Transportation Pooled Fund Program
To create Web-based Traffic Data Visualization and Analysis Tools

Task 3 Report

Prepared for the Federal Highway Administration

By

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1.1 FIGURES AND TABLES

INTRODUCTION

This report details the work of AVAIL in completing Task 3 of the FHWA Transportation Pooled Fund Program to create Web-based Traffic Data Visualization and Analysis Tools. It includes a thorough review of current data and software systems concluding with a set of optimal system recommendations for the Web-Based Analysis Tool.

2 TASK 3A: REVIEW OF CURRENT SYSTEMS

- Scope of Work: The contractor shall identify functionality characteristics and strengths and weaknesses of current systems such as GIS systems, TMAS, VTRIS, HPMS applications, the Mechanistic Empirical Pavement Design Guide (AASHTOWare ME), SAS, or other applicable traffic monitoring / analysis systems. The contractor shall explore new data storage and software options that will maximize performance in a web-based environment allowing multiple users to simultaneously conduct complex traffic data analyses.

AVAIL's review of current systems should produce these outcomes:

1. Identify and assess all data and software resources currently available.
2. Eliminate the possibility of project redundancy.
3. Facilitate AVAILabs effort to build the most informed and cutting-edge tool.

2.1 AVAILABLE DATA SYSTEMS

AVAIL reviewed and assessed all relevant publicly available transportation datasets for their potential uses in developing the Web-Based Analysis Tool.

2.1.1 Traffic Monitoring Analysis System (TMAS)

Overview – The Travel Monitoring Analysis System allows states to report data from Automatic Traffic Recorder stations to the Federal Highway Administration for use in reporting, to facilitate data sharing across states, and for creating reports and use in FHWA programs such as Traffic Volume Trends. TMAS performs quality control functions to assess the integrity of its datasets.[1]

Table 1 Data System Qualities, TMAS

Data System: TMAS			
Volume Reports	**Classification Reports**	**Weight Reports**	**Related Data**
State TVT Report	Class by Day by Hour by Site	Weigh Station Characteristics	Automatic Traffic Recorder Data,
Station by Hour	Class by Station with no data in weight columns	Comparison of Weighted vs. Counted	Volume Counts
MADT by Month with AADT by Station/State	Class by Station Monthly by Day	Average Empty, Loaded, and Cargo Weights	Classification Counts
Volume data upload by State and Month	Station multi-year by month	Equivalency Factors	Weigh In Motion (WIM) Data
	Class by HPMS6 vehicle types by State	Gross Vehicle Weights	Station Files
		Overweight Vehicle Report	
		Distribution of Overweight Vehicles	

2.1.2 Highway Performance Monitoring System (HPMS)

Overview – The Highway Performance Monitoring System is a national level highway information system that includes data on the geographic extent, condition, performance, use and operating characteristics of the nation's highways. HPMS offers high quality geospatial data which can be easily entered into GIS mapping technology.[2]

Table 2 Data System Qualities, HPMS

Data System: Highway Performance Monitoring System (HPMS)
HPMS Road Network Spatial Data
Annual Average Daily Traffic (AADT) Counts for Each segment
Truck Annual Average Daily Traffic (TAADT) Counts

[1] U.S. Department of Transportation, Federal Highway Administration, "Traffic Monitoring Guide, 2013" http://www.fhwa.dot.gov/policyinformation/tmguide/tmg_fhwa_pl_13_015.pdf

[2] U.S. Department of Transportation, Federal Highway Administration, "Highway Performance Monitoring System," https://www.fhwa.dot.gov/policyinformation/hpms.cfm

2.1.3 Freight Analysis Framework (FAF)

Overview - The Freight Analysis Framework (FAF) integrates data from a variety of sources to create a comprehensive picture of freight movement among states and major metropolitan areas by all modes of transportation. FAF provides estimates for tonnage, value, and domestic ton-miles by region of origin and destination, commodity type, and mode.[3]

Table 3 Data System Qualities, FAF

Data System: Freight Analysis Framework (FAF)
FAF Road Network Spatial Data
Tonnage by road segment and commodity type
Ton-miles by road segment and commodity type
Dollar value of freight by road segment and commodity type

2.1.4 RITA - National Transportation Atlas Database

Overview – The National Transportation Atlas Databases 2013 (NTAD2013) is a set of nationwide geographic databases of transportation facilities, transportation networks, and associated infrastructure. These datasets include spatial information for transportation modal networks and intermodal terminals, as well as the related attribute information for these features. Metadata documentation, as prescribed by the International Organization of Standards, is also provided for each database[4]. When combined with the geospatial assets included within HPMS, a more complete picture of our transportation network can be drawn.

Table 4 Data System Qualities, RITA National Transportation Atlas Database

Data System: RITA National Transportation Atlas Database
U.S. Border Crossings
Intermodal Terminal Facilities
National inventory of navigable inland waterway locks
National Bridge Inventory
U.S. Army Corps of Engineers Ports
Travel Monitoring Analysis System (TMAS)
Freight Analysis Framework Regions
Metropolitan Planning Organizations
Freight Analysis Network
Hazardous Material Routes
Highway Performance Monitoring System
National Highway Planning Network

[3] U.S. Department of Transportation, Federal Highway Administration, "Freight Analysis Framework" http://www.ops.fhwa.dot.gov/freight/freight_analysis/faf/

[4] U.S. Department of Transportation, Research Innovation Technology Administration, National Transportation Atlas Database, "Liner Notes," http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_atlas_database/2013/liner.html

2.1.5 Others – MEPDG, VTRIS

The AASHTO Mechanistic-Empirical Pavement Design Guide (MEPDG) provides the highway community with a state-of-the-practice analysis tool for evaluating pavement structures using mechanistic-empirical principles, using project specific traffic, climate, and materials data for estimating damage accumulation over a specified pavement service life. MEPDG is applicable to designs for new, reconstructed, and rehabilitated flexible, rigid, and semi-rigid pavements. Performance and distress predictions models are used to aid the pavement designer in determining the desired pavement section[5]. AVAIL is currently using the MEPDG analysis tool software inputs in the Web-Based Analysis Tool.

Vehicle Travel Information System (VTRIS) validates, facilitates editing, summarizes, and generates reports on vehicle travel characteristics. It also maintains the permanent database of the Station description, Vehicle Classification, and Truck Weight measurements in metric units. It allows repetitive data averaging and report generation with different options without additional source data processing. It allows input of ASCII traffic data as well as import of state-submitted data in internal VTRIS formats. The reports and graphs - final products of VTRIS functionality can be created in both metric and English units[6]. AVAIL is not using VTRIS because it has been superseded by the TMAS program.

[5] AASHTO, Mechanistic-Empirical Pavement Design Guide, http://me-design.com/MEDesign/Documents.html#
[6] U.S. Department of Transportation, Federal Highway Administration, "VTRIS User's Guide – Manual," http://www.fhwa.dot.gov/ohim/ohimvtis.cfm

2.2 SOFTWARE SYSTEMS

The Web-Based Analysis Tool is comprised of a number of software components integrated into a web portal. The development of such a tool requires scrutinizing software options to determine which is best for organizing and visualizing the available data sets.

The AVAIL team categorized software needs into classes based on function. Organizing data requires *Databases*, Visualization requires *GIS/Mapping* software and *Data Analysis/Visualization* software. The *Web Framework* must be capable of coordinating the database with the GIS/Mapping software and it should be easy to develop, agile, compatible with existing systems and transferrable between web applications.

Finally, the *User Interface* is then designed by a team of web-programmers and designers to optimize device flexibility, multimedia adaptability, advanced language for programmatic element formatting, device responsiveness, system performance, and to emphasize bandwidth and resource efficiency.

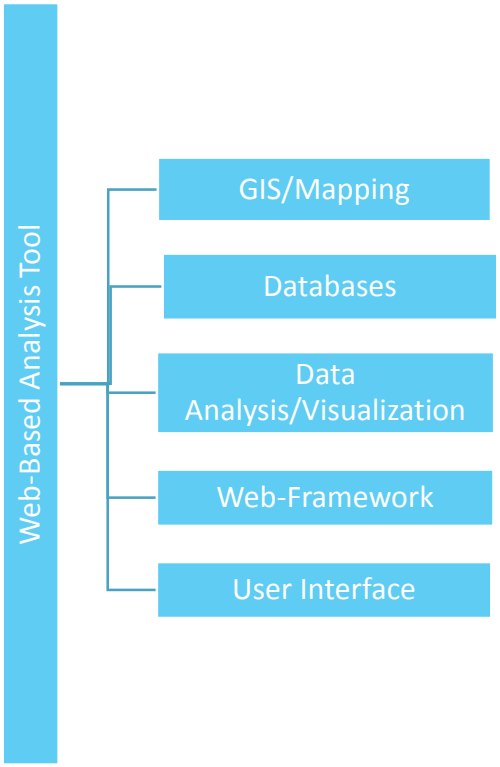

Figure 1 Web-Based Analysis Tool, Software Structure

2.2.1 Software Assessment

AVAIL explored existing data storage and software options to determine which software would maximize performance in a web-based environment for allowing multiple users to simultaneously conduct complex traffic data analyses. Each software item was analyzed for its effectiveness according to an assessment matrix

measuring performance in six areas: Cost, License Type, Documentation, Extensibility/Agility, and Complexity and defined below:

- Cost – the range of costs for acquiring licenses to use software at various scales.
- License Type – the portability and flexibility of the license.
- Documentation – an assessment of the availability of documentation for both use and development of software items. This includes both published and community documentation.
- Extensibility/Agility – Customizability, system design takes future growth into consideration, customizable, speed of development, ease of adaptation, and platform transferability.
- Complexity – How difficult is the software to develop, adapt, and understand.

Table 5 AVAIL Software Assessment Matrix

Poor	Fair	Good	Very Good	Excellent
1	2	3	4	5

Software	Cost	License	Documentation	Extensibility / Agility	Complexity	Overall Score
GIS/Mapping						
ArcGIS Online	$2500-$17,500+ per year	Commercial	4	1	1	1
OpenLayers	Free	MIT	2	3	2	3
D3.js	Free	MIT	1	5	3	5
Leaflet	Free	MIT	3	1	5	4
Database						
MySQL	Free	GPL	4	N/A	3	3
PostGIS	Free	GPL	2	N/A	3	4
Apache Hadoop	Free	Apache 2.0	3	N/A	1	1
Google BigQuery	Query Based	Google SLA	3	N/A	5	5
Amazon RedShift	Query Based	Amazon License	3	N/A	3	4
Data Analysis						
D3.js	Free	MIT	2	5	3	5
HighCharts	$600-$3500	Commercial	4	2	4	4
Web Framework						
pHp	Free	GPL	5	3	5	5
Ruby on Rails	Free	MIT	5	4	3	3
Node.js	Free	MIT	5	5	3	3
ASP.Net	Free	Apache 2.0	5	2	4	2
JSP on Tomcat	Free	Apache 2.0	5	1	1	1

See Appendix A for Software Resources

2.3 User Interface

AVAIL determined that the User-Interface should be designed using agile programming code and be based on sound principles and best practices:

- HTML 5[7]
    - Core markup language – designed for device flexibility and multimedia
- CSS 3[8]
    - Advanced language for programmatic element formatting
- Responsive Design
    - Focused on optimal design independent of device or platform
- Emphasize bandwidth and resource efficiency
- Easy to use
- Vivid data visualization

[7] World Wide Web Consortium, "HTML5," http://www.w3.org/TR/html5/
[8] World Wide Web Consortium, "CSS3," http://www.w3.org/TR/2001/WD-css3-roadmap-20010523/

3 TASK 3B: OPTIMAL SYSTEM RECOMMENDATIONS

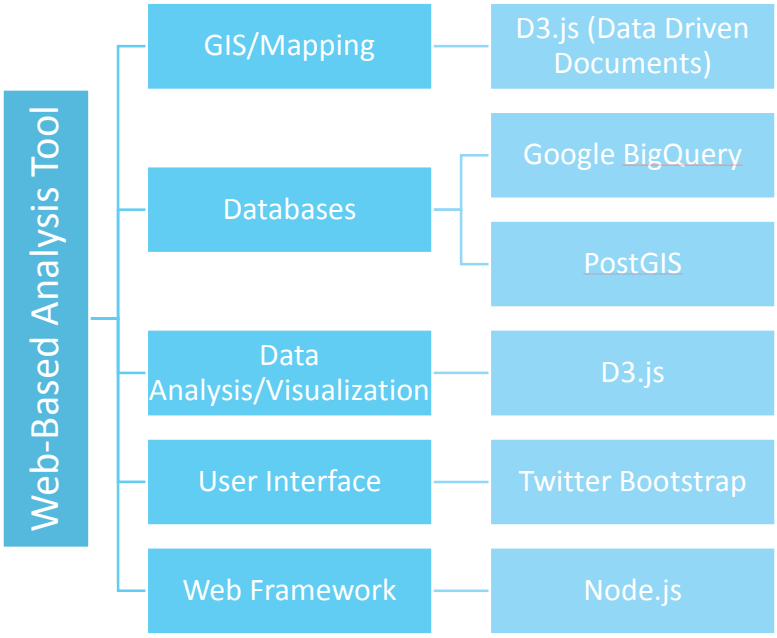

Figure 2 Web-Based Analysis Tool, Software by Function

3.1 GIS SYSTEMS, DATA ANALYSES, AND VISUALIZATION SYSTEMS

AVAIL recommends using D3.js to serve two Web-Based Analysis Tool functions. D3js has dynamic qualities not found in any other software:

1. D3.js allows for the building of custom visualizations and maps in a way that no other system can do. It allows for easy interaction with data. Interactive maps.
2. D3.js provides superior performance. By using D3.js AVAIL can visualize vector tiles which greatly increases the scalability of data in web based GIS applications. This allows for tracking hundreds of thousands of objects instead of just thousands.
3. By choosing D3.js as a both visualization tool and GIS mapping software, AVAIL can develop seamless interactions between spatial and non-spatial visualizations.
4. D3.js allows AVAIL to innovate with new types of data visualizations in ways that would be impossible with High Charts or other types of more traditional libraries.

3.2 DATABASES

AVAIL recommends using a combination of two software options to achieve the best possible database structure for this project. AVAIL chose to use Post-GIS and Google Big Query:

1. Post-GIS allows AVAIL to store, access and export any spatial data format.
2. Post-GIS offers advanced spatial analytical tools.
3. Google Big Query does not serve the function of spatial data.
4. Google Big Query allows AVAIL is an order of magnitude improvement over traditional databases for storing and analyzing data sets greater than 5GB in size.
5. The ease of use, documentation, and support made Google Big Query best in class for processing large datasets.

3.3 WEB FRAMEWORKS

AVAIL recommends Node.js for Web Framework:

1. Node offers cross platform compatibility.
2. Node allows for ease of cross platform installation and setup.
3. Node is an extremely agile framework that also for the quickest possible development and implementation.
4. Using Node allows for full-stack JavaScript development. It is the only framework that allows AVAIL to use a single language, JavaScript, for both server and client side development. The popularity of JavaScript broadens the pool of possible contributors.

4 TASK 3C: BUSINESS DESIGN DOCUMENT

4.1 PROPOSED SYSTEM ARCHITECTURE

The code being used by AVAIL is open source and it is being designed so that it can be integrated into a number of different enterprise structures. Ultimately, the software architecture informs the choice of software and vice versa. AVAIL made all software decisions by keeping in mind both end user experience and database query capacity. Without sound database structure, GIS mapping and visualization are not possible. Advances in programming software allow cutting-edge user interface design and visualization to work in coordination with dynamic database and server side software.

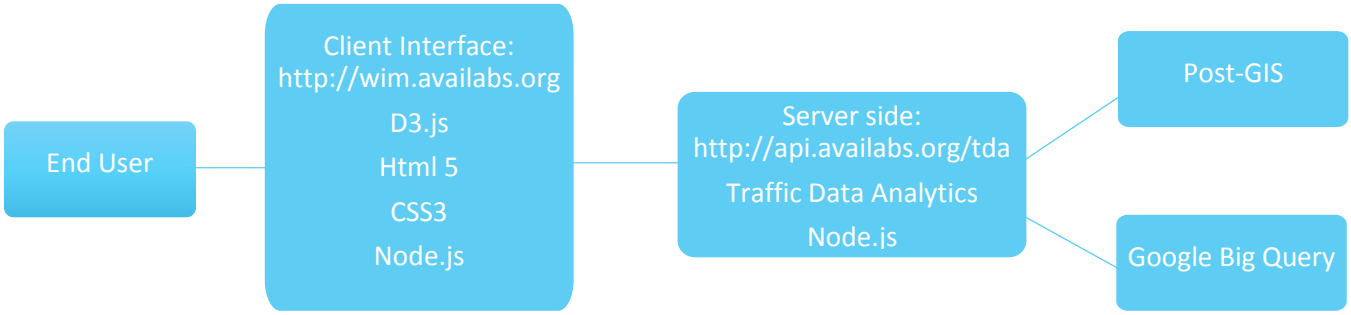

Figure 3 Web-Based Analysis Tool Software Architecture with Software Names

4.2 DEPLOYMENT

There are two options for handing off the administration of the Web-Based Analysis Tool. The first is to deploy the software onto participating state DOT servers. The second option is for AVAIL to maintain the Web-Based Analysis Tool with a service contract.

4.2.1 Individual Deployment

As part of the project, AVAIL will make installation and setup instructions for all modules to be deployed on UNIX-based and Windows-based systems. Each pooled fund study participating state will have the option to deploy the software on their own infrastructure or hire a third party to host the Web-Based Analysis Tool platform. For the duration of the project plus one additional year, AVAIL will make this platform available for all pooled funds study members as a web portal at http://wim.availabs.org.

4.2.2 Software as a Service

AVAIL is offering to host and support the software systems and data in perpetuity with an annual contract. This allows the individual DOTs to avoid incurring internal IT costs such as the purchase of

additional hardware, or training their in-house IT staff in the use, development, and management of the developed software, in order to integrate with current and future systems.

SUMMARY

This report details an assessment conducted by AVAIL of current data and software systems for applicability in building the Web-Based Analysis Tool. Additionally, based upon these assessments, AVAIL completed the process of recommending a software architecture for the Web-Based Analysis Tool. Finally, AVAIL recommends two approaches for future deployment of the Web-Based Analysis Tool to all pooled fund study participants. With this report the AVAIL team has met the requirements of Task 3A, 3B, and 3C as described in the scope of work.

APPENDIX

APPENDIX A

Table 6 Software Resource Links

Software	Function	Resource Links
ArcGIS Online	GIS/Mapping	http://www.esri.com/software/arcgis
OpenLayers	GIS/Mapping	http://openlayers.org/
D3.js	GIS/Mapping	http://d3js.org/ http://bl.ocks.org/mbostock
Leaflet	GIS/Mapping	http://leafletjs.com/
MySQL	Database	http://www.mysql.com/
PostGIS	Database	http://postgis.net/
Apache Hadoop	Database	http://hadoop.apache.org/
Google BigQuery	Database	https://cloud.google.com/files/BigQueryTechnicalWP.pdf
Amazon RedShift	Database	http://docs.aws.amazon.com/redshift/latest/dg/welcome.html
D3.js	Data Analysis	http://d3js.org/ http://bl.ocks.org/mbostock
HighCharts	Data Analysis	http://www.highcharts.com/docs/advanced-chart-features/stacking-charts
pHp	Web Framework	https://php.net/
Ruby on Rails	Web Framework	http://rubyonrails.org/
Node.js	Web Framework	http://nodejs.org/
ASP.Net	Web Framework	http://www.asp.net/
JSP on Tomcat	Web Framework	http://tomcat.apache.org/tomcat-7.0-doc/jasper-howto.html