Performance Management Tools

Success Stories and Lessons Learned

presented to

NATMEC

presented by

Cambridge Systematics, Inc.

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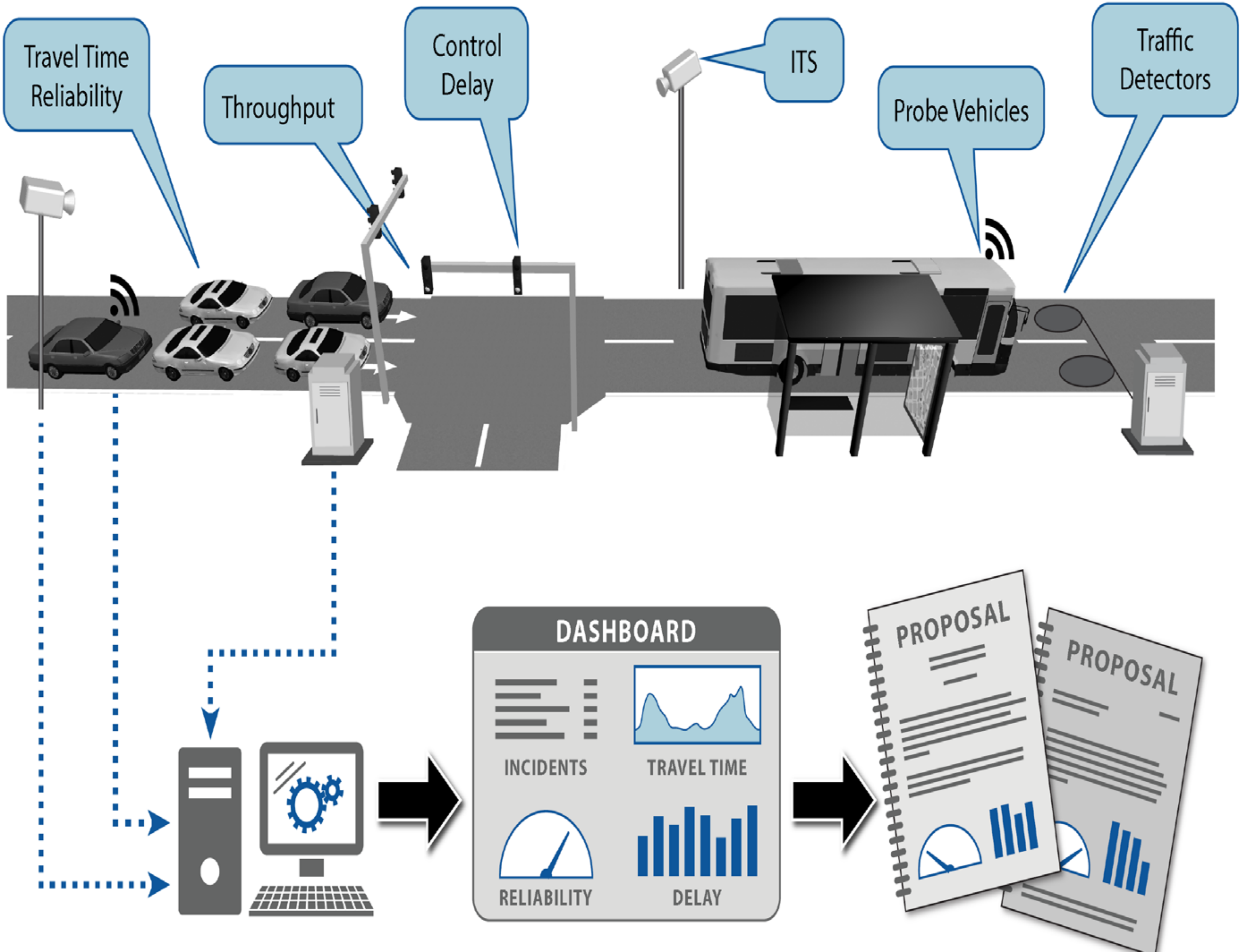
May 2, 2016

Plan of Attack

- Performance Management Tools – Why all the fuss?
- 3 Case Studies
  - » FHWA Virtual Data Access
  - » Florida Mobility Performance Measures System
  - » LA Metro Arterial Performance Measures Concept of Operations
- Lessons Learned
- A Look Ahead



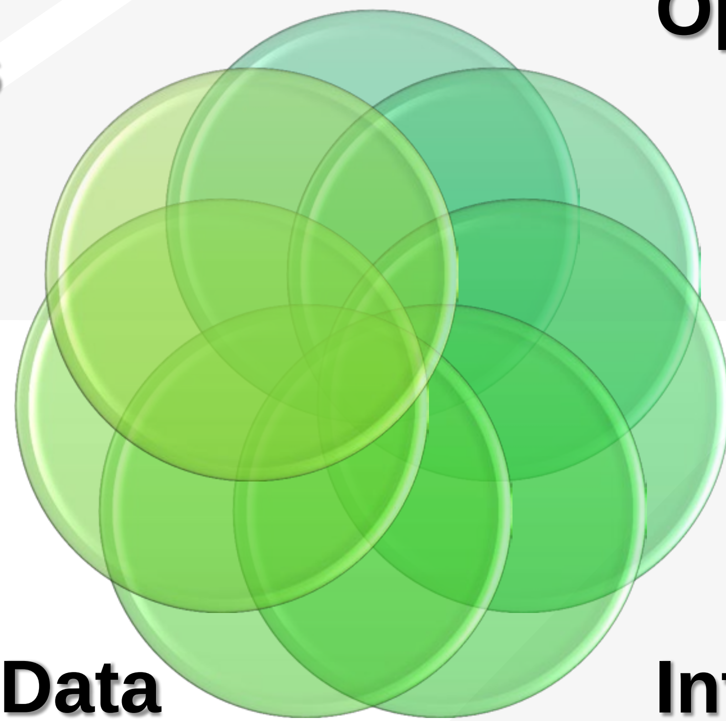
Travel Time Reliability
Throughput
Control Delay
ITS
Probe Vehicles
Traffic Detectors
DASHBOARD
INCIDENTS
TRAVEL TIME
RELIABILITY
DELAY
PROPOSAL
PROPOSAL

PM Tools – Why all the Fuss?

MAP-21

Optimization of resources

Decisions



Bang for the Buck

Visualization

Various Data Sources

Interoperability

Case Study 1
FHWA Virtual Data Integration

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SAXTON

TRANSPORTATION OPERATIONS LABORATORY

Virtual Data Sharing Framework Project

U.S. Department of Transportation
Federal Highway Administration

Project Objectives and Needs

- Develop and test **Data Sharing Framework** and **Data Sharing System** where multiple sources of operations data can be identified, integrated, formatted, shared, and utilized for planning purposes
- Stakeholder Needs (MARC and KC Scout)
  - Access to other agency's data to avoid duplicating collection efforts
  - Demonstrate effectiveness of operations strategies to maintain funding
  - Fulfill MAP 21 requirements for performance measures
  - Identify sources of congestion in region to target investments

Data Sharing and Integration – Findings – Example Data Environments

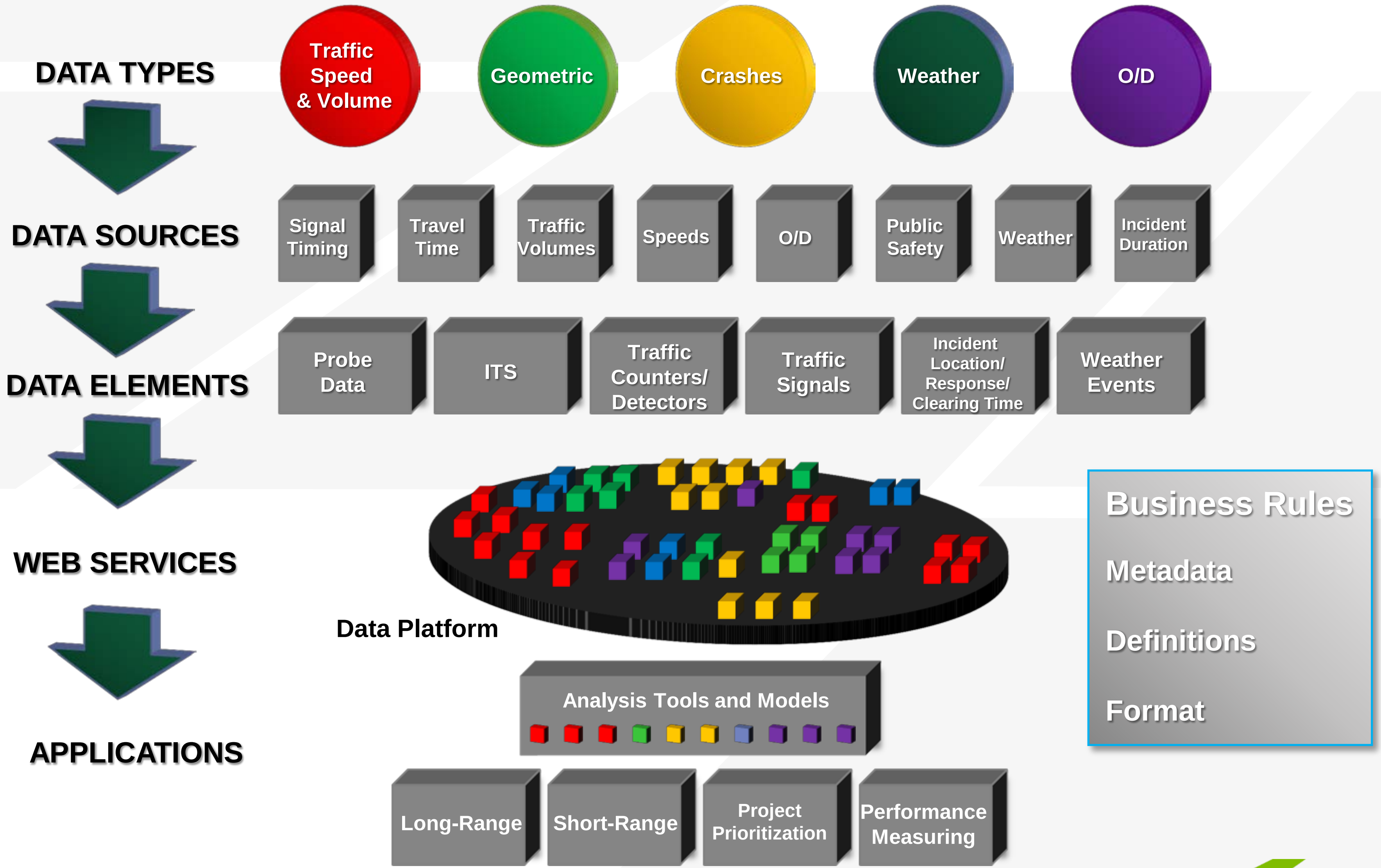
- University of Maryland's RITIS
- Caltrans' PeMS
- Portland State University's PORTAL
- University of Virginia's ADMS
- University of Washington's TDAD
- CLARUS
- Applications for the Environment: Real-Time Information Synthesis (AERIS)
- FHWA Data Capture and Management Program Test Data Sets

Components

Virtual Data Access Framework (VDAF)

Performance Management Analysis Tool (PMAT)

Virtual Data Access Vision

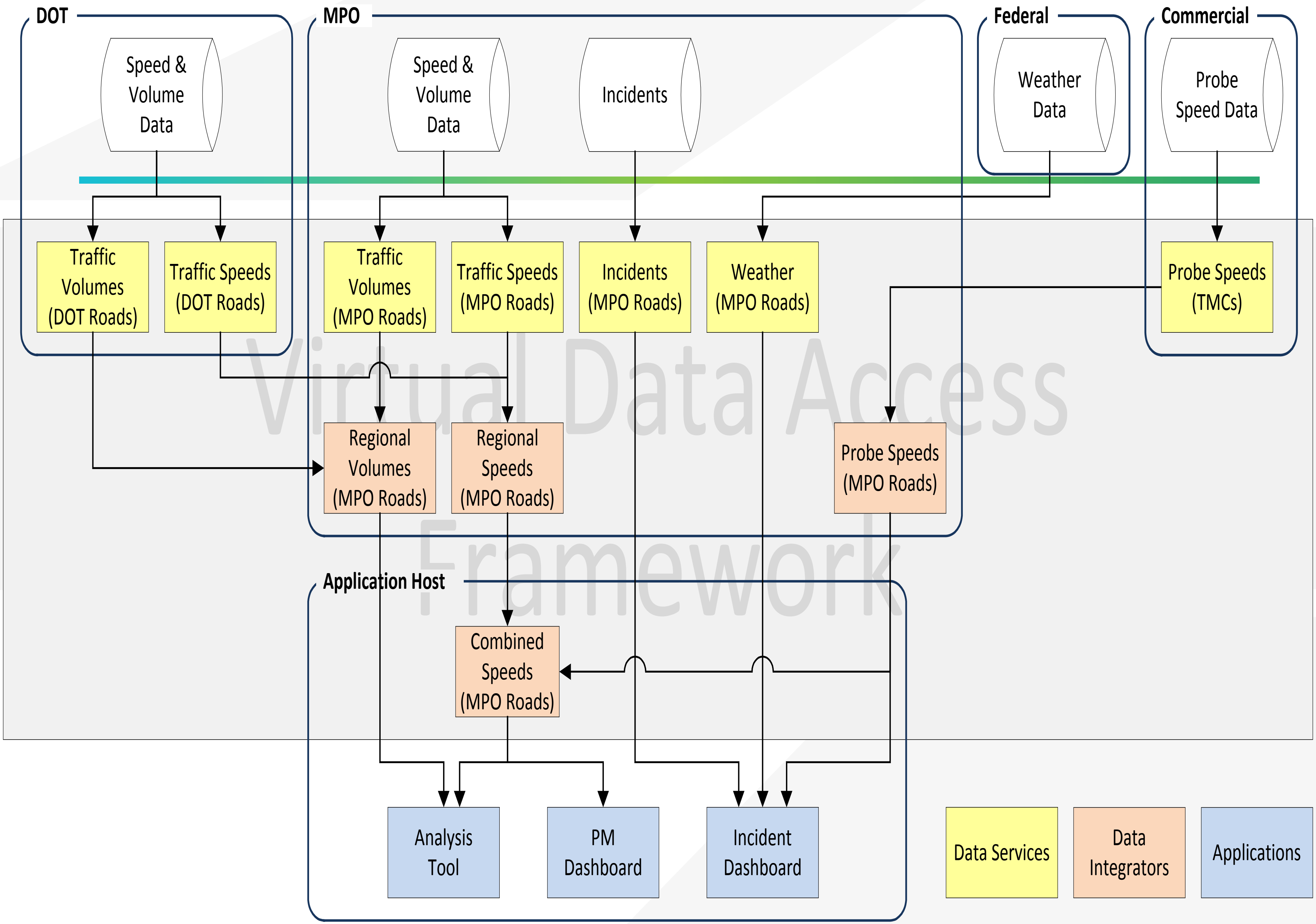


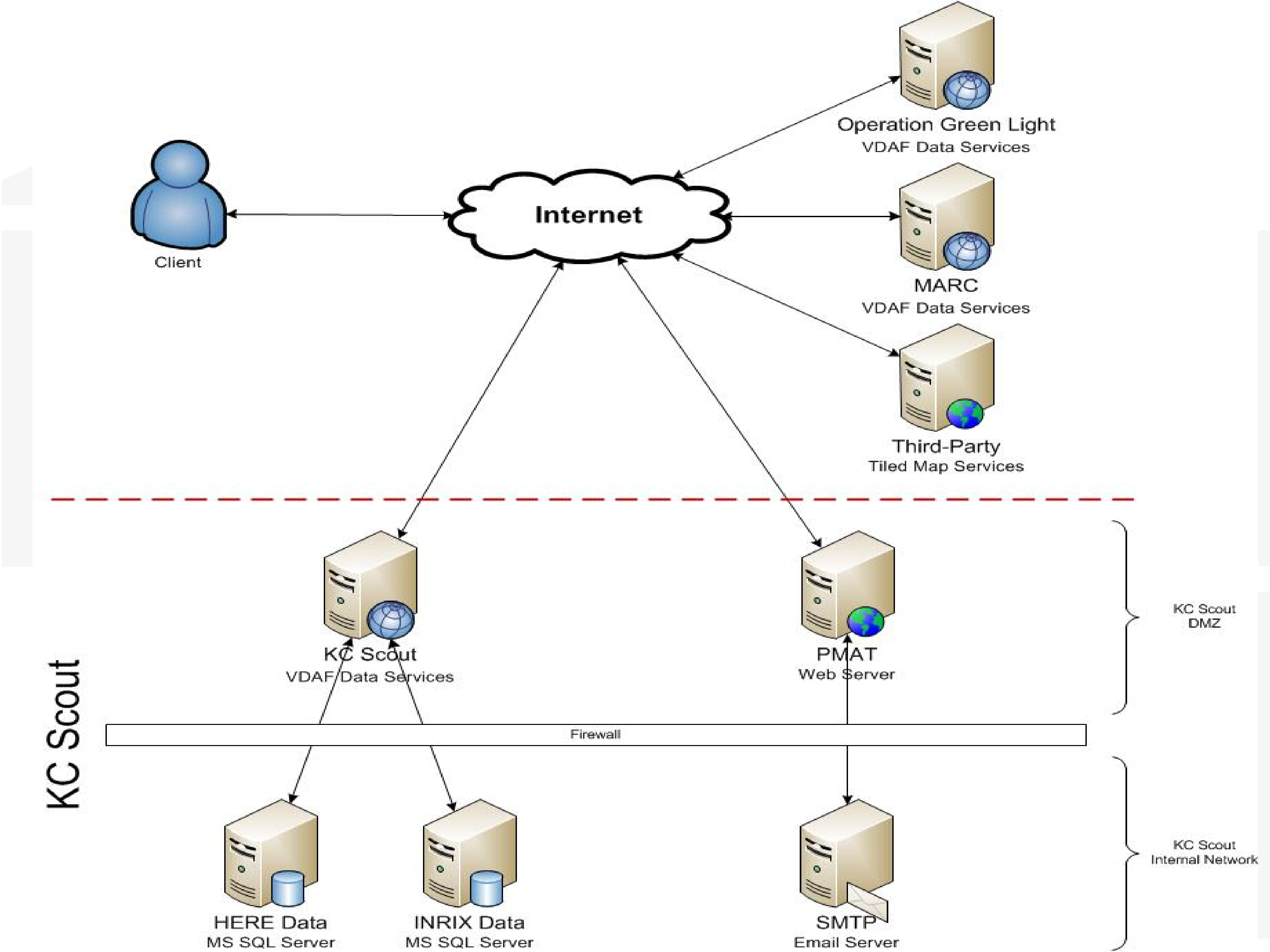
Technical Requirements

- Hardware and software
- Distribution approach Coverage/gaps (data types, spatial, facility type, modes)
- Quality/validation
- Temporal resolution (time period – minute(s), hours, periods, days, month, year)
- Storage/archiving
- Security/access
- Integration/processing/cleaning

Institutional Requirements

- Sharing (within/outside agency)
- Standards/consistency
- Business rules (metadata, definitions, formats)
- Agreements/MOUs
- Documentation
- Resources (cost, staff, staff skills)
- Stakeholder involvement/roles and responsibilities


DOT
MPO
Federal
Commercial
Speed & Volume Data
Speed & Volume Data
Incidents
Weather Data
Probe Speed Data
Traffic Volumes (DOT Roads)
Traffic Speeds (DOT Roads)
Traffic Volumes (MPO Roads)
Traffic Speeds (MPO Roads)
Incidents (MPO Roads)
Weather (MPO Roads)
Probe Speeds (TMCs)
Virtual Data Access Framework
Regional Volumes (MPO Roads)
Regional Speeds (MPO Roads)
Probe Speeds (MPO Roads)
Application Host
Combined Speeds (MPO Roads)
Analysis Tool
PM Dashboard
Incident Dashboard
Data Services
Data Integrators
Applications


Operation Green Light
VDAF Data Services
Client
Internet
MARC
VDAF Data Services
Third-Party
Tiled Map Services
KC Scout
VDAF Data Services
PMAT
Web Server
KC Scout
DMZ
Firewall
KC Scout
HERE Data
MS SQL Server
INRIX Data
MS SQL Server
SMTP
Email Server
KC Scout
Internal Network

PMAT

Proof of concept test

Map based web app

- View travel time reliability, delay and traffic volume throughput on arterials and freeways
- Extract data in GIS shape files and export data necessary to perform analyses

PMAT Data Sources

Road network nodes and links from MARC

Traffic Analysis Zones (TAZ) boundaries, centroids, centroid connectors and Origin-Destination demand matrix from MARC

INRIX and Here probe traffic speed data provided by MARC and hosted at KC Scout

Traffic Count locations and data from KC Scout

Traffic Signal locations and types from MARC's Operation Green Light

PMAT Functionality

Conflates INRIX and HERE probe data against MARC network

Merges INRIX and HERE data into a consistent dataset referenced against MARC network

PMAT Iteration

- Data filter view functionality
- Aggregate data by day and time
- Compute Performance Measures over Peak Times (NEW)
- View Average Speed on the map
- View Percent Congested on the map
- View Travel Time Reliability on the map
- View Travel Time Index on the map
- View Buffer Time Index on the map
- View Planning Time Index on the map
- View Hours of Delay on the map
- Filter VDAF data temporally
- Filter VDAF data spatially
- Filter VDAF data by performance measure range

U.S. Department of Transportation
Federal Highway Administration

Virtual Data Access Framework
Performance Measurment Analysis Tool

Current Filter: From Date: 2013-12-04 06:00 | To Date: 2013-12-04 18:00

Inrix Data | Here Data | Filter | Export Data

Map | Data | Chart | Help

Average Speed
- 0-20 mph
- 20-40 mph
- 40-60 mph
- 60-80 mph
- >80 mph
- No Valid Data:

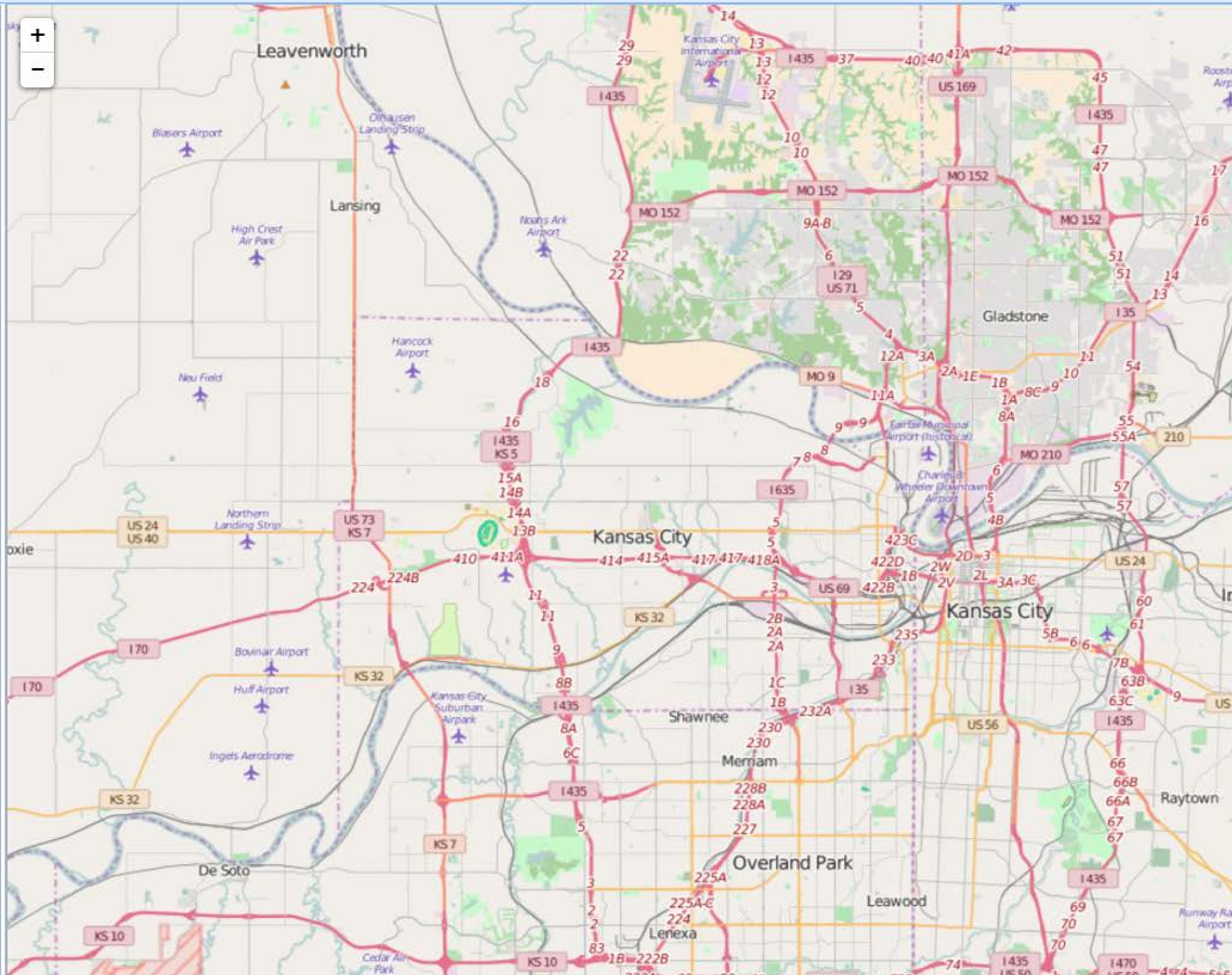
Hours of Delay
- <10 minutes
- 10-20 minutes
- >20 minutes
- No Valid Data:

Buffer Time Index
- Good:
- Average:
- Bad:
- No Valid Data:

Percent Congested
- 0-20%
- 20-40%
- 40-60%
- 60-80%
- >80%
- No Valid Data:

Planning Time Index
- Good:
- Average:
- Bad:
- No Valid Data:

Travel Time Index
- Good:
- Average:
- Bad:



Lessons Learned

- Unfortunately, the flexibility required to implement the VDAF to meet requirements caused limitations in the speed of data retrieval, and the usability of the data, due to:
  - Size of retrieved data
  - Format of original data
- Too much emphasis placed on tool rather than data access framework

Performance Improvement Recommendations

- Create local caches of the results of repetitive data queries
- Update implementation to take full advantage of a multi-threaded environment
- Enhance VDAF API for Data Services to allow for improved querying
- Reduce the size of the raw datasets to reduce overhead and support PMAT analysis items
- Reduce size of datasets passed between Data Services, Data Integrators and PMAT
- Perform pre-processing of the data, either in the source database or as part of a Data Service
- Implement Data Integrators to access the raw data directly

Lessons Learned

- The VDAF and PMAT prototype clearly showed that it is possible to access data stored on multiple networks using a standard API that:
  - Maintains security of data
  - Can be implemented for different operating systems and networks
  - Can access data stored in multiple formats
  - Can access spatial data
  - Allows developers to access metadata

Case Study 2
Florida Mobility PM System

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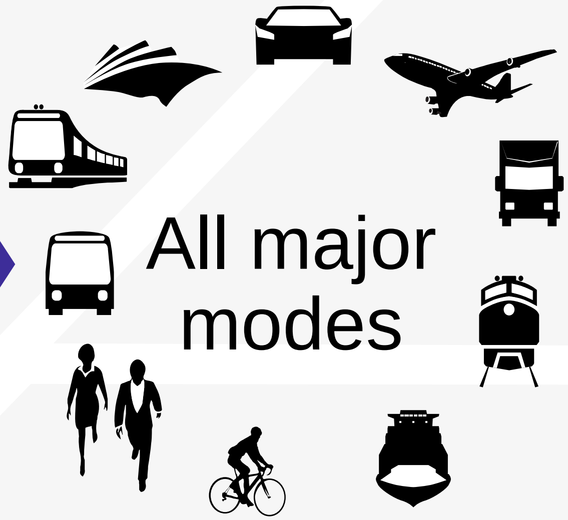
Features of Florida's Statewide Mobility Performance Measures

www.FloridaMPMs.com



All major modes

For FDOT purposes, and MAP-21

http://www.dot.state.fl.us/planning/statistics/sourcebook/

Multimodal Mobility Performance Measures Matrix 2015

	MODE	QUANTITY	QUALITY	ACCESSIBILITY	UTILIZATION
People	**Auto/Truck**	**Vehicle Miles Traveled** ◷ □ ⊙ Person Miles Traveled ◷ □ ⊙	**% Travel Meeting Los Criteria** ◷ ◕ □ % Miles Meeting Los Criteria ◷ ◕ **Travel Time Reliability** ◷ ◕ □ Travel Time Variability ◷ ◕ □ **Vehicle Hours Of Delay** ◷ □ ⊙ Person Hours Of Delay ◷ □ ⊙ Average Travel Speed ◷ ◕	*In Development – To Be Reported In 2015*	**% Miles Severely Congested** ◷ ◕ % Travel Severely Congested ◷ ◕ □ Hours Severely Congested □ ⊙ Vehicles Per Lane Mile ◷
	Transit	Passenger Miles Traveled ⊙ Passenger Trips ⊙	Average Headway ◕		
	Pedestrian		Level Of Service (LOS) ◷	% Sidewalk Coverage ⊙	
	Bicycle		Level Of Service (LOS) ◷	% Bike Lane/Shoulder Coverage ⊙	
	Aviation	Passengers ⊙	Departure Reliability ⊙	Highway Adequacy (LOS) ◷ ◕	Demand To Capacity Ratios ◷
	Rail	Passengers ⊙	Departure Reliability ⊙		
	Seaports	Passengers ⊙		Highway Adequacy (LOS) ◷ ◕	
Freight	**Truck**	**Combination Truck Miles Traveled** □ Truck Miles Traveled □ Combination Truck Tonnage ⊙ Combination Truck Ton Miles Traveled ⊙ Value of Tonnage ⊙	**Travel Time Reliability** ◕ Travel Time Variability ◕ **Combination Truck Hours Of Delay** □ Combination Truck Average Travel Speed ◷		**% Miles Severely Congested** ◷ ◕ Vehicles Per Lane Mile ◷ Combination Truck Backhaul Tonnage ⊙
	Aviation	Tonnage ⊙		Highway Adequacy (LOS) ◷ ◕	
	Rail	Tonnage ⊙		Highway Adequacy (LOS) ◷ ◕ Active Rail Access ⊙	
	Seaports	Tonnage ⊙ Twenty-Foot Equivalent Units ⊙		Highway Adequacy (LOS) ◷ ◕ Active Rail Access ⊙	

Reporting Periods: ◷ *= Peak Hour* ◕ *= Peak Period* □ *= Daily* ⊙ *= Yearly*

Bold = FDOT Map-21-Recommended Measure

Mobility Performance Measures Road Map

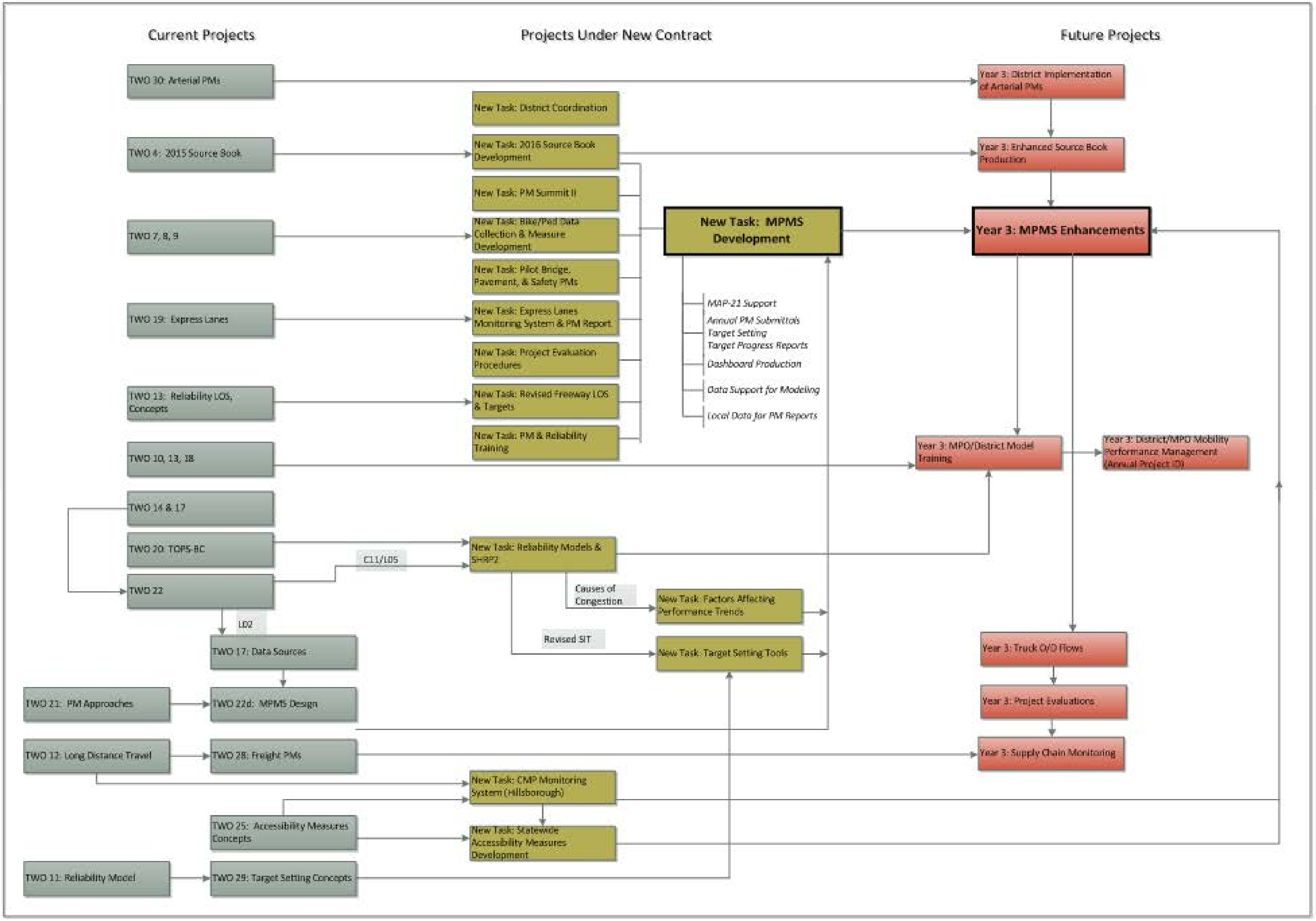
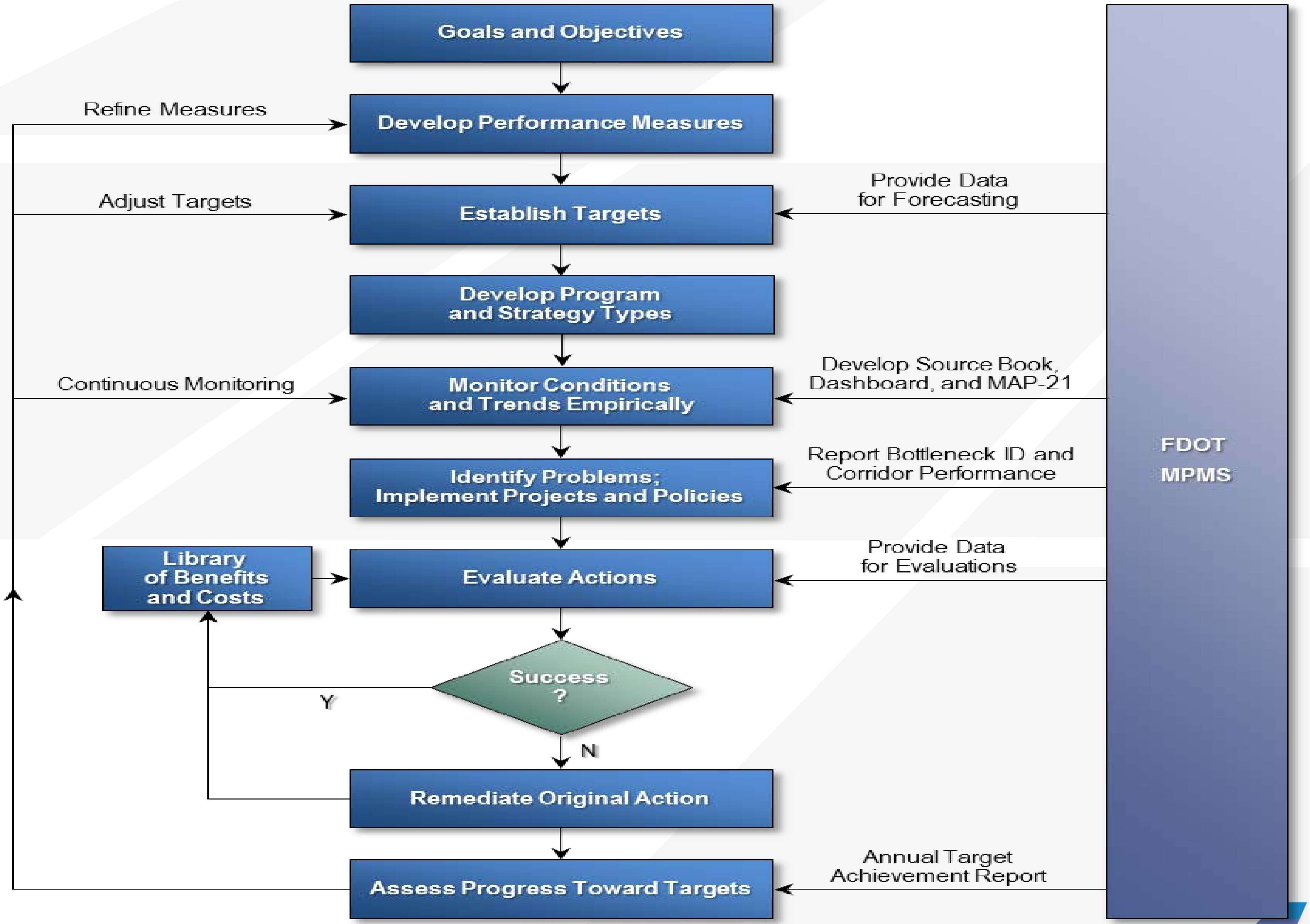


Figure 1. The MPMS Supports FDOT's Performance Management Process



Mobility Performance Monitoring System

Automated data collection process from various sources

Storage capability to store and maintain large amounts of data

Processing capabilities to provide data quality checks, perform needed calculations

Provide access to and ability to manipulate data from different sources

Mobility Performance Monitoring System

Query and reporting capabilities that will provide information in formats required by the Source Book and other customized formats

A maintenance process to maintain the software, hardware and links to data sources

Why Does FL Need an MPMS?

- Forms the core of the Mobility Performance Measures program
  - Culmination of all previous performance measurement efforts
- Supports the eventual adoption of performance management by FDOT
- An ongoing system for continuous performance reporting
  - Meets Central Office, District, and MPO performance monitoring needs
  - MAP-21 reporting

What is the Proposed MPMS?

- NOT a new data system
  - Concept is to pull data from other sources for analysis purposes
  - Probe vehicle (HERE + NPMRDS); SunGuide detector and incidents; weather; work zones; traffic monitoring; RCI
  - RITIS is main repository of needed data
- *“RITIS is the iPhone, the MPMS is an app that uses the iPhone infrastructure”*

What Does a User Get Out of the MPMS?

Develop custom queries of the data

- "What were conditions like in this corridor last year?"

Understand what the main contributors to congestion are

- "What is impact of weather, demand, incidents, or work zones?"

Care and feeding of traffic analysis and travel demand models

- Data for inputs and calibration

Phases

Phase 1

- Detailed user requirements focused on the Districts - developing something useful quickly

Phase 2

- Computational engine for remaining functions (not user grade, minimal interfaces, but analytic core developed)

Phase 3

- User grade system – interfaces allow staff to use the system, not data scientists/analysts

Phase 4

- Enhancements – consider Big Data processing tools, in conjunction with Department's enterprise needs; keep abreast of developments in the private data market – be ready to jump on emerging Big Data sources; plan for eventual processing and use of connected vehicle data

Case Study 3
LA Metro Arterial Framework

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Framework Goals

1. Establish a framework to support deployment of operational improvements by participating agencies

2. Monitor and report on mobility performance on arterial corridors throughout the county

3. Identify an analytical tool for a countywide Performance Measurement Program

4. Measure the effectiveness of arterial Transportation System Management improvements

5. Develop a continuous data source and archive available over time for cities to use for project planning and grant applications

6. Provide useful tools to support local agency and subregional operations and planning efforts

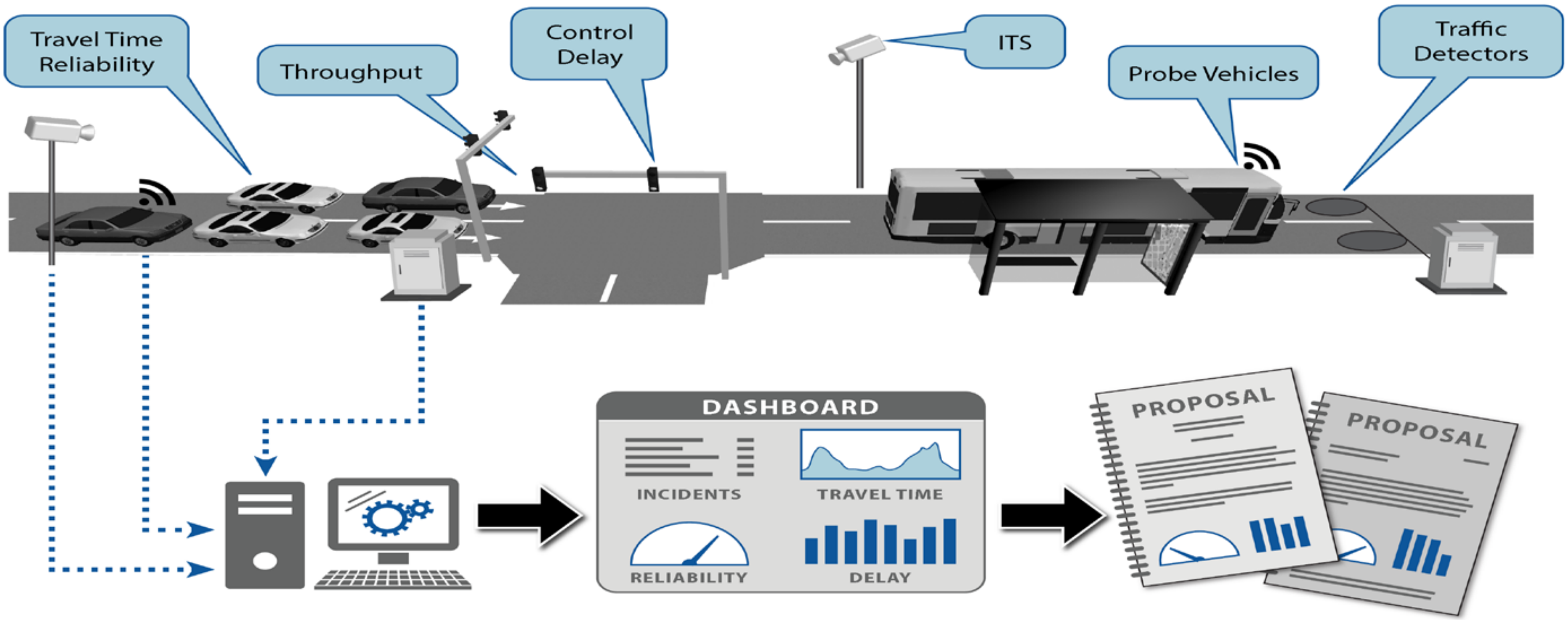
7. Develop consistent methods for mobility performance measures calculations and reporting

1. List of Performance Measures

Transportation System Management (TSM) projects make up a large portion of LA Metro's investments. As these are often focused on improving arterial traffic flow, the performance metrics that LA Metro gathers must also be applicable to arterials. Example metrics include travel time reliability, vehicle throughput, transit on-time performance, and control delay.

2. Data Collection/Sources

There are a variety of sources available to LA Metro that have the data needed for calculation of arterial performance metrics. These sources are both public and private, and include detector data, transit vehicle location data, probe vehicle data, and Intelligent Transportation Systems (ITS) data (e.g., CCTV).



3. Data Management

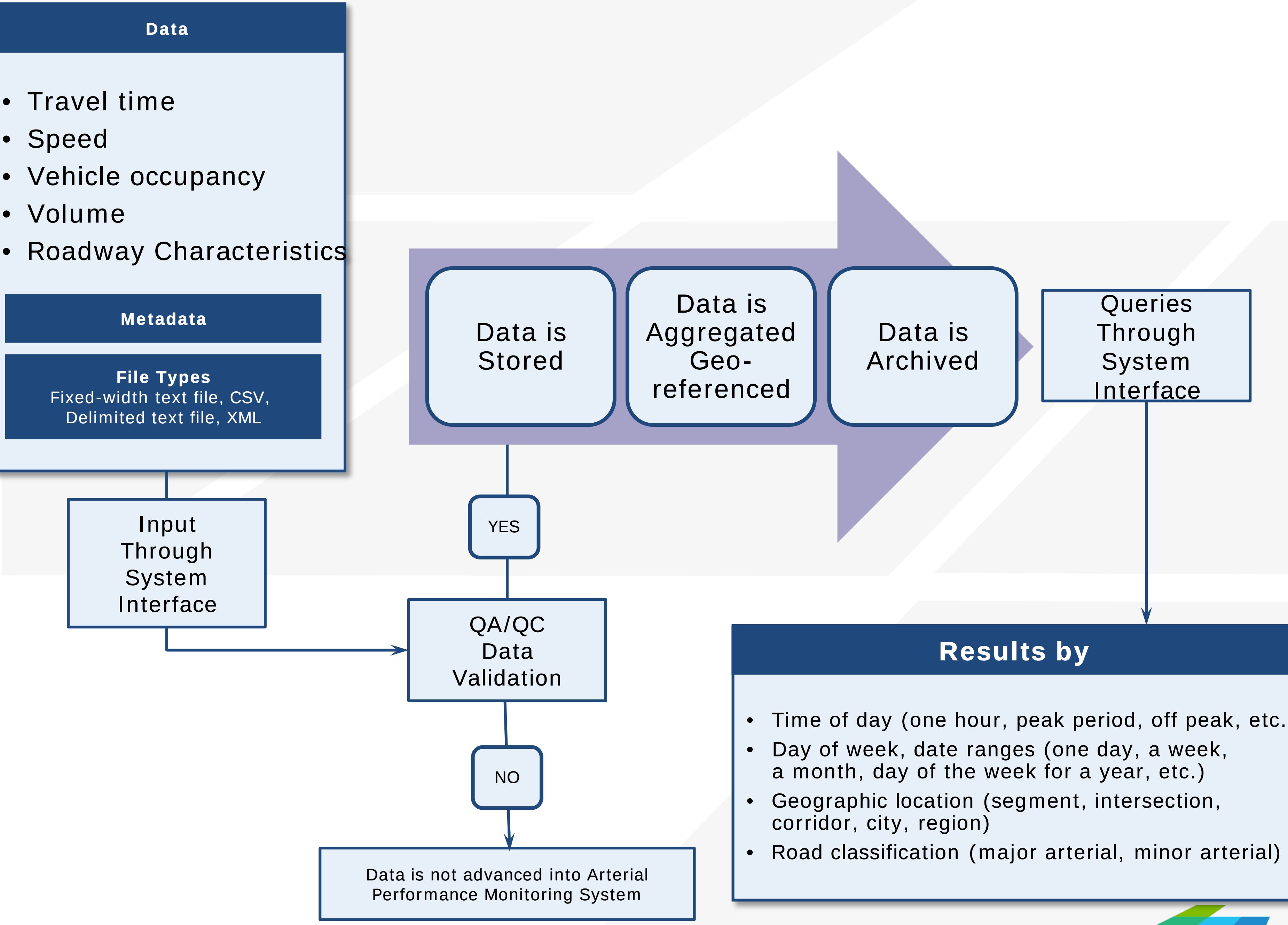
Integrating data into a single, coherent system requires working with different vendors/owners, interfacing with various database systems, and accommodating a range of data formats and types. Data quality validation tools will need to be developed, and strategies for bridging gaps in the data will need to be identified.

4. Performance Measurement Tool

When the backend data management system is complete, a performance measurement tool or dashboard is then implemented to generate usable, actionable information from the data. Summary reports on performance are among the outputs provided by this tool.

5. Input to Planning Processes

Data-driven planning processes are made possible by performance measurement tools. In this step, internal business processes are updated to take advantage of the new performance measurement tool: projects are prioritized and evaluated based on quantifiable performance metrics and outcomes.


Data
• Travel time
• Speed
• Vehicle occupancy
• Volume
• Roadway Characteristics
Metadata
File Types
Fixed-width text file, CSV,
Delimited text file, XML
Input Through System Interface
QA/QC Data Validation
YES
NO
Data is not advanced into Arterial Performance Monitoring System
Data is Stored
Data is Aggregated Geo-referenced
Data is Archived
Queries Through System Interface
Results by
• Time of day (one hour, peak period, off peak, etc.)
• Day of week, date ranges (one day, a week, a month, day of the week for a year, etc.)
• Geographic location (segment, intersection, corridor, city, region)
• Road classification (major arterial, minor arterial)

Lessons Learned

- Involve Planners AND Operators from beginning
  - Consistent and agreed upon performance measures
- Consider private plus public data sources
- Define requirements for tools
- Strive for consistency but allow for innovation

A Look Ahead

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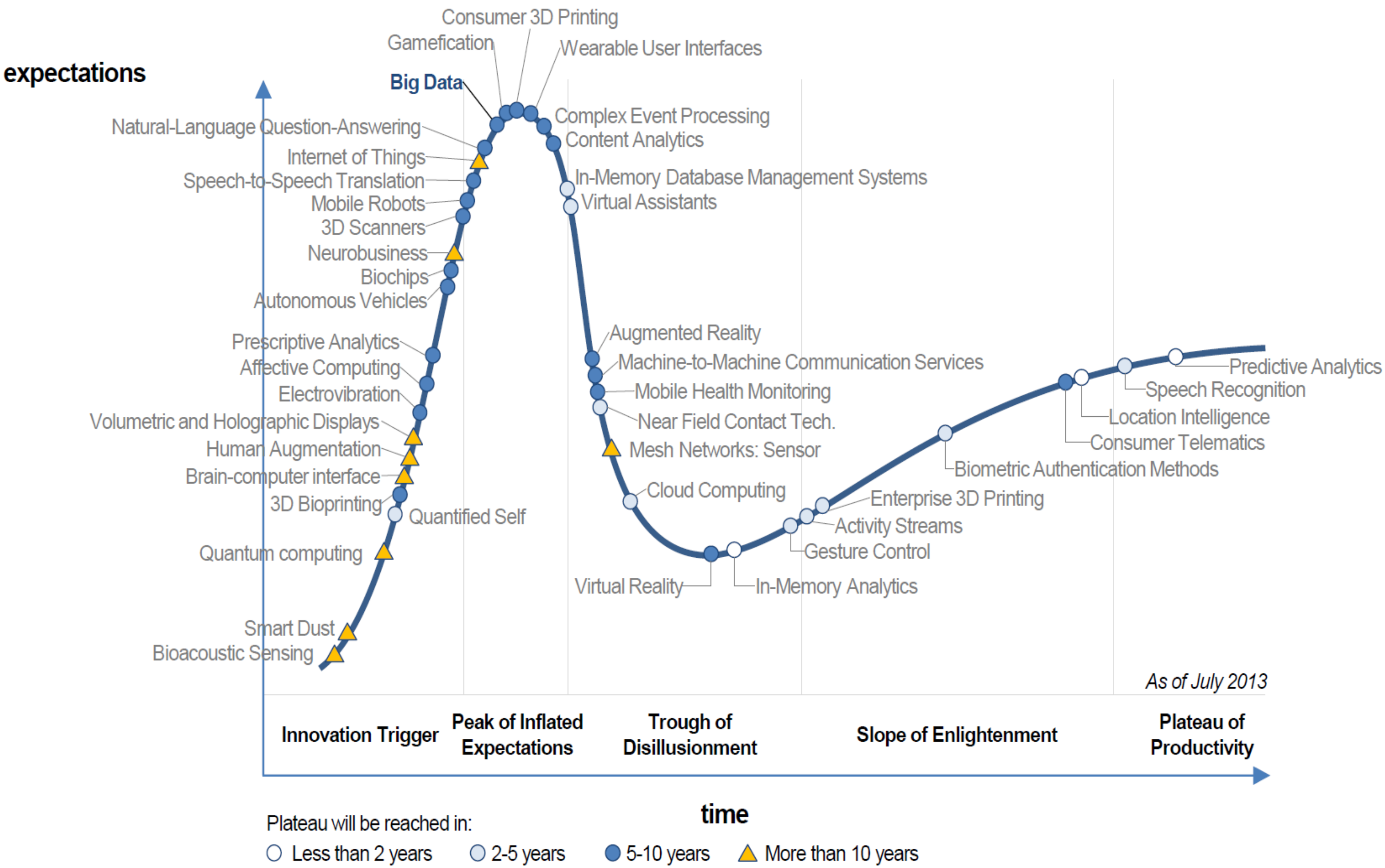
Trends Affecting PM Tools

- MAP-21
- Open Source Software
- Cloud computing
- Visualization
- Big Data
- Predictive Analytics

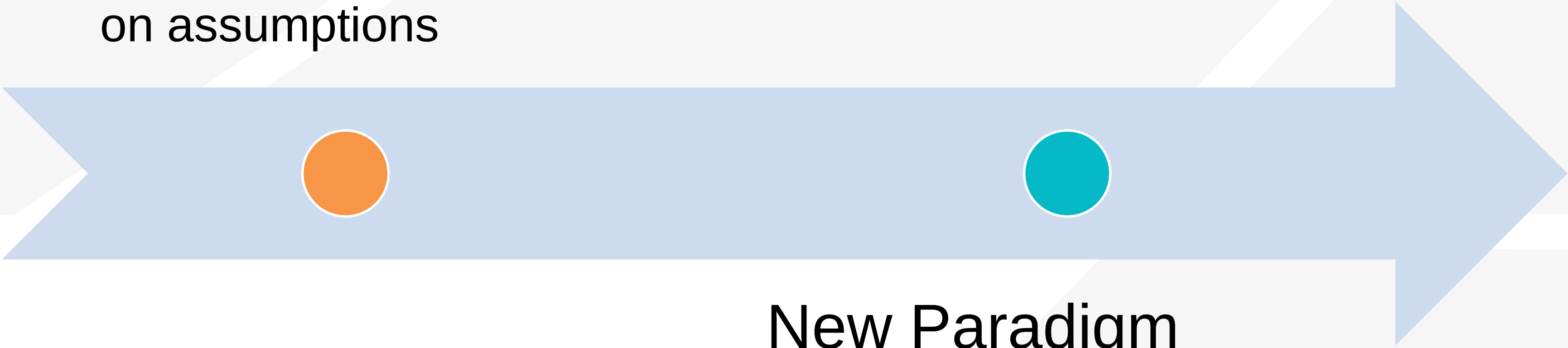
Hype cycle for **emerging** technologies



Emerging Trend in Transportation

Old paradigm

- Scarce and expensive data
- Processes heavily based on assumptions



New Paradigm

- Based on actual *observed data*

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How will Big Data Change the way we think about data and analysis?

- More data is messy
  - Loosens need for exactitude
  - Move away from causality
  - Aggregate of many provides comprehensive picture
  - Sacrifice accuracy for trends
  - Taxonomy is replaced by more flexibility
  - Single version of truth may not be practical
  - Data cleaning less necessary
  - Predictions based on correlations lie at the heart of big data
  - "***Though it may seem counterintuitive at first, treating data as something imperfect and precise lets us make superior forecasts and thus understand our world better***"

Big Data,

Mayer-Schönberger and Cukier

The “Big Data” Promise

“In the next two decades, we will be able to **predict** huge areas of the future with far greater **accuracy** than ever before in human history, including events long thought to be beyond the realm of human inference. The rate by which we can extrapolate **meaningful patterns** from the data of the present is quickening as rapidly as is the spread of the Internet because the two are inexorably linked. The Internet is turning prediction into an equation… as **sensors, cameras, and microphones** constitute one way for computer systems to collect information about their—and our—shared environment, these systems are developing perceptions that far exceed our own.”

The Naked Future Tucker, 2014

Is what we work with "Big" Data?

- Depends on your definition, but probably not
  - The data we deal with is structured, has context added to it, and are not all that voluminous
  - The raw GPS measurements the vendors get are Big Data, but they clean it, aggregate it, and add context (snapped to a roadway link) before we get it
- ***However,*** the data market is constantly evolving and we are likely to see some forms of Big Data become available for our use:
  - Connected vehicle data (very voluminous and little or no context)
  - Data from hand-held devices – raw measurements of a person's position in time and space
  - Social media data directed at traffic (Waze)

Why Would We Need Big Data Method?

- Includes technologies like Hadoop and Apache Spark
  - Support advanced data structures too cumbersome for traditional relational data bases
  - Very good at parallel processing

- Processing power
  - Eg. interactive dashboard
  - Preparation for *bonafide* Big Data

Big Data Analytics: The Basics Are the Same

Degree of intelligence

Optimization	What is the best allocation of resources
Predictive Modeling	What will happen next?
Forecasting/extrapolation	What if these trends continue?
Statistical Analysis	Why is this happening?
Alerts	What actions are needed?
Query/drill down	Where exactly is the problem?
Ad hoc reports	How many, how often, where?
Standard Reports	What happened?

Advanced Analytics:

- Statistics
- Machine-learning

Basic Analytics:

- Reports

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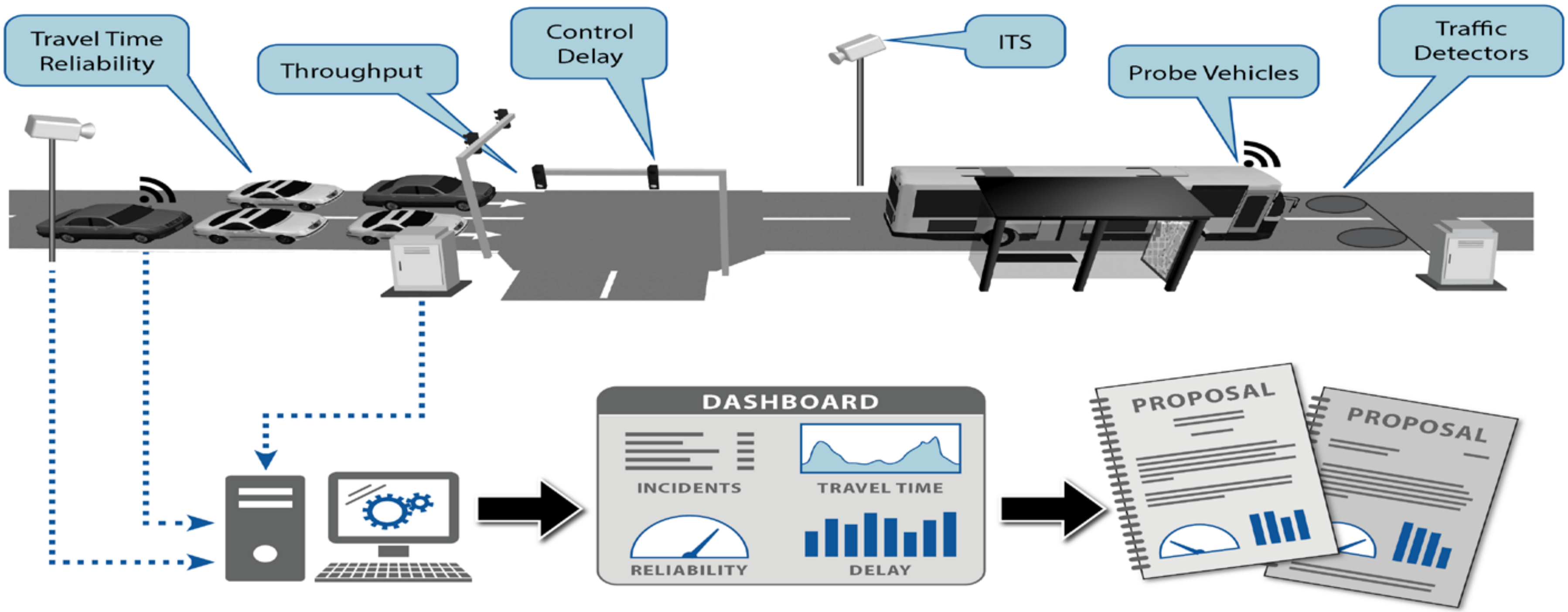

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