NATIONAL FREIGHT FLUIDITY PROGRAM

Technical Memorandum

program design methodology

submitted to

U.S. Department of Transportation, Federal Highway Administration

submitted by

I-95 Corridor Coalition

with

WSP USA

Cambridge Systematics, Inc.

Texas A&M Transportation Institute

June 2018

Table of Contents

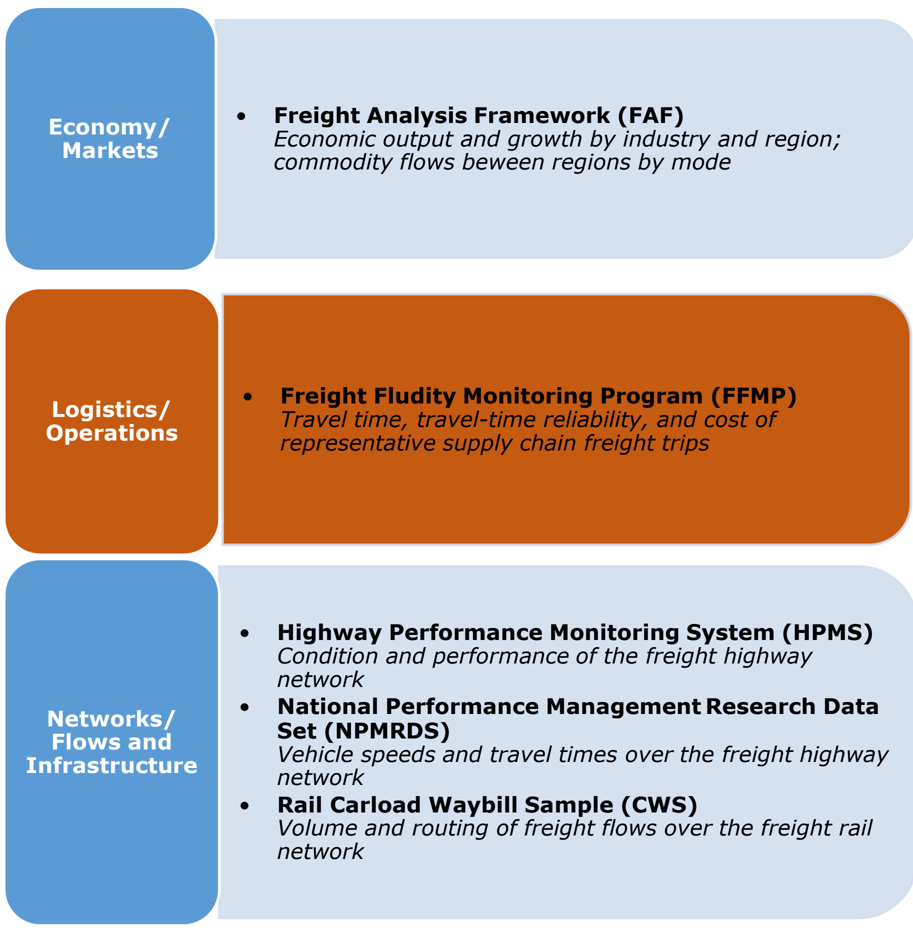
Introduction

This technical memorandum reports the findings and preliminary conclusions of Task 2 – Program Design. The objective of this task is to outline the design of a National Freight Fluidity Monitoring Program capable of near-term implementation and long-term development and maintenance, with a federal-level track for nationwide measurement and a state/ regional-level track for greater granularity.

This task is a precursor to Tasks 3 and 4, which will implement a federal component for measuring freight fluidity at the national level and for managing and coordinating inputs activities from state and local tracks; and Tasks 5 and 6, which will pilot the development and implementation of approaches to mapping out regional supply chains and regional or metropolitan freight fluidity monitoring.

The purpose of the Freight Fluidity Program is to measure the general performance of representative transportation supply chains and their networks over time. Information on how transportation supply chains perform from the perspectives of shippers, carriers and receivers is critical to knowing if supply chains are working or failing, and that information is, in turn, critical to determining if and where public investment or changes in policy and regulation might improve freight system performance and support economic competitiveness and growth.

The program will provide the middle of the three levels of information necessary for informed public sector investments in freight transportation systems. The three levels, illustrated in the accompanying diagram, are: information about the economy and the demand for freight transportation (addressed by existing program such as the Freight Analysis Framework); information about supply chains—the paths along which freight shipments move—and end-to-end trip performance (to be addressed by this project); and information about the condition and performance of the highway, rail and other networks and facilities that carry freight trips (addressed by existing programs such as the HPMS, NPMRDS, Carload Waybill Sample, etc.). Fluidity is thus a necessary bridge between information resources, and a tool that works with other tools to improve the efficacy of the entire set.



The FHWA and I-95 Corridor Coalition (the Coalition) have demonstrated and documented the feasibility of measuring transportation supply chain performance in the white paper: "Freight Performance Measurement: Measuring the Performance of Supply Chains across Multistate Jurisdictions."[1] Task 2 advances the design of the National Freight Fluidity Monitoring Program and sets the stage for initial implementation.

The scope of work for Task 2 has six work steps, listed below:

- Identify key supply chains and geographic dimensions for the national and regional tracks;
- Review with primary public and private sector users.;
- Identify and recruit supply chain participants;
- Specify data requirements and identify data vendors;
- Meet with data vendors to confirm capabilities, develop features and define budgets; and
- Develop the form of reporting for each track, exploring options with agency partners and agreeing on a final design.

Looking ahead to promulgation of the program after it is put in place, there are at least two salient considerations:

- Fluidity is an analytic tool with associated data resources. Its use should be taught as an aspect of freight professional development. The FHWA/NHI *Fundamentals of Freight Data* workshop already touches informally on fluidity as an aspect of supply chain analysis, just as it also treats recent developments in NPMRDS. Both NPMRDS and fluidity can be added as a single combined module in the workshop as part of the maintenance of course content. The I-95 Corridor Coalition Freight Academy similarly can add relevant instruction.
- The Regional Track in the fluidity program is constructed as a pair of pilots, with the purpose of exploring how fluidity should function in combination with state and MPO resources and concerns. It is intended to stimulate further exploration and development by regions beyond the two pilots. The workshops that conclude the pilots are forums to initiate this. Ongoing research, attention and updates can be organized by FHWA as activities led by its Freight Office, and/or as collaborative efforts with groups such as AASHTO and TRB, or by leveraging meetings of regional DOT and MPO coalitions such as the I-95 Corridor Coalition and the Mid-America Freight Coalition.

1 http://i95coalition.org/2016/03/16/new-white-paper-freight-performance-measurement-measuring-the-performance-of-supply-chains-across-multistate-jurisdictions/.

National Track

The national track monitors travel time, travel time reliability, and cost on a quarterly basis for a market basket of approximately two dozen industry sectors. The monitoring components are set forth below.

Industry Sectors

Sectors were selected based on six factors:

- Contribution to national GDP and projected growth among freight-dependent industries
- Geographic coverage of US: regions, urban centers, rural areas, gateways, corridors, direction of travel
- Contribution to regional GDP and projected growth among freight-dependent industries
- Industry importance to resilience of other supply chains and of population
- Industry importance in US trade
- Modal and travel distance diversity

Data to evaluate these factors were drawn from the U.S. Bureau of Economic Analysis for contributions to GDP and historical growth; the U.S. Census Bureau International Trade data and County Business Patterns for industrial geography; the Census Bureau 2012 Commodity Flow Survey and the FHWA Freight Analysis Framework 4.3 for geographic coverage including corridors and gateways, modal and travel distance, and forecasts; InfoUSA for locations of large industrial establishments; and supply chain resiliency research such as the ongoing NCFRP 50 study for pertinent considerations. Sectoral data were compiled and mapped, and 28 sectors then were selected as targets:

#	Industry Sector
1	Oilseed & Grain Farming and Production
2	Oil & Gas Extraction
3	Coal, Metal Ores, and Nonmetallic Minerals
4	Food Products Manufacturing
5	Dairy Products Manufacturing
6	Paper Manufacturing
7	Petroleum and Coal Products Manufacturing
8	Organic Chemicals Manufacturing
9	Resins and Synthetics Manufacturing
10	Pharmaceuticals Manufacturing
11	Plastics & Rubber Manufacturing
12	Nonmetallic Minerals Manufacturing
13	Steel & Fabricated Metals Manufacturing
14	Construction/Industrial Machinery Manufacturing
15	Computers/Electronic Products Manufacturing
16	Motor Vehicles & Parts Manufacturing
17	Aircraft/Other Transportation Manufacturing
18	Medical Instruments Manufacturing
19	Food Service & Wholesale
20	Retail: Home Furniture Stores
21	Retail: Electronics and Appliance Stores
22	Retail: Building Materials Stores
23	Retail: Grocery, Food, Beverage Stores
24	Retail: Drug Stores

25	Retail: Apparel Stores
26	Retail: Consumer Goods (FAK) Stores
27	Service: Hospitals
28	Service: E-Commerce (Package Delivery)

Candidate companies in each of the 28 sectors were identified from InfoUSA data, web research, recommendations from project "ambassadors", and the experience of the team. Individuals and contacts at the companies were determined mainly through the aid of the Council of Supply Chain Management Professionals and the Advisory Committee on Supply Chain Competitiveness of the U.S. Department of Commerce. Over 70 companies were approached with a letter from the Coalition and an accompanying brochure, transmitted via email. Copies of the letter and brochure appear in an Appendix to this document. The objective is to recruit at least one company from at least 24 sectors. Several companies have been contacted through interviews to test the validity of the design approach and interview questions.

Supply Chain Flows

Recruited companies are being asked to describe one to three typical lanes in their supply chain systems, detailing the stages in the lane and the predominant mode between stages. No information on vendors, customers and volumes is being requested because of the commercial confidentiality of that data. More than one lane is being requested from companies to improve the diversity of coverage for geography and distance. The lanes submitted by the Campbell's Soup Company appear below and serve as an example of participant output. DCs are Distribution Centers and may belong to the company or their customer. The modal equipment type is captured because it affects collection of price data. The focus of the flow is the outbound manufactured product. The supply of inbound material is selected for one instance of the many types, just as the selection of the outbound flow also is limited:

Manufacturing Plant: Napoleon, OH
Product Type: Pasta sauce
First Flow Sequence, 5 links total plus rail interchange:

1. Inbound jars from Middletown, NY to Napoleon, OH. Mode: full TL in dry vans
2. Outbound product delivery via DC: Napoleon OH to Campbell's DC in Fort Worth, TX. Mode: Intermodal Rail routed as follows:
    a. Napoleon, OH to Toledo, OH: dry van container TL dray to NS Toledo ramp
    b. Toledo OH to Chicago IL: NS to interchange with BNSF in Chicago
    c. Chicago, IL to Haslet, TX: BNSF to BNSF Alliance ramp
    d. Haslet, TX to Fort Worth, TX: dry van container TL dray from BNSF Alliance ramp to Fort Worth DC
3. DC delivery: Forth Worth TX to customer grocery DC in Houston, TX. Mode: full TL in dry vans

Second Flow Sequence, 2 links total:

1. Inbound jars from Middletown, NY to Napoleon, OH. Mode: full TL in dry vans (same as above)
2. Outbound direct product delivery: Napoleon OH to customer grocery DC in Breinigsville, PA. Mode: full TL in dry vans.

When company recruiting is complete, the lanes, links and modes/equipment types will be compiled in a Tableau database (see comment on Tableau below), along with contact information for each company. Zip codes will assigned for each of the geographic points because they are needed to retrieve price data and will aid the analysis of speed and reliability. The resulting national set of flows will be mapped by the software and reviewed by FHWA to confirm the diversity of coverage for geography, modes and distances. FHWA will have the option of not using all lanes from a single company if doing so will assist the coverage balance. The final selection of flows then will advance to the performance measurement stage.

Looking ahead, there are two points to make about the participating companies:

- The lanes selected by companies should be stable for a number of years and not require update. Indeed, for the sake of the comparability of performance findings in time series, it is preferable that they remain stable. Nevertheless, companies lose customers and change modal choices periodically; markets also change (as they are in the retail sector now). Thus, it will be desirable to confirm the validity of lanes with companies on an annual basis. Lanes should not be changed unless they cease to be valid.
- Participants will expect to see output from the program, to show how their information is being used and the trends that may emerge. Doing so will also maintain the federal relationship with the company. Longer term, when improvements to address performance issues visible in the program are introduced and reported on, companies will want to hear of this. We anticipate that the program output that is made public will suffice for this purpose, but emailing it to participants with an enclosed link would help to personalize the communication.

Performance Measurement

Travel time, reliability and cost will be collected from various vendors for each flow. Reliability will be measured at the 95% level, which is consistent with other FHWA programs and with industry standards. For the most part, data will be captured by link; an example of an exception is rates for through movements – such as Campbell's two railroad combination above – which normally are set from market origin to market destination. An illustration of all of this appears below, taken from the White Paper for the pilot program.

FIGURE 1 - SEATTLE TO NEW YORK RETAIL FLOW

Links and Nodes	**Transit Time/Dwell Time** *(Hours)*	**Reliability** *(95% travel time)*	***Cost*** *(2014 $'s)*
West Coast port (Seattle)	36	86	
Dray move	1.0	1.4	$299
Transload or Consolidation Center			
Dray move	1.0	2.25	$308
West Coast rail intermodal terminal	20		
Rail move	104	154	$3,178
Midwest rail intermodal interchange	71	160	
Rail move			
East Coast rail intermodal terminal			
Dray move	1.1	1.4	$318
East Coast Regional Distribution Center			
Truck P&D move	6.0	9.5	$775
Retail Store			
Totals			**$4,878**

The *output* from performance measurement will be similarly structured and entered in Tableau, with detail by link and with totals for the complete flow. Link and flow information are both useful findings. The database structure will be as follows:

> Flow Number – Company – Link Number – Origin State – Origin Zip Code – Facility Type (Plant, DC, Port/Gateway, Terminal, Interchange, Supplier, Customer) - Destination State – Destination Zip Code – Facility Type - Movement Type (terminal dwell, linehaul, dray/P&D) – Median Transit Hours – 95% Reliability Hours – Cost (USD)

Flows will be summed by link. Origin and destination will be identical in the case of terminal dwell (such as time at port). Values in some performance fields may be blank: thus, in the illustration above, marine costs from overseas are not being tracked, and the rail cost is stated on a through basis from origin to destination terminal. The critical requirement is that performance values for the total flow will sum correctly. A draft illustration of how the database can be organized in Tableau accompanies this document as a separate spreadsheet.

The *input* for performance measurement will vary in form by vendor, according to how their process of calculation works. This raises two points for automation of the collection process:

- The first time set-up for a vendor will be a manual process of entering geographic and modal data into the vendor's format. Thereafter, the vendor should be able to repeat the process without further data entry. This is known to be true for Chainalytics and ATRI, and should be true for INRIX and others. In other words, the vendor process will be effectively automated after the initial set-up.
- The data received from vendors will follow their format, but can be expected to arrive in a form compatible with Tableau (such as Excel) and to do so consistently, so that each receipt from a vendor looks like the last. That allows the vendor input files to be swapped into Tableau each quarter, and Tableau can be programmed to read the right fields into the flow database. In other words, there is a manual step required to swap new data into pre-formed fields, but the calculation of output is automated.

A critical aspect of data needed from vendors for highway performance is the observed, predominant travel route for trucks moving the full distance of each link, and calculation of performance for those trucks. There are two important considerations about this:

- It is desirable to track trucks that travel the length of the link – instead of compiling transit time and reliability by road segment within the link, as would be required from raw NPMRDS data. This is because a truck encountering morning rush hour congestion at 8AM will not face it again a few hours and hundred miles later, so that time of day conditions must be accurately spaced. Tracking trucks also allows accurate capture of the effects of driver hours of service, which is a sensitive component since the requirement for electronic log books took effect this year.
- Performance needs to be associated with specific roadways so that delays can be diagnosed and addressed. Moreover, the *display* of output from the fluidity program needs to be mapped onto those roadways. Routing models allow estimation of the probable route, but observation of the actual route most often traveled is superior.

ATRI offers a solution to both considerations because it can track individual trucks on roads. INRIX can approximate truck tracking at shorter lengths of haul, but loses continuity when there is a break in travel over longer distances (around 400 miles or more). However, it is possible to develop reasonable estimates by viewing the trip in segments and incorporating an allowance for hours of service. This approach would have less precision but would be consistent over time.

Another nuance resides in the fact that, while the travel time and reliability measures will be analyzed by roadway, Chainalytics data captures the door-to-door cost across the length of the link, and does not distinguish component costs by route or roadway segment.

Performance Report

Performance will be collected and reported quarterly. The two sources with the widest ranging effect on measurement – cost data from Chainalytics and highway performance data – are regularly updated and can support quarterly output. Chainalytics can generate output in one day, and the data pull simply needs to be scheduled. The turnaround time for highway performance data presumably would be comparable to what FHWA experiences for its quarterly top 25 corridors report. Vessel data also is continuously collected, but the compilation and response time from the USACE need to be determined. Response from commercial vendors of rail data is expected to be good because it is the vendors' business to be, although that must be confirmed. (See the discussion on vendors below.) Finally, we will look at options for collecting recent historical data by quarter, with the objective of compiling a full calendar year 2018.

The output broadly will have two forms: chart displays of data, and maps. Displays need to present the latest quarterly findings and trends. The key topline numbers are the flow level results by sector, and cross-tabulation by mode. We will also compose an overall index of speed, reliability and cost, with the first quarter (and ultimately the first year) as the base line. The index could be a straight average of all flows, or weighted by the economic output (GDP contribution) by sector; initially, we will present both.

Link-level detail is the critical piece to identify where performance values are improving and deteriorating. This will be most effectively displayed in GIS. While a national composite map is conceptually appealing, the links in fact will overlap in irregular ways and the values will not be by network segment, implying that a composite will not be meaningful. Thus, a series of sector maps will be the best way to present link information. Maps must be interactive, so that a user hovering over or clicking on a link can access the underlying values and trends.

The recommended software tool for data integration, analysis and display is Tableau. Tableau is able to read spreadsheet and database files, manage queries and display graphic/tabular results, and then output the information in various forms (MSAccess, MSExcel, shapefile data, etc.) for transfer to external GIS or other display systems.

Tableau offers many options for data display that can be constructed into a dashboard. The user will be able to select industry-level and/or commodity-level data to query and display. The application allows the user to drill down as far as the available data allows. This is an important consideration for ongoing use, as queries can be performed with sector data when commodity data is unavailable or between update cycles, or vice versa. It has a mapping function that creates geocodes, yet these graphics are not of the best quality and it will be better to connect Tableau GIS output to the HEPGIS tool. Output should appear on an internal FHWA web page and be integrated into a public page, probably with less detail. Dashboard concepts appear below:

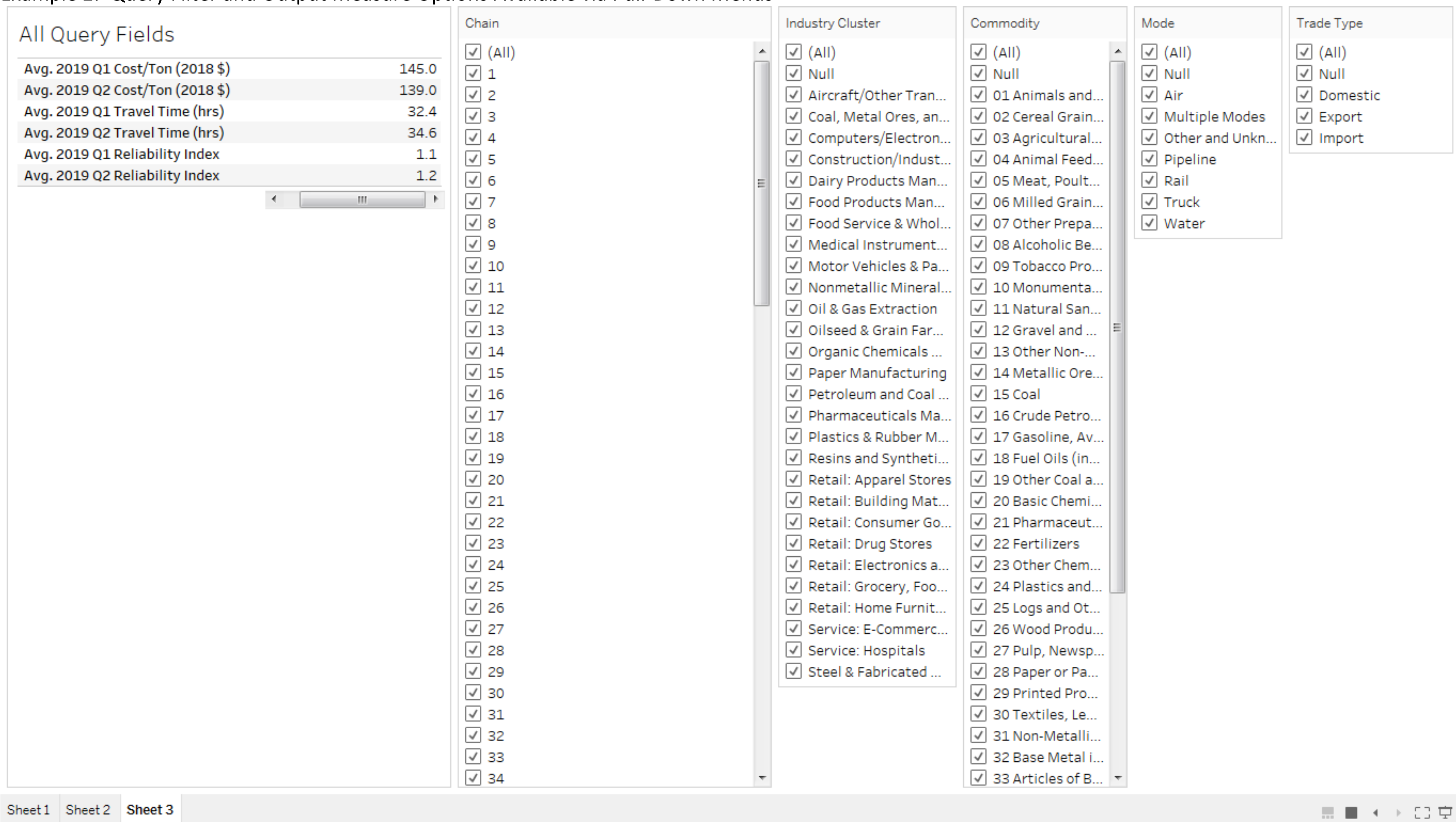
Example 1: Data Array Table

Data Array (Showing Chains 1-5, 2019 Q1 Only)

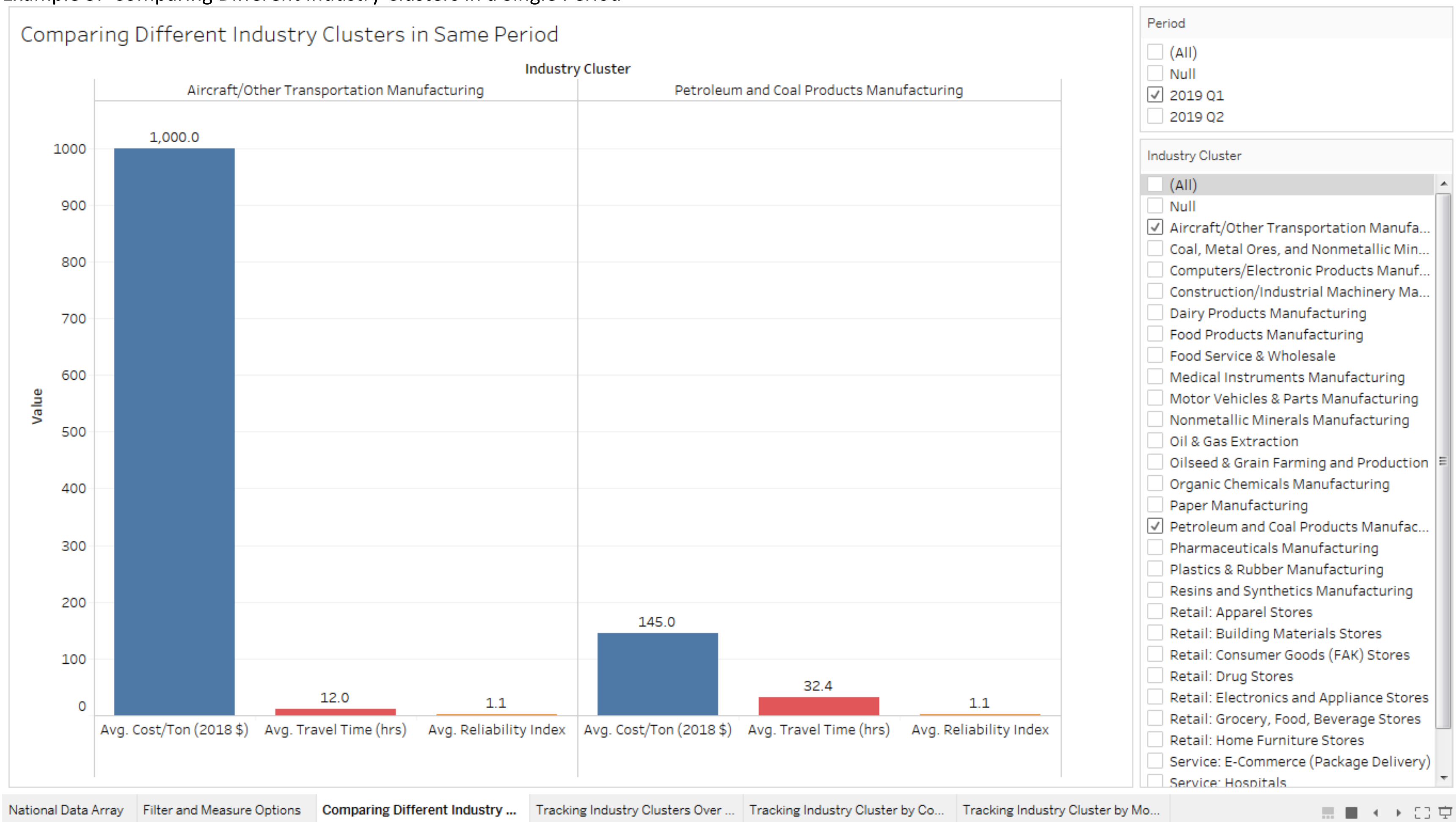
Chain	Commodity	Industry Cluster	Mode	Trade Type	Average US Distance (miles)	2019 Q1 Cost/Ton (2018 $)	2019 Q1 Travel Time (hrs)	2019 Q1 Reliability Index
1	17 Gasoline, Aviation Turbine Fuel, and Et..	Petroleum and Coal Products ..	Truck	Domestic	100.0	200.0	2.0	1.3
2	17 Gasoline, Aviation Turbine Fuel, and Ethanol (includes Kerosene, and Fuel ..	Petroleum and Coal Products Manufacturing	Rail	Domestic	250.0	300.0	10.0	1.0
			Truck	Domestic	50.0	100.0	1.0	1.3
3	17 Gasoline, Aviation Turbine Fuel, and Ethanol (includes Kerosene, and Fuel ..	Petroleum and Coal Products Manufacturing	Truck	Domestic	50.0	100.0	1.0	1.3
			Water	Domestic	400.0	160.0	80.0	1.0
4	17 Gasoline, Aviation Turbine Fuel, and Ethanol (includes Kerosene, and Fuel ..	Petroleum and Coal Products Manufacturing	Pipeline	Domestic	800.0	80.0	160.0	1.0
			Truck	Domestic	50.0	100.0	1.0	1.3
5	17 Gasoline, Aviation Turbine Fuel, and Et..	Petroleum and Coal Products ..	Rail	Export	100.0	120.0	4.0	1.0

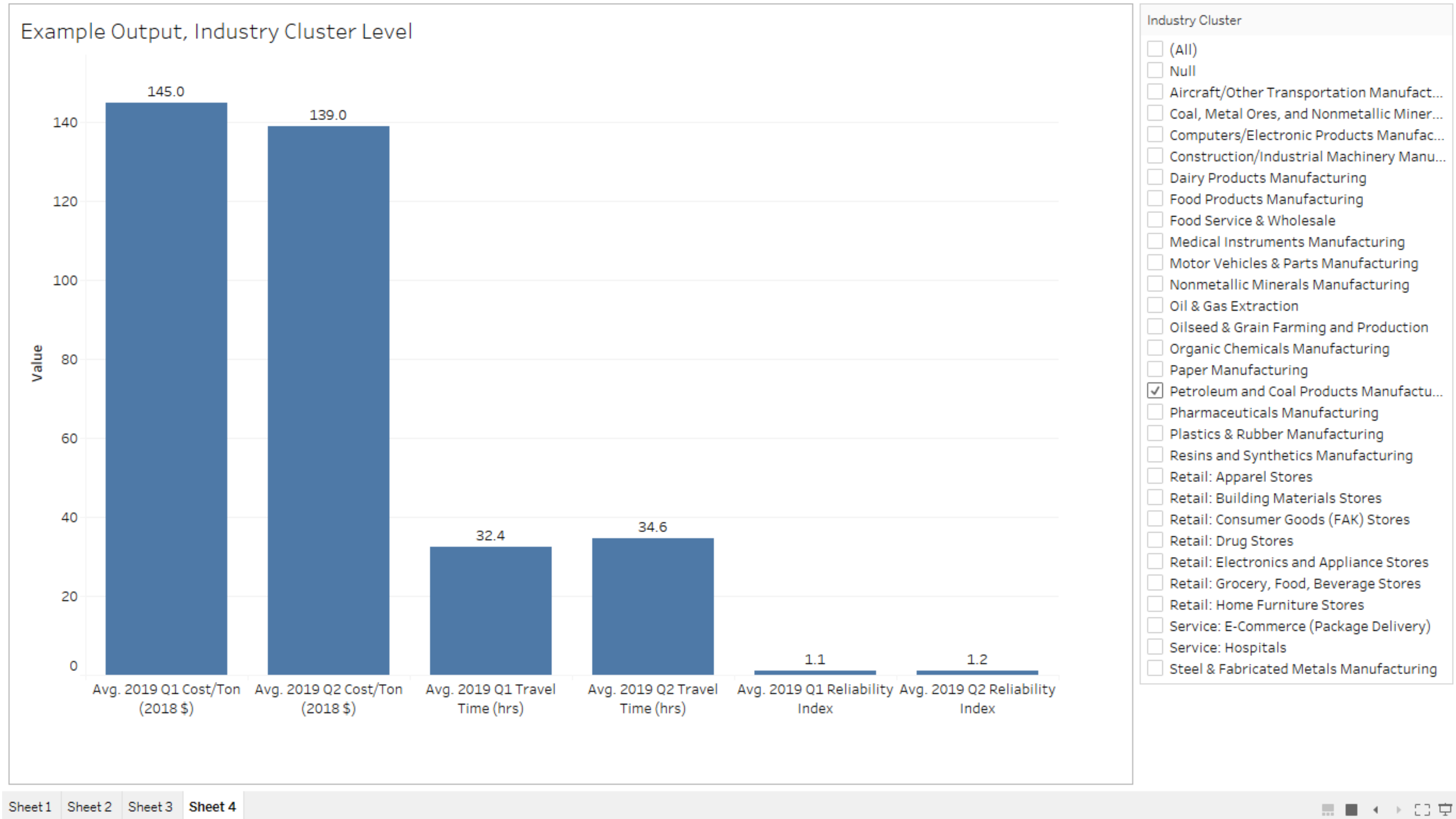
Sheet 1 **Sheet 2**

Example 2: Query Filter and Output Measure Options Available via Pull-Down Menus

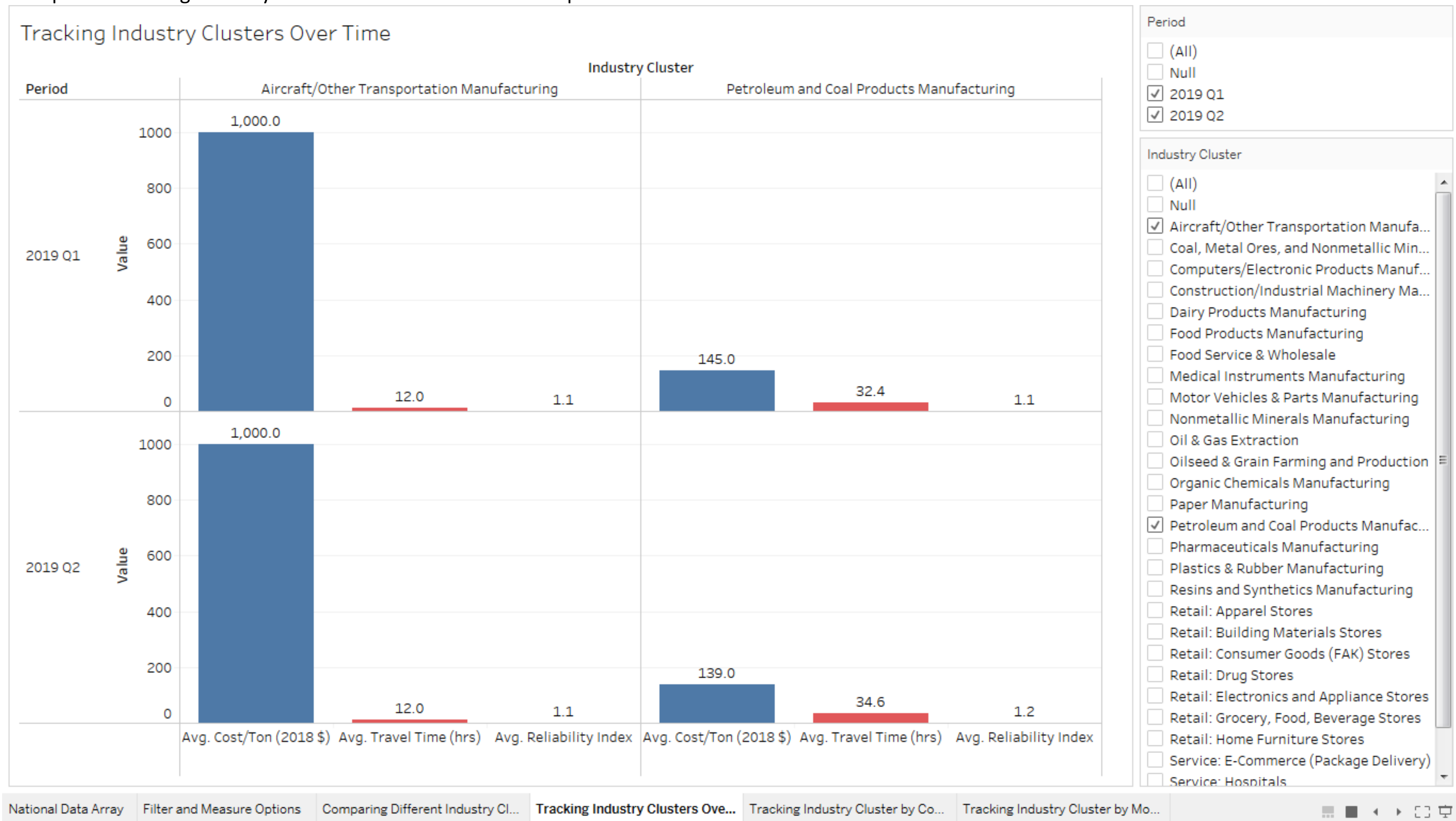


Example 3: Comparing Different Industry Clusters in a Single Period

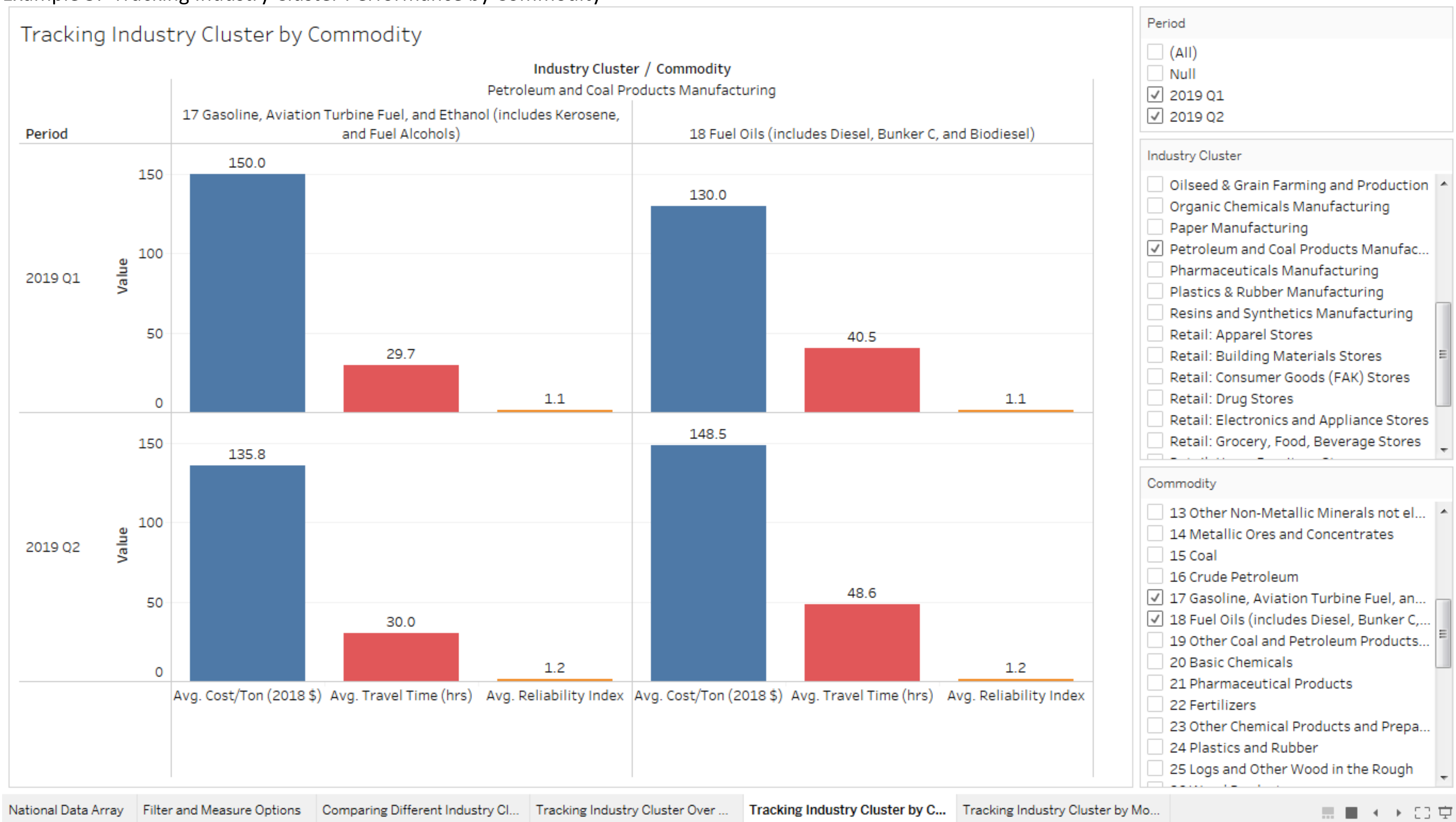



Example Output, Industry Cluster Level
Value
145.0
139.0
32.4
34.6
1.1
1.2
0
20
40
60
80
100
120
140
Avg. 2019 Q1 Cost/Ton (2018 $)
Avg. 2019 Q2 Cost/Ton (2018 $)
Avg. 2019 Q1 Travel Time (hrs)
Avg. 2019 Q2 Travel Time (hrs)
Avg. 2019 Q1 Reliability Index
Avg. 2019 Q2 Reliability Index
Industry Cluster
(All)
Null
Aircraft/Other Transportation Manufact...
Coal, Metal Ores, and Nonmetallic Miner...
Computers/Electronic Products Manufac...
Construction/Industrial Machinery Manu...
Dairy Products Manufacturing
Food Products Manufacturing
Food Service & Wholesale
Medical Instruments Manufacturing
Motor Vehicles & Parts Manufacturing
Nonmetallic Minerals Manufacturing
Oil & Gas Extraction
Oilseed & Grain Farming and Production
Organic Chemicals Manufacturing
Paper Manufacturing
Petroleum and Coal Products Manufactu...
Pharmaceuticals Manufacturing
Plastics & Rubber Manufacturing
Resins and Synthetics Manufacturing
Retail: Apparel Stores
Retail: Building Materials Stores
Retail: Consumer Goods (FAK) Stores
Retail: Drug Stores
Retail: Electronics and Appliance Stores
Retail: Grocery, Food, Beverage Stores
Retail: Home Furniture Stores
Service: E-Commerce (Package Delivery)
Service: Hospitals
Steel & Fabricated Metals Manufacturing
Sheet 1
Sheet 2
Sheet 3
Sheet 4

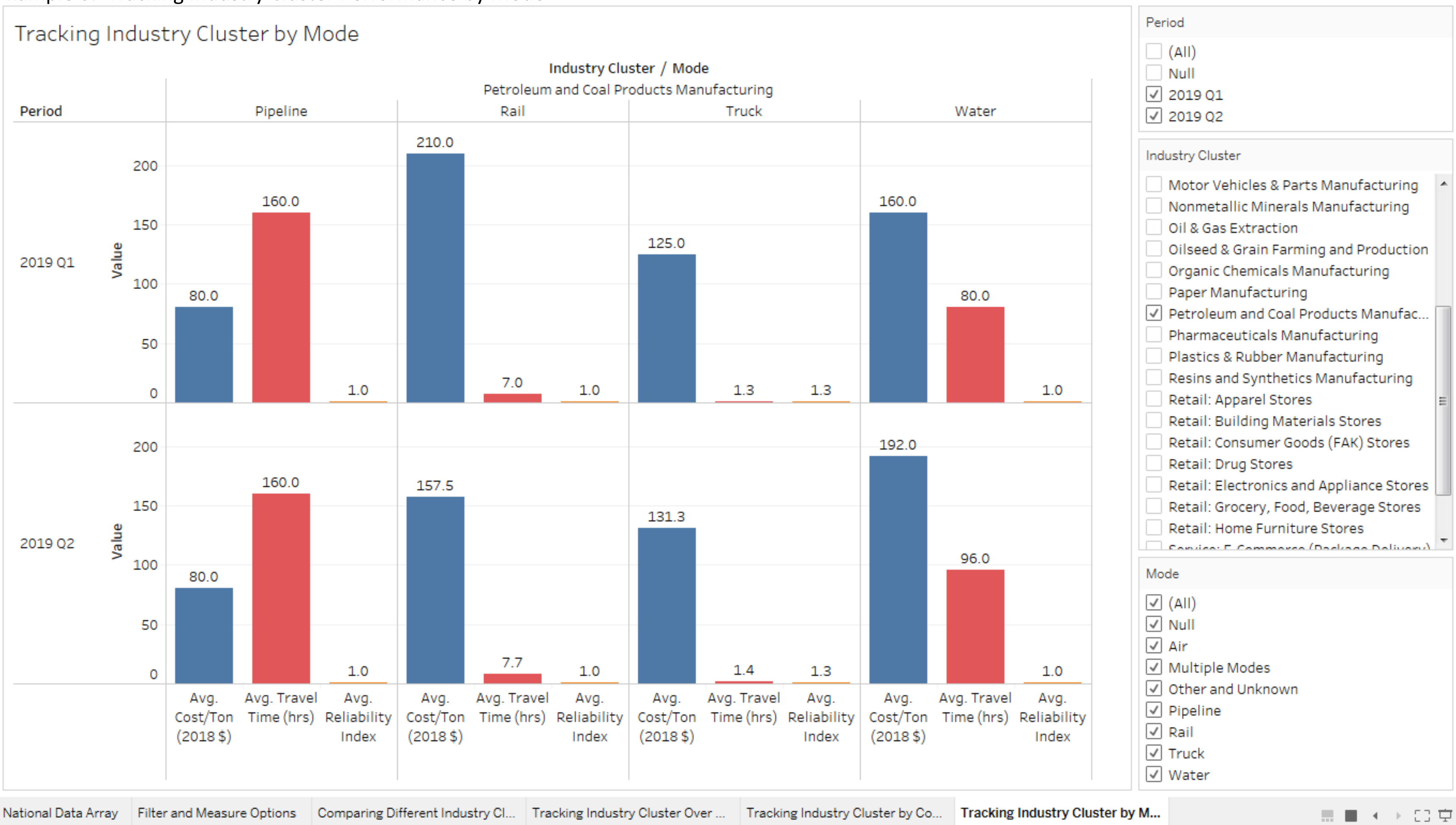
Example 4: Tracking Industry Cluster Performance over Multiple Periods



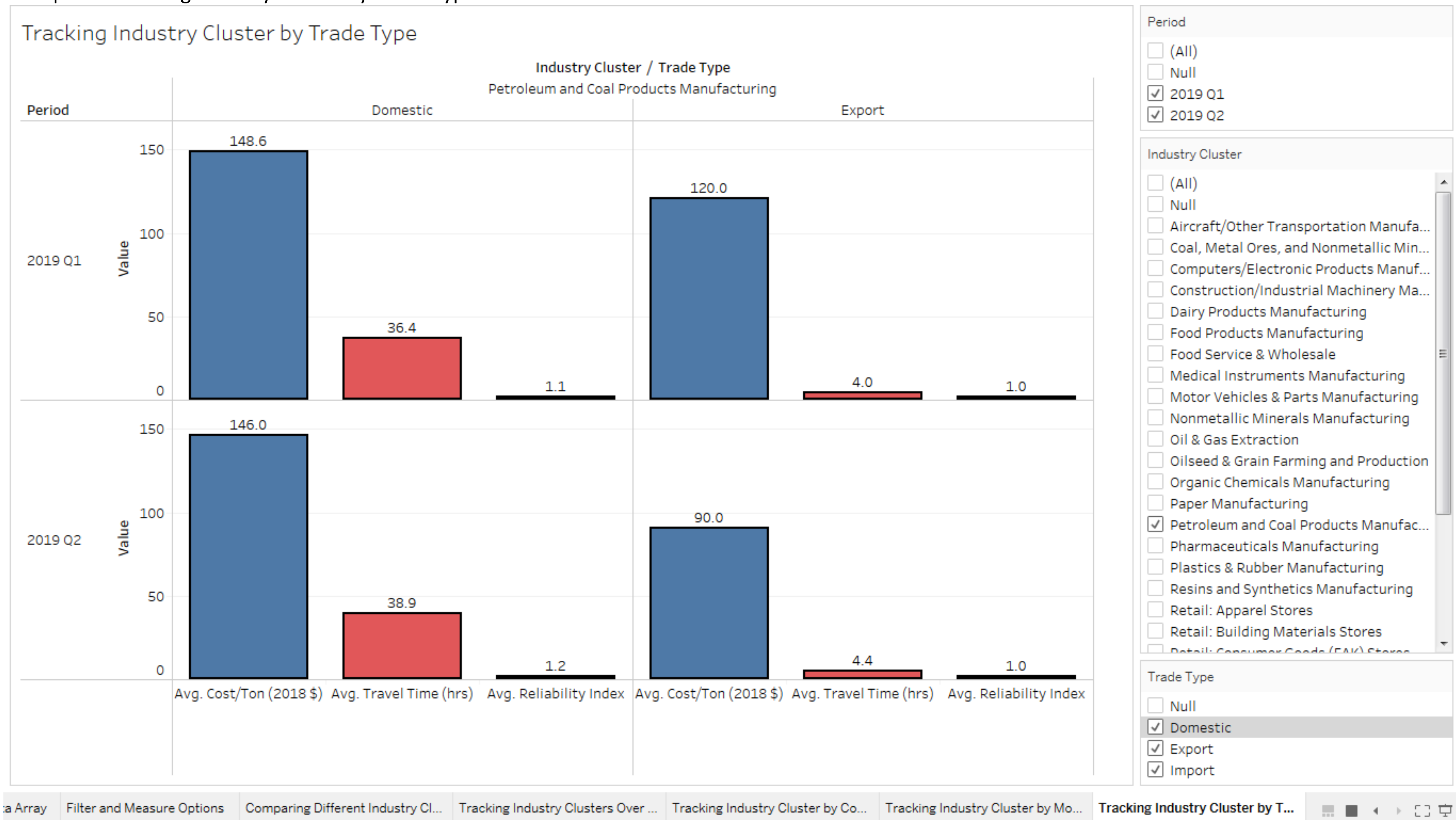
Example 5: Tracking Industry Cluster Performance by Commodity



Example 6: Tracking Industry Cluster Performance by Mode



Example 7: Tracking Industry Cluster by Trade Type



From the full Fluidity Database spreadsheet – which will contain industry-specific information – an extract would be prepared, omitting identifiable industry data. Tableau would then be opened and 'pointed' to the target excel file. Whenever the excel data table is updated with new information, Tableau would be re-pointed to the target excel file, and it would then automatically update each of the analysis displays. This means the data can be continually updated and expanded, almost indefinitely, without impacting the functionality of the Tableau analysis and display procedures, so long as the field names in the original excel table remain the same.

- Example 1 above shows the general structure of the data extract. For illustration, we are showing 'dummy' data for a single industry cluster, representing two commodities, four modes, and two trade types, combined into five distinct supply chains, for a single analysis period. The performance measures shown are: average trip distance; average cost per ton; average travel time; and average reliability index. We expect that for some supply chains, information will be available for the full supply chain but not its component parts, and in those cases the available information will be aggregated to mixed/unknown commodity types or multiple/unknown modes. This structure supports both high-level (aggregated) queries and detailed (commodity, mode, and/or trade type) data display and comparison. Additionally, the data structure also includes four additional measures: NHS travel time, NHS reliability, Non-NHS travel time, and Non-NHS reliability, so that national (NHS-level) data can be supplemented with state and regional highway data addressing non-NHS facilities.

- Example 2 shows the various filters that can be implemented via pull-down menus (industry cluster, commodity, mode, trade type, and analysis period), as well as the available output metrics.

- Examples 3 through 7 illustrate different types of outputs – comparing the performance of industry clusters in one period or across multiple periods, and comparing the performance of specific commodities, modes, and trade types across multiple periods. Many other combinations of factors are available (commodities across all industries, modes across all industries, commodity by mode by trade type for a specific industry, moves over or under a certain distance, etc.). Tableau displays for such combinations are easy to create, and once created – as noted earlier – they update themselves when Tableau reads a new target file.

- These various graphic displays can be exported as small 'crosstab' tables that can be easily read and manipulated by GIS software, such as HEPGIS, allowing them to be incorporated into USDOT's preferred public display system(s).

Additionally, where origin-destination is available, it would also be able to display mode-specific data (as shown in Example 6) using transportation network assignments, and to display data without mode-specificity as centroid-to-centroid desire lines. Tableau can display centroid-to-centroid desire lines if origin and destination information in the target excel file, and it can also display network segment volumes assuming the user provides network shapefiles, link designations, and link volumes. However, it may be preferable to implement these mapping capabilities within other GIS software utilized more broadly by USDOT, such as HEPGIS, for purposes of display consistency.

Vendors

Vendors are being identified based upon their ability to meet the needs of the program. The vendors for this program must be able to:

- Provide dependable link-level performance data for the type of freight movement being measured. This means a) modal travel or dwell time, and the distribution of time in order to calculate speed and reliability; or b) current price information; and c) consistent quality of measurement, capable of accumulation in meaningful time series.

- Supply data on a quarterly basis in a timely fashion, so that results can be promulgated within a useful timeframe for management. Turnaround within 4 weeks of the close of each quarter is a reasonable target after the initial set-up, and faster is better. Automation of data extraction is thus an enabling requirement for vendors. Certain types of data also may not change by quarter (such as annual price contracts), and this should be recognized.
- Provide data that can be published and is thus free of confidentiality limitations. It may be necessary to utilize and restrict access to confidential information (cost data from the STB railroad waybill could be an example), but it is preferable to avoid this.
- Supply data at a fair and affordable cost to the program.

Where discussions with the vendors reveal that there are multiple vendors capable of meeting the criteria for a class of data, such alternatives will be entertained. Probe data for highway travel time and reliability are a case in point: ATRI and INRIX both draw from reasonably deep data pools for nationwide truck activity. Currently there are limitations with INRIX related to the recognition of driver hours of service for longer lengths of haul. Those limitations are not insurmountable, with some processing and estimation. ATRI is able to overcome that issue as well, and in a straightforward fashion. Nevertheless, the fact that INRIX is the current supplier for NPMRDS may create a policy preference to use it as much as possible.

Considerations in other data dimensions include:

- **Cost Data:** there is a criteria-based reason to prefer Chainalytics to others for the data it offers. This 'vendor' is actually a price benchmarking consortium of major American companies that collects millions of records continuously with excellent and consistent national coverage. Data are validated and anonymized as a fundamental part of the service, and can be turned around each quarter in a matter of days. The main alternative sources are freight bill audit houses or conduits for them. These sources have challenges in the breadth of coverage and release restrictions because of confidentiality concerns, there can be problems with data currency, and they are susceptible to inconsistency due to changes in clientele. Such vendors may be needed for rail carload and barge traffic that Chainalytics does not track, but coverage, release currency and consistency issues are obstacles.
- **Rail:** we identified two vendors (RSI and TransCore) for rail travel time and reliability data, yet they cover different segments (carload and intermodal). This is a specialized market without much competition. The real alternative is data collected for the railroads themselves by Railinc, but gaining access requires agreement by the Class I carriers that will not be forthcoming for now.
- **Vessel:** port and waterborne dwell, travel time, and reliability data are generated by the Coast Guard NAIS system and accessed through the US Army Corps of Engineers (USACE). NAIS is the single source, and USACE will need compensation for processing effort.

This discussion underscores how fluidity data is making a new market for data vendors. As the program grows at the national and regional level, it should encourage competition that is not present now. The key thing today is to make pragmatic decisions that put the program in place and establish the market. The fact that it works with paid commercial sources should attract new players over time.

Software Platforms

The software platforms for this program should meet the following criteria:

- Ability to hold and process large data sets in time series, to easily accept updates, and to be versatile in use. The volume of data in the national program initially is not large, but it will grow over time. In addition, a) it is desirable to be able to accommodate data from the metropolitan pilots, and from successor metropolitan programs, without changing platforms; and b) fluidity is a new class of performance measurement, with integrated multimodal facets, inclusion of costs, and capture of sequential travel with cumulative metrics. It is desirable for this data to be combined with others for cross-reference, examination of segments within links, and other purposes that may arise or be invented.

- Accessibility of data to internal and external users, via export into common formats such as spreadsheet software, and directly on the platform without purchase of special tools.
- Ability to restrict access to certain types or levels of data for certain groups of users.
- Varied and high quality graphical and cartographical display must be provided, and the displays must be interactive with the data, so that it is possible manipulate analysis from the data or from the display, and so that the values associated with a display can be immediately accessed, such as by hovering over a section of map.
- Stability as a dependable, tested tool. This is important for program continuity over time. It is also important because the software provides an archive of the output data, and is one of the ways that the program is documented.

The platforms also should fit into the existing suite of FHWA freight measurements tools, able to integrate with them so that they function more as a family than as separate tools in a box. The Tableau and HEPGIS platforms meet this requirement: they are both in use at FHWA today, they are proven and robust, and they can be used in tandem. They satisfy the criteria enumerated above and have been proven to do so. For example, a user may examine data in Tableau on-line, or download a free reader to examine it off-line, or export data to spreadsheets, and restrictions on access can be applied. It produces GIS output that can be fed into the higher quality cartographic environment of HEPGIS, which is already a delivery system for FHWA freight data. While we are open to alternatives if they can be shown to be superior, the combination of Tableau and HEPGIS is a pragmatic solution that meets requirements well and enhances rather than widens the FHWA suite of tools.

The intended use of recommended / potential software platforms within the overall program design is depicted below.

FIGURE 2 – SOFTWARE PLATFORM UTILIZATION WITHIN THE OVERALL DATA INTEGRATION SCHEME

Industry Sectors	Data Needs	Data Sources and Options	Data Tabulation and Dashboard Metrics	Data Export Formats	USDOT Display Platform Options
1	Cost	Chainalytics, supplemented by freight bill audit houses, STB waybill	Tableau	MSAccess / database	HEPGIS Other TBD
2					
3					
…					
1	Travel Time	Truck: ATRI, INRIX		MSExcel/ Spreadsheet	
2		Rail: TransCore, RSI			
3		Water: NAIS/USACE			
…					
1	Reliability	Truck: ATRI, INRIX		GIS Shapefile	
2		Rail: TransCore, RSI			
3		Water: NAIS/USACE			
…					

State and Metropolitan Regional Track

The State and Metropolitan Regional Track has the same logical structure as the National Track, because the supply chains run seamlessly end-to-end from the national to state and metropolitan area levels. The State and Metropolitan Regional Track will, therefore, report and map the same measures as the National Track--travel time, travel time reliability, and cost—using the same means, to the extent practical.

The key differences between the two tracks are that the State and Metropolitan Regional Track will:

- Focus on first- and last-mile moves that are connected to the National Track supply chains;
- Also monitor a set of regionally-significant supply chains in the New York-New Jersey-Pennsylvania region and the Chicago region, which will be identified in coordination with the regional partner agencies, who are the Port Authority of New York and New Jersey (PANYNJ), Chicago Metropolitan Agency for Planning (CMAP); and
- Address gaps in the national data, using state and regional resources, such as supplemental data and regional travel demand model analysis, as available.

In addition, fluidity is a tool that will be used in conjunction with other tools at the regional as well as the national level. These potentially include local GIS databases of land use and establishments; economic and travel demand models; systems supporting performance measures for roadways, ports and other facilities; or commercial data purchased locally for highway monitoring, commodity flow, and other purposes. Moreover, the favored tools may differ between regions in form or type. The implication is that regional usage requires adaptability to the suite of tools employed in the area. It is likely that the software platforms envisioned for the National Track are sufficiently adaptable, but we will test this as we work with the regional partners.

The monitoring components unique to the State and Metropolitan Regional Track are set forth below.

Geography

The boundaries of the two regions will be determined jointly with the regional partners. In Chicago, this is apt to become the CMAP territory, since it corresponds well to the "Chicagoland" market. In New York, no one agency covers the market; the PANYNJ G-MAP program treats the market as extending from southwest Connecticut to Philadelphia, including the distribution clusters in the Lehigh Valley of Pennsylvania.

One question that arises is the risk that a regional partner can no longer continue in the program. In New York, the PANYNJ is the lead for the G-MAP partnership of several agencies, all of whom the I-95 Corridor Coalition team works with routinely, so that the loss of one agency could be shored up through others. In Chicago, Illinois DOT and Chicago DOT will be engaged along with CMAP, and county agencies are available as a backstop. However, based on outreach to the regional groups at this time, we do not anticipate an issue with their engagement in the fluidity work.

Industry Sectors

Our initial steps taken to develop the National Track have identified several companies, including Target, Perdue, and Campbell's Soup, among others, that have significant origin/destination nodes in each of the metropolitan regions. We will identify which of the National Track supply chains contain an origin or destination in each of the metropolitan regions. These chains will be the foundation of the analysis, as they will demonstrate the logical connection between the National Track analysis and the first- and last-mile distribution within the metropolitan regions.

Because the National Track is portraying representative lanes within a given supply chain and not all lanes in a company's system, a participating company may have operations in a given metropolitan area that the National Track does not monitor. In such cases, the participant will be asked for the regional detail; typically, these will be variations on the national pattern, with a different DC but the same distribution structure.

We will work with the agency partners in each region to identify a handful of additional sectors and companies that play key roles in the regional economy, and which have robust distribution, pickup, and delivery activities performed in the region. Through various recent plans and studies, agencies in both regions have performed considerable work to identify key sectors, companies, and to map supply chains in their respective planning areas. As a result, the agencies will bring many ideas to the table. We will identify several to include in this pilot analysis, and develop the guidance at the conclusion of this study to help the agencies monitor other representative supply chains going forward.

Supply Chain Flows

For the supply chains that flow down from the National Track, we will gather information about first- and last-mile and metropolitan flows through the interviews that will be conducted as part of the National Track analysis..

Where interviews are required with additional firms or with metropolitan area specialists from firms contacted as part of the National Track outreach, we will ask interviewees to describe their supply chain systems as they are laid out in the region(s), detailing the stages and the predominant mode between stages. For the chains that flow down from the national track, we will ask interviewees for descriptions of the metropolitan trip ends, including key terminals and pickup and delivery nodes. In some cases, the national expert may not have a firm understanding of the metropolitan distribution, and a follow-up interview with a regional manager or other expert may be necessary.

The interviews will better illustrate how the supply chain operates in the metropolitan areas, and to select the appropriate network links and nodes to monitor. The approach to selecting links and nodes will vary, as follows, depending upon the information gathered:

- For company supply chains in which the pickup and delivery points are few in number, we will aim to develop a set of nodes and routes that connect those points;
- For consumer nondurables and other commodities for which the distribution pattern is more dispersed, we will request information about an individual distribution center or retail store, or a representative delivery route that serves multiple pickup and delivery points in the metropolitan area, and develop the network to represent that service pattern.
- If gaps in our understanding of the pickup and delivery system persist after the interviews, we will work with the regional agency partners to establish a proxy, such as identifying key retail clusters, using land use and/or available establishment data. NJTPA and NYMTC have illustrated sector-specific last-mile trip ends using a combination of establishment, network, and Census data. If needed, we will work with the agency partners to use locally-preferred data and methodology to identify a representative first/last mile scheme.

The supply chain for the Gap stores offers a case in point. The parent company operates stores under five brands, including Old Navy and Banana Republic in addition to the namesake brand. The stores tend to be in similar malls and shopping centers, and the company supplies them from the same DCs with a common truck making several deliveries. For the National Track, it is sufficient to capture final delivery to Philadelphia, whereas the Regional Track may want to distinguish separate addresses.

Performance Measurement

Like the National Track. travel time, reliability and cost will be collected from various vendors for each flow. Reliability will be measured at the 95% level, which is consistent with other FHWA programs and with industry standards. For the most part, data will be captured by link, in a fashion similar to the National Track.

The estimation of travel time will be calculated using a combination of travel times and reliability derived from vendor data, and estimations of non-National Highway System travel times and reliability, which may not be in the vendor databases. If necessary, the estimation of non-NHS travel times and reliability would be developed using the regional travel demand model network and data. Using this approach, the variability of actual travel times gathered quarter-by-quarter would not be discernable for the non-NHS links. However, because the vast majority of trip miles will be on the NHS, we expect that the impact of this gap in observed data would not be detrimental.

For cost, the data will cover the door-to-door move, with no distinction between NHS and non-NHS routing. For that reason, we do not anticipate a need to acquire or analyze local data to estimate cost, beyond what can be provided from the vendor(s).

FIGURE 3 – EXAMPLE: RETAIL DELIVERY IN NY/NJ/PA METROPOLITAN REGION

Links and Nodes	Transit Time/Dwell Time (Hours)	Reliability (95% travel time)	Cost
NY/NJ Port	24	50	
Dray move	1.0	1.4	$225
Regional distribution center			
Store delivery route to PA*	2.5	3.5	$525
Retail Store			
Totals			$750

*Route may include NHS links for which performance data will be available from vendors, and non-NHS links, for which the travel time and reliability may be estimated using regional models.

The *output* from performance measurement will be similarly structured and entered in Tableau, or an alternate application, if necessary to accommodate regional partner agencies' needs, with detail by link and with totals for the complete flow.

The network performance data will consist of data gathered on the National Highway System (NHS), and non-NHS roadways, which may not be covered by some of the vendors, and thus require use of local data sources such as travel demand models to fill gaps in the *inputs*.

Measurement Challenges

There are a number of challenges for performance measurement at the regional level, some of which can be recognized in the foregoing discussion:

- Roadway performance data from INRIX and ATRI is available for the NHS. While both vendors cover trucks moving on non-NHS roadways, coverage of facilities serving particular supply chain locations must be determined. Metropolitan agencies also may have independent relationships with these and other vendors they will prefer to leverage. However, the direct identification of *truck* movements may be less important for non-NHS facilities utilized on first and last mile legs. Effectively, once these legs connect to the NHS, the truck-specific measurement data on the NHS can take over. For the small number of miles between the connection and the shipment origin or destination, performance data for total (instead of truck-specific) traffic should suffice, because route selection will be reasonably clear and hours of service should not be a factor. Thus, a combination of INRIX or ATRI truck data on the NHS with general traffic sources for local roads should prove viable.

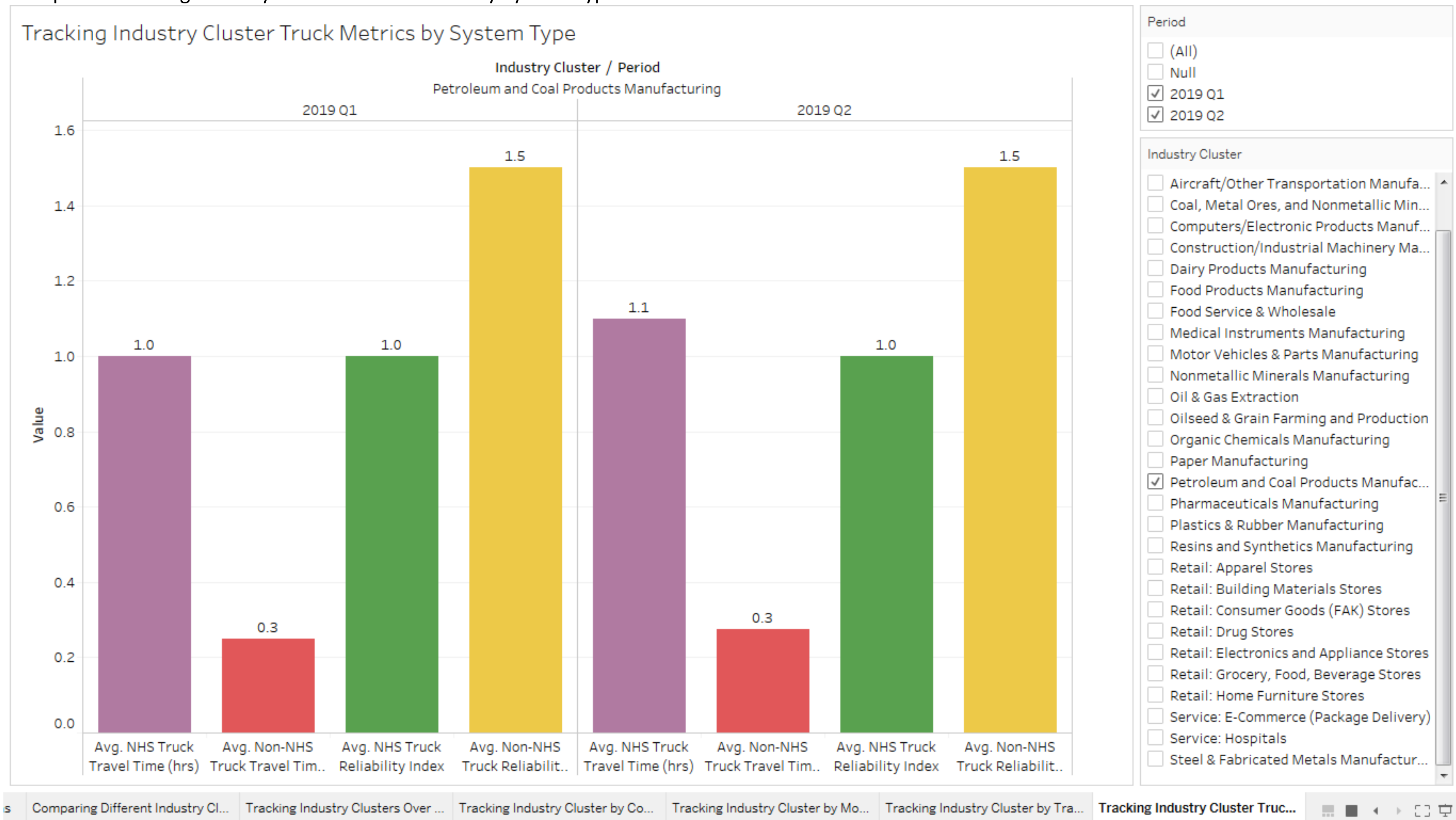
- Model outputs are tools that regional agencies commonly rely upon. However, even if a model is frequently calibrated, it cannot depict quarterly changes in real performance. As suggested above, this may not be a material flaw if the outputs are supplemental and affect a fraction of the trip with low performance risk. However, if the fraction involves something like port drayage with frequent queues, the performance risk is substantial. The credibility of findings is critical to the fluidity program; dependable data will be preferable to model outputs whenever it can be obtained, and the use of models must be judiciously attuned to the operating reality it is expected to portray.
- Turnover of facilities in the Regional Track is a greater risk than in the National, chiefly because retail outlets are added or subtracted more frequently than national supply chains are reconfigured. Planning for this should be part of the regional design. To some extent, closed outlets may be replaced by fulfillment centers or home delivery from other stores, in which case the resulting delivery service may be represented already. Validation of local facilities should be done at least annually and possibly more often in some sectors.
- Cost data may be difficult to obtain for local lanes. Because most multimodal shipping requires truck pick-up and delivery, the local lane is chiefly a truck lane. If cost information cannot be obtained directly, reliability data can provide a proxy because of the correlation to productivity. Motor carriers facing variable transit times offset them with longer duration service schedules. This reduces the amount of work the truck and driver can accomplish and adds to cost. Positive and negative trends in local reliability thus have a corresponding effect on costs in the local lanes and can be tracked for that purpose.

Placing these considerations in the context of Figure 3 above and considering the retailer as similar to the Gap, the challenges all lie with the store delivery leg. Movement from the port through to the regional DC is a sequence the National Track will cover robustly and the same sources and methods can be brought to bear. Movement from the DC to stores will follow NHS routes up to the point where local roads are needed for store access. Transit time and reliability need to be measured from store to store with local data, although the stores monitored could be selected based on where good data is available. Productivity changes could be estimated from changes in reliability for the full route from the DC if cost data cannot be obtained. Several store routes could be monitored as a hedge against closures, and store additions could be monitored if new development warrants it.

Performance Report

Like the National Track, State and Metropolitan Regional Track performance will be collected and reported quarterly. Dashboard concepts would largely be the same as examples shown for the National Track (see Examples 1 through 7). However, the recommended display concept includes the ability to differentiate NHS truck data on travel time and reliability (available from the National Track) and Non-NHS truck data on travel time and reliability (which could be State and Regional-level inputs), as shown in Exhibit 8 following.

Example 8: Tracking Industry Cluster Truck Metrics by System Type



Vendors

The State and Metropolitan Regional Track will have the same vendor requirements as the National Track, listed below, although the need monitor highway performance on local routes that are not part of the NHS will likely be a greater priority at the state and regional level than at the national level.

Software Platforms

The software platforms for this program should meet the criteria specified in the National Track design, and also be consistent with regional partner agencies' applications. The platform should also be fluid enough that it can be used or accessed by the regional partner agencies and/or other agencies the regional partners wish to work with on freight performance monitoring on an ongoing basis, such as MPOs, state DOTs, and other relevant agencies in each region.

Addendum 1: Initial Thoughts on Integrating Fluidity Products and FHWA Data Systems

We understand that FHWA will be undertaking a larger study of how to improve the accessibility and usability of freight mobility measures and freight data more generally. Looking ahead to how the results of the Fluidity study might integrate with existing tools and systems, we performed a brief examination of:

- Data Products expected from the Fluidity Study
- Potential to Integrate Fluidity Products into FHWA's HEPGIS
- Potential to integrate Fluidity Products into a system similar to "Philly Freight Finder"

Data Products Expected from the Fluidity Study

The three main metrics from the fluidity study will be: travel time; travel time reliability; and approximate transportation cost. To date, 76 specific industries representing 25 industry clusters have been contacted to participate in the study. These industries are being asked to provide descriptive information about their supply chains – commodities, modes, sourcing, processing and handling, and market distribution. The actual data/estimates of time, reliability and cost associated with the supply chains they describe will be drawn from other sources, not from the industry representatives. The study is addressing fluidity metrics only between US origins and destinations, although it is distinguishing and noting domestic supply chains that are part of larger export or import flows through US gateways.

As a result, supply chains and associated fluidity measures can be depicted on a national network map, as shown below.

Representative Retail Supply Chain

Consumer Goods—Ports of LA/Long Beach and Seattle/Tacoma via Chicago to Metro NYC

It is easy to envision a version of this map being made available online in "live" form, where a user could click on a commodity type, an origin or destination, or a network link, and have the map display associated travel time, reliability, and cost information as text or table pop-ups.

Potential to Integrate Fluidity Products into FHWA's HEPGIS

FHWA's HEPGIS system (https://hepgis.fhwa.dot.gov/fhwagis/#) is an online TransCad-based system that displays information related to the national highway system, including: NHS facilities; federal-aid system routes; national truck routes; highway primary freight network; HPMS AADT; fatal crashes; urbanized area/MPO/TPO/megaregion boundaries; selected census/demographic information; and network truck volume/GDP/Travel Time Index; FAF-4 highway flows (assigned to the highway network); Transborder Commodity Flows (assigned to ports of entry); and FAF-4 commodity flows for all FAF modes (mapped as origin-destination centroid links, not assigned to networks.) While the fluidity program mainly does not depend on these data sets, its ability to interact with them is important. For example, deterioration in reliability for a certain fluidity supply chain route should be examined as to cause. NPMRDS reliability data combined with AADT can be used to detect bottlenecks along the route and their severity over time; recent HPMS data may uncover other contributing factors. Communication with responsible agencies can reveal whether construction projects are influencing the findings. If not, the bottlenecks can be flagged for regional or national significance, and projects to address them might apply for federal grant programs.

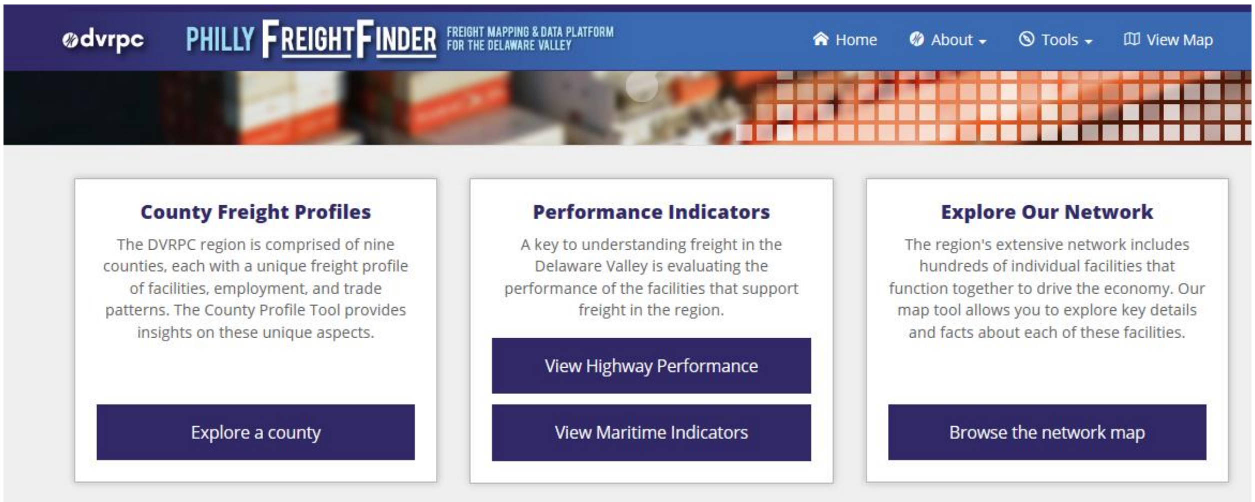
HEPGIS is easy to understand and navigate, and while the level of detail available in the map displays is limited, it is a powerful and intuitively obvious way to convey freight data to a broad range of users. It already displays several mobility measures, including highway facility volume and regional Travel Time Index. Without knowing the details of the system, we would expect that any network performance attributes that can be mapped in TransCad could be displayed in the system.

We expect that the Fluidity measures – time, reliability, and cost – could be ultimately be mapped within TransCad, as data attributes associated with depicted physical origin-destination flows. If so, they could potentially be added to HEPGIS as another display option, allowing the user to select and display the Fluidity information based on origin-destination, industry type, commodity type, or other available HEPGIS filters. The one limitation based on current HEPGIS design is that non-highway flows would have to be depicted as origin-destination centroid moves, rather than being assigned to the transportation network.

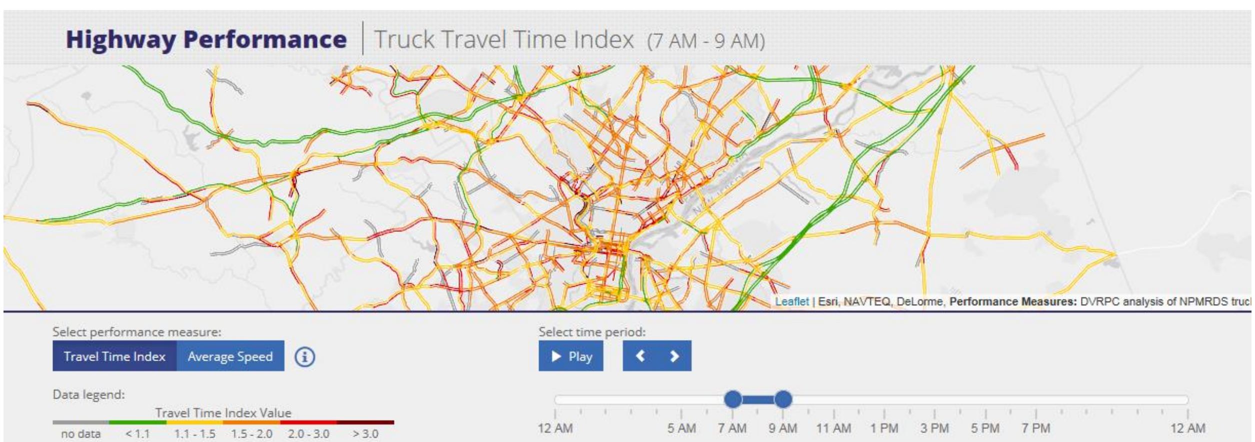
In short, we see strong potential to display the Fluidity measures within the HEPGIS system. As a next step, it would be valuable to learn more about the details of the system, and to discuss with FHWA whether we should target the Fluidity measures development process for eventual HEPGIS integration.

Potential to integrate Fluidity Products into a System Similar to "Philly Freight Finder"

PhillyFreightFinder (https://www.dvrpc.org/webmaps/phillyfreightfinder/#home) is a powerful online system for accessing three different kinds of freight information: county level 'freight profile' data summaries; an interactive display of the locations and attributes of various types of freight facilities; and an interactive display of maritime facility activity and highway performance data.



The highway performance data (shown in the following figure) includes travel time index and travel speed, from NPMRDS, and is mapped over the DVRPC network in both travel directions. The user can filter the displayed information by time of day.



The system is powerful, attractive, and extremely user-friendly, but by its nature is designed to focus on the display of regional data, not national data. For the depiction of national supply chain fluidity data, HEPGIS is a more appropriately scaled tool than PhillyFreightFinder or similar MPO-level data display systems.

Addendum 2: Sample Memorandum of Understanding (MOU) Between Project Team and Data Vendors

We intend to execute an MOU with each data vendor participating in the study. The specifications of the data, method of transfer, confidentiality, and cost will vary as each of the vendors will have slightly different requirements. This document is intended to serve as a guide, which will be adjusted, as needed, according to vendor requirements.

Purpose

The purpose of this agreement is to facilitate the acquisition of freight performance data in order to track the performance of specific nationally- and regionally-significant supply chains on a quarterly basis, to inform federal, state, and regional agencies' planning activities. To that end, [data type, specific to the vendor] will be assembled and transmitted to the project consultant team, according to the specifications detailed in this memorandum. The data will be used for research purposes and will be subject to the analyzed by the project consultant team, and summary reports and presentations will be shared with public agencies participating in the study.

Description of Data and/or Services

The data requested includes [SPECIFY WHAT IS REQUESTED FROM EACH VENDOR].

The data must cover network links identified in the attached list of specifications, associated with each of the supply chains analyzed in this study.

The data must be delivered quarterly for four quarters [SPECIFY START AND END DATE]. The vendor's methodological approach to querying and delivering the data must be consistent quarter-to-quarter to ensure the integrity of the research and analysis to be performed.

Method of Transfer

The vendor will provide data in spreadsheet or database forms native to or compatible with MS Excel or MS Access. The transfer of such data shall be performed electronically via email attachments or web-based file transfer, and any encryption key/codes needed to read encrypted data will be shared with the requestor.

Project Team Custodial Responsibilities

The parties mutually agree that the Consultant Team will be designated as "Custodian" of the file(s) and will be responsible for the observance of all conditions for use and for establishment and maintenance of security agreements as specified in this agreement to prevent unauthorized use. Where and how the data will be stored and maintained will also be specified in this section.

Confidentiality and Disposition of Data

This agreement represents and warrants further that, except as specified in an attachment or except as authorized in writing, that such data shall not be disclosed, released, revealed, showed, sold, rented, leased, loaned, or otherwise have access granted to the data covered by this agreement to any person. Access to the data covered by this agreement shall be limited to the minimum number of individuals necessary to achieve the purpose stated in this section and to those individuals on a need-to-know basis only.

Any summary results, however, can be shared in the form of technical reports and presentations shared directly with public agencies participating in the study, and to be posted on agency websites for public consumption. Summary results include analysis summaries, charts, graphs, maps, tables, and narrative that describe, at a high level, the findings of the analysis performed on the data provided.

The requestor and its agents will destroy all confidential information associated with actual records as soon as the purposes of the project have been accomplished and notify the providing agency to this effect in writing. When the project is complete, the requester will:

1. Destroy all hard copies containing confidential data (e.g., shredding or burning);

2. Archive and store electronic data containing confidential information off line in a secure place, and delete all on line confidential data; and

3. All other data will be erased or maintained in a secured area.

Term of this MOU

This MOU shall be in effect from [START DATE] through [END DATE, COVERING PERIOD NECESSARY TO GATHER ONE YEAR'S WORTH OF DATA].

Cost

Cost and due date for payment will vary by vendor, and are to be specified here, as applicable and necessary.

Signatures

Authorized vendor and project team representatives will sign, thereby binding all parties to the provisions of this memorandum.