U.S. Department of Transportation Volpe Center

FTOT Validation Summary and Takeaways
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Overview

The U.S. Department of Transportation (USDOT) Volpe National Transportation Systems Center (Volpe) developed the Freight and Fuel Transportation Optimization Tool (FTOT) in support of the Federal Aviation Administration, the U.S. Navy's Office of Naval Research, and the U.S. Department of Energy. FTOT is a commodity-agnostic tool for assessing optimal flows and demand fulfillment along current or future supply chains.

FTOT Summary
FTOT is a flexible scenario testing tool intended to support analyses of optimal freight movements under varying supply chain structures, conditions, and network details.

Since 2019, Volpe has supported the Federal Highway Administration (FHWA) in a pilot effort to investigate the feasibility of using FTOT for freight planning and analysis. As part of this effort, Volpe validated FTOT using existing datasets commonly used by public sector freight professionals. Volpe plans to use the validation results to inform enhancements to FTOT documentation and guidance to FTOT users, as well as potential enhancements to FTOT methodology.

This document summarizes the validation exercise that Volpe performed as part of the FHWA pilot effort and outlines results and takeaways. **These results and takeaways are Volpe's observations and do not necessarily represent FHWA viewpoints.**

Optimization

FTOT is designed to identify optimal transportation routing and flows for supply chain scenarios and estimate transport vehicle miles traveled, cost, and emissions. To do so, FTOT uses several optimization factors, which include:

- Transportation and transloading dollar costs,
- Supply chain facility characteristics (size, commodities handled and produced), and
- Network link impedances that encourage flows to behave in realistic ways.

FTOT is not designed to predict real-world operational conditions. To effectively test scenarios, however, FTOT must be able to mimic real-world conditions. In the validation exercise, Volpe compared the mileage of FTOT optimal routing against the mileage of routing provided by three well-established datasets to corroborate the realism of FTOT's routing decisions.

Data

Three datasets were evaluated. The table below provides details.

Dataset (Year)	Overview
Commodity Flow Survey (CFS) (2017)	Component of the Economic Census and conducted every five years by the U.S. Census Bureau in collaboration with the USDOT Bureau of Transportation Statistics. Provides a comprehensive, multimodal picture of national freight flows. Data are highly aggregated (132 zones nationally).
Carload Waybill Sample (Waybill) (2019)	Published annually by the Surface Transportation Board. Restricted dataset that provides detailed information on a sample of actual rail freight movements based on submissions from rail carriers.
Transearch database (2018)	Private dataset published by IHS Markit that models routes. For the validation exercise, Volpe evaluated a sample of Transearch data (road only).

Methods

The validation approach involved: 1) capturing a sample of origin-destination (O-D) pairs with sufficient route information by mode in each of the validation datasets for comparison with FTOT; 2) running the equivalent O-D pairs (restricted to the same mode) in FTOT without any capacity constraints—essentially a "best case" routing optimization; and 3) comparing the mileage generated by FTOT to the mileage in the validation dataset. Mileage comparisons served as a useful proxy for comparing routes given that route paths between O-D pairs were not available in the datasets. The Waybill and Transearch data are more comprehensive than the CFS, which is highly aggregated.

Results

- **Comparison to CFS (380 O-D pairs evaluated across modes)**: FTOT and CFS road mileages were highly correlated (R^2=0.999). FTOT favored slightly more direct (i.e., shorter) road routes than CFS, although the average difference was only 1.9 percent. FTOT rail route mileages were 14.6 percent shorter on average than CFS rail routes. It was difficult to compare FTOT water routes to CFS water routes due to limited data, though the few comparable routes were slightly longer in FTOT on average.
- **Comparison to Waybill (94 rail O-D pairs evaluated)**: Overall, FTOT rail routes were 11.6 percent shorter than the corresponding average Waybill rail mileages. Compared to minimum Waybill rail mileages for each O-D pair, FTOT rail mileages were virtually identical (0.1 percent shorter, with correlation R^2=0.96), consistent with FTOT's optimization routing methodology.
- **Comparison to Transearch (10,000 road O-D pairs evaluated)**: FTOT-generated road routes were highly correlated with Transearch routes (R^2=0.999) and were on average 4.4 percent shorter than Transearch routes.

Takeaways

The validation showed that the FTOT optimization model produces mileage results highly correlated with but shorter than road and rail routes in the three reference datasets; shorter routing is expected given FTOT's emphasis on selecting optimal routes. FTOT users can adjust custom model settings already available within FTOT to more closely approximate real-world conditions as needed. For example, users can adjust network link impedances to encourage flows onto different link types. If users know that freight will move with a particular rail carrier, they can subset the FTOT rail network accordingly.

Additional investigation could expand sampling of comparison datasets to encompass more variations in the O-D locations. The routes for specific O-D pairs could also be compared in more detail with modeled routing outputs (e.g., with Transearch) to identify any key differences in modeling priorities. Real-world validation could also be accomplished through supply chain analyses in a particular region. Feedback from supply chain stakeholders could support assessments of the "realism" of FTOT mode choice and facility location selection.

For More Information

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FTOT documentation available at: https://github.com/VolpeUSDOT/FTOT-Public/wiki/Documentation-and-Scenario-Datasets