The Exploratory Advanced Research Program

EXPLORATORY ADVANCED RESEARCH

# National Multimodal Freight Analysis Framework Research Workshop

WORKSHOP SUMMARY REPORT • December 11, 2013

U.S. Department of Transportation
Federal Highway Administration

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# Technical Report Documentation Page

| | | | | | |
|---|---|---|---|---|---|
| 1. Report No.<br>FHWA-HRT-14-054 | 2. Government Accession No. | | 3. Recipient's Catalog No. | | |
| 4. Title and Subtitle<br>National Multimodal Freight Analysis Framework Research Workshop<br>Workshop Summary Report, December 11, 2013 | | | 5. Report Date<br>January 2015<br>6. Performing Organization Code: | | |
| 7. Author(s)<br>Andrew Berthaume and Tom Morton | | | 8. Performing Organization Report No. | | |
| 9. Performing Organization Name and Address<br>U.S. Department of Transportation Volpe Center,<br>55 Broadway, Cambridge, MA 02142; and<br>Woodward Communications,<br>1420 N Street, NW, Suite 102, Washington, DC 20005 | | | 10. Work Unit No.<br>11. Contract or Grant No.<br>DTFH61-10-V-00031 and<br>DTFH61-09-F-00027 | | |
| 12. Sponsoring Agency Name and Address<br>Federal Highway Administration<br>Office of Corporate Research, Technology, and Innovation Management<br>6300 Georgetown Pike, McLean, VA 22101-2296<br>Office of Freight Management and Operations<br>1200 New Jersey Avenue, SE, Washington, DC 20590 | | | 13. Type of Report and Period Covered<br>Workshop Summary Report, December 2013<br>14. Sponsoring Agency Code<br>HRTM-30 | | |
| 15. Supplementary Notes<br>FHWA's Contracting Officer's Task Manager (COTM): Zachary Ellis, HRTM-30<br>Technical Contact: Ed Strocko, HOFM-1 | | | | | |
| 16. Abstract<br>This report summarizes a 1-day workshop held to discuss national multimodal freight analysis framework (FAF) research. Participants discussed the state of the art, primary gaps in current capailities, and strategies for addressing these gaps, particularly in the areas of multimodal freight networks, freight-demand modeling, and origin–destination data disaggregation. The workshop was designed to identify a set of topics for further research and to ultimately inform the development of the FAF version 4, scheduled for release in late 2015, and beyond. The objectives of the workshop were to understand the nature and purpose of FAF, outline a vision for the next generation of freight analysis, agree on primary gaps in current capabilities, and create a game plan to address gaps. Expert speakers presented historical background of the FAF, as well as perspectives on the state of the art in three specialized topics covered in focused sessions. | | | | | |
| 17. Key Words<br>Freight analysis framework, Exploratory Advanced Research, multimodal freight networks, models, freight-demand modeling, origin–destination data, next generation freight analysis, research gaps. | | 18. Distribution Statement<br>No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161. | | | |
| 19. Security Classif. (of this report)<br>Unclassified | | 20. Security Classif. (of this page)<br>Unclassified | | 21. No. of Pages<br>36 | 22. Price<br>N/A |

# Executive Summary

On December 11, 2013, at the National Academies of Sciences' Keck Center in Washington, DC, the Federal Highway Administration's Office of Freight Management and Operations and the Exploratory Advanced Research Program hosted a 1-day workshop titled, "National Multimodal Freight Analysis Framework Research."

During the workshop, participants discussed the state of the art, primary gaps in current capabilities, and strategies for addressing these gaps, particularly in the areas of multimodal freight networks, freight-demand modeling, and origin–destination (O-D) data disaggregation. The organizers designed the workshop to identify a set of topics for further research and to ultimately inform the development of the Freight Analysis Framework (FAF) version 4 (FAF[4]), scheduled for release in late 2015, and beyond.

The objectives of the workshop were to:

- Understand the nature and purpose of FAF.
- Outline a vision for the next generation of freight analysis.
- Agree on primary gaps in current capabilities.
- Create a game plan to address gaps.

Expert speakers presented historical background of the FAF, as well as perspectives on the state of the art in three specialized topics covered in focused sessions. The topic sessions included:

- O-D Generation.
- Multimodal Transportation Network Assignment.
- Multimodal Routable Network Development.

Following the presentations on each of these three topics, the participants—including university, public, and private sector researchers—identified and discussed the most significant shortcomings in the current state of the art for national-level freight analysis and modeling and examined promising near- and long-term technical approaches.

**FAF: Gaps in Current Capabilities**

At its inception in the late 1990's, FAF was an internal tool for the U.S. Department of Transportation; however, it has gradually become a national resource of use to other researchers. As the Government develops the next generation of FAF, consideration should be given to both current and potential FAF users, their needs, and other possible applications of the FAF. This analysis will help scope the next generation of FAF for greater utility (e.g., for local and regional planners who need a greater level of granularity) and will identify those dimensions that should remain out of scope (e.g., data that raises privacy concerns should not be included in a publicly available FAF).

Workshop participants identified several opportunities regarding new methods for data, as follows:

- Local-level details (e.g., local O-D data, local network data, local truck, local commodity truck, etc.) are not currently captured in the national FAF. Opening data for peer review and creating an architecture that allows information to be passed from the local level to the national level (i.e., establishing ground truth) could increase data validation.

- Data mining could supplement current national-level freight data to capture temporal and seasonal variations or enable tracking of commodity flows—the current FAF displays only in mode-centric, O-D, and annual flows.
- New automated methods for data manipulation could mitigate the variability of data quality—collected and reported on a State-by-State basis—and missing data, which limit the ability to support analysis of intermodal and national-level freight flows.

Workshop participants also identified potential opportunities regarding enhancing a national-level model for freight analysis, as follows:

- Agent-based modeling could assist with the implications of cost and the volatility of cost over time and insights into mode choice.
- Aforementioned enhanced data could provide the ability to assign flows along a multimodal routable network, creating a "flowable" network, that is, one that enables tracking of flows from any origin to any destination.

# SI* (MODERN METRIC) CONVERSION FACTORS

## APPROXIMATE CONVERSIONS TO SI UNITS

| Symbol | When You Know | Multiply By | To Find | Symbol |
|---|---|---|---|---|
| | | **LENGTH** | | |
| in | inches | 25.4 | millimeters | mm |
| ft | feet | 0.305 | meters | m |
| yd | yards | 0.914 | meters | m |
| mi | miles | 1.61 | kilometers | km |
| | | **AREA** | | |
| $in^2$ | square inches | 645.2 | square millimeters | $mm^2$ |
| $ft^2$ | square feet | 0.093 | square meters | $m^2$ |
| $yd^2$ | square yard | 0.836 | square meters | $m^2$ |
| ac | acres | 0.405 | hectares | ha |
| $mi^2$ | square miles | 2.59 | square kilometers | $km^2$ |
| | | **VOLUME** | | |
| fl oz | fluid ounces | 29.57 | milliliters | mL |
| gal | gallons | 3.785 | liters | L |
| $ft^3$ | cubic feet | 0.028 | cubic meters | $m^3$ |
| $yd^3$ | cubic yards | 0.765 | cubic meters | $m^3$ |
| | | NOTE: volumes greater than 1000 L shall be shown in $m^3$ | | |
| | | **MASS** | | |
| oz | ounces | 28.35 | grams | g |
| lb | pounds | 0.454 | kilograms | kg |
| T | short tons (2000 lb) | 0.907 | megagrams (or "metric ton") | Mg (or "t") |
| | | **TEMPERATURE (exact degrees)** | | |
| °F | Fahrenheit | 5 (F-32)/9 or (F-32)/1.8 | Celsius | °C |
| | | **ILLUMINATION** | | |
| fc | foot-candles | 10.76 | lux | lx |
| fl | foot-Lamberts | 3.426 | candela/$m^2$ | cd/$m^2$ |
| | | **FORCE and PRESSURE or STRESS** | | |
| lbf | poundforce | 4.45 | newtons | N |
| lbf/$in^2$ | poundforce per square inch | 6.89 | kilopascals | kPa |

## APPROXIMATE CONVERSIONS FROM SI UNITS

| Symbol | When You Know | Multiply By | To Find | Symbol |
|---|---|---|---|---|
| | | **LENGTH** | | |
| mm | millimeters | 0.039 | inches | in |
| m | meters | 3.28 | feet | ft |
| m | meters | 1.09 | yards | yd |
| km | kilometers | 0.621 | miles | mi |
| | | **AREA** | | |
| $mm^2$ | square millimeters | 0.0016 | square inches | $in^2$ |
| $m^2$ | square meters | 10.764 | square feet | $ft^2$ |
| $m^2$ | square meters | 1.195 | square yards | $yd^2$ |
| ha | hectares | 2.47 | acres | ac |
| $km^2$ | square kilometers | 0.386 | square miles | $mi^2$ |
| | | **VOLUME** | | |
| mL | milliliters | 0.034 | fluid ounces | fl oz |
| L | liters | 0.264 | gallons | gal |
| $m^3$ | cubic meters | 35.314 | cubic feet | $ft^3$ |
| $m^3$ | cubic meters | 1.307 | cubic yards | $yd^3$ |
| | | **MASS** | | |
| g | grams | 0.035 | ounces | oz |
| kg | kilograms | 2.202 | pounds | lb |
| Mg (or "t") | megagrams (or "metric ton") | 1.103 | short tons (2000 lb) | T |
| | | **TEMPERATURE (exact degrees)** | | |
| °C | Celsius | 1.8C+32 | Fahrenheit | °F |
| | | **ILLUMINATION** | | |
| lx | lux | 0.0929 | foot-candles | fc |
| cd/$m^2$ | candela/$m^2$ | 0.2919 | foot-Lamberts | fl |
| | | **FORCE and PRESSURE or STRESS** | | |
| N | newtons | 0.225 | poundforce | lbf |
| kPa | kilopascals | 0.145 | poundforce per square inch | lbf/$in^2$ |

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

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# List of Acronyms and Abbreviations

**General Terms**

| | |
|---|---|
| CFS | commodity flow survey |
| EAR | Exploratory Advanced Research |
| FHWA | Federal Highway Administration |
| FAF | Freight Analysis Framework |
| $FAF^3$ | Freight Analysis Framework version 3 |
| $FAF^4$ | Freight Analysis Framework version 4 |
| FRA | Federal Railroad Administration |
| NCFRP | National Cooperative Freight Research Program |
| ORNL | Oak Ridge National Laboratory |
| O-D | origin–destination |
| USACE | U.S. Army Corps of Engineers |

# Introduction

On December 11, 2013, the Federal Highway Administration's (FHWA) Office of Freight Management and Operations and the Exploratory Advanced Research (EAR) Program hosted a 1-day workshop titled, "National Multimodal Freight Analysis Framework (FAF) Research."

During the workshop, participants discussed the state of the art, primary gaps in current capabilities, and strategies for addressing these gaps, particularly in the areas of multimodal freight networks, freight-demand modeling, and origin–destination (O-D) data disaggregation. The organizers designed the workshop to identify a set of topics for further research and to ultimately inform the development of the FAF version 4 ($FAF^4$), scheduled for release in late 2015, and beyond.

The objectives of the workshop were to:

- Understand the nature and purpose of FAF.
- Outline a vision for the next generation of freight analysis.
- Agree on primary gaps in current capabilities.
- Create a game plan to address gaps.

Expert speakers presented historical background of the FAF, as well as perspectives on the state of the art in three specialized topics covered in focused sessions. The topic sessions included:

- O-D Generation.
- Multimodal Transportation Network Assignment.
- Multimodal Routable Network Development.

Following presentations on these three topics, the participants—including university, public, and private sector researchers—identified and discussed the most significant shortcomings in the current state of the art for national-level freight analysis and modeling and examined promising near- and long-term technical approaches.

# Part One: Presentations

## Welcome, Introductions, and Charge to Participants

**David Kuehn**
*Program Manager, Exploratory Advanced Research Program*
*Federal Highway Administration*
**Ed Strocko**
*Team Leader, Freight Analysis and Research Team*
*Federal Highway Administration*

David Kuehn, Program Manager for the FHWA's EAR Program, opened the workshop by introducing the goals of the workshop and outlining the EAR Program's interest in advancing the state of freight modeling. Kuehn explained that scientific and engineering advances in sensor and probe data, data mining, machine learning, and other computational approaches have the potential to respond to transportation questions about freight data and model improvements to improve investment in and operation of the Nation's highways. In accordance, FHWA would like to identify a set of topics that could be incorporated into future EAR Program solicitations and ultimately inform the development of the FAF[4], scheduled for release in late 2015, and beyond.

Ed Strocko, Team Leader for the Freight Analysis and Research Team at FHWA's Office of Freight Management and Operations, asked participants to help scope the problems and shortcomings surrounding past and current versions of the FAF and identify areas of possible research to improve future iterations of the FAF. FHWA organized the workshop to identify areas of improvement for future versions of the FAF, to determine the level of information required to perform multimodal assessments, and to identify whether the new FAF needs a fully routable network and predictive capabilities.

# **Topic Session 1:** Freight Analysis Framework, Mission, Goal, and Objectives

## Opening Remarks

**Bruce Lambert**
*Executive Director, Institute for Trade and Transportation Studies*
**Rolf Schmitt, Ph.D.**
*Deputy Director, Bureau of Transportation Statistics*
*Research and Innovative Technology Administration*

Bruce Lambert, now Executive Director at the Institute for Trade and Transportation Studies, was a former manager of the FAF study at FHWA. Lambert stated that freight is an essential piece of the national economy and must be considered in transportation systems analysis. The FAF was originally created to inform Federal-level users, but over time diverse groups (e.g., planners and shipping companies) began to use the FAF. Lambert explained that users of the FAF today have a range of different requirements. As a result, he suggested that the major question FHWA needs to investigate is, "How do we make the FAF relevant to address users'—both internal and external to the U.S. Department of Transportation—many different requirements?"

Rolf Schmitt, Deputy Director of the Bureau of Transportation Statistics (formerly with the Office of Freight Management and Operations), added that the FAF went from a "what if?" tool to a "what is?" tool, meaning that it is more of a reference tool than a predictive tool. Schmitt noted the FAF needs a complete O-D matrix, based on all obtainable freight-related information, to get the clearest picture of O-D patterns possible. This O-D matrix is then converted into flows on a network, which can be used to answer forecasting "what if?" questions.

Schmitt noted that there are significant problems with data collection and aggregation on a national scale, which limit the level of detail and accuracy in the resulting O-D matrices. These problems limit the ability to disaggregate FAF flows to the county level, a problem that is counterintuitive when considering the FAF is created by the aggregate data collected at these levels.

In summary, Schmitt stated that FAF accuracy should be assessed and compared against a benchmark (and asked what that benchmark should be) to gauge how accurate the FAF needs to be. Schmitt also noted a recent National Cooperative Freight Research Program (NCFRP) report describing collection and integration of local data on the aggregate data that FAF can provide. This report, *NCFRP Report 25: Freight Data Sharing Guidebook,* can be viewed at http://onlinepubs.trb.org/onlinepubs/ncfrp/ncfrp_rpt_025.pdf.

## Next Generation Freight Analysis Framework Activities

**Peter Bang, Ph.D.**
*Freight Analysis Framework Program and Data Manager*
*Federal Highway Administration*

Peter Bang, FAF Program and Data Manager and member of the FHWA Office of Freight Management and Operations' Freight Analysis and Research Team, presented background information on the FAF mission and questions to be answered. According to Bang, the FAF today provides a big picture of goods movements and truck transportation throughout the United States. The FAF supports national freight policy decisionmaking by establishing known O-D flows across the country; however, there are limitations with this tool, including:

- **Incorporating current data**. The current FAF lacks the ability to incorporate more "real-time" data and information.
- **Providing insight**. There are no predictive elements to address "what if?" scenarios for national policy decision support. This limits the FAF's ability to provide multimodal, multiclass solutions and to provide insight in terms of causal freight relationships and future estimations.
- **Understanding variables**. It is difficult to use the FAF to understand variables such as the effect of fluctuating gas prices, the impact of an energy policy change, the impact of a pilot or truckers' strike, seasonal fluctuations (e.g., harvest and weather), and the impact of a port shutdown. These variables tend to be multimodal, have cause and effect relationships, and can be local or national.
- **Ongoing maintenance**. The FAF experiences a complete overhaul every 5 years to address data consistency and reproducibility issues. The maintenance and update procedure needs to be modular and requires a level of systemization and openness.
- **Addressing regional and local needs**. The FAF cannot be used to address concerns at a level of granularity more detailed than annual statewide flows and therefore cannot be used to address growing regional and local needs.

According to Bang, there are many ways in which the FAF can be improved. For example, it could be useful to enhance the FAF to provide users with some level of understanding regarding freight movements at the regional level to inform local freight studies and projects. Creating and maintaining this level of granularity might require a transparent model, an open model and data sharing, and public participation.

Bang stated that the FAF mission for tomorrow is to provide an analysis tool that can capture details within the big picture of national goods movements. The current FAF structure is created using a survey-based, hybrid O-D construction process. Bang proposed a future alternative structure for the FAF that is based on a multimodal, travel-demand model.

Bang went on to identify three categories of questions that needed to be addressed during the workshop, as follows:

- **O-D Data Generation**. What is the future for the FAF structure? Will the FAF become a set of comprehensive travel-demand modeling tools? What kind of data need to be collected and in what format, from what, and for whom?
- **National Multimodal Assignment**. What are the traffic assignment and mode choice techniques? What about FAF adaptation and localization?
- **Multimodal Routable Network**. Should the model be nationwide, multimodal, or multiclass? Should it include a routable network for everyone?

## Open Discussion

Following the presentations, participants provided feedback in an open discussion. The following is a summary of the key points made:

- Looking toward the future, FHWA should be mindful of the need to capture commodity flows. To address this need, commodity flow surveys (CFSs) could produce a micro-flow file based on shipment flow records (rather than the status quo of region-to-region tables by attributes).
- FAF version 3 ($FAF^3$) and FAF version 2 have been used as a data source for a number of analyses; however, they never generated a complete, free-standing freight-demand model. They could never provide the complete picture and always required additional inputs to perform meaningful analyses. For example, FAF users never had the ability to see how widening the Panama Canal would alter freight flows across the Nation.
- Modeling comes down to calibration and validation. A model is only as good as the dataset from which it is constructed; therefore, any model created is only as accurate as the data collected. A supply-chain model would be a huge step forward in making use of data that is currently available. Releasing this model to the public could also give FHWA free peer data. The ability to provide a forecast based on data that are publicly available would be a significant improvement.

# **Topic Session 2:** Origin-Destination Generation

## Opening Remarks

**Ho-Ling Hwang, Ph.D.**
*Center for Transportation Analysis*
*Oak Ridge National Laboratory*

Ho-Ling Hwang, of the Center for Transportation Analysis at Oak Ridge National Laboratory (ORNL), presented a high-level approach and considerations regarding the generation of O-D data in $FAF^3$ and associated challenges. Hwang explained that $FAF^3$ O-D data, specifically the estimates of base year tonnage and value for domestic shipments, are built on data from the 2007 CFS. A large number of CFS O-D cells are suppressed, due to disclosure issues or concerns related to publication standards, so it is necessary to use a modeling approach to fill gaps and missing information when generating the $FAF^3$ O-D matrix for domestic movements. In addition to the CFS-based domestic shipments, Hwang explained that the FAF also integrates other data sources for many out-of-scope CFS components (e.g., farm-based agricultural shipments and imports). Hwang noted that, to maintain transparency for the FAF O-D data, these other data sources are mostly public data. These data are incorporated into models to accomplish mode share and geographic assignment needs.

Hwang explained that base year ton–mile data are estimated by using modeling approaches that disaggregate tonnage from FAF zones to counties. These disaggregated county-level tonnages are then multiplied by route distance. This is estimated by mode on the multimodal network systems to generate ton–mile estimates. Base year O-D data, including tonnage, value, and ton–mile by commodity by mode, are used for estimation of forecasts and truck network assignment.

Hwang highlighted that there are major challenges regarding the generation of FAF O-D flows. For example, there is currently insufficient information regarding domestic movements of foreign goods (i.e., imports and exports), specifically in terms of mode choice, mode-sharing, and the geographic detail of U.S. origin (exports) and U.S. destination (imports). In addition, Hwang noted that a level of detail and validity is a concern when FAF users try to look beyond FAF zones and attempt to "cut and slice" the FAF for local applications. A challenge for FAF users is how to integrate locally collected information, either with FAF or to supplement FAF. An additional challenge is how to seamlessly stitch together data from various sources. Hwang stated that the approach of simply combining data could create numerous problems, because local datasets are collected by local agencies and may include varying levels of accuracy, levels of detail, and specific definitions of data. Other data needs featured during Hwang's presentation included the distribution of shipment distance by commodity carried (e.g., for out-of-scope shipments).

## Open Discussion

Following the presentation, the presenters asked participants to provide their feedback in an open discussion. The group discussed problems and potential solutions, which are summarized below.

***Problem A: Privacy and intellectual property concerns create data restrictions for data included in a publicly released model. These data restrictions limit the capabilities of a model.***

Participants discussed several specific concerns within this problem area, as follows:

- **Confidentiality constrictions**. Privacy concerns may require that publicly available datasets are reduced to protect privacy or to avoid intellectual property issues.
- **Restricting data**. Participants noted that the agencies that currently collect data could provide insight regarding what datasets can be released to the public (based on the governing rules laid out when the data were collected). A potential first step could be to look at agency regulations to see what data can be released. Questions should include, Is the data internal? Can it be released? As an example, participants highlighted that business income tax data with restrictive regulations might provide some insight and be applicable to a host of highway and railway datasets.
- **Protecting trade secrets**. Karen McClure indicated that these issues also exist within the Federal Railroad Administration (FRA). Details relating to the business operations of a particular shipper cannot be released to the public (to protect their business information). Without this information, however, the remaining dataset has limited capabilities. To account for these privacy and intellectual property issues while maximizing the usefulness of the remaining dataset, McClure explained that the FRA developed some tools that make some of this processed information available to the States. These tools are designed to help States identify the major points for each State without revealing business-specific information.
- **Disaggregating data**. The FAF ultimately needs to be able to disaggregate data to the county level, maintain a quality and level where it would be useful, and remain mindful of privacy and intellectual property concerns.

Participants discussed the following solutions to address privacy and intellectual property concerns.

***Solution A1: Create and distribute different datasets or different models for different user groups.***

Providing different models, with different datasets, for different user groups could be an optimal solution to the privacy problem, thereby limiting the distribution of sensitive information. During discussion, participants suggested that there could be two sets of data: one for Federal internal use and one that would consist of input data for different external user groups. To make this work, an internal Federal freight group could be established; however, a meta-data framework and a mechanism to perform meta-data review would be needed.

Models and input data ultimately could be created separately and distributed separately, catering to the specific needs (e.g., level of detail, datasets included, and model capabilities) and addressing the potential privacy concerns of each FAF user group.

***Solution A2: Synthetic Data.***

By using a synthetic dataset, participants confirmed that it might be feasible to capture the required level of detail at an appropriate level of accuracy in a publicly released model, without violating privacy and intellectual property policy issues.

One of the biggest concerns regarding synthetic data relates to whether data appear realistic and what level of accuracy a synthetic dataset needs to have to be considered useful. Participants also questioned at what level are the data wrong. During discussion, it was noted by participants that there are ways to generate data synthetically. For example, synthetic data are currently being used in California; however, the most difficult aspect is validating and calibrating such data. The validity of such a dataset is affected directly by the quality of the data from which the synthetic dataset is constructed.

Participants commented that synthetic data would need to be validated against local data and local understanding of freight activity.

***Problem B: Quality and type of data collected and data available are inadequate to serve current needs.***

Participants discussed several specific concerns within this problem area, as follows:

- **Improving available data**. One of the recurring themes throughout this workshop was that the quality, type, availability, and granularity of the data collected across the Nation are inadequate to serve the Government needs. Workshop participants stated that a higher quality national-level model cannot be developed without first improving available data. Areas for improvement include:
    - Uniformity of data collected (e.g., State-by-State and region-by-region, with variations in the data that are collected).
    - Granularity of data collected.
    - Type of data collected.
- **Improving accuracy**. Some local, regional, and State agencies adjust the data included in the FAF; however, these data adjustments remain at the local level and often are not passed back up to the Federal level. As a result, the base model remains inaccurate. Additional information is available, but there are no frameworks or incentives currently available to feed this information back up the chain. As a result, an opportunity is lost to make the model more accurate.
- **Improving decisionmaking**. In some instances, there is already State-level aggregation of data to help inform local agencies, short-line railroads, and others to improve coordination and decisionmaking on a local level. Releasing information could create data misuse or abuse concerns (e.g., companies who misuse the data to gain an unfair advantage from a competitor); however, the participants made the point that data released at any level could raise

these concerns to one degree or another, and that the threat of misuse should not impede the Federal effort in creating a more efficient model to improve the freight network. Participants ultimately noted that the optimal solution would involve communicating this information to the public without putting any agency, company, or business at risk. In addition, the goal is to optimize the system by improving decisionmaking abilities.

- **Incorporating real-time updates**. Participants highlighted that there is no mechanism in place to facilitate the timely reporting of data. If data could be updated in the model more frequently, then the model could prove more useful.

Other data-related problems and concerns that participants voiced during this session included:

- **Incorporating geographical data**. The lack of these data in the current version of the FAF means that users are not able to identify areas of high activity and what percentage of that freight activity is inbound or outbound.
- **Incorporating O-D data**. Another problem highlighted by the group is the overall lack of sufficient O-D data for public use.

Participants discussed the following short- and long-term solutions to address data collection and quality concerns.

***Solution B1: Short-term research.***

- Develop a tool in which users would be responsible for approaching agencies and obtaining the data directly (this would remove restrictions based on data-sharing and privacy).
- Establish an agreement or terms of use to restrict misuse of data. This could be accomplished by implementing a fine or other penalty designed to deter misuse of data and misuse of the system.
- Emulate California's aggregated data and create a database to distribute it statewide. The Online California Freight Data Repository can be viewed at http://freight.its.uci.edu/calfred/.

***Solution B2: Long-term research.***

- Develop new techniques for disaggregation for modeling purposes. Participants noted that this was key to addressing the problem.
- Develop a methodology or system in which peers submit data to allow agencies to share data at a level at which they feel comfortable.
- Capture levels of activity in an area and make adjustments to the network based on localized freight volumes.

# **Topic Session 3:** National Multimodal Network Assignment

## Opening Remarks

**Kenneth ("Ned") Mitchell, Ph.D.**
*U.S. Army Corps of Engineers*
**Karen McClure**
*Federal Railroad Administration*

Ned Mitchell of the U.S. Army Corps of Engineers (USACE) shared his experiences regarding freight and port activity. To identify and monitor port activity (for port dredging and maintenance), Mitchell worked with Doug McDonald and the USACE Navigation Data Center. The Navigation Data Center details waterway data, allowing users to look at the system as a whole.

To answer questions regarding multimodal travel, Mitchell has worked with Ho-Ling Hwang at ORNL, where they were able to aggregate domestic flows and other modes. Mitchell explained that this aggregate dataset will give USACE insight into the system function as a whole and will help determine the impact that U.S. waterways play on freight. He noted that this aggregate dataset will allow USACE to maintain and create waterway infrastructure to suit the needs and demands of the region. Mitchell went on to highlight that to assess multimodal freight movement accurately, it is vital to maintain detailed waterway data and to reconcile this information with land-based datasets, making connections into a workable analysis.

Karen McClure of FRA talked about an existing O-D matrix maintained by FRA. McClure explained that the matrix is accurate, contains commodity O-Ds, and provides insight regarding the flow of these commodities along a rail network. This matrix gives the most accurate look along well-established and heavily traveled corridors.

Current issues noted by McClure involve assigning an O-D matrix to a rail network. Although it is known that commodity flows may occur along the links of a well-traveled corridor or major corridor, existing datasets only include reported car volumes and tons of freight on an annual level (total values per year). There is no monthly, seasonal, daily, or hourly breakdown of these data. McClure noted that seasonal fluxes in commodity flows are not captured, and therefore fluxes in demands cannot be considered when attempting to alleviate highway congestion caused by freight movements. For logistics planners to effectively divert fluxes in truck volume, it is important for national freight data to identify modal supply costs.

In summary, McClure stated that to plan and facilitate multimodal freight shipments using the FAF, the next generation should provide some insight regarding the size of these multimodal nodes and facilities. This information should include the number of tracks and cars that can be used.

McClure also noted that including only yard sizes in the next-generation FAF would not provide sufficient insight for planning multimodal travel; however, yard sizes would be ideal for classification purposes. At a bare minimum, the location and size of intermodal yards and any highway access to a yard (not just rail access to a yard) would be required to use the FAF for any level of planning. From a modeling standpoint, McClure claimed that this could begin to answer some of the high-priority questions, particularly about how to link the rail network to the highway network.

McClure informed participants that intermodal terminal locations and the rail network are available on the ORNL Web site in various formats. In addition, an intermodal facility database exists (including highway-to-rail, water-to-rail, and air-to-rail); however, McClure noted that this database needs to be updated and that the current update procedure is to use the *Official Railway Guide* and to convert text into updates.

## Open Discussion

Following the presentation, presenters asked participants to provide their feedback in an open discussion and to highlight several problems. The following is a summary of these problems.

***Problem A: Multimodal, trans-modal, intermodal, and mode-split analysis need to be assessed and addressed in the next generation of FAF.***

Introducing multimodal, trans-modal, intermodal, and mode-split analysis capabilities into the FAF requires the incorporation of additional datasets. These will include commodity-specific variables, the impacts of other modal users (and potential impacts created by a mode shift of these modal users), a detailed financial breakdown of each system and mode (the cost of each system), and the timeframe for each of these modes.

Workshop participants highlighted that the Government cannot model these impacts without first understanding them; however, the Government cannot fully understand them without thorough data collection and aggregation. Participants also noted that State-by-State variances in some reported data creates fluxes in data quality; thus, the Government actually cannot get a clear picture of the status quo by using currently available datasets.

An attendee inquired whether the FRA had publicly available information regarding rail yards in terms of flows, size, and ability to serve as a multimodal node. McClure identified a quarterly publication that provides insight into which rail yards were built to service intermodal operations, including detailed rail yard information. The publication, *Official Railway Guide* (https://ubm-sub.halldata.com/site/UBM000455LUnew/init.do), could theoretically be turned into a database, although McClure indicated that this would take an incredible effort. McClure noted there is a rail yard database compiled for security purposes; however, this database is not integrated with other modes.

***Problem B: To model multimodal, trans-modal, intermodal, and mode-split shipments, a better understanding of modal operations across the country needs to be established. To develop the required understanding, a higher quality dataset needs to be collected from regions across the country.***

To model multimodal, trans-modal, and intermodal shipments, or the mode-split choices of different shipments accurately, the variables that impact modal decisionmaking in freight must first be known and understood. To develop a working understanding, a national, uniform, detailed dataset must be collected from across the country. These data should include and provide insight into the following items:

1. **Commodity flows along the network and commodity-specific variables including:**

- Demands and variations in demand for each commodity.
  - Seasonal, monthly, weekly, and daily.
- Restrictions and requirements regarding how each commodity needs to be transported (e.g., hazardous materials, perishable goods).
  - This includes items that can or cannot be transported together and transport container requirements.
- Time sensitivity regarding the shipment of certain commodities.
  - Any seasonal variations in the time-sensitive nature regarding the transport of these commodities.
  - This includes perishable goods and shipments that must be delivered to their destination prior to a major deadline (e.g., "Black Friday").
- Shipment sizes.
  - Tonnage, volume, and quantity of each shipment.

2. **Seasonal and time-specific variations of the flows along each link, including:**

- Vehicle–miles traveled.

3. **Cost and variations within the cost, including:**

- Labor costs and shipping costs for each mode.
- Time-based variations in the cost (e.g., time of day, day of week, month of year, season).
- Establishment of a freight-specific economic model that could grant the user forecasting capabilities.
- Granularity of this information is vital to establish a true working model.

4. **Timeframes for transport along the links of each mode, including:**

- Turnover times and total delivery time.
  - Variable value of time for different commodities.
- This would include any "dwell time" or time required to transfer goods to another mode and any delays that might be incurred along the trip.
  - Includes the location, capacity, and abilities of multimodal transfer nodes throughout the country.

5. **Understanding how these different elements interact, including:**

- How does commodity flow impact overall cost and pricing along each mode or time frames for shipment across each mode?

Participants noted that with modal decisions, the forecasting abilities of the model, or "what if?" scenario analysis capabilities of this model, hinge on accurately capturing all of the variables that impact mode split and their interdependencies.

***Problem C: The model should grant insight into the short- and long-term issues.***

Workshop participants noted that, at the micro-level, the model should bring in operational models that railroads themselves use to simulate movement (e.g., a FRA simulator that integrates multiple variables; the Uniform Rail Costing Model). These models, unfortunately, have high data requirements and a high level of expertise is required to use them. Again, one of the major problems here is the quality and quantity of data required.

At the macro-level (long term or strategic), planners need to understand the network and network interactions to make informed decisions geared toward optimizing freight movement across the country. An example of this would be estimating how much money railroads have to invest in infrastructure to handle increases in demand and how this estimate might change to reflect the widening of the Panama Canal. On the basis of current standards, the existing condition of a rail line is not a high concern and therefore is often overlooked in modeling.

# **Topic Session 4:** Multimodal Routable Network

## Opening Remarks

**Katherine Hancock, Ph.D.**
*Associate Professor, Transportation Infrastructure and Systems Engineering*
*The Charles E. Via, Jr. Department of Civil and Environmental Engineering*
*Virginia Polytechnic Institute and State University*

Katherine Hancock, Associate Professor at Virginia Polytechnic Institute and State University, focused on freight operations and planning, transportation safety, and geospatial solutions to transportation problems. Hancock stated that, from a modeling standpoint, it is impossible to have multimodal networks without multimodal assignment. In addition, it is impossible to assess multimodal assignment without multimodal networks. Hancock also noted that the FAF network has only a few attributes, and what is necessary for a true flowable network is not available in the publicly available version of FAF.

According to Hancock, the publicly available public transportation network is not where it needs to be. For example, 12-million values need to be filled for highway alone, and these values are currently missing, with feasibility issues associated with obtaining them. Moreover, assignments are different across modes. Hancock noted that FHWA has not captured these differences in the FAF and currently does not know what attributes would be required, because the volume–capacity ratio does not work as it does for other modes. Hancock stated that the Government needs to identify what the accuracy requirements are for mode choice.

## Open Discussion

Following the presentation, the presenters asked participants to provide their feedback in an open discussion. What follows is a summary of this discussion.

***One possible solution to the issues discussed during this workshop would be to develop agent-based models and to assign demand to a multimodal, routable network.***

Workshop participants suggested that the Government needs to focus on mode choice or needs to break this into manageable parts. It would be optimal to create a detailed multimodal network for which FAF users can assign demand to each link. This can be achieved through agent-based modeling.

Agent-based modeling could capture and evaluate the dynamics and variables that need to be evaluated to create a model with a multimodal, routable network. From a systems-level perspective, there is no single owner of the national highway system; however, from a shipper's perspective, they must have some concept of a network. Participants noted that if something needs to move from one place to another, a shipper needs to be able to move it across the network by using the vehicles that he or she has available (or any combination of the vehicles he or she possesses and other modal vehicles available). From the shipper's perspective, it is not comprehensive, but it gives the planner a path (similar to the mental model that drivers have to make about routing decisions).

A set of variables exists that impact freight planning decisions, yet these are not in use by freight planners. An agent-based model could therefore be designed to incorporate the vital elements that need to be included in network analysis. These could include information and variables that influence local-level decisionmaking in freight but that are not currently factored into decisionmaking processes. An agent-based model could then show how this additional information might impact the freight network.

***Providing tools that allow more informed decisions will inherently alter how decisions are made within the system. The network model for assignment does not have to be the same as the model for trip generation.***

Workshop participants noted that different levels of granularity are required for groups who use the models for different purposes. Rather than a multimodal network from the top down, the Government could look at creating this network from the ground up. Participants suggested that the model should focus on heuristic decisionmaking by shippers and supply chains, rather than on other decisionmaking.

***Additional questions and comments discussed during this session.***

Workshop participants asked whether existing regional models should be stitched together to provide a fuller picture or whether data should be collected and created by a national-level agency to create a national model. Participants noted that the FAF cannot provide insight regarding local or regional impacts of a major project without this level of detail. For example, how would the Panama Canal expansion project impact the network? Participants suggested that to answer this, planners would have to understand the resolution of this project among various modes, across various links, and within the entire network.

Additional questions posed during this discussion are outlined as follows:

- Should different models be distributed for different user groups? Distributing different models would address some of the concerns expressed during the workshop, including:
    - Protecting privacy concerns and proprietary business information.
    - Limiting the ability to use data for malicious intent.
    - Meeting the needs of different FAF user groups (e.g., answering questions at the global, regional, or country-wide level).
    - Distributing FAF global, FAF regional, and FAF nationwide models would provide users with answers tailored to their specific questions and concerns.
- Should a synthetic dataset be created to provide the required level of detail to FAF users without creating privacy issues?
- Should the new FAF include all variables or simply those variables that may have the biggest impact on freight-planning decisions?
- Would a highly detailed model have the capacity to also include an intermodal network? Should this model be created to answer all questions or only the big questions? Will it answer these questions at a high level or on a detailed level?
- Would an overly detailed model lose a level of usefulness? Would it run the risk of becoming unwieldy? Would an all-inclusive model actually be used? If so, by whom?
- Should the Government invest in a model that includes all variables versus different models to serve different users for different purposes? Before this question can be addressed, workshop participants suggested that the Government should consider the market needs for modeling, specifically that the Government should be able to answer the following questions:
    - For what are the models being used? What is important to include? What would be a poor use of public resources to investigate?
    - What level of detail is sufficient? Could the next generation of FAF incorporate loosely coupled or connected data?
- Should all of the required data be gathered first, or should the model be created and then data used afterward? Participants questioned which would be the optimal approach. In addition, calibration requires full datasets—does the Government have the luxury to wait for a complete set of data, or do they need to address this issue now?

# Part Two:
# Workshop Conclusions

## Research Opportunities

During the workshop, participants discussed a variety of opportunities for improving the data, analysis, and modeling of freight travel at the national level. Two potential research directions that surfaced in this workshop were as follows:

1. **Behavioral-based (or agent-based) national freight-demand modeling.** Incorporating agent-based modeling could represent a significant step forward for the FAF and could enhance the model's predictive capabilities. Seasonal fluxes, the impact of business decisions, and other variables that have been previously unaddressed by the FAF, yet influence the decisionmaking of shipping entities, could be incorporated in a meaningful way.
2. **Freight data development and enhancement to support national freight transportation analysis, modeling, and forecasting practices.** To create a predictive model, the FAF requires more detailed, higher quality data. New methods of data collection and integration for the FAF could represent a significant leap in terms of FAF potential capabilities.

### *Freight Analysis Framework: Future Direction*

Workshop participants offered potential research areas to enhance the FAF in the categories of data and modeling. As the FAF dataset is based on a national-scale compilation of different surveys and field databases, challenges with the FAF data include:

- Applying the data for reasoning, "what if?' scenario analyses, and trend or pattern study.
- Provisional and future year estimation.
- Inadequate cost and temporal factors.
- Calibration and validation issues of the FAF data that are due to a lack of reference data.
- Insufficient geographic scale.
- Data deficiencies of coverage, aggregation, sparseness, consistency, and accuracy.

Workshop participants made the following conclusions in the data category:

- Key data use is validation.
- Rather than tracking international shipments, the intent is to characterize international shipments (e.g., port of origin or final destination and mode to or from a U.S. port) and to track domestically from the port to the final destination or in reverse from the point of shipment to the port for export.
- Temporal data may be an important enhancement from data mining.
- Cost and economic data may be an important enhancement from data mining.
- It is important to reduce the reporting lag time of local data to keep the FAF current but not necessarily to the extent where near-real-time data are being collected and reported at the national level.

Workshop participants made the following conclusions in the modeling category:

- Considering both the Federal and non-Federal uses of the next FAF and future FAFs is important to consider before making any substantial modifications to the FAF.
- In considering different user groups, there exists the potential for providing an application-programming interface.
- An important modeling component would be the accurate capture of transfers among modes.

***Addressing Challenges***

To address these challenges, participants noted that new innovations in freight data development and its management are needed. The research outcome in the form of nationwide, disaggregated freight-flow data will feed a broad range of further studies and applications. One of the major beneficiaries is on the freight-travel demand model improvement side. The future FAF will likely be developed in the form of a national supply-chain–based, comprehensive multimodal freight-travel demand model. FAF could extend its capacity by supporting national and regional freight policy making, strategic scenario analyses, and future freight and economic impact estimations in a timely manner.

Improved FAF modeling could aid in economic impact studies, road maintenance plans, cost–benefit analyses, air quality, and toll or pricing studies. Major economic sectors and industries, including general public domain, could also benefit from the geographically detailed, cost-sensitive, and temporal nature of datasets on their policy and decisionmaking.

Suggested approaches discussed during the workshop include, but are not limited to:

- Designing and testing novel, cost-effective, transparent, and accurate data collection methodologies to feed national and regional freight-travel demand models and analyses.
- Maximizing the usage of current FAF data sources by improving methods and techniques in data collection, format, and processing.
- Developing better validation and calibration methods for freight models and analyses in both the national and regional levels through the use of improved data.
- Developing novel data collection and modeling strategies for estimating policy-sensitive variables (e.g., cost) for more robust "what if?" analysis.
- Developing novel data disaggregation methods from national and yearly levels to regional, metropolitan, and seasonal levels.
- Developing methods for using new data sources and formats to increase connectivity and integration of locally collected data in different levels of data density, seasonality, accuracy, and geography (e.g., "crowd sourcing," bottom-up data-sharing, and "grass-root" data build-up) to support FAF and similar products.

## Freight Analysis Framework Issues

Although FAF has many strengths and benefits, there are also issues to be addressed. These issues include:

- **FAF objective**. The FAF objective should be reviewed and examined on a continual basis. Areas such as Federal, State, and local roles and needs, private (rail) business and public–private (highway–truck) codependency, as related to multimodal exploration, should be thought through.
- **Static data sources**. On the basis of mostly census data, surveys, and field data collections, FAF is a static snapshot of national goods movement. This conglomeration of nationwide freight data is helpful to understand the big picture of America's economic and freight activity today; however, FAF is not currently designed as a systematic analytical tool with modeling power in its structure. As a result, it lacks the power to explain the causes and effects of dynamic freight activities and their ripple effects, both now and in the future. The current architecture of FAF limits what a national freight-demand modeling tool can provide (e.g., national "what if?" scenario analyses and forecasting functions).
- **Incomplete and disconnected datasets**. Many datasets from different sources and levels in different formats are combined to create the FAF. Gaps and level of detail constrains FAF's suitability to mainly national- and regional-scale analysis. To fill the gaps, advanced statistics and fitting methods are applied along with experts' judgment and adjustment. As a result, FAF achieves reasonableness and pattern of goods movement in both national and regional levels; however, there are accuracy and reliability limitations in adopting the FAF at the regional and local level. There are also consistency and reproducibility issues related to the data-cleaning and integration steps.
- **Timeliness**. The FAF has a significant time lag in processing and providing availability for its interim outputs and further applications due to the dependency of its data sources on the most recent census and surveys. In several cases, it might reduce its utility (e.g., time-sensitive alternative studies).
- **Detail versus scale**. The background need for the creation of the FAF was to capture and understand the national freight movement of the time. FAF has been focusing FHWA's internal use in drawing the big picture in an aggregated format with less interest on local disaggregated detail; however, with increasing roles inside and growing popularity outside FHWA, there are growing demands to support a deeper and wider scope of tasks. With numerous resource limitations, proprietary and confidentiality concerns, and technical issues, it is important to challenge and balance those limits to maximize the benefits of the freight-demand model.
- **Information integration and sharing**. FAF's study area covers all 50 States and

the District of Columbia. Without local data feedback, it is almost impossible to keep the FAF data and its modeling accurate and up to date. Most of the State Departments of Transportation and Metropolitan Planning Organizations have their own limitations on data and modeling development and their updates. The State Departments of Transportation, Metropolitan Planning Organizations, and academia tend to resort to FAF as a base for their freight studies. There are growing needs from both ends for a breakthrough, new approach in information integration and sharing. Systemized, standardized, and technically sound methods will likely help in the steps of collecting, integrating, and sharing information—not only of data but also in modeling.

For more information on FAF, visit http://ops.fhwa.dot.gov/freight/freight_analysis/faf/index.htm.

# Appendix

# Appendix A: Workshop Participants

**Attended in person**

| First | Last | Organization |
|---|---|---|
| Peter | Bang | Federal Highway Administration |
| Dan | Beagan | Cambridge Systematics, Inc. |
| Andrew | Berthaume | U.S. Department of Transportation / Volpe Center |
| Joe | Bryan | Parsons Brinkerhoff |
| Dave | Damm-Luhr | U.S. Department of Transportation / Volpe Center |
| Chester | Ford | Research and Innovative Technology Administration |
| Kathleen (“Kitty”) | Hancock | Virginia Polytechnic Institute and State University |
| Raquel | Hunt | Federal Railroad Administration |
| Ho-Ling | Hwang | Oak Ridge National Laboratory |
| Steven | Jessberger | Federal Highway Administration |
| Nick | Kehoe | Leidos |
| David | Kuehn | Federal Highway Administration |
| Bruce | Lambert | Institute For Trade and Transportation Studies |
| David | Jones | Federal Highway Administration |
| Charles (“Chick”) | Macal | Argonne National Laboratory |
| Karen | McClure | Federal Railroad Administration |
| Doug | McDonald | U.S. Army Corps of Engineers |
| Kenneth ("Ned") | Mitchell | U.S. Army Corps of Engineers |
| Rolf | Moeckel | University of Maryland |
| Vidya | Mysore | Federal Highway Administration |
| Eric | Pihl | Federal Highway Administration |
| Bud | Reiff | Portland Metro |
| Mark | Sarmiento | Federal Highway Administration |
| Rolf | Schmitt | Bureau of Transportation Statistics |
| Mike | Sprung | Bureau of Transportation Statistics |
| Ed | Strocko | Federal Highway Administration |
| Myung | Sung | Gannett Fleming |
| Coral | Torres | Federal Highway Administration |
| Supin | Yoder | Federal Highway Administration |

**Attended via Webinar and call-in**

| First | Last | Organization |
|---|---|---|
| Maks | Alam | Maks Group |
| Al | Arana | California Department of Transportation |
| Diane | Davidson | Oak Ridge National Laboratory |
| Zachary | Ellis | Federal Highway Administration |
| John | Gliebe | Resource Systems Group, Inc. |
| Michael | Hilliard | Oak Ridge National Laboratory |
| Brandon | Langley | Oak Ridge National Laboratory |
| Jane | Lin | University of Illinois at Chicago |
| Doug | MacIvor | California Department of Transportation |
| Tom | Morton | Woodward Communications |
| Bruce | Peterson | Oak Ridge National Laboratory |
| Stan | Reecy | |
| Kaveh | Shabani | Resource Systems Group, Inc. |
| Frank | Southworth | Georgia Institute of Technology |
| Dave | Taylor | |
| Patrick | Zhang | Federal Highway Administration |

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Publication No. FHWA-HRT-14-054
HRTM-30/01-15(1M)E