. Several practitioners we interviewed also noted the value of NCFRP Report 10. They found this report useful in helping them think about the new MAP 21 requirements to develop freight, safety, and mobility performance measures. They noted a push within their agencies to make performance measures more robust, and this report informed their efforts.

The Iowa DOT used NCFRP Report 10 to help them select performance measures for their freight plan. They used the report for background knowledge and examples. They have a Freight Advisory Council, which they consult to determine what is important. NCFRP Report 10 provided ideas and good examples for starting a conversation with the Freight Advisory Council.

Researchers at the American Transportation Research Institute noted that state DOTs use NCFRP Report 10 as a starting point to define the measures they should use. State DOTs ensure their actions align with the contents of Report 10. “People call saying they need a map similar to what was in that report, a measurement that is similar ... how would you do the reliability measurement?”

NCFRP products, such as *Report 9: Guidance for Developing a Freight Transportation Data Architecture*, have been useful for helping planners integrate data and solve real-world challenges. The Baltimore Metropolitan Council noted that they have been gathering freight datasets from many different groups—including the state highway data, data from economic development agencies, commodity flows—and assembling them in a hub. Report 9 has been useful in conceptualizing this effort.

Washington State DOT noted that they have referenced NCFRP Report 9, in their work, including the development of a freight library. NCFRP Report 9 provided them with information on what data sources are available. Washington State DOT has been interested in the procedure to develop a freight data tool useful for various user groups. NCFRP Report 9 served as a starting point for developing approaches to storing and sharing freight data.

ICF's survey also identified two other data-related reports (Reports 22 and 25) as being among the top 10 NCFRP reports that survey respondents use most frequently. ICF's interviews with practitioners identified examples of how these reports were used. One MPO used *NCFRP Report 22, Freight Transportation Cost Data Elements* to help identify freight projects for their long-range plan and estimate the cost impacts for freight projects.

A freight planner at the Baltimore Metropolitan Council noted the practical value of *NCFRP Report 25, Freight Data Sharing Guidebook*. The MPO used this document in preparing for a data-sharing working group that included both private- and public-sector members. They used the examples of data-sharing agreements to inform their efforts and help them obtain data from railroads. Collecting these data was part of a project to create a freight finder app. The application pulls together data from many publicly available sources and some private-sector data. They found NCFRP Report 25 useful to ensure that private-sector data are protected and to avoid antagonizing any public- or private-sector partners. Washington State DOT also noted that they used NCFRP Report 25 when preparing their freight data library.

Several practitioners noted *NCFRP Report 29, Making Trucks Count: Innovative Strategies for Obtaining Comprehensive Truck Activity Data* was useful for considering data gaps and their remedy. One planner noted “we look at freight routes – we look at the percentage of trucks on the route, but we want to make it commodity based – we know we have 100 trucks, but what do they carry ... we want to make this more of an economic analysis.” Their agency was seeking to understand how the value of the commodities carried affects the benefit-cost calculation for different types of investments.

The Iowa DOT used NCFRP Report 29 to help them identify freight bottlenecks. They examined data to find truck bottlenecks, obtained INRIX data, and then overlaid the truck counts. In general, they found many NCFRP reports useful for background research and literature reviews. These reports assisted them in identifying what their options were.

Washington State DOT also has used *NCFRP Report 26, Guidebook for Developing Subnational Commodity Flow Data*, to develop a data collection program. They are studying urban food distribution and are interested in understanding commodity flows in the face of natural

disasters. Recently, they also have been studying the rural wheat supply chain and are developing an understanding of other supply chains in their state. The agency has a statewide geographic information system-based tool to support the freight network. This research is informing a larger statewide model development project being conducted as a pilot study.

5. Future Research Needs

Given the increasing emphasis on performance-based management of transportation networks at all levels (and the accompanying data needs), it is not surprising that data issues came in second-highest in ICF's survey as a topic area in which additional research is most needed. (Survey participants were not asked to gauge the need for additional research on performance measurement.)

Our interviews identified numerous areas in which additional research was necessary. Potential topics for needed research included updating existing reports, complying with MAP 21, developing an approach to leverage private-sector data, improving the quality and utility of national datasets, integrating data, and improving capabilities for multimodal freight analysis. Each of these research agenda items is discussed below in more detail.

Updating Existing Reports

Some interest was expressed in updating several existing NCFRP reports. One respondent noted that anything 10 years or older has little value. Changes in data collection technology should be incorporated in several of the reports. Some compilations of freight tools are becoming dated with the release of new models. The following reports were considered good candidates for updating:

- *Report 29, Making Trucks Count: Innovative Strategies for Obtaining Comprehensive Truck Activity Data* – This report has become outdated quickly. Changes in truck GPS data collection over the past 2 years should be incorporated.
- *Report 9, Guidance for Developing a Freight Transportation Data Architecture* – This report should be updated to reflect new vehicle probe data.
- Any reports containing technology-related material should be updated.

Complying with MAP 21 Requirements

Practitioners expressed considerable interest in obtaining research on how to comply with MAP-21. Additional research would help states understand how to respond to performance measurement requirements. Information on activities of other states and technical guidance on how to create performance measures would be welcomed. The following are topics of interest:

- Freight performance measurement under MAP-21—What are the requirements and what are states doing? (This should be a quick-turnaround project, ideally completed in time to inform reauthorization of federal surface transportation legislation.)
- Guidance for MAP-21 reporting.

Approaches to Leveraging Private-Sector Data

Significant data resources are available to analyze transportation, but many of these are private-sector databases. Understanding the needs of the private sector for data privacy is critical for developing a partnership to share data. The following projects could be useful in better leveraging private-sector data:

- Best Practices in Freight Data Privacy,
- Freight Fluidity Measures, and
- Guidance on Leveraging Private-Sector Data.

Investing in National Datasets

More granular data are needed on freight movements at the national, regional, county, and local levels. Although the FAF provides freight data at the national level, the data are limited for characterizing regional and local freight movements. Because it uses data from the Commodity Flow Survey, the FAF shares with this data source the same limitations of sample size and survey design. New data and methods are therefore needed to estimate local truck movements or to synthesize such from national datasets.

Some states are using truck probe data from private sources, and all states have access to the U.S. DOT's National Performance Management Research Data Set (NPMRDS). In the future more vehicle probe data will become available, particularly as connected vehicles become widespread. There is a need for information on how to use this data for performance measures

Additional guidance on the following is warranted:

- Opportunities for improving national freight datasets, and
- Disaggregation methodology for FAF data, particularly with FAF 4.0.

Multimodal Data

To better plan for multimodal freight movements, planners need better data on the cost of freight moved by all modes, that is, more accessible freight movement and cost data for all modes.

Integrating Data

Great interest was expressed for creating data libraries and standardizing data resources. Several potential projects suggested by interviewees include the following:

- Standardizing local, state, and federal data examples,
- Developing a state or local freight data clearinghouse, and
- Standardized methods for truck trip tables.

Other

Subjects suggested several additional research projects, including the following.

- Defining and Measuring the Benefits of Freight Projects,
- Using Private-Sector Facilities to Solve the Truck Parking Problem, and
- Freight Technology Trends.

White Paper

Urban Freight Mobility: NCFRP Contributions and Future Research Needs

1. Introduction

This white paper is one of five that document the contributions of the National Cooperative Freight Research Program (NCFRP) to specific freight research areas, provide examples of how NCFRP research in these areas has been used, and present recommendations on future research needs. The paper was prepared as part of NCFRP Project 48. This white paper covers the topic of urban freight mobility.

Urban freight mobility was selected as a topic based on an analysis of the research areas the current body of NCFRP research addresses and on the results of a survey of freight practitioners at state departments of transportation, metropolitan planning organizations (MPOs), federal agencies, academia, and the private sector. Survey participants were asked to indicate which (if any) NCFRP reports they had used and in what context. They were also asked to identify future research needs in the fields of freight policy and planning. In addition to the online survey, the research team interviewed several freight practitioners to obtain additional input on how NCFRP research has been put to use and what are the priority freight research topics.

2. Role and Importance Urban Freight Mobility

The U.S. freight transportation network and activity levels are highly concentrated in urbanized areas. With dense populations, urban areas consume vast quantities of consumer products, most of which are produced elsewhere and delivered by truck. Manufacturers in urban areas rely on the transportation system to receive supplies and move their products to markets. Urban areas also are home to many of the nation's most important seaports and airports that facilitate domestic and international trade. As noted in recent reports from Brookings:

“The country relies on 25 port complexes to move 85 percent of all internationally traded goods. The majority of these port complexes are in large metropolitan areas, ranging from the seaports and airports in Los Angeles, New York, and Houston to single major ports in metro areas like Anchorage, Alaska; Buffalo, N.Y.; and Savannah, Ga.”¹

“The country's 100 largest metropolitan areas drive national goods trade, with more than 80 percent of all goods either starting or ending in these areas. In

¹ Adie Tomer and Joseph Kane, *The Great Port Mismatch U.S. Goods Trade and International Transportation*, Brookings, June 2015.

total, \$16.2 trillion in domestic and international goods flow annually through the largest metropolitan areas.”²

In most urban areas, the competition for roadway space and parking is steep. The built environment in many large cities reflects an era before the dominance of motor vehicles, with roadways, bridges, and other infrastructure that was not designed for the large vehicles used to move today’s freight. With dense populations of residents and workers, freight transportation in urban areas often conflicts with the movement of pedestrians, bicyclists, and public transit. Urban areas are also prone to some of the more serious environmental challenges, such as air pollution and noise, which freight vehicles and equipment can exacerbate.³

Maintaining urban freight mobility is made more challenging by the explosive growth of e-commerce, which is reconfiguring the urban freight needs of the retail sector. Part of what underpins the rapid growth in e-commerce is fast, low-cost order delivery that makes the Internet competitive with brick-and-mortar stores. This growth is evident in the surging volume of parcel delivery trucks.



Source: U.S. Department of Commerce

Many urban areas also are experiencing a resurgence in population growth and associated residential development. This growth and development can conflict with freight-related land uses, particularly when development occurs in locations historically dominated by warehousing or in proximity to major freight terminals like seaports and airports.

Collectively, these trends make managing freight movement in urban areas increasingly challenging—and increasingly important. Transportation agencies, local governments, and the

² Adie Tomer and Joseph Kane, “Mapping Freight: The Highly Concentrated Nature of Goods Trade in the United States,” Brookings, November 2014.

³ From NCFRP Report 24

private sector have begun exploring innovative approaches to maintaining efficient urban freight movement, while minimizing its impacts on residents and workers who share these spaces.

3. Contributions of NCFRP to Advancing the State of the Practice

Although it constitutes less than 50 separate research efforts, the NCFRP has addressed an impressive range of topics relevant to the freight community. Urban freight mobility is one topic that has received more attention than most, with at least five reports specifically addressing the topic. The freight community has been receptive to these reports. The research team’s online survey found that 3 of the top 10 reports that survey respondents used most frequently focused on urban goods movement (Reports 14, 23, and 24).

Three NCFRP reports offer broad treatment of urban freight movement issues. *NCFRP Report 14, Understanding Urban Goods Movements*, serves as an “Urban Freight 101” primer, explaining why urban goods movement is important and describing supply chains that pass through urban environments. The report is intended to be a comprehensive yet concise guide for public decision-makers on how to accommodate and expedite urban goods movement, while minimizing environmental and community impacts. It describes the supply chains of 12 goods and services that are characteristic of many urban environments. It then identifies urban planning codes, ordinances, regulations, and policies that affect mobility and access for urban goods movements and explains their impacts. Next, the report suggests steps to help local planning officials evaluate goods movement issues in their urban areas. Finally, the report presents nine case studies that demonstrate how cities have overcome regulatory and zoning issues to improve the efficient movement of goods.

NCFRP Report 23, Synthesis of Freight Research in Urban Transportation Planning provides a compilation of international practices in managing the “first and last mile” of goods movement (i.e., pick-up and delivery) in urban areas. Much of the report is based on a review of international literature (primarily in Europe). The report focuses on “last-mile/first-mile” strategies but also discusses (1) environmental strategies to reduce emissions and noise from trucks and vans, and (2) strategies dealing with the particular problems of metropolitan areas serving as hubs for national and international trade. After identifying strategies, the report assesses their relative effectiveness and the feasibility of implementing them in the United States.

The third, broadly focused report is *NCFRP Report 33, Improving Freight System Performance in Metropolitan Areas*, released in April 2015. The report is intended to serve as a comprehensive reference that identifies potential strategies to improve the performance of the freight system in diverse metropolitan areas. The report first outlines the basic elements of the decision-making process for urban freight transportation. It then provides guidance on how to identify potential public-sector initiatives. Finally, it describes a catalog of 54 initiatives for consideration by public agencies. These initiatives were classified into eight major groups:

- infrastructure management;

- parking/loading areas management;
- vehicle-related strategies;
- traffic management;
- pricing, incentives, and taxation;
- logistical management;
- freight demand/land-use management; and
- stakeholder engagement.

Report 33 includes several case studies to complement and add illustrative depth to decision frameworks, which provide real-life examples in several U.S. cities of some of the intricacies involved in planning. In addition to the report itself, the project also produced an online Initiative Selector tool to aid in selecting alternatives for various problems, and Freight Trip Generation software (not yet posted online) to help planners identify main locations where freight is an issue based on freight trips produced and attracted.



Source: usa.streetsblog.org

In contrast, other NCFRP reports on urban freight are more focused in scope. *NCFRP Report 16, Preserving and Protecting Freight Infrastructure and Routes*, illustrates the types of conflicts that occur between freight and other land uses and presents various tools for preventing or resolving them. The four major tools discussed in the report are (1) long-range planning, (2) zoning and design, (3) mitigation, and (4) education and outreach. The report is based in part on the results of two surveys, one of freight industry representatives and the second of planners in local government and MPOs. Six case studies provide real-world examples of how actual or potential conflicts between freight and other land uses were handled.

NCFRP Report 24, Smart Growth and Urban Goods Movement, addresses the interrelationships of urban goods movement and the land-use patterns commonly described as “smart growth” (e.g., compact infill development, mixed uses). The researchers conducted focus group meetings with stakeholders in two jurisdictions. They used regional travel-modeling tools to examine the impacts of the smart-growth land-use scenarios on miles of truck travel, hours of truck travel, truck delay, truck trip length and travel times, and emissions. The research suggests that a smart-growth land-use configuration results in benefits directly to, and stemming from, goods movement. The largest benefits were observed when a smart-growth, land-use scenario was coupled with commensurate transit and non-motorized transportation investments. For trucking and shipping firms, the benefits included a reduction in overall travel distances and hours on the road. Secondary benefits related to overall travel included reductions in pollutant emissions, especially carbon dioxide, and the potential economic gains from a more efficient and productive goods-movement system.

4. How NCFRP Research Has Been Used for Improving Urban Freight Mobility

This section discusses how freight planners or policymakers have used the NCFRP research products on urban freight mobility. This discussion is based on ICF’s survey results and interviews with staff at organizations including:

- U.S. Federal Highway Administration,
- Washington State Department of Transportation,
- California Department of Transportation,
- North Central Texas Council of Governments, and
- Several transportation consultants.

As noted previously, ICF’s survey of the use of NCFRP research found that 3 of the top 10 most used reports are focused on urban freight issues. Note that Report 33 had not been released at the time of the survey.

Report 14, Guidebook for Understanding Urban Goods Movements, was identified as useful by 58 of 133 survey respondents (44 percent). Regarding this report, one respondent commented:

“I was challenged to get my state’s MPOs to incorporate freight planning in their planning processes. I was able to share the *Report 14: Guidebook for Understanding Urban Goods Movements* with MPOs as well as others in attendance at a state chapter conference of the American Planning Association.”

Another respondent noted, “I needed to better understand urban goods movements, and this report helped educate me.”

Report 23, Synthesis of Freight Research in Urban Transportation Planning, has also been well received. It was identified as useful by 25 percent of respondents. One respondent provided this comment:

“NCFRP 23 was desperately needed. We haven’t had a synthesis of freight planning research in at least two decades. This report has become required reading in transportation planning classes I lecture in and has measurably advanced the research and literature on freight planning.”

Others provided more general comments regarding these reports, such as:

“From an international perspective, the NCFRP has produced important lessons about and designs for outreach from government to the public and to private stakeholders. Also, for purposes of international comparison, reports on urban freight and modeling were very useful.”

North Central Texas Council of Governments (NCTCOG) offered a specific example of using an NCFRP report. In 2010, NCTCOG began a comprehensive review of the freight transportation system in the Dallas-Ft. Worth region. In addition to assessing the current state of the system, this study process included a needs assessment for future policies, programs, projects, and studies to improve freight planning and operations in the region.⁴

NCTCOG staff indicated that two NCFRP reports were particularly useful to them during this study process:

- *NCFRP Report 7, Identifying and Using Low-Cost and Quickly Implementable Ways to Address Freight-System Mobility Constraints, and*
- *NCFRP Report 10, Performance Measures for Freight Transportation.*

The influence of these NCFRP reports is shown in Chapter 4 (Current System Issues) of the NCTCOG report, *The North Central Texas Regional Freight System*. In this chapter, NCTCOG presents a set of performance measures to be used in either prioritizing projects or in determining the effectiveness of freight policies, programs, or projects. NCTCOG also makes the case for more fully considering freight needs during the project prioritization process. The agency asserts that many projects intended to enhance freight mobility can be implemented quickly and at low cost. NCTCOG included a table of “Quickly Implementable Freight Projects” that was obtained from NCFRP Report 7.

In another example, the Atlanta Regional Commission (ARC) used *Report 19, Freight Trip Generation and Land Use* to improve their modeling of truck trips in the region. The Commission has a 20-county regional travel-demand model. NCFRP Report 19 helped the agency review specific corridors and identify the special trip generators. The Commission’s planners identified more than a dozen special trip generators and included them in their model. The updated model provided a better treatment of truck traffic to and from these areas and

⁴ *Freight North Texas: The North Central Texas Regional Freight System*, May 2013, accessed 7/29/15 at: <http://www.nctcog.org/trans/goods/freight/plan.asp>

improved how these trips were assigned to network, which resulted in a more accurate model at the local level.

5. Future Research Needs

ICF used several means to gather suggestions for future research needs in the area of urban mobility. As described previously, an online survey afforded participants the opportunity to suggest research needs. In addition, the ICF research team interviewed freight stakeholders to obtain more suggestions. The third effort was to review the NCFRP reports, some of which include recommendations for additional research. Based on these inputs, this section lays out possible future research topics for sponsors of freight research.

Freight and Land Use

Despite the fact that NCFRP Report 16 addressed how to prevent or manage conflicts that occur between freight and other land uses, survey respondents and interviewees reported that the topic remains an important one that future research could address. One survey respondent said that future research should focus on freight policies to protect freight gateways and ports from gentrification. Another suggested research on how best to determine and dedicate freight corridors and routes in urban areas. A third survey respondent asked for research on how best to communicate the importance of maintaining freight routes to advocates of “Complete Streets” treatments and similar capacity reductions. An interviewee said she was aware of rail car transload facilities that cannot expand because of adjacent land uses.

Two interviewees suggested that updating the 2003 Transportation Research Board publication *NCHRP Synthesis 320, Integrating Freight Facilities and Operations with Community Goals* would be worthwhile. This report, informally referred to as “Freight as a Good Neighbor,” identified practices that had been or were being used by private-sector freight companies and public transportation agencies in siting freight facilities, modifying operations at those facilities, and managing community relations. The report also recognized “good neighbor initiatives” and “balancing practices” (i.e., mitigation) employed by metropolitan planning and economic development organizations, local governments, and others.

Impact of New Technologies

The potential use of automated delivery vehicles for freight transportation was on the minds of some survey respondents and interviewees. Some interviewees expressed concern that providing useful guidance or best practices to planners and policymakers might be premature.

Others suggested research into the use of intelligent transportation systems to help with freight routing decisions. Getting information on real-time conditions to carriers and drivers far enough in advance is essential to influence trip planning. This research could document pilot tests under the U.S. Federal Highway Administration’s Freight Advanced Traveler Information System (FRATIS) program.

Advanced technologies and data have the potential to improve freight system efficiency in new and innovative ways, which is a topic ready for research. For example, is there potential for better load consolidation through real-time sharing of data on truck movements? If so, what are the obstacles and how can they be overcome?

Rail Transport in Urban Areas

The issue of safe and efficient freight rail transport in urban areas has been heightened by the growth in the domestic oil and gas industry. More research is needed on ensuring safety for rail shipments of petroleum products and other hazardous materials through cities. Another suggested topic is a compendium of best practices regarding rail freight bridges in urban areas.

Freight Planning Practices

Although many elements of freight planning have been covered in past research, one interviewee noted a continuing high rate of turnover in freight planning/policy positions at state departments of transportation and MPOs, the need to educate newcomers to the field persists. The freight community might also benefit from a review and assessment of some current practices. Such a review could include, for example, a report on the status of implementation of all freight requirements from MAP-21 and identification of resulting best practices. Specific to urban freight have been questions about how statewide freight plans could better address urban freight issues. Finally, an MPO planner noted a need for “scalable” freight analysis tools that can be used by smaller, as well as larger, MPOs.

Urban Truck Mobility

Research has shown the promise of off-peak deliveries as a way to reduce urban freight congestion. More research is needed to understand how to achieve widespread adoption of deliveries during off-peak hours, including the appropriate type and level of incentives. Truck parking continues to be a critical issue in urban areas and could warrant additional research.

Freight System Resiliency in Urban Areas

More research is needed to understand how to improve the resiliency of urban freight systems in the face of extreme weather events and other natural and manmade disasters. The sole NCFRP report on resiliency focuses on ports. An MPO planner noted that recent floods have forced freight trucks to detour for long distances.

White Paper

Ports and Waterways: NCFRP Contributions and Future Research Needs

1. Introduction

This white paper is one of five that document the contributions of the National Cooperative Freight Research Program (NCFRP) to specific freight research areas, provide examples of how NCFRP research in these areas has been used, and present recommendations on future research needs. The paper was prepared as part of NCFRP Project 48. This white paper covers the topic of ports and waterways.

This topic was selected based on an analysis of the research areas addressed by the current body of NCFRP research and on the results of a survey of freight practitioners at state departments of transportation, metropolitan planning organizations, federal agencies, academia, and the private sector. Survey participants were asked to indicate which (if any) of the NCFRP reports they had used and how they had used them. They were also asked to identify future research needs in the fields of freight policy and planning. In addition to the online survey, the research team interviewed several freight practitioners to obtain additional input on how NCFRP research has been used and what are the priority topics for freight research.

2. Role and Importance of Ports and Waterways

Operations of ports and waterways are critically important to the nation's economy. Historically, the original settlements formed around ports as trade centers. The criticality of ports is even more evident today. U.S. Department of Transportation Secretary Anthony Foxx observed,

“Our ports are truly opportunity multipliers. In addition to the direct employment America's ports sustain managing the critical economic activity of moving freight to and from ships, our ports are economic engines, fueling good jobs—not just on our coasts, but across the country—from manufacturing jobs on land to skilled crew at sea.”¹

Ports and maritime businesses are key elements of the freight system and epitomize intermodal systems—port and waterway facilities connect to inland customers by truck, rail, pipelines, and, in some locations, air. Major importers through U.S. ports include Wal-Mart,

¹ <https://www.transportation.gov/fastlane/our-nations-ports-americas-opportunity-multipliers>

Target, Home Depot, Lowe’s, Dole Food, Sears, Chiquita Brands, Heineken, Samsung, and Dollar Stores.²

Ports are also crucial for export activities. According to the American Association of Port Authorities:

U.S. ports and waterways handle more than 2 billion tons of domestic and import/export cargo annually. By 2020, the total volume of cargo shipped by water is expected to be double that of 2001 volumes. Much of total domestic production of basic commodities and finished products is shipped by water, including apples, wastepaper, corn, lumber, iron ore, steel, scrap steel, potatoes, phosphate, plastics, film, machinery, and modular homes. About two-thirds of all U.S. wheat and wheat flour, one-third of soybean and rice production and almost two-fifths of U.S. cotton production is exported via U.S. ports. U.S.-produced coal, grain and forest products also compete well in international markets because of our efficient transportation system.³

Ports and the maritime industry generally are not funded through or governed by the provisions of MAP-21. Many ports are self-financing authorities or state or local governmental entities, and many are operated primarily by private businesses for their on-site facilities. Ports, however, do make use of federal funding mechanisms, including Congestion Mitigation Air Quality (CMAQ) grants, Transportation Investment Generating Economic Recovery (TIGER) grants, and other federal funds. Further, ports can also be affected by related highway, grade-crossing, and intermodal investments and policies governed by federal legislation.



Source: American Commercial Lines, <http://www.aclines.com>

Since authorization of the NCFRP in 2006, much has changed in the port and maritime industry, including:

- steep economic declines and fiscal austerity,
- changing vessel designs and technologies,
- increased focus on resiliency,
- expanded focus on environmental sustainability,
- shifting ownership as private institutions purchase controlling interest in terminals, and

² http://www.joc.com/international-trade-news/trade-data/united-states-trade-data/joc-top-100-importers-2014_20150528.html

³ <http://www.aapa-ports.org/Industry/content.cfm?ItemNumber=1022&navItemNumber=901>

- enhanced policy focuses on exports and overall trade.

These changes affect the structure of the industry, and they affect the research subjects and results that are of most use to these organizations.

A Great Recession, a Gradual Recovery, and Fiscal Austerity

The U.S. economy was doing well when the SAFETEA-LU legislation was enacted and the NCFRP program initiated. In February 2007, the *Washington Post* noted that,

“The report from the Commerce Department, showing that economic growth picked up in 2006 from the 3.2-percent growth of 2005, dispelled any lingering doubts about the momentum of the economy going into this year. Many economists predict growth will slow this year, but gone are the recession worries of last summer.”⁴

As the economy moved forward, international trade and domestic commerce moved forward. Investments in global gateways such as ports and supply chain facilities such as distribution centers also progressed. Maritime terminals were viewed as valuable investments, with such purchases as AIG’s acquiring the company now known as Ports America in 2006⁵ and a division of Deutsche Bank’s acquiring Maher Terminals in 2007.⁶

In 2008, however, everything changed. The Great Recession began in the United States. Economies around the world reeled during in a global economic slowdown. International trade and domestic commerce declined, fueled by tens of thousands of workers losing their jobs, businesses failing, and global concerns mounting. The U.S. government seized control of AIG in an \$85-billion deal in 2008 “that signaled the intensity of its concern about the danger a collapse could pose to the financial system.”⁷

Fiscal austerity impacted most businesses, including the port and maritime community. Within these fiscal constraints, these organizations had to continue investing to adapt to radical changes in vessel designs and recovery from a series of devastating natural disruptions.

New Vessel Designs

Radical changes in vessel designs, modifications to improve environmental sustainability, and the potential for new marine services also occurred between the time NCFRP was authorized and this current review of the use of the program’s products.

Container vessels grew in size and capacity, reflecting both increased global trade and the drive to reduce per-container costs. As shown in the figure below, between 1996 and 2006, Maersk, the leading carrier, more than doubled vessel capacity. Even with the Great Recession, vessel

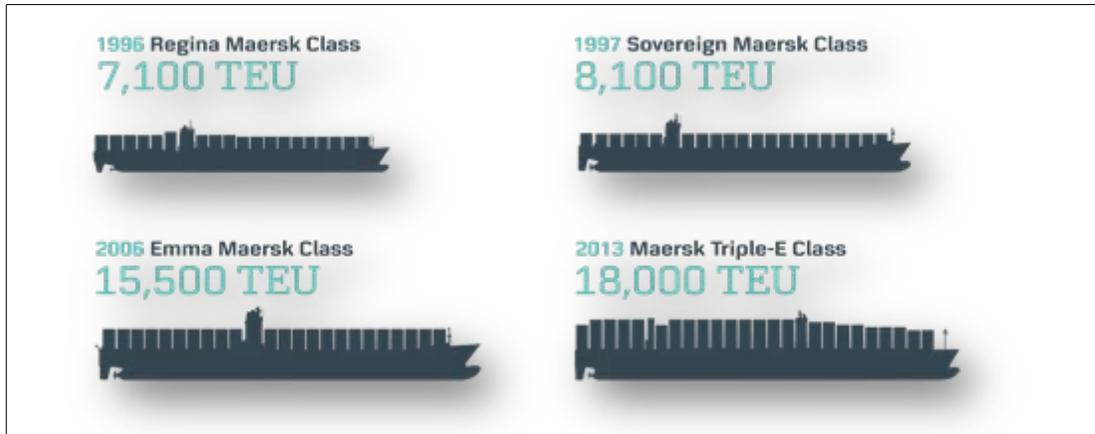
⁴ Henderson, “Economy Gained Strength in 2006,” *The Washington Post*, February 1, 2007.

⁵ <http://www.prnewswire.com/news-releases/aig-global-investment-group-closes-the-acquisition-of-pos-us-marine-terminal-operations-from-dp-world-52168092.html>

⁶ https://www.db.com/medi/en/content/press_releases_2007_3405.htm

⁷ <http://www.wsj.com/articles/SB122156561931242905>

sizes continued to grow, with Triple-E Class vessels entering service in 2013 and the carrier announcing a \$1.8-billion order for 11 newer class vessels capable of carrying 19,630 containers in 2015.⁸



Source: <http://www.maersk.com>

The larger vessels require deeper channels, higher air drafts under bridges, much larger and more cranes at the maritime terminals, and substantial terminal and inland transportation investments to handle the larger number of containers.

In addition, new options for enhancing the coast-wise movement of domestic and international products continue to be pursued. The Energy Independence and Security Act of 2007 established the America's Marine Highway Program in the U.S. Maritime Administration (MARAD).⁹ As noted on the MARAD site, the objective of the program is "to expand the use of our Nation's navigable waterways to relieve landside congestion, reduce air emissions, and generate other public benefits by increasing the efficiency of the surface transportation system."¹⁰ Initiatives have progressed, including a Richmond-Norfolk barge and an effort led by the Port of Maine to establish an articulated barge service between the state and the Red Hook Terminal in New York City.

An Increased Focus on Resiliency

Economic extremes and vessel changes were not the only trends affecting ports and maritime businesses. Hurricane Katrina struck in 2005. Hurricane Ike hit in 2008. Superstorm Sandy occurred in 2012. Each event significantly disrupted key components of the nation's port and maritime industry.

Each disruption was catastrophic, but also led to improved approaches and solutions for improving resiliency. Analyses, discussions, lessons learned, and best practices became increasingly important to ports and the maritime industry.

⁸ <http://www.wsj.com/articles/maersk-ceo-predicts-big-squeeze-for-small-container-ship-operators-1433501620>

⁹ <http://www.marad.dot.gov/ships-and-shipping/dot-maritime-administration-americas-marine-highway-program/>

¹⁰ *Ibid*

New York Container Terminal during Superstorm Sandy



Source: NCFRP Report 30, Making U.S. Ports Resilient as Part of Extended Intermodal Supply Chains

Particularly with cargo's increasing and the size of vessels growing, communities and ports have focused on reducing the environmental impacts of port and maritime operations. Initiatives continued, even during the Great Recession, and included:

- Increased use of electrified and/or alternatively fueled equipment at terminals, such as electrified cranes and compressed natural gas-powered terminal equipment.
- Mandates to use trucks with newer engines and fuels that met increasing stringent U.S. Environmental Protection Agency standards combined with truck replacement programs.
- Programs to change engines and fuel types used by railroad locomotives, tugboats, and other equipment serving the port.
- Pursuit of more stringent standards for the fuels burned by ocean-going vessels near ports combined with implementation of onshore electrical powering of vessels while docked.
- Enacting of requirements concerning release of ballast water to reduce the spread of non-native invasive marine species.

Shifts in Ownership

Significant changes in the ownership of port facilities have also occurred since the original inception of the NCFRP. As financial institutions focused on international trade as possible long-

term investments, private entities of increasing size moved to take ownership or play substantial financial roles in terminal operations. The port industry shifted from a more public-sector framework to private-sector orientation, with shorter business cycles and pragmatic considerations for investments and operations. For NCFRP, these shifts meant that the audiences shifted, in terms of both the types of organizations and the issues of importance to them.

Policy focus on exports and trade

The federal government also has continued to increase its focus on growing international trade and export activities, which has ramifications for port facilities that serve as global gateways. For example, the “National Export Initiative,” overseen by the International Trade Administration of the U.S. Department of Commerce, is considered a top priority of the Obama Administration and geared toward improving the conditions that directly affect the private sector’s ability to export.¹¹ With more cargo anticipated, along with the larger vessels, the focus of the port and maritime industry on efficiency has increased.

3. Contributions of NCFRP to Advancing the State of the Practice

Under the NCFRP, at least nine research studies have been conducted that are focused directly on port and waterways topics.

NCFRP Report 5, North American Marine Highways, explores the potential for moving intermodal containers on chassis, noncontainerized trailers, or rail cars on marine highways in North America. The report assesses the conditions for the feasibility of these freight movements and analyzes the economic, technical, regulatory, and logistical barriers inhibiting greater use of the marine highway system, as well as opportunities to overcome these barriers.

NCFRP Report 11, Truck Drayage Productivity Guide, is intended to help shippers, receivers, draymen, marine terminal operators, ocean carriers, and port authorities address inefficiencies, control costs, and reduce associated environmental impacts of truck drayage. The report identifies and quantifies the impacts of bottlenecks, associated gate processes, exceptions (trouble tickets), chassis logistics, congestion, and disruption at marine container terminals.

NCFRP Report 17, Multimodal Freight Transportation within the Great Lakes-Saint Lawrence Basin, analyzes the performance of the Great Lakes freight system and identifies opportunities for and constraints to improving performance and meeting projected freight flows.

NCFRP Report 18, Marine Highway Transport of Toxic Inhalation Hazard Materials, examines the benefits of increasing the share of chlorine and anhydrous ammonia that is moved via the marine highway system. The report develops a business case for increasing marine highway shipments of these materials, addressing return on investment, obstacles, impacts on other modes and their likely reactions, labor issues, environmental concerns, risks, and lessons learned from international experience.

¹¹ <http://www.trade.gov/nei/>

NCFRP Report 20, Guidebook for Assessing Evolving International Container Chassis Supply Models, describes the historical and evolving models of international container chassis ownership and management in the United States. It is intended to provide stakeholders, including beneficial cargo owners, public policymakers and planners, trucking companies, ocean carriers, and terminal operators with an understanding of the most salient issues and implications as the chassis supply market continues to evolve so they can make informed decisions going forward.

NCFRP Report 30, Making U.S. Ports Resilient as Part of Extended Intermodal Supply Chains, provides a set of high-level guidelines, illustrated by two case studies, that help seaport authorities (and state departments of transportation in which such ports are located) to minimize lost throughput capacity resulting from major disruptions. The report describes steps needed to coordinate freight movements through ports in times of severe stress on existing operating infrastructures and services, whether being stressed because of damage to port facilities, to the highway, rail, and waterway routes leading into and out of the port, or because of the need to handle additional cargo volumes due to port disruptions elsewhere. The report built on *NCHRP Report 732, Methodologies to Estimate the Economic Impacts of Disruptions to the Goods Movement System*, which, along with information for other freight modes, provides a set of high-level guidelines to help seaport authorities minimize lost throughput capacity resulting from major disruptions.

NCFRP Report 32, Integrating MTS Commerce Data with Multimodal Freight Transportation Performance Measures to Support MTS Maintenance Investment Decision Making, addresses both inland and coastal waterways. The report examines the feasibility of evaluating potential navigation operation and maintenance projects on the MTS (Marine Transportation System), not only as they relate to waterborne commerce, but also in light of the landside freight connections.

NCFRP Report 34, Evaluating Alternatives for Landside Transport of Ocean Containers, compares the various alternatives to transporting ocean containers to and from port terminals, considering the entire container drayage scenario between a deep-water port and a location up to 100 miles inland.

Enhancing Sleep Efficiency on Towboats in the U.S. Inland Waterway Industry, was developed under NCFRP Project 45. The report has been completed but not yet published. The objective of this study was to develop a compendium of best practices for enhancing sleep efficiency on towboats in the U.S. inland waterway industry.

In addition to these reports, port stakeholders interviewed for this paper identified several other NCFRP reports as useful for their activities, as discussed in the next section.

4. How NCFRP Research Has Been Used for Improving Ports and Waterways

Seven industry executives were interviewed for this white paper. The individuals selected represent a cross-section of the industry – private sector, port authorities, a federal agency, an industry association, and an academic. The organizations represented included:

- American Association of Port Authorities,
- PHB Public Affairs,
- Port of Portland,
- San Diego Association of Governments,
- Stevens Institute of Technology,
- The Port Authority of New York and New Jersey, and
- U.S. Maritime Administration (MARAD).

The daily responsibilities of the executives vary, which include operations, project development and implementation, strategy and policy review and development, analyses, and research. The interviewees represent a spectrum of involvement with the Transportation Research Board (TRB), ranging from minimally involved to leadership roles in the TRB organization.

General Observations Regarding the NCFRP Program

The interviewees made numerous observations regarding the NCFRP with the goal of improving the use of the current Program's products and enhancing future research programs. The observations primarily focused on awareness of products, usefulness to their organizations, and intended audiences.

Awareness

The interviewees, with one exception, were aware of the NCFRP Program, along with the research conducted and the products produced. The extent of their awareness, however, was often limited. Indeed, the interviewees found that a list of NCFRP projects and reports, provided in advance of the interview, was a useful compilation of the research conducted and a way of quickly linking to the products of most interest.

Although the usefulness of the report list is a good indicator that the searchable database developed as part of this project will advance knowledge of the NCFRP, the list also epitomizes the key observation of the interviewees—***the awareness, dissemination, and easy identification of relevant NCFRP projects and reports has been extremely limited.***

One interviewee noted that the reports did not readily appear during online searches, which is a prevalent means for finding relevant studies and information. Other observations regarding awareness included:

- They learned about the relevant reports through presentations at TRB and other organizations, such as MARAD.

- They discovered relevant reports by seeing them on desks and bookcases. One interviewee characterized this form of dissemination as “learning through osmosis.”
- If they had known about the research before seeing the list, they would have disseminated information about the products and reports.

The interviewees noted that search and summary lists, such as the products produced during this project, were most useful. The comments also indicated that efforts needed to be pursued to expand dissemination and identify how to ensure that NCFRP reports and research appear in standard Internet search engines.

Usefulness to their Organizations

Observations regarding the usefulness of the NCFRP and the reports was mixed. The most relevant research focused on critical topics to the ports and maritime community and provided solid defensible bases for use in certain forums. As noted in the next section, NCFRP reports were referenced in congressional and local government board testimonies. Reports also provided best practice information.

With the exception of several reports as noted in the next section, however, the interviewees sometimes found the reports of little relevance to their organizations or, at times, already out of date when published. Interviewee comments included, “These studies are not in the practitioners’ world,” and “You don’t go first to the TRB study.”

Alternative sources the interviewees used for relevant information included published reports found via internet searches, material from the SHRP 2 (the second Strategic Highway Research Program), and agencies conducting the needed research themselves in a timely manner. One interviewee noted that their organization occasionally reviews NCFRP research when beginning a study, but that they did not use the reports on a frequent basis. Other interviewees noted that if they needed research on a topic quickly, they undertook the work internally or hired consultants.

Audiences and Research Topics

Several of the interviewees also did not feel that they were part of the target audiences for NCFRP; the interviewees felt that the reports targeted researchers and public transportation agencies. One interviewee noted that port organizations might have changed structurally since the inception of the NCFRP, commenting that in previous years, the organization included staff focused on research. In current leaner times, those positions have been eliminated, with the use of reports such as those produced by the NCFRP reduced.

One interviewee also noted that the NCFRP research and report titles often appeared repetitive. One interviewee noted it sometimes felt as though two words were changed in the title and the same type of research was being repeated.

Reports Most Often Used

As noted previously, the interviewees, with one exception, had read one or more of the NCFRP reports. Moreover, these interviewees also used these reports in meaningful ways. The primary

uses of the NCFRP reports were as important reference documents. Two of the interviewees noted that reports were referenced in congressional testimony and cited as a reference with a state’s air quality review board. Graduate students were urged to review the reports as critical resource tools in their research, although that the students would not have known about the reports otherwise was also noted; again, they often did not appear in Internet searches.

The specific characterizations of the importance of these products as reference tools included:

- “Solid defensible references.”
- “Not many other objective research reports exist.”
- “Scholarly and intellectually valuable reports are hard to find with freight.”

With so many recent major disruptions, *NCFRP Report 30, Making U.S. Ports Resilient as Part of Extended Intermodal Supply Chains*, was the report most often cited by the interviewees. Interviewees used this report to familiarize themselves with best practices related to resiliency. The report was used to disseminate examples, lessons learned, and best practices to private maritime terminal operators.

NCFRP Report 5, North American Marine Highway Operations, was cited as useful by more than half the interviewees, reflecting the importance of this subject. In ICF’s survey on the use of NCFRP research and future freight research needs, 31 respondents (23 percent) identified this report as useful.

One port executive, who teaches a class at a local university, noted that his students relied heavily on *NCFRP Report 20, Guidebook for Assessing Evolving International Container Chassis Supply Models*, to produce several research papers on truck drayage.

Port experts interviewed for this paper also identified as useful several reports that are not focused primarily on ports. For example, *NCFRP Report 28, Public-Sector Sustainability Strategies Addressing Supply Chain Air Emissions*, was cited as an objective source for the California Air Resources Board. In this role, the report was noted as very helpful in discussing a relevant matter with this decision-making authority. Interviewees noted that ports are located in urban areas, which explains why *NCFRP Report 14, Understanding Urban Goods Movement*, was cited as useful by three of the interviewees. *NCFRP Report 10, Performance Measures for Freight Transportation*, was cited by interviewees whose organizations are creating such metrics.

5. Future Research Needs

In discussing future topics for port-related research, the interviewees provided ideas and potential opportunities to improve future research efforts, including:

- improving the applicability to the port and maritime community,
- shortening the duration of and budgets for research projects, and
- broadening the audience.

General Opportunities for Improving Research Relate to Ports

Applicability

The guidance that most interviewees provided was that future research topics should be of immediate applicability to the ports and waterways community and released on an expedited basis so that the reports can be used quickly.

Many of the subjects the interviewees suggested for future research topics involved the critical issues and operational considerations facing ports and the maritime community today. Indeed, one interviewee noted that he “didn’t think about research topics but more in terms of pressing port issues.” The interviewees noted that practical application was important and the case studies were helpful. As one interviewee summarized the overall sentiment, “The reports have to be applicable.”

A survey of anticipated critical issues in the next 10 years conducted by TRB was suggested, with the resulting research efforts focused on the outcomes that emerge from the survey. An interviewee commented that the research should address the questions asked today, noting, “In an era of competitive grants, such as TIGER, more focus on funding solutions should be made.” Another interviewee indicated that questions and issues of concern to agencies, private-sector port organizations, and Congress could be identified and incorporated into the topics researched.

The interviewees also suggested that the recommendations sections of NCHRP reports be enhanced and more targeted. One interviewee commented that, “For the practitioner, no recommendations is not helpful.”

Length and Budgets of Research Efforts

Within the context of current trends and expediting research, several interviewees noted that many NCFRP projects involved budgets exceeding \$250,000 with research undertaken over a period of 18 to 24 months. A future research program focus was suggested with projects undertaken over a shorter period and with commensurately reduced budgets. One key observation an interviewee made was that, “the marine highway report [NCFRP Report 5] was already out of date by the time it came out.”

Broadening the Audience

The observations of the interviewees focused on how the research products could be better formatted for their organizations and use, as well as broadening the audiences for the reports.

Several interviewees noted that the current reports are lengthy and noted that, if the executive summary did not immediately attract their attention, they did not read the report. Interviewees recommended that the format of the reports consider executives and operations staff—the reports should include succinct, bulleted executive summaries and be much briefer. As one interviewee noted, “The executive summary has to convince the practitioner to read the full report. The [current] studies do not recognize that practitioners have a lot on their plates.” Another interviewee commented that he “only had an hour to use the report. You’re in a big

rush; you need quick facts in an executive summary.” A third interviewee noted that he had read many of the NCFRP abstracts but did not use them—the abstracts did not convince the reader to peruse the full report.

Specific recommendations for revised formats included:

- creating bulletin reports that are much shorter;
- developing an “executive bullet series” wherein each report was a short synthesis of a key issue;
- undertake a best practices series; and
- structuring reports so that they can be used as textbooks or college reference material.

These recommendations are consistent with the recommendations to reduce the timeframes and budgets of research selected and undertaken. Essentially, the interviewees recommended a more nimble research program reflective and responsive to critical issues and needs.

Interviewees also believe that the audiences of the NCFRP are principally federal and state transportation agencies, along with the academic communities. They suggested additional audiences, including metropolitan planning organizations, port authorities, private-sector members of the maritime community, and inland transportation providers (such as railroads and the trucking community).

The interviewees commented that an oversight committee could assume a stronger role in a future research program. One objective of the enhanced oversight committee would focus on how the research could be used, identifying the audiences, and disseminating the products to those audiences.

Future Research Topics

Interviews conducted for this white paper also identified future research needs related to ports and waterways. The online survey additionally afforded participants the opportunity to suggest research needs. Based on these inputs, possible future research topics for sponsors of freight research are discussed below.

Operational considerations. Topics included the means and best practices for enhancing security; operating within footprints constrained by other land uses, environmental considerations, and fiscal conditions; optimizing information systems across all modes involved in port and maritime cargo movements; and creating ports resilient in the face of natural and manmade disruptions, such as labor issues.

Landside connections to ports. Several interviewees noted the importance of maintaining efficient landside road and rail access to port facilities. One suggested research topic involves comparing increased maritime cargo volumes with available freight rail capacity. Another related topic would develop methods for forecasting ocean shipping and the associated impacts on ports and inland connection. Future research also could support the development of best practices to better integrate ports with rail and highway movements to create a seamless system.

Ports as part of freight systems and corridors. The interviewees understood that ports are part of broader systems wherein each element influences the effectiveness of overall movements. One suggested research topic would focus approaches and best practices to assess freight flows both on corridors and in freight bottlenecks—including ports and maritime facilities—to inform decisions as to where public investments in freight are most warranted. Additional topics focused on documenting and providing guidance on how to improve integration of ports with rail and highway movements to create a seamless system, methods for forecasting ocean shipping and the impacts on ports and inland connections, and the relationship between freight rail capacity and increased maritime cargo volumes.

Marine transportation optimization. Considerable interest continues in how to encourage, implement, and sustain the use of waterways and coastal marine transport as part of the nation’s overall freight system. Suggested research areas included approaches and best practices regarding implementation and best practices for advancing the marine highway concepts.

Appendix D. Peer Exchange Agenda and Attendee List

NCFRP 48 Peer Exchange Workshop – Agenda October 2, 2015

**Transportation Research Board, Keck Center, Room 100
500 Fifth Street, NW, Washington, DC 20001**

Time	Topic
8:15 – 9:00	Check-in, Breakfast and coffee (provided)
9:00 – 9:15	Welcome and Workshop Overview
9:15 – 9:35	Keynote Address <i>Neil Pedersen, TRB Executive Director</i>
9:35 – 10:00	How Freight Research has Supported Decision Making <i>Presentation by ICF International</i>
10:00 – 10:45	Federal Perspectives on Need for Freight Research <i>Lauren Brand, U.S. Maritime Administration</i> <i>Scott Greene, Federal Railroad Administration</i> <i>Caitlin Rayman, Federal Highway Administration</i> <i>Rolf Schmitt, Bureau of Transportation Statistics</i>
10:45 – 11:00	Break
11:00 – 11:45	State and MPO Perspectives on Need for Freight Research <i>Erik Johnson, Virginia Department of Transportation</i> <i>Tom McQueen, Georgia Department of Transportation</i> <i>Kermit Wies, Chicago Metropolitan Agency for Planning (retired)</i>
11:45 – 12:30	Local and Private Sector Perspectives on Need for Freight Research <i>Stacey Hodge, New York City Department of Transportation</i> <i>Ken Allen, HEB Grocery Company (retired)</i> <i>Tina Casgar, San Diego Association of Governments</i> <i>John Gray, Association of American Railroads</i>
12:30 – 1:15	Lunch (provided)
1:15 – 2:30	Future Freight Research Topics <i>Introduction followed by small group discussions</i>
2:30 – 3:15	Future Freight Research Topics – Report Back <i>Small groups report back, with research topic priorities</i>
3:15 – 3:30	Break
3:30 – 4:15	Demonstration of NCFRP 48 website and new NAS website
4:15 – 4:30	Closing Remarks

NCFRP 48 Peer Exchange Workshop Attendees

Name	Organization	Email
Bala Akundi	Baltimore Metropolitan Council	bakundi@baltometro.org
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Kermit Wies	Chicago Metropolitan Agency for Planning (retired)	wieskw@live.com

Appendix E. Website User Guide

Section 1. Introduction and Overview

A major objective of NCFRP Project 48 is to facilitate easy access to NCFRP products by creating a web-based tool that is customized to the needs of freight transportation practitioners, researchers, and stakeholders. The tool, currently available in beta version at <https://ncfrp48-stage.icfwebservices.com/NCFRP48/reports/>, allows users to search within a number of research documents related to freight policy, planning, and programming activities, and will return research findings and other information that can assist with their research activities. The site will likely move to a permanent host, with a different URL (web address), in the future.

This manual describes the website’s purpose, how to access it, and its functions. Previous work on the project developed the preliminary web-development materials and the subject matter to the point that development could begin. This work is described in detail in the first deliverable on the project, a document entitled “NCFRP Technical Memorandum 1”, which was submitted to TRB in mid-2014.

In Section 2 of this user manual, we give an overview of the website and discuss main features, as well as present the sitemap. Section 3 details the site’s pages and content.

Section 2. Web Tool Overview and Site Map

The Web Tool’s functionality is designed around its main purpose: to house, and make easily accessible, research related to transportation freight. The web tool’s Home Page is the starting point for most visitors to the site. The Home Page facilitates access to NCFRP products in multiple ways:

- 4) **Select a report (or project) by name and number.** From the Home Page, the user can click on the “NCFRP Reports” link in the top navigation. This page lists all the NCFRP reports (or projects). By clicking on a report’s title, the “Report Detail” page appears, which displays a report summary, other publication details (date of publication, number of pages, author, etc.), a link to the report PDF, and additional links to buy a print version or create a sponsor order from the TRB site.
- 5) **Keyword search.** An additional option to locate relevant report results allows search by any word or phrase. The web site search function performs a keyword search of the body of completed NCFRP reports (in PDF) that are included on the site, and displays research results. The user can click on search results to bring up the NCFRP Reports page, with a list of reports containing the keyword or synonyms.
- 6) **Identify research by category.** An alternative search method, available towards the bottom of the home page, allows the user to select a research Topic, Mode, and/or Geographic Scale. All NCFRP reports on the site are classified according to their

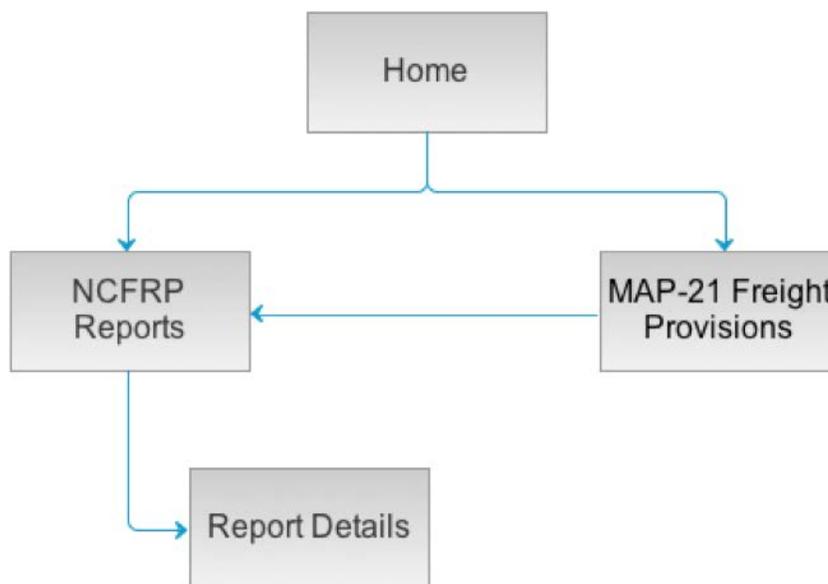
relevance along these three dimensions. After selecting a link under Topic, Mode, or Geographic Scale, the web site will display the associated reports, ranked by relevance. A user can then select an individual report to proceed to the Report Details page.

Some users may wish to first view the freight provisions of MAP-21, and use this to identify relevant NCFRP products. For these users, a link on the Home Page brings users to a listing of the MAP-21 Freight Provisions and corresponding NCFRP research Topics. The research team’s assignment of Topics to MAP-21 freight provisions is included on the far right column on the MAP-21 Freight Provisions page. By clicking on a Topic, the user can view ranked report results similar to those describe above for a Topic search.

A site map was prepared to display the basic site content hierarchy (see

Figure E-1). The site map is intended to demonstrate a high-level view of the site structure.

Figure E-1. NCFRP Web Tool Site Map



The sitemap served as one of the key tools in the development of the final web tool, which is described in detail in the next section.

Section 3. NCFRP Web Tool Pages and Functions

The NCFRP Web Tool has three main pages, designed to allow easy access to a growing body of research of related to transportation freight research. These pages are always available from the top navigation search toolbar: the Home Page, the NCFRP Reports page, and the MAP-21 Freight Provisions page. Each page is detailed below.

The Home Page

The Home Page (Figure E-2) allows easy access to all site features, including reports, search, and the MAP-21 Freight Provisions page. The home page’s main features are described in the remainder of this section, as they are laid out vertically from top to bottom on the page.

Figure E-2. NCFRP Web Tool Home Page



Browse the still-growing body of research produced by the NCFRP program.

<h4>Research Topics</h4> <ul style="list-style-type: none"> Air quality impacts Data Economics/benefit-cost analysis Economics development impacts Institutional/organizational arrangements Land use impacts Modeling/forecasting Operations - current practices Operations - efficiency improvements Other environmental and community impacts Performance measurement Regulatory issues Resiliency Revenue/finance Safety Security Stakeholder involvement Technology (new) 	<h4>Mode</h4> <ul style="list-style-type: none"> Air Corridor Inland waterway Intermodal Marine/ocean Pipeline Rail Truck 	<h4>Geographic Scale</h4> <ul style="list-style-type: none"> International National Port State or multi-state Terminal or facility Urban or metropolitan
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In the top navigation bar, which is persistent (i.e., available from all site pages), there are links to the two other main site pages: the “NCFRP Reports”, and the “Map-21 Freight Provisions” pages. A direct search entry panel is located at the far right. The bar shown in Figure E-3.

Figure E-3. The Site Navigation Bar, which is persistent on all pages

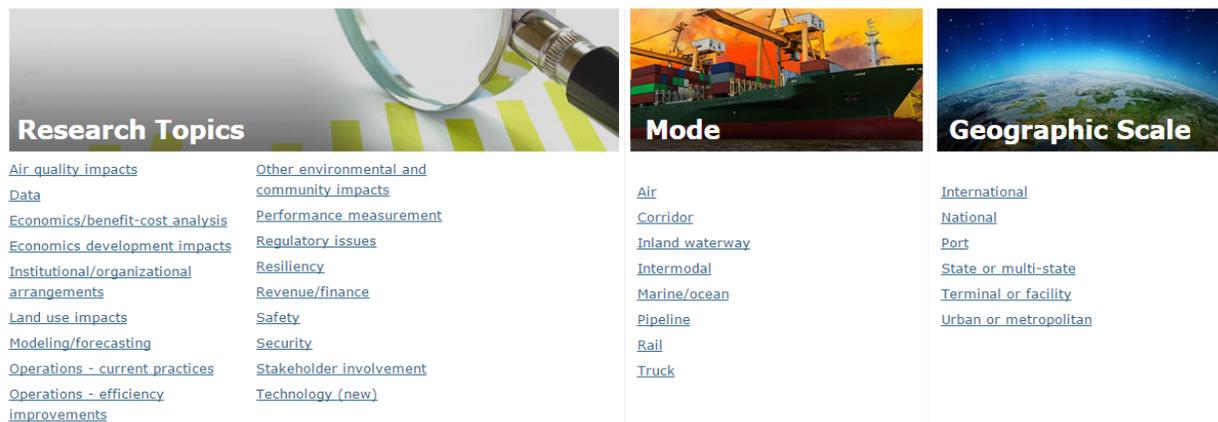


Beneath the header on the main page, there is explanatory text to allow users to understand the purpose of the site. At the bottom, there is a section entitled “Browse the still-growing body of research produced by the NCFRP Program”. This section is divided into three horizontal columns, labeled “Research Topics”, “Mode”, and “Geographic Scale”.

Each of these columns, as shown in Figure E-4, contain keywords that are search terms for the site’s NCFRP reports. A user can simply link click on any of the links below the three vertical sections, and they will be taken to a page containing a list of the relevant reports for that topic.

Figure E-4. Direct links to search results for terms related to Research Topics, Mode and Geographic Scale, in the "Browse" section.

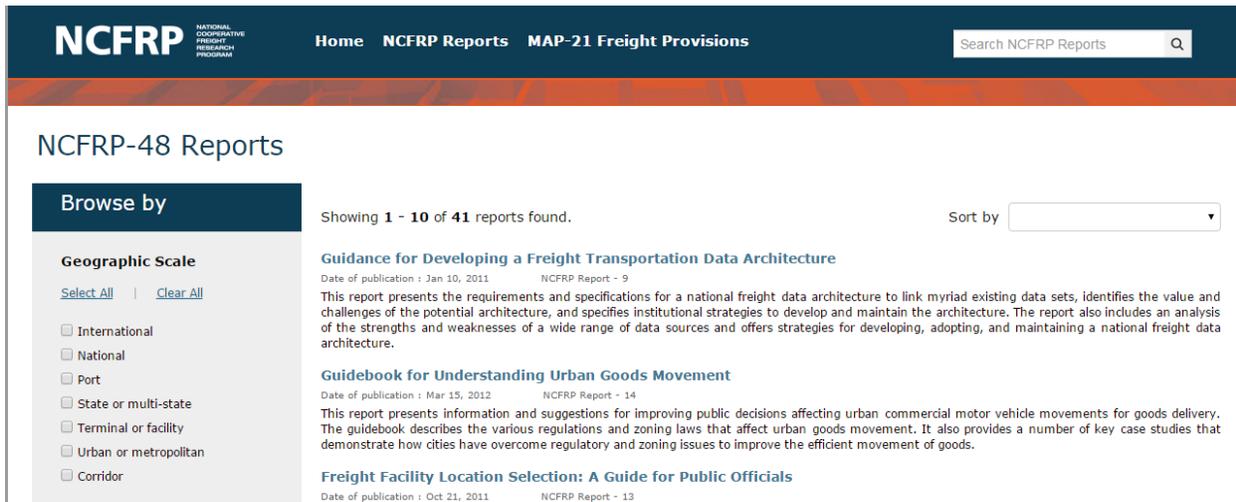
Browse the still-growing body of research produced by the NCFRP program.



NCFRP Reports Page

Users have direct access to the NCFRP Report page/report database by clicking on the “NCFRP Report” link in the top navigation, as well as any of the searchable links at the “Browse the still-growing body of research produced by the NCFRP” section of the Home Page. When any of these links on the main page are clicked, it will open a new page with the reports. Currently, there are a total of 41 reports included in the database as of January 2016. However, additional reports can be added as needed in the future, to keep the database up to date. The initial view of the NCFRP Reports page can be viewed in **Error! Reference source not found..**

Figure E-5. NCFRP Reports Page



On this page, the user will see only ten reports at a time. At the bottom of the page, there are links to view the next (or previous) ten reports.

One useful site feature is a “Sort by” filter option on the top right (Figure E-6), which enables the user to sort the by Report Number, Relevancy, and Publication Date.

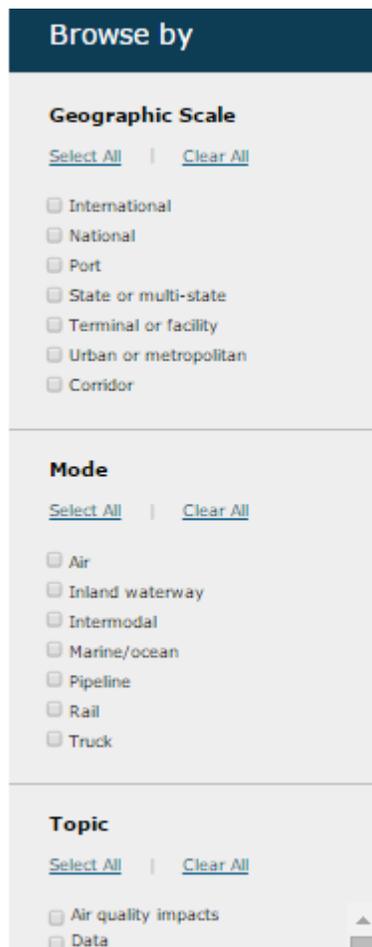
Figure E-6. "Sort By" feature to allow report sorting



Another feature is a set of filters on the left side of the page. Using this filtering tool, the user can filter the reports based on three categories available. In addition, there is another, more powerful filtering tool located on the left side of the page. Multiple filters in multiple categories can be selected, allowing much more powerful and detailed filtering.

The filter menu is displayed in Figure E-7.

Figure E-7. "Browse By" section containing filter options for search results



Browse by

Geographic Scale
[Select All](#) | [Clear All](#)

- International
- National
- Port
- State or multi-state
- Terminal or facility
- Urban or metropolitan
- Corridor

Mode
[Select All](#) | [Clear All](#)

- Air
- Inland waterway
- Intermodal
- Marine/ocean
- Pipeline
- Rail
- Truck

Topic
[Select All](#) | [Clear All](#)

- Air quality impacts
- Data

The list of reports contains the title in hyperlink, date of publication, NCFRP number, and a summary description as seen in Figure E-8.

Figure E-8. Reports page displaying report title, summary, publication date and report number.

NCFRP-48 Reports

Browse by

Geographic Scale

[Select All](#) | [Clear All](#)

- International
- National
- Port
- State or multi-state
- Terminal or facility
- Urban or metropolitan
- Corridor

Mode

[Select All](#) | [Clear All](#)

- Air
- Inland waterway
- Intermodal
- Marine/ocean
- Pipeline
- Rail
- Truck

Showing **1 - 10** of **41** reports found. Sort by

Guidance for Developing a Freight Transportation Data Architecture
Date of publication : Jan 10, 2011 NCFRP Report - 9

This report presents the requirements and specifications for a national freight data architecture to link myriad existing data sets, identifies the value and challenges of the potential architecture, and specifies institutional strategies to develop and maintain the architecture. The report also includes an analysis of the strengths and weaknesses of a wide range of data sources and offers strategies for developing, adopting, and maintaining a national freight data architecture.

Guidebook for Understanding Urban Goods Movement
Date of publication : Mar 15, 2012 NCFRP Report - 14

This report presents information and suggestions for improving public decisions affecting urban commercial motor vehicle movements for goods delivery. The guidebook describes the various regulations and zoning laws that affect urban goods movement. It also provides a number of key case studies that demonstrate how cities have overcome regulatory and zoning issues to improve the efficient movement of goods.

Freight Facility Location Selection: A Guide for Public Officials
Date of publication : Oct 21, 2011 NCFRP Report - 13

This guide describes the key criteria that the private sector considers when making decisions on where to build new logistics facilities. It also suggests best practices for transportation, land use, economic development, and regional partnerships. With this insight, public sector agencies may successfully plan for, attract, locate, and partner with freight-related activities in their jurisdictions.

Guidebook for Sharing Freight Transportation Data
Date of publication : Jun 3, 2013 NCFRP Report - 25

This guidebook provides a series of guidelines for sharing freight data, primarily between public and private freight stakeholders. The guidebook identifies barriers and motivators to successful data sharing, offers guidelines for freight data sharing, and provides two successful case study examples. The guidebook also provides examples of data-sharing agreements.

Making U.S. Ports Resilient as Part of Extended Intermodal Supply Chains
Date of publication : Aug 6, 2014 NCFRP Report - 30

This report provides a set of high-level guidelines, illustrated by two case studies, that will help seaport authorities (as well as departments of transportation in states where such ports are located) to minimize lost throughput capacity resulting from a major disruption. The report identifies and elaborates on the steps needed to coordinate freight movements through ports in times of severe stress on existing operating infrastructures and services.

Report Detail Page

Clicking on the title hyperlink for a report allows the user view a detailed description page for the report. It displays the Publication Date, Author or Authors, Report Number, the Number of NCFRP Projects related to this report, Research Topics, Mode, and Geographic Scale. It provides options for the user to download the report in PDF format, or to buy print or sponsor orders directly from the TRB website. There is also a thumbnail of the report cover on the left of the description. Additionally, the summary and table of contents of the report are included. An example Report Detail page can be viewed in Figure E-9.

Figure E-9. NCFRP Report Detail Page

NCFRP Reports

[« Back to reports list](#)



Guidance for Developing a Freight Transportation Data Architecture

Publication Date:	Jan 10, 2011
Author(s):	TEXAS TRANSPORTATION INSTITUTE, THE TEXAS A&M UNIVERSITY SYSTEM
Report number:	9
NCFRP project that resulted in this report:	12
Research topics:	Data
Mode:	Marine/ocean, Intermodal, Truck, Rail, Inland waterway, Air
Geographic Scale:	

[Download Report \(PDF, 0MB\)](#) | [Buy Print](#) | [Sponsor Order](#)

Summary

This report presents the requirements and specifications for a national freight data architecture to link myriad existing data sets, identifies the value and challenges of the potential architecture, and specifies institutional strategies to develop and maintain the architecture. The report also includes an analysis of the strengths and weaknesses of a wide range of data sources and offers strategies for developing, adopting, and maintaining a national freight data architecture.

Table of Contents

NCFRP Report 9 Project 12 Specifications for Freight Transportation Data Architecture

Summary

Chapter 1 Introduction
Background
Research Objectives

Chapter 2 Data Sources, Systems, and Architectures
Introduction
Data Sources
System and Architecture Review
General Observations and Lessons Learned

MAP-21 Freight Provision Page

The final major section of the site is the Map-21 Freight Provision page (Figure E-10), which provides the user the details of the laws related to National Freight policy. The main feature of the page is a table displaying Map-21 Sections, U.S. Code, Short Title, Description, and Relevant NCFRP-48 Topic Areas. The first four column headers are locations and descriptions for the related MAP-21 Freight Provisions in US Federal legal code. The last columns provides searchable fields to find related NCFRP reports in the website database. By clicking these links, the user is taken to the NCFRP Reports page, which will display the relevant report results.

Finally, the MAP-21 Freight Provision page provides a PDF version of the MAP-21 legal code.

Figure E-10. MAP 21 Freight Provision Page

MAP-21 Provisions

The table below lists the freight-related provisions of MAP-21 and provides search terms for identifying relevant NCFRP research products. Clicking on a particular search term in the table will perform a search for NCFRP products that address that topic. [View MAP-21 law \(PDF, 1.3MB\)](#).

MAP-21 Section	US Code	Short Title	Description	Relevant NCFRP-48 Topic Areas (Click to search reports)
Sec. 1115	23 USC 167	National Freight Policy	Establishes a policy to improve the condition and performance of the national freight network to provide the foundation for the United States to compete in the global economy and achieve goals related to economic competitiveness and efficiency; congestion; productivity; safety, security, and resilience of freight movement; infrastructure condition; use of advanced technology; performance, innovation, competition, and accountability in the operation and maintenance of the network; and reduction of environmental impacts.	<ul style="list-style-type: none"> Economics/benefit-cost analysis Operations - efficiency improvements Safety Security Resiliency Technology (new) Air quality impacts Other environmental and community impacts
Sec. 1115	23 USC 167	National Freight Network	Requires DOT to establish a national freight network to assist States in strategically directing resources toward improved movement of freight on highways.	<ul style="list-style-type: none"> Economics/benefit-cost analysis
Sec. 1115	23 USC 167	National Freight Strategic Plan	Directs DOT to develop a national freight strategic plan and to update the plan every five years. The plan must – <ul style="list-style-type: none"> assess the condition and performance of the national freight network; identify highway bottlenecks that cause significant freight congestion; forecast freight volumes; identify major trade gateways and national freight corridors; assess barriers (statutory, regulatory, technological, institutional, financial, other) to improved freight transportation performance; identify routes providing access to energy areas; 	<ul style="list-style-type: none"> Modeling/forecasting Performance measurement Air quality impacts Other environmental and community impacts Operations -