U.S. DOT Roadway Transportation Data Business Plan (Phase 2)

Data Business Plan

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Final Report — June 2013
FHWA-JPO-13-085

U.S. Department of Transportation

Produced by Contract No. DTFH61-06-D-00004, Task CA04-075M2, U.S. DOT
U.S. DOT Roadway Transportation Data Business Plan (Phase 2)
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FHWA Office of Operations

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Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA-JPO-13-085		

4. Title and Subtitle U.S. DOT Roadway Transportation Data Business Plan (Phase 2) Data Business Plan	**5. Report Date** June 2013
	6. Performing Organization Code
7. Author(s) Anita Vandervalk, Dena Snyder, and Judith K. Hajek	**8. Performing Organization Report No.**
9. Performing Organization Name And Address Cambridge Systematics, Inc. 1566 Village Square Boulevard, Suite 2 Tallahassee, FL 32309	**10. Work Unit No. (TRAIS)**
	11. Contract or Grant No. DTFH61-06-D-00004
12. Sponsoring Agency Name and Address U.S. Department of Transportation ITS Joint Program Office-HOIT 1200 New Jersey Avenue, SE Washington, DC 20590	**13. Type of Report and Period Covered** Final Report 2013
	14. Sponsoring Agency Code HOTM & JPO

15. Supplementary Notes

FHWA COTM: Walter During

16. Abstract

In 2011, the FHWA Office of Operations, Office of Transportation Management commissioned a study to address needs and gaps related to the operation and coordination of U.S. DOT Data Capture and Management Programs. The development of the Data Business Plan (DBP) was approved in 2011. Phase 2 of the DBP includes two major components: 1) Execution of the Data Business Plan Coordination; and 2) Conducting data integration test pilots to demonstrate the benefits and values of the DBP. This document describes the results of two data integration test pilots conducted as part of Phase 2:

- Pilot 1 (section 2) examines the potential usefulness of connected vehicle and Dynamic Mobility Applications (DMA) data for national performance measurement needs and discusses how this data could be used to supplement existing national, State, and regional mobility data programs.
- Pilot 2 (section 3) examines the various sources used for collection of speed data and discusses how this data can be integrated and used to support national performance measurement needs.

17. Key Words	18. Distribution Statement
Data business plan, connected vehicle data, dynamic mobility applications, national performance monitoring, data integration, speed data	No restrictions. This document is available to the public through the National Technical information Service, Springfield, VA 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	120	N/A

Form DOT F 1700.7 (8-72) **Reproduction of completed page authorized**

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Executive Summary

In 2011, the FHWA Office of Operations, Office of Transportation Management commissioned a study to address needs and gaps related to the operation and coordination of U.S. DOT Data Capture and Management Programs. The development of the DBP was approved in 2011. Phase 2 of the Data Business Plan (DBP) includes two major components: 1) Execution of the Data Business Plan Coordination; and 2) Conducting data integration test pilots to demonstrate the benefits and values of the DBP. This document describes these two pilot tests. The two test pilots approved by the FHWA Office of Operations as part of Phase 2 are:

- Pilot 1 (section 2) will illustrate how these and other benefits can be derived from use of connected vehicle and Dynamic Mobility Application (DMA) data when integrated with national datasets.
- Pilot 2 (section 3) examines the various sources used for collection of speed data and discusses how this data can be integrated and used to support national performance measurement needs.

Test Pilot 1: Applicability of Connected Vehicle Data for National Performance Monitoring

The pilot study applied the data business planning principles to address the following specific problem statement/questions:

1. **Is there data that will be available from connected vehicle and Dynamic Mobility Applications that could be used for national performance monitoring purposes?** The results of this pilot study indicate that data available from connected vehicle and Dynamic Mobility Applications could be used for national performance monitoring purposes. The analysis presented in this report documents the various types of data and their sources from the connected vehicle and Dynamic Mobility Applications that could be used to enhance or even replace at some point traditional data collection methods used by State DOTs and the U.S. DOT. This assessment indicates that all of the existing mobility data capture programs can be supported by connected vehicle and Dynamic Mobility Applications.
   As these applications come on-line over the next decade, each of the existing data capture programs should be evaluated to determine if connected vehicle/DMA data will enhance the existing program, or if the existing program can be completely replaced by the data captured in the connected vehicle/DMA program. The potential exists that, given the continuous timescale and ubiquitous location of the connected vehicle/DMA data, a much richer data set will be available in the future compared with existing programs that primarily capture only a sampling of data. Additionally, it is reasonable to conclude that the connected vehicle/DMA program will provide the needed data to support all of the performance measures included in the MAP-21 authorization. There are concerns and challenges with the sharing and use of this data that must be addressed before any of it can be used in the future to meet national performance measurement needs.

2. **Are all stakeholders informed of the availability of such data?** While all stakeholders may not currently be informed of the availability of such data (from connected vehicle and DMA), it is the intent to present this report to a select group of data providers at the U.S. DOT. This presentation represents another step in the continued implementation of the Roadway Transportation Data Business Plan, which can be utilized to facilitate ongoing dialog between the communities of interest (COIs) identified as part of the U.S. DOT Mobility Data Coordination Working Group and the data providers.

The following recommendations are based on the results of this pilot study to further the potential use of connected vehicle and DMA data as it becomes available within and beyond the next decade:

1. Identify and document in a Memorandum of Understanding which offices comprise the Connected Vehicle Data Capture Working Group as a Community of Interest of the U.S. DOT Mobility Data Coordination Group.
2. Present the findings of this pilot study to the Connected Vehicle Data Capture Working Group and solicit their feedback based on the results of this study.
3. Members of the Connected Vehicle Data Capture Working Group should establish and maintain outreach to the FHWA Data Governance Board (under direction of David Winter) to keep the Data Governance members informed on availability and potential use of future connected vehicle and DMA datasets, especially with regard to meeting national performance measurement needs identified in MAP-21.
4. Finally, the Connected Vehicle Data Capture Working Group should identify potential national datasets that can be used as a pilot to test integration of specific connected vehicle or DMA data with national datasets. Initial pilot testing should consider using the data available through the Research Data Exchange (RDE) (Appendix A), although most of the RDE datasets are test datasets, which have been collected for a trial period of time only.

Test Pilot 2: Reconciliation of Speed Data from Multiple Sources

The pilot study applied the data business planning principles to address the following specific problem statement/questions:

1. **What are the requirements for speed data collection and reporting at FHWA?** There is currently no specific statute (CFR or USC) that gives FHWA authority to collect speed data. However, CFR 23 420.105(b) gives the agency broad authority to collect any data needed to administer the Federal-Aid Highway program, support internal analyses and business needs, and fulfill FHWA's reporting responsibilities to the Administration, United States Congress, and the traveling public. Business needs for Federal speed data relate to safety, operations, and policy development, as described in Section 3.2.
2. **Is there possible duplication of effort occurring?** Although there is possible duplication in the data elements/timeliness/coverage of speed data programs, it is important to note that each program was initiated in response to specific mandates and/or business needs regarding reporting of speed data, as documented in Section 3.4.

The pilot study indicated that there are several specific areas for coordination among the FHWA offices and opportunities for data sharing and merging. Recommendations from the pilot study include:

1. Activate the US DOT Mobility Coordination Group and the Speed Data Working Group and conduct regular meetings.
2. Task each group to work on the items in the rules of engagement listed in the Data Business Plan and in Section 3.4 of this report.
3. Conduct a feasibility analysis to merge data from the TTID program and the National Performance Management Research Data Set. Considerations should include contact restrictions, speed and travel time conversions, data format, data storage and accessibility and data quality compatibility.
4. Conduct a feasibility study to assess the possibility of enabling states and local operating agencies to submit real time operations data to FHWA. The study should consider if a new data portal is needed or if TMAS is feasible for that function.

1.0 Introduction

In 2011, the FHWA Office of Operations, Office of Transportation Management commissioned a study to address needs and gaps related to the operation and coordination of U.S. DOT Data Capture and Management Programs. The development of the DBP, approved in 2011, was conducted in two phases, where Phase I produced the following three deliverables: 1) documented stakeholder needs related to specific data capture and management programs; 2) documented inventory of relevant national, State, and regional programs that support the goals and objectives of the DBP; and 3) a Data Governance Framework to guide future governance of data programs at the FHWA Office of Operations.

Phase 2 of the Data Business Plan (DBP), currently in progress, includes two major components: 1) Execution of the Data Business Plan Coordination; and 2) Conducting data integration test pilots to demonstrate the benefits and values of the DBP. Two test pilots were approved by the FHWA Office of Operations as part of Phase 2.

- Pilot 1 (Section 2.0) will illustrate how these and other benefits can be derived from use of connected vehicle and Dynamic Mobility Application (DMA) data when integrated with national datasets.
- Pilot 2 (Section 3.0) examines the various sources used for collection of speed data and discusses how this data can be integrated and used to support national performance measurement needs.

These pilots support the overall U.S. Data Capture and Management (DCM) program. Specifically, the purpose of data integration test pilot projects was to:

- Demonstrate the value of integrating connected vehicle data with national data sets;
- Demonstrate the value of integrating proposed and existing national or project data sets; and
- Eliminate gaps and overcome redundancies in national and project data sets associated with mobility data.

Several positive outcomes could result from the data integration test pilot projects:

- Elimination or enhancement of certain data elements in some national data sets;
- Creation of a link between an existing data set and a connected vehicle data set in the future;
- Maximization of data sharing opportunities for national data sets for performance measurement and asset management purposes;
- Investigation of how regional and national datasets can best be combined;
- Recognition of how a project data set (such as TTID) could be leveraged in the future;

- Creation of value added to the Research Data Exchange or other U.S. DOT research data sets; and
- Documentation of lessons learned for the U.S. DOT, State DOTs, and regions.

2.0 Test Pilot 1: Applicability of Connected Vehicle Data for National Performance Monitoring

2.1 Background

The first test pilot study examines the potential usefulness of connected vehicle and Dynamic Mobility Applications (DMA) data for national performance measurement needs and discusses how these data could be used to supplement existing national datasets. This pilot study supports the overall U.S. DOT Data Capture and Management (DCM) Program. In particular, the DCM Vision document includes the following as one of the stated program objectives: *Develop data environments that enable integration of data from multiple sources for use in transportation management and performance measurement.*

Objectives

The objectives for both pilot studies were developed in coordination with the FHWA Office of Operations. The initial objective for Pilot 1 (identified in January 2013) focused on research related to available data from the Research Data Exchange (RDE). This objective was subsequently revised in April 2013, and the focus shifted to an investigation of available future datasets from connected vehicle and Dynamic Mobility Applications. The current objectives for Pilot 1 are to conduct research to answer the following specific problem statement/questions: 1) Is there data that will be available from connected vehicle and Dynamic Mobility Applications that could be used for national performance monitoring purposes; and 2) Are all stakeholders informed of the availability of such data?

Methodology

The methodology for conducting Pilot 1 involved a multi-step approach to determine the feasibility of the future use of connected vehicle and DMA data with national datasets. These steps are in keeping with the basic principles used in data business planning for evaluating the usefulness of data and information systems to provide information to decision makers in support of business needs. Pilot 1 focuses on priority needs of the U.S. DOT Office of Operations related to the use of connected vehicle and Dynamic Mobility Applications and their potential for integration with datasets (which are relied upon for meeting national performance measurement needs). With the recent implementation of MAP-21, performance measurement is one of the critical focus areas for the nation’s multi-modal transportation system. The methodology followed for this project included the following steps:

1. Discuss the vision of national performance measurement given potential use of future data from connected vehicle and Dynamic Mobility Applications. This step identified and documented the vision for national performance measurement with respect to the potential for use of future connected vehicle and DMA datasets to support performance measurement needs.

2. Assess the usefulness of future available connected vehicle and DMA data for performance measurement needs. This step included preliminary research to document the types of applications that comprise the connected vehicle and Dynamic Mobility Applications. These applications are identified along with brief descriptions and potential data products of each. Road Weather Management applications are also included because of their potential use in performance measures related to environmental sustainability as identified in MAP-21.
3. Cross-reference available and future data to performance measurement needs. This step involved reviewing and documenting at the data element level the types of data that can be generated from the connected vehicle and Dynamic Mobility Applications and aligning these data with the performance measures that relate to each of the data types.
4. Compare the future connected vehicle and Dynamic Mobility Applications to the existing national datasets to identify future applications that may enhance, support or possibly replace the existing data sets.
5. Present findings to performance measurement data providers (Office of Policy, Operations, etc.). This step included the presentation of results from Pilot 1 to a select group of data providers at U.S. DOT responsible for the collection, or integration, or use of national datasets for performance measurement needs. The offices to be represented in this presentation are yet to be determined but are anticipated to include members of the U.S. DOT Mobility Data Coordination Group (per the Data Business Plan).

Organization

The results of the Pilot 1 study are organized into the following sections:

2.2 – Performance Measurement Needs Identified in MAP 21;

2.3 – Assessment of Connected Vehicle and Dynamic Mobility Programs;

2.4 – Connection of Connected Vehicle and DMA with existing National Data Programs;

2.5 – Challenges with Use of Connected Vehicle and DMA Data; and

2.6 – Conclusions and Recommendations.

Appendix A documents the potential sources of data associated with the applications and test datasets available from the Research Data Exchange (RDE).

2.2 Performance Measurement Needs Identified in MAP-21

The cornerstone of MAP-21's highway program transformation is the transition to a performance and outcome-based program. States will invest resources in projects to achieve individual targets that collectively will make progress toward national goals.

MAP-21 establishes national performance goals for Federal highway programs:

- Safety – To achieve a significant reduction in traffic fatalities and serious injuries on all public roads.

- Infrastructure condition – To maintain the highway infrastructure asset system in a state of good repair.
- Congestion reduction – To achieve a significant reduction in congestion on the NHS.
- System reliability – To improve the efficiency of the surface transportation system.
- Freight movement and economic vitality – To improve the national freight network, strengthen the ability of rural communities to access national and international trade markets, and support regional economic development.
- Environmental sustainability – To enhance the performance of the transportation system while protecting and enhancing the natural environment.
- Reduced project delivery delays – To reduce project costs, promote jobs and the economy, and expedite the movement of people and goods by accelerating project completion through eliminating delays in the project development and delivery process, including reducing regulatory burdens and improving agencies' work practices.

The Secretary, in consultation with States, MPOs, and other stakeholders, will establish performance measures for pavement conditions and performance for the Interstate and NHS, bridge conditions, injuries and fatalities, traffic congestion, on-road mobile source emissions, and freight movement on the Interstate System. States (and MPOs, where applicable) will set performance targets in support of those measures, and State and metropolitan plans will describe how program and project selection will help achieve the targets. States and MPOs will report to DOT on progress in achieving targets. If a State's report shows inadequate progress in some areas – most notably the condition of the NHS or key safety measures – the State must undertake corrective actions. The performance measurement program, targets, and corrective actions are being determined at this time.

For this Pilot study, five of the MAP-21 performance areas are relevant. Each of these performance areas are briefly described in the following paragraphs:

- **Safety.** The goal of the safety area is to reduce roadway fatalities and serious injuries. To measure these goals the following data are needed:
    - Number of fatal and injury crashes;
    - Location of fatal and injury crashes; and
    - External factors at crash location – i.e., weather, pavement condition, proximity to another incident, roadway geometry, lighting, vehicle types involved (trucks).
- **Congestion Reduction.** The goal of the congestion reduction area is to reduce congestion on the National Highway System (NHS). To measure this goal the following data are needed:
    - Free flow speed;
    - Speed by time of day;
    - Delay; and
    - Volume by time of day.
- **System Reliability.** The goal of the system reliability area is to improve the efficiency of the surface transportation system. To measure this goal the following data are needed:

  - Travel time by time of day on all roads;
  - Transit schedules by route; and
  - Transit on-time performance by route.

- **Freight Movement and Economic Vitality.** The goal of the freight movement area is to improve the national freight network. To measure this goal the following data are needed.
  - Travel time for commercial vehicles;
  - Delay for commercial vehicles;
  - Commercial vehicle volumes; and
  - Commercial vehicle origins and destinations.

- **Environmental Sustainability.** The goal of the environmental sustainability area is to enhance the performance of the transportation system while protecting and enhancing the natural environment. To measure this goal, the following data is needed:
  - Reduction in petroleum based fuels used for transportation; and
  - Reduction in air quality pollutants produced by vehicles.

Much of the data needed to support these performance measures exists to some degree in a variety of national datasets. There is also a multitude of data from connected vehicle and Dynamic Mobility Applications that could be mined to support performance measurement needs at the national level.

The performance measures related to the MAP-21 performance areas are based on the current availability of data. The Connected Vehicles program offers the opportunity to develop new performance measures based on ubiquitous speed and volume data. Examples of measures that could be reported for the entire NHS may include congested lane miles, congested VMT or lost productivity (volume of traffic operating at a speed below normal speed).

2.3 Assessment of the Connected Vehicle and Dynamic Mobility Applications

This section describes the multiple applications that comprise the connected vehicle, Dynamic Mobility, and Road Weather Applications. It also assesses the relationship of the applications to MAP-21 and includes the data elements possibly available. Although the mobility applications are the focus of this study, the Road Weather Applications are included to illustrate how these particular applications could also support performance measurement needs related to environmental sustainability.

For each of the applications, the following is described:

- Description of the application;
- Relationship between the data generated from these applications relative to performance measurement needs; and
- Data that could be available from the application.

Connected Vehicle Applications and Assessment of Potential Impact on Performance Measurement

Vehicle-to- Vehicle (V2V) Communications for Safety Applications

Description:

The V2V research will investigate key questions such as, are vehicle based safety applications using V2V communications effectively and do they have benefits? Research is designed to determine whether regulatory action by the National Highway Transportation Safety Administration is warranted to expedite the adoption of these safety capabilities.

Most of the data is provided by either Part 1 or Part 2 of the Basic Safety Message (BSM) which is broadcast from the vehicle over the 5.9 GHz Dedicated Short Range Communication (DSRC) band. However, data defined as part of Part 2 of the BSM are not required by vehicle manufacturers and may only be available as optional data.

Potential Impact Relative to Performance Goals Outlined in MAP-21:

Safety: The vision for V2V is that eventually, each vehicle on the roadway (inclusive of automobiles, trucks, buses, motor coaches, and motorcycles) will be able to communicate with each other and that this rich set of data and communications will support a new generation of active safety applications and safety systems. V2V communications will enable active safety systems that can assist drivers in preventing 76 percent of the crashes on the roadway, thereby reducing fatalities and injuries that occur each year. Additionally, weather and vehicle data will provide a rich data set for determining crash causality and the causes of congestion. In addition, vehicle type data will provide information on truck crashes. Volume data would be much more accurate, which would provide better, more accurate crash rates. This improved data will provide for more accurate performance measures such as crashes and crash rates.

Mobility: V2V will provide speed and travel time data for each vehicle. This will provide speed data for every road rather than just instrumented roadways as is currently. This speed and travel time data will allow for direct calculation of many performance measures such as congestion, delay and travel time reliability.

Freight: V2V will provide data broken out for trucks. Data will include crashes, crash causes, speed, and travel time. All of the performance measures mentioned above can be directly calculated for trucks.

Transportation Planning: Volume, speed, travel time, crash, cause of crashes are all important data to transportation planning analysis. Additionally, origin-destination that is not currently available except through expensive, time consuming surveys would be provided directly from V2V data.

Transit: Transit vehicles will have the same data available as other vehicles, including speed, travel time, and crashes. Passenger count data will be available for each bus.

It should be noted that while the V2V applications will collect vast amounts of speed, volume and other data there must be a mechanism to collect that data and deliver it to a portal accessible to an operating agency (or in the cloud) so it can be stored, managed and analyzed. Currently the likely method will require a dense deployment of V2I devices to collect that data.

Possible Data Elements:

- Vehicle data as follows: Vehicle size, Vehicle type, Road coefficient of friction, Rain (precipitation) sensor, Relative humidity, Ambient air temperature, Ambient air pressure, Origin and Destination locations and time, Other misc. data about lights, wiper status, and traction control and antilock brake system for vehicle.
- Position: Positional accuracy, Speed, Location (latitude/longitude/elevation).
- Motion: Transmission state, Speed, Heading, Steering wheel angle, Acceleration set (includes 3 axes of acceleration and yaw rate).
- Emergency Vehicles only: Approach road to intersection, Intended turning movement at intersection.
- Freight Vehicles only: Trailer weight, Cargo weight, Vehicle height, Vehicle type, Oversize/Overweight permitting request, Load matching request, Pickup or drop-off time request.
- Light vehicles only: Origin, Destination, Selected route and mode.
- Maintenance vehicles only: Location, Pavement temperature, Roadway segment freeze point.
- Transit vehicles only: Transit service type, Passenger count.

Vehicle-to-Infrastructure (V2I) Communications for Safety Applications

Description:

This research will investigate similar questions about V2I communications, with an initial focus on applications based on the relay of traffic signal phase and timing information to vehicles. The purpose is to accelerate the next generation of safety applications through widespread adoption of V2I communications.

Potential Impact Relative to Performance Goals Outlined in MAP-21:

- Infrastructure condition (i.e., indicates if a traffic signal is working or is not operational);
- Safety; and
- Congestion reduction (i.e., improve mobility).

The vision of V2I Communications is that a minimum level of infrastructure would be deployed to provide the maximum level of safety and mobility benefits for nationwide highway safety and operational efficiency. Importantly, V2I communications have the potential to resolve an additional 12 percent of crash types not addressed under V2V communications. V2I Communications for Safety is a key technology in the USDOT's Connected Vehicles Program, and complements the V2V communications research. While the primary goal is safety, V2I communications are also significant in improving mobility and environment by reducing delays and congestion caused by crashes, enabling wireless roadside inspections, or helping commercial vehicle drivers identify safe areas for parking.

The research will concentrate on the key FHWA and FMCSA application areas of interest, including intersection safety, run-off-road prevention, speed management, and commercial vehicle enforcement and operations.

Also the V2I SPAT data will allow traffic engineers to improve traffic signal system timing by providing real time lane volume, travel time, vehicle density and delay data. Traffic engineers will be able to fine tune signal timing that will increase throughout and capacity at intersections.

This SPAT data will provide better information for arterial performance measures like travel time and delay as well as reduce crashes and performance measure calculations.

Possible Data Elements:

- Signal Phase and Timing (SPAT) data between signals and vehicles.

Real Time Data Capture and Management Program

Description:

This research will assess what traffic, transit and freight data are available today from various sources, and consider how to integrate data from vehicles acting as probes in the system. The goal is to accelerate the adoption of transportation management systems that would be the safest, most efficient and environmentally friendly.

Potential Impact Relative to Performance Goals outlined in MAP-21:

Safety and Congestion: Supports transportation management and performance measures including those related to Safety and Congestion reduction. This supports the collection of data for calculation and for management of historical data, and would provide information needed for performance measure calculations.

Possible Data Elements:

The Real Time Data Capture and Management Program addresses the cross-cutting data capture and management issues associated with mobility, environmental and other non-safety applications, which are the generators of the data.

Assessment of Potential Impact on Performance Measurement

This assessment indicates that there is significant potential for connected vehicle and Dynamic Mobility Applications to provide data to support performance measurement needs in each of the following categories: safety, infrastructure condition, congestion reduction, system reliability, freight movement and economic vitality, environmental sustainability, and reduced project delivery delays.

It is evident from the information documented above that potential data from the Vehicle-to-Vehicle (V2V) Communications for Safety and Vehicle-to-Infrastructure (V2I) Communications for Safety can support performance measure needs related to safety.

The volume and speed data available from V2V can also have a significant impact on improving freight and transit transportation by relaying information to truck and transit vehicle drivers if alternate routing choices are required to avoid travel delays on a given route. This type of information can be used to support freight and transportation planning performance measurement needs as identified in MAP-21.

The connected vehicle initiative utilizes a wide range of technology, some of which is still under development. This technology is developed by a combination of government, industry, and academic partners. One coalition known as the Vehicle Infrastructure Integration Coalition (VIIC) is primarily focused on the deployment of cooperative safety and mobility applications based on the 5.9 GHz Dedicated Short Range Communication (DSRC) band.[1]

Dynamic Mobility Applications and Assessment of Potential Impact on Performance Measurement

The Dynamic Mobility Applications are also a key part of the assessment process for this pilot study due to their potential for providing a wealth of information to support national datasets and performance measurement. The Dynamic Mobility Applications represent a category of connected vehicle applications that use connected vehicle technology to collect real-time data and relay this information to travelers to allow them to make informed travel decisions prior to or during travel. The 'dynamic' aspect of these applications is in their great flexibility to provide travelers (e.g., the general public, emergency responders, freight transporters, etc.) with real-time information to make decisions regarding transportation choices.

The Dynamic Mobility Applications include 30 applications that are grouped into seven bundles of applications. Each bundle contains a group of applications with a specific type of technology and capability for relaying information to travelers. These travelers may include the general public, freight transporters, emergency response vehicles, or typical transit vehicles (e.g., buses). The bundles are listed below:

- Enable Advanced Traveler Information Systems (ATIS);
- Freight Advanced Traveler Information Systems (FRATIS);
- Integrated Dynamic Transit Operations (IDTO);
- Intelligent Network Flow Optimization (INFLO);
- Multi-Modal Intelligent Traffic Signal Systems (MMITSS) (and Multi-Modal Intelligent Signal Control (M-ISIG));
- Response, Emergency Staging, Communications, Uniform Management and Evacuation (R.E.S.C.U.M.E.); and
- Next Generation Integrated Corridor Management (ICM).

The Dynamic Mobility Applications program positions the Federal government to take on an appropriate and influential role as a technology steward for the continually evolving integrated transportation system.

Enable Advanced Traveler Information Systems (ATIS)

Description:

Enable ATIS represents a framework around a desired end state for a future traveler information network, with a focus on multimodal integration, facilitated sharing of data, end-to-end trip perspectives, and use of analytics and logic to generate predictive information specific to users. As the traveler information marketplace continues to evolve, Enable ATIS seeks to facilitate, support, and enable those advancements and innovations to provide transformative traveler information.

[1] http://www.nritsconference.org/downloads/Presentations11/SessionD3_Wendling.pdf.

Potential Impact Relative to Performance Goals Outlined in MAP-21:

Congestion: Provides detailed information on travel times, speed, O-D data, road and weather conditions. Improves (multi-modal) mobility for travelers, with a 3.4 percent reduction in vehicle delay and 5-16 percent improvement in travel time reliability.

Safety: Provides information on crash location, road and weather conditions, and causality. Provides real-time information for incident management and performance measure calculations.

Possible Data Elements:

- Vehicle size;
- Vehicle position;
- Toll tag data (for travel speed);
- Selected route and mode;
- Directions and times by mode;
- Departure location (origin);
- Destination;
- Target departure time;
- Target arrival time;
- Ambient air pressure;
- Ambient air temperature;
- Wiper status;
- Exterior lights (status);
- Rain sensor;
- Road coefficient of friction;
- Traction Control System active over 100 msec; and
- Antilock Brake System active over 100 msec.

Freight Advanced Traveler Information Systems (FRATIS)

Description:

The Freight Advanced Traveler Information Systems (FRATIS) is a bundle of applications that provides freight-specific dynamic travel planning and performance measures information and optimizes drayage operations so that load movements are coordinated between freight facilities to reduce empty-load trips.

Potential Impact Relative to Performance Goals Outlined in MAP-21:

The FRATIS bundle of applications provides travel time and delay reduction for freight vehicles (by approximately 20%, as documented in the one available study), as well as significantly reducing the total number of truck movements (thus reduction in overall congestion), as well as other benefits. It also provides information for performance measure calculations.

Possible Data Elements:

- Oversize/Overweight Permitting;
- Request;
- Destination and stops;
- Vehicle type (fleet);
- Vehicle mass;
- Vehicle height;
- HAZMAT status;
- Ambient air temperature;
- Ambient air pressure;
- Rain sensor;
- Road coefficient of friction;
- Traction Control System active over 100 msec; and
- Antilock Brake System active over 100 msec.

Integrated Dynamic Transit Operations (IDTO)

Description:

Integrated Dynamic Transit Operations (IDTO) is the next generation of applications that transform transit mobility, operations, and services through the availability of new data sources and communications.

Potential Impact Relative to Performance Goals Outlined in MAP-21:

Congestion: Improves transit mobility, provides information for transit operations analyses and performance measure calculations.

Possible Data Elements:

- Vehicle type (fleet);
- ETA for pickup;
- ETA at destination;
- Target departure time;
- Destination ;
- Target arrival time;
- Departure location ;
- Number of occupants in vehicle ;
- List of number of passengers by route;
- Passenger count; and
- Location.

Intelligent Network Flow Optimization (INFLO)

Description:

Intelligent Network Flow Optimization (INFLO) is a collection of high-priority, transformative applications that aim to maximize roadway throughput, reduce crashes, and reduce fuel consumption through the use of frequently collected and rapidly disseminated multisource data drawn from connected vehicles, travelers' mobile devices, and the infrastructure.

Potential Impact Relative to Performance Goals Outlined in MAP-21:

Congestion: Improves Mobility.

Safety: Reduce crashes.

Environmental impact: Reduce fuel consumption.

Provides information not currently available for arterial management, optimization, and performance measure calculations.

Possible Data Elements:

- Vehicle size;
- Vehicle data;
- Vehicle mass;
- Trailer weight;
- Cargo weight;
- Geocoded road segment;
- Location (latitude/longitude/elevation);
- Road coefficient of friction;
- Rain sensor;
- Date/time of obstacle detection;
- Traction Control System active over 100 msec;
- Antilock Brake System active over 100 msec;
- Position (local)-3D(ramp);
- Status of ramp meter;
- Ambient air temperature;
- Ambient air pressure;
- Signal Phase and Timing (SPaT) data; and
- Target speeds by lane.

Multi-Modal Intelligent Traffic Signal Systems (MMITSS)

Description:

Multi-Modal Intelligent Traffic Signal Systems (MMITS) (and Multi-Modal Intelligent Signal Control (M-ISIG)) is the next generation of traffic signal systems that seeks to provide a comprehensive traffic information framework to service all modes of transportation, including general vehicles, transit, emergency vehicles, freight fleets, and pedestrians and bicyclists in a connected vehicle environment.

MMITSS will process multiple requests for signal priority control, assess the prevailing traffic conditions, and execute the most appropriate priority strategy to accommodate the requests while limiting the negative impacts on general traffic.

The vision for MMITSS is to provide overarching system optimization that accommodates transit and freight signal priority, preemption for emergency vehicles, and pedestrian movements while maximizing overall arterial network performance.

Potential Impact Relative to Performance Goals Outlined in MAP-21:

Congestion (Mobility): Reduced Extent of Congestion, Reduced Temporal Duration of Congestion, Reduced Travel Time, Reduced Travel Time Variability, Reduced Queue Length, Reduced Degree of Saturation, Data-driven Performance Metrics and Feedback.

Possible Data Elements:

- Vehicle size;
- Vehicle type (fleet);
- Position (latitude, longitude, elevation);
- Approach road to intersection;
- Rain sensor;
- Ambient air temperature;
- Ambient air pressure;
- Road coefficient of friction;
- Traction Control System active over 100 msec;
- Antilock Brake System active over 100 msec;
- Weather info for freight;
- Intended turning movement at intersection;
- Pedestrian location;
- Pedestrian intended crossing directions;
- Crossing status;
- Crossing heading correction;
- Passenger count; and
- Transit service type.

Response, Emergency Staging and Communications, Uniform Management and Evacuation (R.E.S.C.U.M.E.)

Description:

R.E.S.C.U.M.E. is the next generation of applications that transform the response, emergency staging and communications, uniform management, and evacuation process associated with incidents. The vision for R.E.S.C.U.M.E. is to leverage wireless connectivity, center-to-center communications, and center-to-field communications to solve problems faced by emergency management agencies, emergency medical services (EMS), public agencies, and emergency care givers, as well as persons requiring assistance.

Potential Impact Relative to Performance Goals Outlined in MAP-21:

Safety and Congestion: Clears incidents more quickly. Provides information needed to conduct evacuations in real time more effectively and provides data for pre-planning and after event analysis and performance measure calculations.

Possible Data Elements:

- Vehicle type (fleet);
- Position (latitude/longitude/elevation);
- Origin;
- Destination;
- Route;
- Evacuation routes information;
- Road conditions;
- Traffic reports;
- Lane closure information;
- Incident or work zone speed limit;
- Crash Delta;
- Number of occupants;
- Vehicle fuel type;
- Road coefficient of friction;
- Traction Control System active over 100 msec;
- Antilock Brake System active over 100 msec;
- Rain sensor;
- Ambient air temperature;
- Ambient air pressure;
- Number of occupants;
- Satellite imagery and GIS data;
- Still and video images;
- Road conditions;
- Traffic reports;

- Weather information, including winds; and
- Segments and lanes plowed.

Next Generation Integrated Corridor Management (ICM)

Description:

The Next Generation ICM application makes use of the data found in parts 1 and 2 of the BSM. Although it uses the same information, the information needs to be grouped and transmitted cached, bundled, and transmitted in one or more new messages, either using DSRC, another medium, or a combination of media. The other ICM applications do not make use of the information found in the BSM messages. Additional information, such as account information and vehicle identification, would be needed from vehicles (but not necessarily from the vehicle data bus) to support electronic tolling and mileage-based user fees. It would also be of value to capture the type and amount of chemicals spread from maintenance vehicles to support the WX-MDSS application.

Potential Impact Relative to Performance Goals Outlined in MAP-21:

Congestion: Estimated 5.9 percent delay reduction (from ICM app), 30 percent reduced delay, 30-89 percent speed increases, 20-50 percent travel time reduction (from VMT app).

Provides information not currently available for arterial management and coordination with freeway operations and performance measure calculations.

Possible Data Elements:

- Vehicle type (fleet);
- Vehicle ID;
- Vehicle log (including time, location, direction); and
- Roadway segment freeze point.

Road Weather Management

Description:

Road Weather Management research will consider how vehicle-based data on current weather conditions can be used by travelers and transportation agencies to enable decision-making that takes current weather conditions and future weather forecasts into account.

Potential Impact Relative to Performance Goals outlined in MAP-21:

Safety: Reduce crash risk due to inclement weather.

Congestion: Improve mobility by restoring capacity, reducing delays and creating more uniform traffic flow. Provides information not currently available for current roadway conditions and for crash causality and performance measure calculations.

Possible Data Elements:

- Vehicle-based data on current weather conditions
- Infrastructure-based data

Applications for the Environment: Real-Time Information Synthesis (AERIS)

Description:

AERIS research will explore how anonymous data from tailpipe emissions can be combined with other environmental data. The goal is to enable transportation managers to manage the transportation network while accounting for environmental impact.

Potential Impact Relative to Performance Goals Outlined in MAP-21:

Environmental sustainability: Manage the transportation network while accounting for environmental impact. Provides information not currently available for emissions and fuel efficiency analysis and performance measure calculations.

Possible Data Elements:

- Captures anonymous data from tailpipe emissions and compares it with other environmental data;
- Fuel consumption; and
- Fuel efficiency.

Assessment of Potential Impact on Performance Measurement

Detailed descriptions of the seven bundles that comprise the Dynamic Mobility Applications are provided in Table 2.1. As indicated in the descriptions for each of these applications, there is a variety of technology tools and other applications that are used with each application. These include but are not limited to the following:

- Personal mobile devices;
- Variable Message Signs (VMS);
- Interactive screens at transit stations;
- In-vehicle devices to alert for presence of emergency or other vehicles;
- Internet;
- 511 systems;
- Proprietary map applications;
- Satellite imagery;
- Dynamic Routing applications;
- Ramp metering systems;
- Lane control systems;
- Wireless communication for traffic signal operations;
- Automated pedestrian call from smart phones for visually impaired pedestrians;
- CCTV for road weather conditions;
- Electronic toll collection systems; and
- Use of DSRC technology.

These technological applications provide a unique mechanism for the relay of real-time information to travelers in routine or emergency situations. While some of these technologies have been in use for several years, there are great expectations regarding the use of new technology for connected vehicle and Dynamic Mobility Applications during the next 10- or 20-year horizon. The capacity for use of connected vehicle and DMA data in the next decades will rely on a system of applications that can collect, process, store, and distribute traveler information between vehicles, infrastructure, and travelers through a seamless virtual network on the nation's highways, similar to the information highway network on the internet. State DOTs continue to explore the use of the cloud (internet) as a potential repository for storing large datasets, where security and privacy of data can be built into the cloud interface architecture.

As noted with the V2V and V2I applications, the data from the DMA applications are basically real-time data. However, in order for this data to be useful for any future type of planning related work, it would need to be archived in a secured system for later use, such as a tool for multi-modal planning at State DOT or MPOs for instance. More information on these and other challenges with the use of connected vehicle and DMA data are discussed in Section 2.5.

Table 2.1 Dynamic Mobility Application (DMA) Bundles (Source: http://rde.indrasoft.net)

DMA Bundle	DMA Application	Description
Enable Advanced Traveler Information System (EnableATIS)	Multi-Modal Real-Time Traveler Information (ATIS)	This application will utilize connected vehicle-enabled real-time data and communications capabilities to empower travelers to make informed travel choices in real time, pre-trip and en-route. Based on real-time and historical travel conditions for the traveler's trip (pre-specified origin, destination, and time of departure) the application will suggest potential routes and modes (e.g., auto, transit, bicycle, walk) with approximate travel times, travel time reliability, and costs for each alternative. If transit is included in one of the alternatives, locations of transit stations, arrival time of next bus or train, parking availability and cost, will be also be provided. The application will "predict" travel times based on existing and predicted traffic congestion, weather and pavement conditions, incident locations, work zone locations and timings, transit availability and schedule, parking availability, possible use of HOT and HOV lanes (depending on time of travel). Information may be provided via: personal mobile devices, transit stations on vehicle interactive screens, in-vehicle devices, internet, and 511. The collected information, including traveler choices, can also be used by the transportation system operators and managers for performance monitoring as well as for selecting congestion pricing strategies.
	Smart Park and Ride (S-PARK)	This application will combine monitoring sensors with connected vehicle communications to provide more real-time information on park and ride lot availability, and communicate that to potential travelers at effective decision points that would encourage more use of transit for commuting, and more efficient utilization of limited park and ride capacity.
	Universal Map Application (T-MAP)	Most, if not all, current CAD/AVL systems use proprietary map applications. Consequently, transit agencies often need to load additional map applications for accommodate information from other sources, such as traffic alerts, weather and transit travel information. This requires additional time, leads to operational cost and adds complexity in integration and analysis of data to support decision making. This application will use the open map concept to establish a universal map application supported by private transit CAD/AVL systems. The application could then receive information feeds from supporting agencies and automatically incorporate critical traveler information, such as incidents, detours, street closures, alternative transit alternatives, and traffic flow on the transit agency's map application. Likewise, transit agencies could also provide vehicle locations, passenger amenities, and service level to municipalities who need to schedule street repairs, or other road closures or detours.
Enable Advanced Traveler Information System (EnableATIS) (continued)	Real-Time Route Specific Weather Information for Motorized and Non-Motorized Vehicles (WX-INFO)	This application will continuously collect weather-related probe data generated by probe vehicles, analyze, and integrate those observations with weather data from traditional weather information sources, and develop highly localized weather and pavement conditions for specific roadways, pathways, and bikeways. The current and forecasted information will be available in-vehicle, and via the internet, variable message signs (VMS), highway advisory road (HAR), 511, and personal communication devices. Knowledge of real-time weather conditions along an anticipated route can help a traveler determine whether to reschedule or postpone the trip, or take an alternate route or mode. The localized weather information can also be used by transportation system operators to implement strategies that minimize the impact of inclement weather.

DMA Bundle	DMA Application	Description
Freight Advanced Traveler Information System (FRATIS)	Freight-Specific Dynamic Travel Planning and Performance	This application will enhance traveler information systems to address specific freight needs by providing route guidance to freight facilities, incident alerts, road closures, work zones, routing restrictions (hazmat, oversize/overweight), and performance monitoring. It will: • Build on the Cross-Town Improvement Project (C-TIP) Real Time Traffic Monitoring (RTTM) and Dynamic Route Guidance (DRG) applications for best route between freight facilities; • Provide intermodal connection information, container disposition and schedule; and • Leverage existing data in the public domain, as well as emerging private sector applications to provide benefits to both sectors.
	Drayage Optimization (DR-OPT)	This application will reduce freight delays at key facilities that currently overbook their capacity to ensure uninterrupted operations within the terminal/warehouse. DR-OPT will optimize drayage operations so that load movements are coordinated between freight facilities. Individual trucks will be assigned time windows within which they will be expected to arrive at a pickup or drop-off location. Early or late arrivals to the facility are dynamically balanced and web-based forums for load matching will be provided to reduce empty moves.
Integrated Dynamic Transit Operations (IDTO)	Connection Protection (T-CONNECT)	Connection Protection (T-CONNECT) enables public transportation providers and travelers to communicate to improve the probability of successful transit transfers, e.g., by delaying a bus departure to accommodate a late arriving subway train). This application would potentially include intermodal and interagency coordination.
	Dynamic Ridesharing (D-RIDE)	This application makes use of in-vehicle (drivers) and hand-held devices (riders) to dynamically identify and accept potential ridesharing opportunities along the travel route. This application makes ridesharing easier by enabling the use of location information and in-vehicle and handheld devices to arrange ridesharing between drivers and riders.
	Dynamic Transit Operations (T-DISP)	This application links available transportation service resources with travelers through flexible, dynamic transit vehicle scheduling, dispatching and routing capabilities. It would also enable travelers to make real-time trip requests through personal mobile devices.

DMA Bundle	DMA Application	Description
Intelligent Network Flow Optimization (INFLO)	Dynamic Speed Harmonization (SPD-HARM)	This application will dynamically adjust and coordinate vehicle speeds in response to congestion, incidents, and road conditions to maximize throughput and reduce crashes.
	Queue Warning (Q-WARN)	This application will provide drivers timely warnings and alerts of slow moving or stopped traffic ahead.
	Cooperative Adaptive Cruise Control (CACC)	This application will dynamically adjust and coordinate cruise control speeds among platooning vehicles to improve traffic flow stability and increase throughput.
Multi-Modal Intelligent Traffic Signal System (MMITSS or M-ISIG)	Intelligent Traffic Signal System (I-SIG)	This application integrates data collected through wireless communications and other sources to improve traffic signal operations. It integrates several more specific applications in order to provide overarching system optimization. It will maximize overall arterial network performance, taking into account transit and freight signal priority, emergency vehicle preemption and pedestrian movements.
	Transit Signal Priority (TSP)	This application utilizes connected vehicle technology provide improved signal priority to transit at intersections. Equipment onboard the transit vehicle would communicate information such as passenger count data, service type, scheduled and actual arrival time so that algorithms could determine the optimum trade-off between expediting transit vehicles and delays to other vehicle types.
	Mobile Accessible Pedestrian Signal System (PED-SIG)	This application will allow “Automated pedestrian call” from smart phones for visually impaired pedestrians; communicate wirelessly with the traffic signal controller to obtain real-time signal phase and timing (SPAT) information, and inform visually impaired pedestrian as to when to cross and how to remain aligned with the crosswalk.
	Freight Signal Priority (FSP)	This application gives priority to freight vehicles at intersections near freight facilities (ports, rail terminals, warehouses, distribution centers), resulting in reduced delays, reduced negative environmental impacts, and increased travel time reliability for freight traffic.
	Emergency Vehicle Preemption (PREEMPT)	This application uses connected vehicle technology to provide improved signal preemption for emergency vehicles. It could also inform drivers through in-vehicle alerts and roadside signs of the presence of emergency vehicles, thus reducing the risk of accidents for motorists and pedestrians due to lack of awareness of the location and likely path of responding emergency vehicles.

DMA Bundle	DMA Application	Description
Response, Emergency Staging and Communications Uniform Management, and Evacuation (R.E.S.C.U.M.E.)	Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG)	This application will provide situational awareness information to responders while en route to the scene of an incident. It will also provide input to responder vehicle routing, staging, and secondary dispatch decisions, including: • Staging plans; • Satellite imagery; • GIS data; • Current weather data; and • Real-time modeling outputs.
	Advanced Automatic Crash Notification Relay (AACN-RELAY)	When a connected vehicle is involved in a crash, but outside of cellular communications coverage, This application will continually send a mayday message that includes vehicle location via DSRC. When a passing connected vehicle receives the message, it would forward it as soon as possible, either via cellular or a roadside DSRC receiver.
	Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE)	This application has two components: • It alerts drivers about lane closings and unsafe speeds for temporary work zones (and may also provide drivers with guidance on merging and speeds); and • It warns on-scene workers of vehicles with trajectories or speeds that pose a high risk to their safety.
	Emergency Communications and Evacuation (EVAC)	This application provides information to address the needs of two different evacuee groups. Provides those using their own transportation with: • Dynamic route guidance information; • Current traffic and road conditions; • Location of available lodging; and • Location of fuel, food, water, cash machines, and other necessities. Provides those requiring assistance with: • Identify and locate people who are more likely to require guidance and assistance; and • Identify existing service providers and other available resources.

DMA Bundle	DMA Application	Description
Next Generation Integrated Corridor Management (ICM)	Electronic Toll Collection System (ETC)	The purpose of the proposed application is to upgrade existing electronic toll collection (ETC) systems to the 5.9 GHz DSRC standard. This concept can be leveraged to potentially simplify the infrastructure necessary to handle toll payments, as well as provide flexibility with regard to tolling schemes, toll payment options, and operating models. The proposed application will make use of connected vehicle technology (DSRC), along with the appropriate back office agreements and information exchange to afford the capability for a toll authority to accept electronic payments from vehicles equipped with electronic-payment services (EPS), regardless of who owns the EPS account.
	Next Generation Integrated Corridor Management (ICM)	This application will augment corridor management through the use of multi-source, real-time connected vehicle data. Connected vehicle technology affords the capability to capture and use high-fidelity data in near real-time on freeways, arterials, rural roads, freight networks, and transit systems. The application will also allow traffic management and transit agencies to leverage their existing systems, including traffic signal systems, ramp metering systems, lane control systems, and transit systems to directly affect freeway, arterial, and transit performance. The application will improve system throughput, increase travel time reliability by improving travel predictability, and enhance incident management by providing an integrated and coordinated response during major incidents and emergencies.
	Enhanced Maintenance Decision Support System (MDSS) Communication (WX-MDSS)	The application improves MDSS by providing the systems with expanded data acquisition from connected vehicles. Snow plows, other agency fleet vehicles, and other vehicles operated by the general public will provide road-weather connected vehicle data to the Enhanced-MDSS, which will use this data to generate improved plans and recommendations to maintenance personnel.
	Mileage Based User Fee (VMT)	As electric and high efficiency vehicles become more common, there will continue to be less gas tax revenue for transportation for the same amount of vehicle miles traveled (VMT), while the cost of providing transportation infrastructure and services will increase due to rise in inflation. Mileage Based User Feed (MBUF) may eventually replace the gas tax. The proposed application will accumulate miles driven in categories determined by policy and charge for the miles driven. Categories may or may not include vehicle type, time of day, roadway type, jurisdiction, direction of travel, geographic area of travel, etc. Revenue could augment or replace the gas tax as determined by policy. The system will be interoperable across the U.S. and allow for charges by Federal, state, and local governments.

2.4 Connections with National Data Programs

The vision of the U.S. DOT Connected Vehicle Research Program includes a data capture element that will provide continuous vehicle and roadway specific data on vehicle location, vehicle movement, environmental conditions, and crashes for transportation operations and planning. There is significant potential for data from connected vehicle and Dynamic Mobility Applications to support many of the national datasets, especially those related to travel data that rely on speed and volume data. Some of the greatest potentials for use of connected vehicle and DMA datasets with the national datasets are listed below:

- Urban Congestion Report (UCR) program;
- State Traffic Monitoring Stations (for Planning Data Programs);
- National Speed Data Collection and Reporting Program;
- Traffic Volume Trends (TVT) Report;
- Travel Monitoring and Analysis System (TMAS); and
- Vehicle Travel and Information System.

Data capture from connected vehicle and Dynamic Mobility Applications may be able to supplement, enhance, or even replace many existing Federal, state, and local mobility data programs at some point in the future.

Table 2.2 identifies the existing Federal and state mobility data capture programs, along with a description of each program. Also included are the connected vehicle and Dynamic Mobility Applications that could provide data to support, enhance, or replace that existing program. The symbols in the table represent the following:

(●) Existing national data programs

(○) Future national data programs

(▲) Potential use of connected vehicle and DMA applications data programs

Table 2.2 Connected Vehicle and Dynamic Mobility Applications that will Support, Enhance, or Replace Existing Data Capture Programs

			Data Type			Connected Vehicle and Dynamic Mobility Applications											
Existing Data Capture Program	**Description**	**Data Owner**	**Infrastructure**	**Travel**	**Climate**	**Vehicle-to-Vehicle (V2V) Communication for Safety**	**Vehicle-to-Infrastructure (V2I) Communications for Safety**	**Real-Time Data Capture and Management**	**DMA – Enable ATIS**	**DMA – FRATIS**	**DMA – IDTO – Integrated Dynamic Transit Operations**	**DMA – INFLO – Intelligent Network Flow Optimization**	**DMA – MMITSS – Multi-Modal Intelligent Traffic Signal Systems**	**DMA – R.E.S.C.U.M.E.**	**DMA - ICM**	**Road Weather Management**	**Applications for the Environment: Real-Time Information Synthesis (AERIS)**
Infrastructure																	
State Roadway Inventory Programs	State roadway inventory programs document the extent (length), point and linear feature data of public roadways, along with attributes such as classification, ownership, physical conditions, pavement conditions, highway performance monitoring information, and more. Data is collected and stored for both on-state system and off-state system roadways.	State DOTs	●			▲	▲			▲				▲			
Highway Performance Monitoring System (HPMS)	HPMS is a national level highway information system that includes data on the extent, condition, performance, use, and operating characteristics of the nation's highways.	FHWA Office of Highway Policy Information	●	●		▲	▲			▲							
National Transportation Atlas Databases	NTAD is a set of nationwide geographic databases of transportation facilities, networks, and associated infrastructure. The datasets include spatial information for transportation modal networks and intermodal terminals, as well as related attribute information for these features.	RITA Bureau of Transportation Statistics	●				▲										

Existing Data Capture Program	Description	Data Owner	Data Type			Connected Vehicle and Dynamic Mobility Applications											
			Infrastructure	Travel	Climate	Vehicle-to-Vehicle (V2V) Communication for Safety	Vehicle-to-Infrastructure (V2I) Communications for Safety	Real-Time Data Capture and Management	DMA – Enable ATIS	DMA – FRATIS	DMA – IDTO – Integrated Dynamic Transit Operations	DMA – INFLO – Intelligent Network Flow Optimization	DMA – MMITSS – Multi-Modal Intelligent Traffic Signal Systems	DMA – R.E.S.C.U.M.E.	DMA - ICM	Road Weather Management	Applications for the Environment: Real-Time Information Synthesis (AERIS)
Travel (Speed and Volume)																	
Archived Data User Service (ADUS)	ADUS enables transportation agencies to retain ITS-generated volume, speed, and lane occupancy data and make them available for analysis.	FHWA Office of Highway Policy Information		●		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Transportation Technology Innovation and Demonstration (TTID)	The TTID Program is the primary source of loop detector data on many major interstate highways, particularly in smaller metropolitan areas that do not have ITS infrastructure in place. Polled data is converted into travel information (e.g., congestion levels, speed, etc.), and the data is then shared with local traffic management centers.	FHWA Office of Operations		●		▲	▲										
Urban Congestion Report (UCR)	Reports characterize emerging traffic congestion and reliability trends at the national and city level. The reports utilize archived traffic operations data gathered from state DOTs and a private traffic information company. Performance measures include congested hours, travel time index, planning time index, percent change in VMT, and percent of usable data.	FHWA Office of Operations		●		▲	▲	▲	▲	▲		▲	▲	▲	▲		

Existing Data Capture Program	Description	Data Owner	Data Type			Connected Vehicle and Dynamic Mobility Applications												
			Infrastructure	Travel	Climate	Vehicle-to-Vehicle (V2V) Communication for Safety	Vehicle-to-Infrastructure (V2I) Communications for Safety	Real-Time Data Capture and Management	DMA – Enable ATIS	DMA – FRATIS	DMA – IDTO – Integrated Dynamic Transit Operations	DMA – INFLO – Intelligent Network Flow Optimization	DMA – MMITSS – Multi-Modal Intelligent Traffic Signal Systems	DMA – R.E.S.C.U.M.E.	DMA - ICM	Road Weather Management	Applications for the Environment: Real-Time Information Synthesis (AERIS)
Travel (Speed and Volume) (continued)																		
State Traffic Monitoring Stations (for Planning Data Programs)	State DOTs install and maintain traffic monitoring stations throughout the state to support their traffic monitoring programs. These stations are established at both permanent and portable sites to collect volume, vehicle classification, and truck weight data.	State DOTs		●		▲	▲	▲	▲	▲		▲	▲	▲	▲		
National Speed Data Collection and Reporting Program	FHWA is evaluating the feasibility of establishing a national speed data collection and reporting program. The proposed program would standardize speed data collection procedures and provide monthly speed trends at the national level to evaluate travel trend and travel conditions.	FHWA Office of Highway Policy Information		○		▲	▲	▲	▲	▲		▲	▲	▲	▲		
Traffic Volume Trend (TVT) Reports	The Traffic Volume Trends (TVT) report is published monthly by the Federal Highway Administration (FHWA). The report estimates the vehicle miles traveled (VMT) by state and several functional classes of roads. The estimates are based on the Highway Performance Monitoring System (HPMS) and monthly traffic counts from automatic traffic recorders (ATRs).	FHWA Office of Highway Policy Information		●		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲		

Existing Data Capture Program	Description	Data Owner	Data Type			Connected Vehicle and Dynamic Mobility Applications											
			Infrastructure	Travel	Climate	Vehicle-to-Vehicle (V2V) Communication for Safety	Vehicle-to-Infrastructure (V2I) Communications for Safety	Real-Time Data Capture and Management	DMA – Enable ATIS	DMA – FRATIS	DMA – IDTO – Integrated Dynamic Transit Operations	DMA – INFLO – Intelligent Network Flow Optimization	DMA – MMITSS – Multi-Modal Intelligent Traffic Signal Systems	DMA – R.E.S.C.U.M.E.	DMA - ICM	Road Weather Management	Applications for the Environment: Real-Time Information Synthesis (AERIS)
Travel (Speed and Volume) (continued)																	
Travel Monitoring and Analysis System (TMAS)	TMAS provides online data submitting capabilities to State traffic offices to submit travel monitoring data to FHWA. These data currently include monthly volume data for the Traffic Volume Trends report, vehicle classification, and truck weight data.	FHWA Office of Highway Policy Information		●		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Vehicle Travel Information System (VTRIS)	VTRIS is database management system designed to assist states in processing and storing vehicle classification and weigh-in-motion data.	FHWA Office of Highway Policy Information		●						▲							
National Transportation Statistics	NTS presents statistics on the U.S. transportation system, including its physical components, safety record, economic performance, energy use, and environmental impacts.	RITA Bureau of Transportatio n Statistics	●	●		▲	▲	▲	▲	▲		▲	▲	▲	▲		▲
Climate (Weather)																	
Road Weather Information Systems (Environmental Sensor Stations)	RWIS is a combination of technologies that collects, transmits, models, and disseminates weather and road condition information.	FHWA Office of Operations – Road Weather Management			●	▲	▲		▲				▲	▲		▲	▲

Existing Data Capture Program	Description	Data Owner	Data Type: Infrastructure	Data Type: Travel	Data Type: Climate	Vehicle-to-Vehicle (V2V) Communication for Safety	Vehicle-to-Infrastructure (V2I) Communications for Safety	Real-Time Data Capture and Management	DMA – Enable ATIS	DMA – FRATIS	DMA – IDTO – Integrated Dynamic Transit Operations	DMA – INFLO – Intelligent Network Flow Optimization	DMA – MMITSS – Multi-Modal Intelligent Traffic Signal Systems	DMA – R.E.S.C.U.M.E.	DMA - ICM	Road Weather Management	Applications for the Environment: Real-Time Information Synthesis (AERIS)
Climate (Weather) (continued)																	
Clarus	Clarus is a robust data assimilation, quality checking, and dissemination system that provides near real-time atmospheric and pavement observations from road weather information systems, environmental sensor stations (ESS), and mobile observations from Automated Vehicle Location (AVL) equipped trucks.	FHWA Office of Operations – Road Weather Management			●	▲	▲		▲				▲	▲		▲	▲
Modal																	
Border Crossing Data	Border Crossing/Entry Data provides summary statistics for incoming crossings at the U.S.-Canadian and the U.S.-Mexican border at the port level. Data are available for trucks, trains, containers, buses, personal vehicles, passengers, and pedestrians.	RITA Bureau of Transportation Statistics		●		▲	▲		▲	▲		▲					
North American Transborder Freight Data	The North American Transborder Freight Database contains freight flow data by commodity type and by mode of transportation (rail, truck, pipeline, air, vessel, and other) for U.S. exports to and imports from Canada and Mexico.	RITA Bureau of Transportation Statistics		●		▲	▲		▲	▲		▲					

Existing Data Capture Program	Description	Data Owner	Data Type			Connected Vehicle and Dynamic Mobility Applications											
			Infrastructure	Travel	Climate	Vehicle-to-Vehicle (V2V) Communication for Safety	Vehicle-to-Infrastructure (V2I) Communications for Safety	Real-Time Data Capture and Management	DMA – Enable ATIS	DMA – FRATIS	DMA – IDTO – Integrated Dynamic Transit Operations	DMA – INFLO – Intelligent Network Flow Optimization	DMA – MMITSS – Multi-Modal Intelligent Traffic Signal Systems	DMA – R.E.S.C.U.M.E.	DMA - ICM	Road Weather Management	Applications for the Environment: Real-Time Information Synthesis (AERIS)
Modal (continued)																	
Commodity Flow Survey	The CFS is the primary source of national and state-level data on domestic freight shipments in mining, manufacturing, wholesale, auxiliaries, and selected retail industries. Data are provided on the types, origins and destinations, values, weights, modes of transport, distance shipped, and ton-miles of commodities shipped. The CFS covers shipments by truck, rail, water, air, pipeline and multiple modes. CFS outputs include tabular data and reports.	RITA Bureau of Transportation Statistics		●		▲				▲		▲					
Intermodal Passenger Connectivity Database	A nationwide data table of passenger transportation terminals, with data on the availability of connections among the various scheduled public transportation modes at each facility. In addition to geographic data for each terminal, the data elements describe the availability of rail, air, bus, transit, and ferry services.	RITA Bureau of Transportation Statistics		●							▲						
National Transit Database (NTD)	The NTD is a national database of statistics for the transit industry. The NTD is comprised of data reported by more than 600 transit agencies across the U.S., which is then analyzed and compiled into reports published by FTA and made available to the public on the NTD Program website.	Federal Transit Administration		●							▲		▲				

Existing Data Capture Program	Description	Data Owner	Data Type			Connected Vehicle and Dynamic Mobility Applications											
			Infrastructure	Travel	Climate	Vehicle-to-Vehicle (V2V) Communication for Safety	Vehicle-to-Infrastructure (V2I) Communications for Safety	Real-Time Data Capture and Management	DMA – Enable ATIS	DMA – FRATIS	DMA – IDTO – Integrated Dynamic Transit Operations	DMA – INFLO – Intelligent Network Flow Optimization	DMA – MMITSS – Multi-Modal Intelligent Traffic Signal Systems	DMA – R.E.S.C.U.M.E.	DMA - ICM	Road Weather Management	Applications for the Environment: Real-Time Information Synthesis (AERIS)
Modal (continued)																	
Cross-Town Improvement Project (C-TIP)	C-TIP is a freight information sharing/transfer system that will enable coordination to maximize loaded movements and minimize unproductive movements within the Intermodal Transportation Network.	FHWA Office of Freight Management and Operations		○		▲	▲			▲							
FHWA Freight Performance Measures Initiative	The FPM initiative includes a data processing tool that estimates average operating speeds for trucks traveling on interstate highways. Speeds are calculated using confidential, onboard data from several hundred thousand trucks including periodic time, location, speed, and anonymous unique identification information.	FHWA Office of Freight Management and Operations		●		▲	▲			▲		▲	▲				
Freight Analysis Framework (FAF)	The 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. With data from the 2007 Commodity Flow Survey and additional sources, FAF version 3 provides estimates for tonnage and value, by commodity type, mode, origin, and destination for 2007, the most recent year, and forecasts through 2040. Also included are truck flows assigned to the highway network for 2007 and 2040.	FHWA Office of Freight Management and Operations		●		▲	▲			▲		▲	▲				

Existing Data Capture Program	Description	Data Owner	Data Type			Connected Vehicle and Dynamic Mobility Applications													
			Infrastructure	Travel	Climate	Vehicle-to-Vehicle (V2V) Communication for Safety	Vehicle-to-Infrastructure (V2I) Communications for Safety	Real-Time Data Capture and Management	DMA – Enable ATIS	DMA – FRATIS	DMA – IDTO – Integrated Dynamic Transit Operations	DMA – INFLO – Intelligent Network Flow Optimization	DMA – MMITSS – Multi-Modal Intelligent Traffic Signal Systems	DMA – R.E.S.C.U.M.E.	DMA - ICM	Road Weather Management	Applications for the Environment: Real-Time Information Synthesis (AERIS)
Modal (continued)																	
Motor Carrier Management Information System (MCMIS)	MCMIS contains information on the safety fitness of commercial motor carriers (truck and bus) and hazardous material (HM) shippers subject to the Federal Motor Carrier Safety Regulations (FMCSR) and the Hazardous Materials Regulations (HMR). Components include carrier registration (census file) information, inspection data, and crash data for crashes involving a large truck or bus.	Federal Motor Carrier Safety Administration		●		▲	▲			▲		▲					
Licensing and Insurance (L&I) Database	For-hire and passenger carriers are required to have minimum levels of liability insurance, and this information is collected through the Licensing and Insurance (L&I) Database.	Federal Motor Carrier Safety Administration		●													
International Freight Data System (IFDS)	The IFDS will examine transportation trade data and how long it takes goods to move between O-D pairs. It will provide a one stop shop for international trade data for all DOT modal administrations.	RITA Bureau of Transportation Statistics		○						▲							
Travel Behavior																	
National Household Travel Survey (NHTS)	The NHTS is the nation's inventory of daily and long-distance travel. The dataset allows analysis of daily travel by all modes, including characteristics of the people traveling, their household, and their vehicles.	RITA Bureau of Transportation Statistics		●		▲											

			Data Type			Connected Vehicle and Dynamic Mobility Applications											
Existing Data Capture Program	**Description**	**Data Owner**	**Infrastructure**	**Travel**	**Climate**	**Vehicle-to-Vehicle (V2V) Communication for Safety**	**Vehicle-to-Infrastructure (V2I) Communications for Safety**	**Real-Time Data Capture and Management**	**DMA – Enable ATIS**	**DMA – FRATIS**	**DMA – IDTO – Integrated Dynamic Transit Operations**	**DMA – INFLO – Intelligent Network Flow Optimization**	**DMA – MMITSS – Multi-Modal Intelligent Traffic Signal Systems**	**DMA – R.E.S.C.U.M.E.**	**DMA - ICM**	**Road Weather Management**	**Applications for the Environment: Real-Time Information Synthesis (AERIS)**
Travel Behavior (continued)																	
Omnibus Household Survey	The OHS is conducted to collect information about specific transportation issues (e.g., cell phones, distracted driving) and to assess public satisfaction and attitudes about the transportation system and its interaction with DOT agencies (e.g., airline passenger opinions on security screening procedures).	Transportation Research Board		●		▲											
Other Data Programs																	
Data.gov	The Data.gov is a data repository for Federal datasets and tools. It contains searchable catalogs that provide access to raw datasets and various tools from different Federal agencies.	All Stakeholders	●	●	●	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Integrated Corridor Management (ICM) Program	The U.S. DOT is partnering with eight "Pioneer Sites" in a 5-year initiative to develop, deploy and evaluate ICM concepts in eight of the nation's busiest corridors. The ICM Initiative aims to advance the state of the practice in transportation corridor operations to manage congestion. This initiative will provide the institutional guidance, operational capabilities, ITS technology and technical methods needed for effective ICM systems.	RITA ITS Joint Program Office		●		▲	▲								▲		

Existing Data Capture Program	Description	Data Owner	Data Type			Connected Vehicle and Dynamic Mobility Applications												
			Infrastructure	Travel	Climate	Vehicle-to-Vehicle (V2V) Communication for Safety	Vehicle-to-Infrastructure (V2I) Communications for Safety	Real-Time Data Capture and Management	DMA – Enable ATIS	DMA – FRATIS	DMA – IDTO – Integrated Dynamic Transit Operations	DMA – INFLO – Intelligent Network Flow Optimization	DMA – MMITSS – Multi-Modal Intelligent Traffic Signal Systems	DMA – R.E.S.C.U.M.E.	DMA - ICM	Road Weather Management	Applications for the Environment: Real-Time Information Synthesis (AERIS)
Other Data Programs (continued)																	
I-95 Corridor Coalition Data	The I-95 Corridor Coalition Vehicle probe project acquire travel times and speeds on freeway and arterials using probe technology to provide regional management of traffic and traveler information useful to long-distance travelers.	I-95 Corridor Coalition		●		▲	▲	▲	▲	▲	▲	▲		▲	▲	▲	▲
VII Data Use Analysis and Processing (DUAP) Project	The DUAP project is evaluating how new connected vehicle data sources may be combined with other data sources, and how use of these new data sources may impact MDOT's current transportation system operations through improved methods and processes.	Michigan DOT		●		▲	▲	▲	▲	▲		▲	▲	▲	▲	▲	▲
Real-Time Data Capture and Management Program																	
TFHRC Data Resources Testbed	The testbed will host real-time and archived transportation data from a variety of sources to support performance measurement and transportation system management applications.	Turner-Fairbank Highway Research Center		○		▲	▲	▲	▲	▲		▲	▲	▲	▲	▲	▲

Existing Data Capture Program	Description	Data Owner	Data Type: Infrastructure	Data Type: Travel	Data Type: Climate	Vehicle-to-Vehicle (V2V) Communication for Safety	Vehicle-to-Infrastructure (V2I) Communications for Safety	Real-Time Data Capture and Management	DMA – Enable ATIS	DMA – FRATIS	DMA – IDTO – Integrated Dynamic Transit Operations	DMA – INFLO – Intelligent Network Flow Optimization	DMA – MMITSS – Multi-Modal Intelligent Traffic Signal Systems	DMA – R.E.S.C.U.M.E.	DMA - ICM	Road Weather Management	Applications for the Environment: Real-Time Information Synthesis (AERIS)
Real-Time Data Capture and Management Program (continued)																	
DCM Program Research Data Exchange	The RDE is a new decentralized, Internet-based, federated system of systems. The RDE serves as a research repository for the Real-Time Data Capture and Management Program, and it contains data environments (collections of related data sets and possibly real-time data feeds), individual data sets, and real-time data feeds.	RITA ITS Joint Program Office	●	●	●	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
DCM Program Test Data Sets	Well-documented, quality test data sets are available from recent or ongoing operations, field tests, or simulations of emerging technologies support mobility, environment, transit, freight, weather, and other surface transportation research.	RITA ITS Joint Program Office	●	●	●	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Dynamic Mobility Application Datasets	Well-organized data and associated descriptors (data environments) that include data from field tests and advanced simulation models in support of high-priority arterial, freeway, regional, and corridor applications.	RITA ITS Joint Program Office	○	○		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲

● Existing National Data Program

○ Future National Data Program

▲ Indication that connected vehicle and DMA data could potentially support one of the existing national data programs

2.5 Challenges With Use of Connected Vehicle and DMA Data

Much of the research for Pilot 1 indicates there will be the availability of vast amounts of connected vehicle and DMA datasets as the Connected Vehicle program advances. However, there remain certain technical issues related to integration of these datasets with national datasets and the technology methods and tools that would impact the integration of these data with existing national datasets, including data to support national performance measurement needs. There are also considerations that must be addressed regarding data quality and privacy when using the data. The following paragraphs describe these anticipated challenges in more detail.

Technology Considerations for Data Sharing

The technology considerations for use of connected vehicle and DMA data with national datasets must be evaluated from the perspective of State DOTs and the U.S. DOT. The State DOTs are currently the primary data providers for many of the national datasets identified in the Roadway Transportation Data Business Plan – Data Inventory report (June 18, 2012). As such, the State DOTs rely on their own individual technology tools and methods for data collection, processing, and reporting. This includes, but is not limited to, a State's traffic monitoring program, supported by a traffic monitoring information system, and their road inventory database and linear referencing system(s) (LRS), which are now typically integrated into some kind of Geographic Information System (GIS). Not all states use the same GIS system/platform, nor do they all use the same GIS system/platform used by the U.S. DOT for the various national datasets. Integration of connected vehicle and DMA data to match a State's existing LRS would not be seamless and would require a certain amount of middleware or customized Commercial Off the Shelf (COTS) software to accomplish the integration.

There are many other technology issues that must be considered, all of which are unique to individual State DOTs based on their IT hardware/software architecture. Typically, State DOT IT Departments govern their policies and procedures for the installation and use of hardware and software. Each State would need to evaluate the potential uses and feasibility of integrating data from external datasets into their data systems. Feasibility analysis may include legal/contractual issues, data collection procedures, data format and differences in data quality procedures.

From the U.S. DOT perspective, there is a need to ensure that whatever data is provided by the States can be integrated into national datasets using the methods and technology tools required by the U.S. DOT. In particular, this need is illustrated through the use of the User Profile and Access Control System (UPACS) for submitting Highway Performance Monitoring System (HPMS) data annually from the States and also the use of the Travel Monitoring Analysis System (TMAS) for submitting quarterly and annual traffic data to FHWA.

As the Connected Vehicles program progresses it is possible that other business models may be developed that will collect store and manage the large amounts of data produced by the applications. For example, a large data company such as IBM or Google or the OEMs (i.e., GM or Ford) could setup a business to provide data to state DOTs (possibly for a fee).

Recommendation: Recommendations for addressing these technology issues include ensuring that the State DOT develops and maintains current documentation on the policies and standards regarding the use of hardware/software for supporting and managing their information systems and associated databases. A review of these policies/standards would need to be done prior to use of any external datasets, as is currently done in instances where a State DOT may use local traffic datasets or city street GIS network data to enhance the DOTs base map and LRS system. States also need to stay informed on the latest developments regarding applications, new data business models, and technology used by U.S. DOT for submitting data, through webinars or attendance at FHWA sponsored meetings and workshops.

Data Quality Considerations for Data Sharing

Considerations related to data quality must also be addressed. Data quality encompasses many criteria including data validity, accuracy, timeliness, completeness, coverage, and accessibility. Each State DOT and the U.S. DOT has requirements and/or guidelines dictating what are acceptable data quality standards regarding the management and use of state and national datasets. It is imperative that consideration for integration of data from connected vehicle and DMA datasets continue to meet these requirements if the intent is to use these datasets to support national performance measurement needs. The requirements may include the use of specific data formats, data definitions, and data standards (including metadata standards) for collection, processing (including integration) and reporting of data and information to U.S. DOT.

Recommendation: Development and use of data dictionaries or data catalogs that contain data formats and standards for collection, processing, and use of data can provide the necessary documentation (when made available through a secure FTP site or other secure mechanism) to all parties responsible for use and/or management of the datasets, whether the data providers are internal or external to the State DOT or U.S. DOT.

Privacy Considerations with Use of Data

Many of the datasets available through connected vehicle and Dynamic Mobility Applications provide detailed information about dates/times/locations of vehicles. Due to a variety of concerns related to maintaining privacy of this information on behalf of the traveling public, it is imperative that the anonymity of the driver of the vehicle is protected. The type of technology and information available from connected vehicle and Dynamic Mobility Applications must account for these concerns and ensure that they are addressed in the wide-scale deployment and use of connected vehicle and DMA data. This includes, but is not limited to, manufacturers of passenger vehicles providing opt-in or opt-out mechanisms to purchasers that the vehicles may be/are equipped with electronic systems that are capable of recording minute details about a vehicle's travel. This includes latitude/longitude/elevation location information of the vehicle, air pressure in each of the tires, deployment status of air bags, and whether passengers are utilizing seat belts in the vehicle.

Recommendation: Data encryption software and technology can be utilized to protect the anonymity of vehicle drivers and passengers, and all methods currently available as well as those under development should continue to be explored by State DOTs and the U.S. DOT to address concerns related to privacy and security of datasets.

Other Data Considerations

There may be additional data considerations as the availability of connected vehicle data becomes widespread. There is a considerable existing infrastructure supporting the current data systems. During the period of transition from existing data to use of connected vehicle data the integration of connected vehicle data with legacy data systems will be important. There is potential for the development of new business models and data markets to supply data to the end users (state DOTs, MPOs, Federal agencies). The operating and planning agencies should monitor business model development and participate in discussions as these new models are implemented. It is expected that there will be an uneven evolution of connected vehicle data (e.g., mobile device data may occur early, with a slower roll-out for OEM-dependent connected vehicle data). Again the operating and planning agencies should monitor this data evolution and be aware of new developments and the availability of new data forms.

2.6 Conclusions and Recommendations

Pilot Study 1 applied the data business planning principles to address the following specific problem statement/questions:

1. **Is there data that will be available from connected vehicle and Dynamic Mobility Applications that could be used for national performance monitoring purposes?** The results of this pilot study indicate that yes, there is data that is/will be available from connected vehicle and Dynamic Mobility Applications that could be used for national performance monitoring purposes. The analysis presented in this report documents the various types of data and their sources from the connected vehicle and Dynamic Mobility Applications that could be used to enhance or even replace at some point traditional data collection methods used by State DOTs and the U.S. DOT. This assessment indicates that all of the existing mobility data capture programs can be supported by connected vehicle and Dynamic Mobility Applications. There are a number of benefits that US DOT, state DOTs, and MPOs will derive from moving to the connected vehicle data. Some of these benefits include:

   - Better understanding of congestion causality and the relationships among contributing factors;
   - More comprehensive geographic coverage;
   - Higher resolution of detail on delay and congestion dynamics;
   - Highly improved travel time reliability reporting when integrated with traveler intent and trip purpose data (from mobile devices);
   - Higher resolution of modal data – i.e., freight and transit;
   - Lower overall costs for data collection; and
   - New ways of measuring total travel and the quality of travel.

   As these applications come on-line over the next decade, each of the existing data capture programs should be evaluated to determine if connected vehicle/DMA data will enhance the existing program, or if the existing program should be completely replaced by the data captured in the connected vehicle/DMA program. The potential exists that, given the continuous timescale and ubiquitous location of the connected vehicle/DMA data, a much richer data set will be available in the future compared with existing programs that primarily capture only a sampling of data. Additionally, it is reasonable to conclude that the connected vehicle/DMA program will provide the needed data to support all of the performance measures included in the MAP-21 authorization. There are concerns and challenges with the sharing and use of this data that must be addressed before any of it can be used in the future to meet national performance measurement needs.

2. **Are all stakeholders informed of the availability of such data?** While all stakeholders may not currently be informed of the availability of such data (from connected vehicle and DMA), it is the intent to present this report to a select group of data providers at the U.S. DOT. This presentation represents another step in the continued implementation of the Roadway Transportation Data Business Plan, which can be utilized to facilitate ongoing dialog between the communities of interest (COIs) identified as part of the U.S. DOT Mobility Data Coordination Working Group and the data providers.

The following recommendations are based on the results of this pilot study to further the potential use of connected vehicle and DMA data as it becomes available within and beyond the next decade:

1. Identify and document in a Memorandum of Understanding which offices comprise the Connected Vehicle Data Capture Working Group as a Community of Interest of the U.S. DOT Mobility Data Coordination Group (reference Figure 3.1 from the Data Business Plan).
2. Present the findings of this pilot study to the Connected Vehicle Data Capture Working Group and solicit their feedback based on the results of this study.
3. Members of the Connected Vehicle Data Capture Working Group should establish and maintain outreach to the FHWA Data Governance Board to keep the Data Governance members informed on availability and potential use of future connected vehicle and DMA datasets, especially with regards to meeting national performance measurement needs identified in MAP-21.
4. Finally, the Connected Vehicle Data Capture Working Group should identify potential national datasets that can be used as a pilot to test integration of specific connected vehicle or DMA data with national datasets. Concurrence would be needed from the responsible U.S. DOT office for access to a copy or portion of the national dataset to be used to test the integration methods and tools. Based on the findings of this data integration pilot, additional U.S. DOT offices may consider similar integration efforts for Federal programs and national datasets under their direction. Initial pilot testing should consider using the data available through the Research Data Exchange (RDE) (Appendix A), although most of the RDE datasets are test datasets that have been collected for a trial period of time only. Some of these datasets may also require additional technology or scripts to be developed in order for the data to be used in other applications. The value in including the RDE information in this report is in documenting the different types of data available, the multiple formats in which this data is available, and the types of technology currently used or under development that is required to use these datasets.

3.0 Test Pilot 2: Reconciliation of Speed Data from Multiple Sources

3.1 Background

The Data Inventory Report conducted as part of the U.S. DOT Surface Transportation Data Business Plan project found that speed data is currently being collected through the following contracts and data programs within U.S. DOT:

- Transportation Technology Innovation and Demonstration (TTID) Program, FHWA Office of Operations;
- National Performance Management Research Data Set, FHWA Office of Operations; and
- National Speed Data Collection and Reporting Program (National Traffic Database), FHWA Office of Highway Policy Information.

The stakeholder outreach process for the DBP identified a potential overlap in the data being collected in these national programs. This second test pilot study makes recommendations to FHWA regarding use of the Data Business Plan to integrate data from these sources to meet performance measurement needs.

Objectives

The objective of the pilot is to apply and demonstrate the benefits of data business planning principles to address the following specific problem statement/questions: 1) What are the requirements for speed data collection and reporting at FHWA? 2) Is there possible duplication of effort occurring?

Methodology

The following methodology was applied:

1. Interview owners for each of the speed data programs to determine the life of the program and possible overlaps in the collection of speed data. The interview guide is provided in Appendix B.
2. Determine the purpose and Federal role for collecting speed data.
3. Identify opportunities for coordination among the speed data programs.
4. Make recommendations for the use of the DBP to resolve the coordination issues.

Organization

This section on the results for Test Pilot 2 is organized as follows:

3.2 – Purpose and Federal Role for Collecting Speed Data.

3.3 – Overview of Speed Data Programs.

3.4 – Opportunities for Coordination.

3.5 – Conclusions and Recommendations.

3.2 Purpose and Federal Role for Collecting Speed Data

Legislation and Federal Role in Speed Management

Traditionally, State and local governments have been responsible for speed regulation, and the Federal role has been to compile speed trend and safety statistics, conduct and coordinate research, fund national highway and safety programs, and regulate new vehicle standards. However, this role shifted to one of monitoring compliance and enforcement of speed limits in response to the OPEC oil embargo in 1973, when Congress enacted a Federal mandate to implement a National Maximum Speed Limit (NMSL) of 55 mph to conserve fuel. Although fuel consumption savings were lower than anticipated, there was an apparent decline in annual traffic fatalities of more than 16 percent. As a result, Congress enacted Public Law 93-643 making the NMSL permanent. The NMSL was modified in 1987 and 1988 to allow speed limits of 65 mph on rural Interstates and certain limited access, rural roadways.

FHWA and NHTSA shared responsibility for the implementation of the NMSL compliance program through joint regulation 23 CFR Part 1260, and, in 1978, State compliance became a prerequisite for receiving Federal funding for highway projects. The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) included a formula for calculating a State's compliance score based on the product of relative fatality and crash severity (as derived from the Fatal Accident Reporting System data) and the percentage of vehicles exceeding 60, 65, and 70 mph on all 55 mph highways, and 70, 75, and 80 mph on all 65 mph highways. States were required to achieve 50 percent of the maximum allowable compliance score, and States in non-compliance incurred sanctions of a maximum of 2.5 percent of Federal funds apportioned for Federal-aid highways and highway safety construction programs in the State.[2] State speed monitoring programs were implemented to monitor travel speeds, determine compliance rates, and meet certification requirements.

The National Highway System (NHS) Designation Act of 1995 (P.L. 104-59) repealed the NMSL and granted State and local governments full authority to set posted speed limits on all public roads. The repeal ended Federal sanctions for noncompliance with the NMSL, and, as a result, States are no longer required to monitor and report travel speed data to FHWA.[3] However, States are strongly encouraged to continue monitoring speed for their own information and to provide data required for the Safety Report specified under Section 347 of P.L. 104-59, if they change their speed limits from NMSL levels.[4]

After repeal of the NMSL, an interagency task force was formed to study the speed management issue and develop a U.S. DOT policy on speeding and speed management, which is still in use today:

> *The DOT's policy on highway speed is to provide guidance to State and local governments to set speed limits that maximize the efficient and rapid transportation of people and goods while eliminating the unnecessary risk of crashes due to unsafe speeds. This policy promotes the concept that Federal, State, and local governments should have balanced programs that use the most cost-effective strategies for decreasing crash risks from speeding. These strategies include: 1) ensuring that posted speed limits are reasonable and appropriate for conditions; 2) providing*

[2] Federal Register Volume 59, Number 114 (Wednesday, June 15, 1994). Available at: http://www.gpo.gov/fdsys/pkg/FR-1994-06-15/html/94-14463.htm.

[3] http://safety.fhwa.dot.gov/speedmgt/policy/.

[4] http://www.ibiblio.org/rdu/nmsl-rqa.html.

> *public information and education on the risks associated with speeding; 3) understanding who speeds, where, when, and why; 4) using a variety of techniques and technologies beyond enforcement for speed management; and 5) targeting enforcement where speeding presents the most serious hazard and accompanying it with public information and education.*[5]

As a result, the Federal role has now shifted to one of conducting research and providing science-based countermeasures and technical guidance for managing speed. The policy also led to the creation of a U.S. DOT Speed Management Team with representatives from the National Highway Traffic Safety Administration (NHTSA), Federal Highway Administration (FHWA), and the Federal Motor Carrier Safety Administration (FMCSA), whose goal is to promote the importance of both engineering and behavioral countermeasures in reducing the number of speeding-related fatalities and injuries occurring on U.S. highways.[6] The Team is responsible for the following activities related to speed management:[7]

- Delivery of the Speed Program Management Workshop to Federal, State and local traffic safety program managers, providing them with a tool for the development of expertise in speed management issues.
- Delivery of the U.S. DOT Speed Management Workshop to States and local jurisdictions, providing them with a tool for obtaining cooperation and support of traffic safety stakeholders and elected officials responsible for implementing speed management measures.
- Evaluation and review of speed and speed management research efforts to include engineering, enforcement, behavioral and technology-based solutions and countermeasures.
- Development and implementation of a model Speed Management Action Plan to provide guidance to State and local governments for the design, implementation and maintenance of balanced and effective speed management programs.
- Develop and disseminate outreach materials on how appropriate speed limits are determined; the relationships among travel speed, posted speed limits, and crash risks; and, appropriate strategies and countermeasures for reducing speeding-related crashes/fatalities.

In summary, there is currently no specific statute (CFR or USC) that gives FHWA authority to collect speed data. However, CFR 23 420.105(b) gives the agency broad authority to collect any data needed to administer the Federal-Aid Highway program, support internal analyses and business needs, and fulfill FHWA's reporting responsibilities to the Administration, United States Congress, and the traveling public. Traffic data reported by States under this Federal regulation is submitted as part of the Annual Highway Performance Monitoring System (HPMS) report from each State.

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[5] Speeding and Highway Safety: The U.S. Department of Transportation's Policy and Implementation Strategy. NHTSA, FHWA, DOT HS 809, 130, August 2000, Washington, D.C. Available at: http://safety.fhwa.dot.gov/speedmgt/policy/ docs/spdppolicybro.pdf

[6] U.S. Department of Transportation Speed Management Strategic Initiative. U.S. DOT Speed Management Team, DOT HS 809 924, June 2005, Washington, D.C. Available at: http://www.nhtsa.gov/people/injury/enforce/SpeedManagement-content/index.html

[7] U.S. Department of Transportation Speed Management Program, Team Charter, revised January 11, 2011. http://safety.fhwa.dot.gov/speedmgt/spd_mgt_charter.cfm

MAP-21 Requirements for Speed Data

The Moving Ahead for Progress in the 21st Century (MAP-21) legislation requires DOTs to identify national-level performance measures in the areas of safety, pavements, bridges, freight, emissions, performance, and congestion. FHWA is working to develop a Notice of Proposed Rulemaking (NPRM) for provision of the legislation, including the establishment and implementation of national performance measures. As a result of the pending NPRM, performance measures (and associated speed data requirements) for MAP-21 have not been fully defined. However, the AASHTO Standing Committee on Performance Management (SCOPM) created a Task Force on Performance Measure Development, Coordination and Reporting in order to inform FHWA's rulemaking process and provide a clear, defensible, and unifying statement on each national level performance measure.

A November 2012 SCOPM report[8] documents the recommended measures and key characteristics such as: measure definition, methodology, target setting, reporting, progress assessment, and additional considerations. The following national-level performance measures from this report include speed related data variables:

Table 3.1 Speed Related Variables for Recommended National Performance Measures (Source: SCOPM Task Force Findings on National-Level Performance Measures. AASHTO Standing Committee on Performance Management, Task Force on Performance Measure Development, Coordination and Reporting, November 9, 2012.)

Performance Area	Measure	Speed Related Variables	Type	Source	Availability
Freight Performance: Delay	Annual Hours of Truck Delay (AHTD)	Agency-specified Threshold Speed	Determined and used in calculations	State DOT	Determined by each State DOT for each corridor segment. The agency-specified threshold speed may change over time for individual corridors
		Truck Travel Speed	Measured – An hourly value would be calculated for each hour of the day and each corridor segment	FHWA National Travel Data Set (could be separate data sets for passenger vehicles and truck speeds)	Annually

8 SCOPM Task Force Findings on National-Level Performance Measures. AASHTO Standing Committee on Performance Management, Task Force on Performance Measure Development, Coordination and Reporting, November 9, 2012.

Performance Area	Measure	Speed Related Variables	Type	Source	Availability
Freight Performance: Reliability	Truck Reliability Index (RI_{80})	Agency-specified Threshold Speed	Determined and used in calculations	State DOT	Determined by each State DOT for each corridor segment. The agency-specified threshold speed may change over time for individual corridors
		5-Minute Truck Travel Speed	Measured – A 5-minute value would be calculated for each day of the calendar year (365) and each corridor segment	FHWA National Travel Data Set (could be separate data sets for passenger vehicles and truck speeds)	Annually
National Highway Performance: Delay	Annual Hours of Delay (AHD)	Agency-specified Threshold Speed	Determined and used in calculations	State DOT	Determined by each State DOT for each corridor segment. The agency-specified threshold speed may change over time for individual corridors
		Travel Speed	Measured – An hourly value would be calculated for each hour of the day and each corridor segment	FHWA National Travel Data Set (could be separate data sets for passenger vehicles and truck speeds)	Annually
National Highway Performance: Reliability	Reliability Index (RI_{80})	Agency-specified Threshold Speed	Determined for congested corridors and used in calculations	State DOT	Determined by each State DOT for each corridor segment. The agency-specified threshold speed may change over time for individual corridors
		Posted Speed	Used as 80th percentile speed for uncongested corridors	State DOT	Determined for each corridor segment

Performance Area	Measure	Speed Related Variables	Type	Source	Availability
National Highway Performance: Reliability (continued)	Reliability Index (RI_{80}) (continued)	5-minute Travel Speed	Measured – A 5-minute value would be calculated for each workday (240) or day of the calendar year (365) and each corridor segment	FHWA National Travel Data Set	Annually
CMAQ Traffic Congestion	Annual Hours of Delay (AHD) in nonattainment or maintenance areas	Agency-specified Threshold Speed	Determined and used in calculations	State DOT	Determined by each State DOT for each corridor segment included in CMAQ funded programs and projects
		Travel Speed	Measured – An hourly value would be calculated for each hour of the day and each corridor segment	FHWA National Travel Data Set (could be separate data sets for passenger vehicles and truck speeds)	Annually for each corridor segment included in CMAQ funded programs and projects

The report notes that implementation of these measures are dependent on U.S. DOT providing to State DOTs and MPOs private sector speed data and vehicle miles traveled data from HPMS volume data and other analysis tools. A combination of the FHWA Highway Performance Monitoring System (HPMS) data set and nationwide private sector historical speed data (i.e., FHWA National Travel Data Set) provided to states in a ready-to-use format could provide a basis for states to produce these measures. To ensure the private sector historical speed data is of high quality, the report recommends that FHWA institute a requirement for evaluation of the datasets similar to the I-95 Corridor Coalition validations, in which a third-party evaluation of private sector vendor data is conducted in order to validate speed data for performance analyses.

The final rule on performance measures will be finalized by March 15, 2014, and States have another year to set targets and start reporting on the measures.

Customer and Business Needs for Federal Speed Data

Potential customers for Federal speed data include the following:

- U.S. DOT National Highway Traffic Safety Administration (NHTSA);
- Internal FHWA offices;
- State and local transportation agencies;

- American Association of State Highway and Transportation Officials (AASHTO);
- Federal Motor Carrier Safety Administration (FMCSA);
- Governors Highway Safety Association (GHSA);
- Institute of Transportation Engineers (ITE);
- Insurance Institute for Highway Safety (IIHS);
- International Association of Chiefs of Police (IACP);
- National Safety Council; and
- AAA Foundation for Traffic Safety.

Users' business needs for Federal speed data relate to safety, operations, and policy development, as described in more detail below.

- **Safety Analysis:** At the State level, speed data is critical for supporting State Highway Safety programs and making decisions about the design and operation of roadways. The Model Inventory of Roadway Elements (MIRE) provides a structure for roadway inventory data that would allow State and local transportation agencies to use advanced analytic tools such as SafetyAnalyst, the Interactive Highway Safety Design Model (IHSDM), and the Highway Safety Manual in their roadway safety analytic processes. MIRE Version 1.0 identifies the following roadway segment elements related to speed data:

  - Speed Limit (critical data element);
  - Ramp Advisory Speed Limit (critical data element);
  - Truck Speed Limit (value added data element);
  - Nighttime Speed Limit (value added data element);
  - 85^{th} Percentile Speed (value added data element); and
  - Mean Speed (value added data element).

  Both mean and 85th percentile speeds on a segment are important predictors of safety. A 2010 report on MIRE[9] notes the importance of collecting speed data through speed zoning studies or automated data collection systems used for other purposes (e.g., vehicle classification systems, freeway surveillance systems, and weigh-in-motion systems) and consolidating the data into a single database that could be linked to the basic inventory files to support safety analyses.

- **Freight Movement:** Speed trend information (i.e., speed by type of vehicle) is used by FHWA and the FMCSA to develop and monitor programs to ensure safe and efficient travel for all vehicle types. FHWA's Office of Freight Management and Operations uses speed data collected through the Freight Performance Measures Initiative to produce:

  - Average speed, travel time and reliability of truck movement on large transportation networks such as the Interstate Highway System;
  - Quantification and ranking of highway bottlenecks, urban congestion and localized system deficiencies on the nation's freight transportation system;

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[9] Lefler, N., F. Council, D. Harkey, D. Carter, H. McGee, and M. Daul. Model Inventory of Roadway Elements – MIRE, Version 1.0. FHWA Report No. FHWA-SA-10-018, October 2010.

- Crossing time and delay statistics at freight significant U.S./Canadian border crossings; and
- Information describing demand for truck routes and highway facilities throughout the U.S.

They are also working to incorporate average speed data from the initiative to better project travel times for the Freight Analysis Framework (FAF), which integrates data from a variety of sources to provide a comprehensive picture of freight movement among States and major metropolitan areas by all modes of transportation.

- **Congestion and Performance Management:** Measuring congestion and transportation system performance is becoming a vital activity for Federal, state and local transportation agencies for a number of reasons, including maintaining accountability for transportation investments, monitoring congestion as part of a region's Congestion Management Process, and meeting MAP-21 requirements for performance based management of transportation programs. The FHWA Office of Operations has been monitoring traffic congestion and reliability trends at the national and city level through the Urban Congestion Report (UCR) Program in order to:

  - Provide timely congestion and travel reliability information to State and local agencies;
  - Demonstrate the use of archived traffic operations data for performance monitoring; and
  - Promote State and local performance monitoring to support transportation decision making.

  The Urban Congestion Report is compiled from 5-minute section level speeds and vehicle-miles of travel (VMT) for 23 urban areas in the U.S.

- **Work Zone Management:** In 2004, FHWA published the *Work Zone Safety and Mobility Rule* (23 CFR Part 630) to address the safety and mobility impacts of work zones, as well as methods and strategies to limit these impacts on the traveling public. Section 630.1008 of the Rule requires agencies to use work zone data at the project and program levels to enhance work zone safety and mobility. The *Work Zone Safety Data Collection and Analysis Guide*[10] notes the importance of collecting, analyzing, and responding to work zone speeding in real-time to prevent work zone crashes and associated injuries and fatalities.
- **Noise Abatement:** 23 CFR Part 772, *Procedures for Abatement of Highway Traffic Noise and Construction Noise*, requires States to conduct noise analyses to identify potential highway traffic noise impacts for certain types of Federally-aided highway projects. Speed, traffic volume, and vehicle composition data are often collected simultaneously with noise level measurement to provide information on the number and types of vehicles that are speeding.
- **Fuel Usage Estimates:** A problem of increasing importance is the concern that high-speed travel raises fuel consumption. On a monthly basis, each State is required to report to FHWA the amount of gallons of fuel taxed by that state. This data is analyzed and compiled by FHWA staff to examine usage by various vehicle types. The data on the amount of on-highway fuel use for each State is then used to attribute Federal revenue to each State.

[10] Chandler, B., N. Kehoe, C. O'Donnell, T. Luttrell, E. Perry. Work Zone Safety Data Collection and Analysis Guide, FHWA, Washington, D.C., January 2013.

3.3 Overview of Speed Data Programs

This section provides an overview of the following speed data programs within U.S. DOT:

- Transportation Technology Innovation and Demonstration (TTID) Program, FHWA Office of Operations
- National Performance Management Research Data Set, FHWA Office of Operations
- National Speed Data Collection and Reporting Program (National Traffic Database), FHWA Office of Highway Policy Information

This section builds on the information provided in the *Data Inventory Report* and includes the following information for each program:

- **Data Owner:** Identification of the FHWA Program Office responsible for the provision, capture, and management of data to support the data program.
- **Description:** A brief overview of the data program.
- **Purpose:** A description of the purpose of the data program, particularly as it relates to meeting specific legislative mandates.
- **Users:** Customers or primary users of the data program.
- **Data Source Hierarchy:** Indicates whether the data program is a source of raw data, a report, a system, or a repository. These concepts are defined in the *Data Inventory Report*.
- **Format:** The format of data included in the data program.
- **Metadata:** Descriptive information on the data content included in the data program.
- **Accuracy/Validity:** Describes the data quality procedures for measuring accuracy/validity of the data, along with results (if applicable).
- **Timeliness:** Identifies the collecting/reporting frequency of the data program.
- **Coverage:** The geographic coverage of the data program, including whether it is national, regional, or project specific in geographic scope/coverage.
- **Accessibility:** The relative ease with which data can be retrieved and manipulated by data consumers to meet their needs.
- **Longevity/Future Plans:** Describes future plans for the data program or improved functionality of the reporting system for the program that will be available in the future.
- **Contact:** Contact information for the data owner.

A summary of the data programs is provided in Table 3.2.

Table 3.2 Summary of Speed Data Programs

Data Program	Owner	Contents	Purpose	Coverage	Data Collection Methodology	Timeliness	Data Quality
Transportation Technology Innovation and Demonstration (TTID)/Traffic.com	FHWA Office of Operations, Bob Rupert and Jimmy Chu	Volume, speed, lane occupancy data	Provide expanded coverage of detector data and historical archived speed data	Freeways in 27 cities across the U.S. (only where there is sensor coverage)	Private vendor detectors on the roadside. Data is merged with existing local TMC detector data and archived	Detectors are polled every 60 seconds. Cleaned data stored in 5, 15, 60 min, and 24 hour bins.	Vendor responsible for data quality checks data quality and providing metadata
National Performance Management Research Data Set	FHWA Office of Operations, Rich Taylor	Travel time data (speed could be imputed from segment travel time data)	Support data analysis for Urban Congestion Reporting (UCR) and Freight Performance Measures (FPM) Programs Development and reporting of performance measures to support national goals for reliability and congestion reduction under MAP-21	220,000 centerline miles to include Interstates and the National Highway System (including NHS intermodal connectors)	Private vendor probe vehicle data	Data reported in 5 min intervals Data made available to FHWA monthly	Vendor to provide quarterly reports on data quality and validity as measured by average absolute speed error and speed error bias
National Speed Data Collection and Reporting Program (National Traffic Database)	FHWA Office of Highway Policy Information, Tianjia Tang	Speed (in addition to volume, vehicle classification, truck weight data)	Support States in collecting and reporting on speed data and meet MAP-21 requirements for performance monitoring. Support FHWA reporting requirements to Congress and the public under CFR 23 420.105(b)	2,500 State Traffic Monitoring Sites. HPMS sampling guidelines dictate minimum coverage (NHS, Interstates, freeways / expressways, principal arterials, minor arterials, major collectors, urban minor collectors)	Travel Monitoring Guide (TMG) describes requirements for data collection	5, 15, or 60 minute data reporting interval Data will be reported to FHWA monthly by 25 days after close of the month	Analysis of speed difference between consecutive vehicles and adjacent lane vehicles, the volume and speed relationship, and vehicle type and speed relationship

Transportation Technology Innovation and Demonstration (TTID) Program

Data Owner: FHWA Office of Operations.

Description: FHWA's Transportation Technology Innovation and Demonstration (TTID) Program funds travel time data collection by Navteq (formerly Traffic.com) in several metropolitan areas. The TTID Program is the primary source of loop detector data for many major interstate highways, particularly in smaller metropolitan areas that do not have an ITS infrastructure in place. Polled data is converted into travel information (e.g., congestion levels, speed, etc.), and the data is then shared with local traffic management centers. Sensor data within the metropolitan areas are made available to support FHWA research through the Intelligent Transportation Infrastructure Program (ITIP) Stakeholder Applications Data Warehouse.

Purpose: The purpose of this program is to address national, local, and commercial data needs through enhanced surveillance and data management in major metropolitan areas. This involves integration of data from existing surveillance infrastructure and strategic deployment of supplemental surveillance infrastructure to provide real-time and archived roadway system performance data. The sensors placed by the TTID program are located so that they fill gaps in the instrumented networks of the participating agencies. At the national level, the goal is to measure the operating performance of the roadway system. Locally, such roadway system performance data can be used to assist in planning, evaluation, and management activities. The data also has value for traveler information purposes (such as, for motorists and commercial vehicles).

Users: Customers of TTID data include local traffic management centers, FHWA Program Offices, and participating State agencies.

Data Source Hierarchy: The TTID program is a source of raw speed and travel time data, while the ITIP Data Warehouse is a repository for archiving and accessing the data.

Format: The real-time traffic data is fed back to the TMCs through the Traffic.com Stakeholder Application and via an XML data feed.

Metadata: Sensor Owner, State, Descriptive Station ID, Unique Station ID, Route, Direction, ITS Direction Code, Station Description, Station Milepost, Unique Site ID, Site Milepost (if available), Latitude, Longitude, Unique Sensor ID, Lane Type, Lane Number, Lane Position, Device Number, Sensor Type, ITS Sensor Type Code, Activation Date, Inactivation Date, Sensor Station Status, Sensor Status, and Device Status.

Accuracy/Validity: Navteq is responsible for data quality, as dictated through the contract language, and FHWA conducts quarterly audits to evaluate the sensor data quality in ten cities on a rotational basis. As there is no direct, cost-effective way to measure accuracy, an alternative method was adopted in which the average speed and volume reported for each station-direction for each five-minute period is compared to the historical average speed and volume for that station-direction for that time of day and day of week. The previous one year period is used for historical comparison. The assessment combines Tuesdays, Wednesdays, and Thursdays traffic volume into one group and combines Saturdays, Sundays and holidays into another group, while Mondays and Fridays are in groups by themselves. The TTID Program regularly achieves above 95 percent accuracy from its participating 27 State agencies. This is higher than that achieved by State agencies on their own (below 60 percent) because they often do not have funding for maintenance of equipment.

Timeliness: A 60-second data collection interval is used for Traffic.com sensors installed for the project. Data is stored in its raw format by minute, and in 5-minute lane-by-lane data, 15-minute, 1 hour and 24 hour data aggregated by direction in CSV format. The raw data is available for 90 days on the stakeholder site and then stored off-line. CSV reports are available for four years then stored off-line. Archived data is currently available from 2007 to the present. TTID data was not archived prior to 2007; as such, these historical data are not available.

Completeness: Rather than measuring completeness, the audit includes a data availability test to assess how many sets of data values are available during the course of each day in the month, from each station in each direction. At the finest level of detail, the data warehouse should contain values for every five minutes, making a total of 288 (24 hours x 12 five minute intervals per hour) sets of values each day. Traffic.com reports the total number of times data values are available in the data warehouse, and the figure is divided by 288 to give the percent availability for each day. The TTID Program regularly achieves above 95 percent availability for the 27 State agencies.

Coverage: Geographic scope/coverage is limited to the following 27 cities that are part of the programs under which Traffic.com provides traffic data services for FHWA. Two cities, Philadelphia and Pittsburgh were part of the ITIP Federal project, while the remaining 25 cities were part of the Federal TTID program. Traffic data is available only on freeways where there are sensors. There is no data for arterials.

TTID Program Participants

Atlanta	Los Angeles	Sacramento
Baltimore	New Orleans	Salt Lake City
Boston	Norfolk	San Diego
Chicago	Oklahoma City	San Francisco
Cincinnati	Philadelphia	San Jose
Columbus	Phoenix	Seattle
Detroit	Pittsburgh	St. Louis
Indianapolis	Providence	Tampa
Las Vegas	Raleigh-Durham	Washington, D.C.

Accessibility: Access to the data is provided through the ITIP Stakeholder Applications Data Warehouse,[11] which is available to FHWA and the participating State agencies (currently 27). Each FHWA Program and participating agency is provided with a User ID and password for the data warehouse. The only restriction on use is that users are not allowed to sell the data.

Longevity/Future Plans: The TTID program is a public-private partnership that is currently funded through an earmark program from SAFETEA-LU. The contract is scheduled to end in April 2014. FHWA plans to continue the partnership and overall program and Navteq has agreed to maintain the data warehouse beyond 2014 once the contract ends. The details of the new agreement are still to be determined. FHWA will continue to collect and report on the data, and agencies will be given the opportunity to continue their participation in the program.

[11] ITIP Stakeholder Applications Data Warehouse website, http://stakeholder.traffic.com

Contact: Bob Rupert, 202-366-2194, Robert.Rupert@dot.gov; Jimmy Chu, 202-366-337, Jimmy.Chu@dot.gov.

National Performance Management Research Data Set

Data Owner: FHWA Office of Operations.

Description: In December 2012, the FHWA Office of Operations put out an RFP for a private sector vendor to provide FHWA with perpetual access to an average travel time dataset derived from vehicle probes, disseminate this data to other government agencies, and provide ongoing technical support for the data set.

Purpose: The purpose of the program is to establish and maintain an average travel time dataset for use in measuring travel time reliability on major roadways. The program builds on the previous Urban Congestion Report (UCR) and Freight Performance Measures (FPM) Program research and will support data analyses for both programs. FHWA and its contractors will use this data set to research and develop transportation system performance measures and information related to mobility, including travel time and reliability. The data will also be shared with other government agencies for use in meeting MAP-21 performance management requirements and would be aggregated and analyzed for sharing with the public.

Users: Customers for the National Performance Management Research Data Set include FHWA offices, FHWA contractors, State DOTs, and MPOs. It is anticipated that aggregated data will be shared with the public. FHWA anticipates approximately 500 organizations outside of FHWA will receive the data.

Data Source Hierarchy: The National Performance Management Research Data Set is a source of aggregated travel time data.

Format: Average travel time from vehicle probe data will be provided for the following three classifications: 1) all vehicles; 2) passenger vehicles; and 3) freight trucks (defined as commercial motor vehicles over 26,000 pounds that are used for the movement of goods). Data will be delivered in a universal format such as DBF or CSV file format.

Metadata: FHWA will require the travel time data to include the following types of metadata: Time; Date; Direction; Travel Time; and Location (segment ID, route, State).

Accuracy/Validity: The vendor will be responsible for providing quarterly reports on data quality as measured by average absolute speed error and speed error bias. The absolute speed error is defined as the absolute value of the difference between the mean speed reported from the data service and the mean speed provided by validation procedures for a specified time period or polling interval. Error bias is defined as the average speed error (not the absolute value) in each speed range. FHWA will undertake periodic analyses of the data set for independent validation and quality control.

Timeliness: Prove data sets must be able to provide data at the frequency and accuracy required to calculate travel time measures for use in performance management. FHWA requires that this data to be provided in 5 minute increments. The data set shall be analyzed and processed, at a maximum, on a monthly basis. Data shall be provided and made available within 5 business days after the close of the month. Continuous or weekly data feeds throughout the month may be considered as an alternate to a monthly delivery.

Coverage: At a minimum, the travel time dataset will be provided at a statistically significant sample size for both freight and passenger traffic for the following geographic coverage (approximately 220,000 centerline miles of road):

- United States Interstate System;
- National Highway System (NHS), including NHS intermodal connectors;
- Any roadway facilities classified as principal arterials not included in the current NHS;
- Strategic Defense Network Roadways (STRHANET); and
- Border crossings on principal arterials.

Accessibility: The historical data will be stored with the Office of Highway Policy Information. The contract includes restrictions regarding the use of the data. The vendor will enter into data sharing agreements with FHWA, their contractors that work on performance measures activities, State DOTs, MPOs, and others as follows:

- For FHWA, full rights to the vehicle probe travel time data sets to use in support of internal organization operations, and sufficient rights to the vehicle probe data to disseminate aggregated information to the public consistent with FHWA's transportation planning, programming, management and operations responsibilities. Some analysis activities will be undertaken by other FHWA contractors, and data access shall be granted to FHWA to undertake the specified work with the data provided under this contract. The data sharing agreement for this data will be between FHWA and the contractor allowing FHWA to share the data with their contractors.
- For any State DOT or MPO receiving Federal transportation funds, full rights to the vehicle probe travel time data sets, to use in support of meeting any Federal requirements related to performance indicators, measures, and transportation program management; and sufficient rights to the travel time vehicle probe data sets to disseminate aggregated information to the public consistent with the organizations' transportation planning, programming, management and operations responsibilities as they pertain to Federal performance management requirements.

FHWA and State/MPO contractors will also be allowed to use the data, although they must sign a non-disclosure agreement with the vendor. FHWA will not own the detailed data, but they will own any products created using the data (e.g., monthly summary reports). The final contract terms are still in negotiation as of April 2013.

Longevity/Future Plans: FHWA is in final negotiations with the selected provider and anticipates the data will become available in early summer 2013. The contract is being negotiated as a one year contract with four one year options for renewal. FHWA anticipates collecting the travel time data for the foreseeable future, contingent on the re-authorization of MAP-21.

Contact: Rich Taylor, 202-366-1327, rich.taylor@fhwa.dot.gov

National Speed Data Collection and Reporting Program (National Traffic Database)

Data Owner: FHWA Office of Highway Policy Information.

Description: Increased emphasis on performance-driven funding and growing public demand for accountability associated with transportation investments has heightened the Government's oversight in these areas; FHWA is considering establishing a national speed data collection and reporting program. Most traffic monitoring technologies used today are capable of measuring speed as part of their routine function, and a recent FHWA survey found that nearly all States (45

States) are currently collecting speed data through their State traffic monitoring stations.[12] The proposed program will standardize speed data collection procedures and provide monthly speed trends at the national level to evaluate travel trend and travel conditions. FHWA is in the process of updating the Traffic Monitoring Guide (TMG) and modifying the Travel Monitoring and Analysis System (TMAS) to allow States to start collecting and reporting on speed data as part of their statewide traffic monitoring program. States would be recommended to, but not required to, report speed data through TMAS.

TMAS provides online data submitting capabilities to State Traffic Offices so that travel monitoring data can be submitted to FHWA. These data currently include HPMS data, monthly volume data for the Traffic Volume Trends Report, vehicle classification, and truck weight data. TMAS currently hosts more data records than any other data program within FHWA. It is not a true FHWA data program, but it is authorized by the Transportation Research Board (TRB) and managed by Turner-Fairbank Highway Research Center (TFHRC).

Purpose: The purpose of the National Speed Data Collection and Reporting Program is to support States in collecting and reporting on speed data, which is critical for analyses in supporting State highway safety programs and in meeting new requirements for performance monitoring based on MAP-21 legislation. FHWA uses traffic data from the States to meet its reporting requirements under CFR 23 420.105(b), which requires States to provide data that supports FHWA's reporting responsibilities to Congress and the public. Traffic data reported under this Federal regulation are submitted as part of the annual Highway Performance Monitoring System (HPMS) report from each State.

Users: Users of TMAS include all State agencies and FHWA field offices.

Data Source Hierarchy: The state traffic monitoring sites are a source of raw speed data, while TMAS is a system for submitting and accessing the data.

Format: Data format requirements are established based on Federal guidelines in the TMG. The speed data file format is used to report the number of vehicles traveling in specified 5 mph speed bins during specified time periods. Each record can contain 5, 15, or 60 minutes of data. The submitting State chooses the time interval for which data is being reported and indicates that time interval as a field in the record. To submit data to FHWA, the speed data format must have a minimum of 15 bins up to a maximum of 25 bins and should supply data in 5-mph speed bins as required by FHWA. Any speed data records that do not meet these requirements are purged by the TMAS software.

States also have the option to submit speed data as individual vehicle records rather than using the more traditional formats described in the TMG. The Per Vehicle Format allows for more detailed analysis of traffic flow and vehicle characteristics (e.g., vehicle gap analysis, speed by class, and changes in axle spacing distributions) that are not possible with aggregated records.

Metadata: Vehicle speed records include the following: Record Type, FIPS State Code, Station ID, Direction of Travel Code, Lane of Travel, Year of Data, Month of Data, Day of Data, Hour of Data, Speed Data Time Interval, Definition of First Speed Bin, Total Number of Speed Bins Reported, Total Interval Volume, Bin 1 Count, Bin (n) Count (minimum of 15 and maximum of 25 bins).

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[12] More information on the survey results and FHWA Speed Monitoring Data Collection Summit is provided in Appendix C.

Accuracy/Validity: The TMG requires each State to have formal, documented rules and procedures for data quality to ensure data truly represents travel on the given location/time period. Key data quality requirements include analyses of the speed difference between consecutive vehicles and adjacent lane vehicles, the volume and speed relationship, and vehicle type and speed relationship.

Timeliness: States choose the time interval for which data is being reported and indicates that time interval as a field in the record. Each record can contain 1 hour of data, 15 minutes of data, or 5 minutes of data. States will be required to submit speed data monthly, by 25 days after the close of the month for which the data was collected.

Coverage: There are approximately 2,500 State traffic monitoring stations. Placement of stations is primarily determined by the DOT in accordance with Highway Performance Monitoring System (HPMS) sampling guidelines. Coverage includes Federal-aid roads (National Highway System, Interstates, freeways/ expressways, principal arterials, minor arterials, major collectors, urban minor collectors). Speed data by vehicle class would not be readily available except for States that submit their data using the Per Vehicle Format. However, States are being strongly encouraged to participate in the program, which could allow speed trends to be covered at the National level.

Accessibility: Speed data will be accessible via TMAS through the FHWA's User Profile and Access Control System (UPACS) website.[13] Access is limited to State DOT, FHWA Division office personnel, and others with a legitimate reason for accessing the system. User authorization must be obtained through the UPACS Administrator within the FHWA Division office in the individual State. Contact information for all the Division offices is available on the FHWA website.[14] A new initiative would grant TMAS access to non-State highway agencies. TMAS 2.0 currently allows States to access other States' data.

Longevity/Future Plans: FHWA recently started developing the functional requirements for TMAS 2.5, which would allow States to start reporting speed data. A future TMAS version (v3.0) will provide the following additional functionality related to speed data: Per Vehicle Format to allow reporting of speed by vehicle class, quality control, reporting, exporting, GIS based tools and views, and data aggregation/merging.[15] This version will be available in two to three years.

Contact: Tianjia Tang, 202-366-2236, tianjia.tang@dot.gov; Steven Jessberger, 202-366-5052, steven.jessberger@dot.gov

3.4 Opportunities for Coordination

Gaps and Overlaps

The speed data programs have similar but not necessarily duplicating efforts. For example, although there are overlaps in the data elements and frequency of data collection among the speed data programs, the geographic coverages significantly differ. Also, it is important to note that each program was initiated in response to specific mandates and/or business needs regarding reporting of speed data. For examples:

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[13] FHWA Information Systems – UPACS Login website, https://fhwaapps.fhwa.dot.gov

[14] FHWA Field Offices website, http://www.fhwa.dot.gov/field.html#fieldsites

[15] S. Jessberger. Speed Data Collection and Format. Presented at 2012 Highway Information Seminar (HIS) Breakout Session 2: What's New with Traffic Monitoring, Arlington, Virginia, October 2012.

- **Transportation Technology Innovation and Demonstration (TTID) Program:** The FHWA Office of Operations' TTID program is being funded through an earmark program from SAFETEA-LU. The TTID Program provides supplemental detector data that is integrated with existing surveillance infrastructure in metropolitan areas. The data is then shared with local traffic management centers to assist in real-time operations and management activities. At the national level, the data supports monitoring of operational performance of the roadway system in the participating 27 cities across the nation.
- **National Performance Management Research Data Set:** The FHWA Office of Operations is acquiring travel time data on the NHS for performance monitoring purposes. The data would be used to support FHWA's internal performance measure needs. The travel time data will be used to support development of an internal DOT performance dashboard, strategic implementation plans, and operating budgets. The data will also support analytic needs and research for the current Urban Congestion Reporting (UCR) and Freight Performance Measures (FPM) Programs. Externally, the data will be used by State and local government agencies in meeting MAP-21 performance management requirements.
- **National Speed Data Collection and Reporting Program (National Traffic Database).** The Office of Highway Policy Information is developing the National Traffic Database from HPMS traffic monitoring site data to fulfill their own reporting requirements under 23 CFR 420.105(b). HPMS data are used extensively in the analyses of highway system condition, performance, and investment needs that make up the biennial Condition and Performance Reports to Congress. These Reports are used by the Congress in establishing both authorization and appropriation legislations, activities that ultimately determine the scope and size of the Federal-aid Highway Program, and determine the level of Federal highway taxation. The data are also used for assessing changes in highway system performance brought about by implementing funded highway system improvement programs under the GPRA, and for apportioning Federal-aid Highway Funds to individual States under TEA-21. At the State level, speed data is critical for supporting State highway safety programs and meeting new requirements for performance monitoring based on MAP-21 legislation.

NHTSA has an interest in collecting nationally representative estimates of travel speeds on public roads. They conducted a National Travel Speed Study (NTSS) in 2007 and 2009 to measure travel speeds and prepare nationally-representative speed estimates for all types of motor vehicles on freeways, arterial highways, and collector roads across the U.S. Speed data from the National Performance Management Research Dataset and the National Speed Data Collection and Reporting Program (National Traffic Database) could potentially fulfill NHTSA's needs for this data in the future since it would provide excellent 24/7 speed data across the nation.

Technology and Data Quality Considerations for Data Sharing

A strong need exists for sharing and merging both operations and planning data streams to support the core business needs for Federal speed data as documented in Section 3.2. Data sharing of existing and soon to be available speed data sources is an important consideration that offers the following benefits:

- Sharing of data from existing sources would leverage FHWA's current investment in data collection activities.

- Private sector vendors have data available for all segments of roadways, but sample sizes may be limited. Data merged from a variety of sources would leverage the high data validation and quality requirements that are already in place through existing data programs at FHWA.

A key factor in determining how well speed data can be merged is the locational referencing method (LRM) used to describe where each data item is located. The Office of Highway Policy Information is currently addressing this challenge through its Data Integration Initiative, which is developing a Data Integration Platform to facilitate the collection, comparison, and aggregation of data from core data systems within FHWA, including the Highway Performance Monitoring System (HPMS), National Bridge Inventory (NBI), Fiscal Management Information System (FMIS), and Recovery Act Data System (RADS). The purpose of the data integration effort is to provide a comprehensive source of information on the condition and performance of the nation's infrastructure for performance management purposes.

The LRS approach for the Data Integration Platform leverages the HPMS data model, which allows roadway geometry data to be used to locate assets within a geographic information system (GIS) framework. The system will be accessible to internal FHWA users through UPACS and will include tools such as analytics, mapping, spatial analyses, and event reporting. OHPI is in the process of securing approval and funding for Phase 2 of the project, which would incorporate additional systems including TMAS, Fatality Analysis Reporting System (FARS), Weigh in Motion (WIM), Freight Analysis Framework, and Fuels and Finance Analysis System on Highways (FASH). Phase 2 will also include the development of additional analytic and reporting tools, as well as expansion of the user base to include State DOT, MPO, and local agency users.

The following are technical, institutional, and data quality considerations for data sharing for each of the speed data programs:

Transportation Technology Innovation and Demonstration (TTID) Program: There may be technical problems sharing TTID data with other speed databases because it is not accessible through the FHWA server. Also, there could be institutional issues with sharing TTID data with other State and local agencies because it is privately owned data. There are no restrictions on sharing data with other Federal agencies or the traveling public. The information is already being shared, and the revenue is shared with the participating agencies.

National Performance Management Research Data Set: The National Performance Management Research Data Set is acquiring travel time data only, although speed data could potentially be imputed from the segment travel time data. One institutional consideration is that the vendor contract is still in negotiation but will include restrictions on how the data can be used. For example, FHWA will not own the data but will own the data products produced using the data. The data is intended for use by government agencies in managing the performance of the transportation system, and in particular, the Federal aid highway system. Under a performance management approach, agencies will have access to the data for use in transportation planning, programming, management, and operations responsibilities. States and MPOs will not be able to use the data for any other purposes.

One consideration for data sharing is whether there would be contract limitations on FHWA developing a dataset of average hourly (or 15-minute) speeds and potentially merging that data with National Traffic Database data. The National Performance Management Research Data Set could potentially be used to supplement data collection occurring under the TTID Program once that earmark program ends, if such use is allowable under the contract terms with the negotiated vendor.

Geocoding for the National Performance Management Research Data Set will be based on Traffic Message Channel (TMC) location codes, which is a commonly used convention used by electronic map database vendors to uniquely define roadway segments. One consideration for data sharing and merging is that State and local agencies would have to do segment mapping to correlate the TMC location codes to their transportation network. Many agencies have reported as struggling in this area.

National Speed Data Collection and Reporting Program (National Traffic Database). Geocoding for the National Speed Data Collection and Reporting Program (National Traffic Database) is based on the latitude/longitude of the traffic monitoring site. Forty seven States and the District of Columbia have provided this information for their sites in TMAS 2.0. TMAS 2.5 will provide an additional 60 characters to enable linking HPMS data with the State's linear referencing system. This will enable full linking of TMAS data with the roadway inventory data within each State's HPMS submittal.

Regarding accuracy of speed data collected under the National Speed Data Collection and Reporting Program (National Traffic Database), there is a magnitude of accuracy differences in various types of speed data monitoring technology. Axle-based sensors tend to be the most accurate. Passive acoustic array sensors measure about ½ mph different than axle-based sensors. Microwave/loop technology is not as accurate and has a 2 to 3 mph difference in accuracy. This is the reason why FHWA decided to use 5 mph bins for speed data reporting.

Speed data reported for the National Speed Data Collection and Reporting Program (National Traffic Database) will generally be aggregated at higher levels (5, 15, or 60 minute intervals), as determined by the discretion of each State, and availability will vary based on each State's willingness to participate in the program. These temporal and availability differences may not support envisioned achievements of other stakeholders. However, data integration should not be an issue given that it is spot speed data.

The new Per Vehicle Format will provide additional benefits to using speed data that will be reported in TMAS 3.0, including use of the Per Vehicle Format to allow reporting of speed by vehicle class, quality control, reporting, exporting, GIS based tools and views, and data aggregation/merging capabilities. OHPI distributed information on the Per Vehicle Format to all offices who might use it back in 2012, and they are willing to work with other offices to make sure the speed data meets their needs by providing support with raw data, graphical user interfaces (GUIs), export features, reports, and QC of the speed data.

Table 3.3 summarizes data quality considerations in meeting identified data end-user business needs.

Table 3.3 Data Quality Considerations

Data Quality Component	Transportation Technology Innovation and Demonstration (TTID) Program	National Performance Management Research Data Set	National Speed Data Collection and Reporting Program (National Traffic Database)
Type of Data	Speed, Volume, Lane Occupancy	Travel Time	Speed, Volume, Vehicle Classification, Truck Weight
Accuracy/ Validity/ Completeness	Vendor responsible for data quality; FHWA conducts quarterly reports on data quality - 95 percent accuracy and availability maintained	Vendor responsible for providing quarterly reports on data quality as measured by average absolute speed error and speed error bias	Analysis of speed difference between consecutive vehicles and adjacent lane vehicles, the volume and speed relationship, and vehicle type and speed relationship

Data Quality Component	Transportation Technology Innovation and Demonstration (TTID) Program	National Performance Management Research Data Set	National Speed Data Collection and Reporting Program (National Traffic Database)
Timeliness	60-second data collection interval Data stored in 1 min (raw); 5 min (lane-by-lane); 15 min, 60 min, and 24 hour intervals (aggregated by direction)	5-minute data collection interval Data will be made available to FHWA monthly	5, 15, or 60 minute data reporting interval Data will be reported to FHWA monthly, by 25 days after the close of the month for which data was collected
Coverage	Freeways in 27 cities (only where there is sensor coverage)	220,000 centerline miles of roadway to include Interstates and the National Highway System, including NHS intermodal connectors	2,500 State Traffic Monitoring Sites. HPMS sampling guidelines dictate minimum coverage on Federal-aid roads (National Highway System, Interstates, freeways/ expressways, principal arterials, minor arterials, major collectors, urban minor collectors)
Accessibility	ITIP Stakeholder Applications Data Warehouse. There are no restrictions on sharing data with other Federal agencies or the public. The information is already being shared, and the revenue is shared with the participating agencies.	Data will be stored on OHPI servers and made available to anyone within FHWA, including those working on connected vehicle research, as well as State DOTs and MPOs for use in meeting MAP-21 requirements	TMAS, accessible through FHWA's User Profile and Access Control System (UPACS) website. Access is limited to State DOTs, FHWA Division office personnel, and others with a legitimate reason for accessing the system

Using the Data Business Plan for Coordination

Speed data program stakeholders expressed a willingness to coordinate data activities with other offices, particularly as it relates to sharing best practices and addressing issues related to gaps, duplicity, etc. The FHWA Office of Operations would benefit from coordinating with other stakeholders on potential uses for the National Performance Management Research Data Set that would fall within the realm of contract limitations regarding use of the data. The stakeholders would be willing to participate in a Speed Data Working Group, provided it does not overstep its bounds.

The Speed Data Working Group would benefit from coordination with the Office of Highway Policy Information's Data Integration Initiative to share best practices and lessons learned regarding technical issues associated with merging various data systems.

The US Roadway Transportation Data Business Plan recommended a list of activities or rules of engagement that the Speed Data Working Group should pursue to enhance coordination:

1. Share RFP's for current and upcoming initiatives.
2. Share current initiatives, activities, and best practices related to speed data.
3. Share current activities and best practices related to data strategies, policies, standards, metadata, architecture, procedures and metrics.

4. Identify opportunities to coordinate resources to reduce data redundancy and implement cost-sharing strategies for the collection, management, and maintenance of roadway travel mobility data. Redundancy could be addressed through data standardization and an annual review of data programs to identify where duplicate data collection and storage can/should be eliminated in and replaced with a single source of data for specific data programs. This will help to ensure that data is collected once and used many times.
5. Identify opportunities to reduce redundancy in the development and maintenance of data systems, promote efficiency in system maintenance, and promote open source initiatives.
6. Identify needs and opportunities to integrate national speed data sets to support performance measurement and asset management purposes.
7. Identify needs and opportunities to create links between existing speed data sets and connected vehicle data sets in the future.
8. Explore methods to enhance access to information on speed data programs. This includes developing webportals easily accessible by internal and external stakeholders for each of these programs to obtain data and information as needed. This will facilitate sharing of data with internal/external stakeholders, thereby reducing costs associated with data collection.
9. Understand and promote the value of speed data as a U.S. DOT-wide asset.

3.5 Conclusions and Recommendations

The pilot study applied the data business planning principles to address the following specific problem statement/questions:

1. **What are the requirements for speed data collection and reporting at FHWA?** There is currently no specific statute (CFR or USC) that gives FHWA authority to collect speed data. However, CFR 23 420.105(b) gives the agency broad authority to collect any data needed to administer the Federal-Aid Highway program, support internal analyses and business needs, and fulfill FHWA's reporting responsibilities to the Administration, United States Congress, and the traveling public. Business needs for Federal speed data relate to safety, operations, and policy development, as described in Section 3.2.
2. **Is there possible duplication of effort occurring?** Although there is possible duplication in the data elements/timeliness/coverage of speed data programs, it is important to note that each program was initiated in response to specific mandates and/or business needs regarding reporting of speed data, as documented in Section 3.4.

The pilot study indicated that there are several specific areas for coordination among the FHWA offices and opportunities for data sharing and merging. Recommendations from the pilot study include:

1. Activate the US DOT Mobility Coordination Group and the Speed Data Working Group and conduct regular meetings.
2. Task each group to work on the items in the rules of engagement listed on the previous page and in the Data Business Plan.
3. Conduct a feasibility analysis to merge data from the TTID program and the National Performance Management Research Data Set. Considerations should include contract restrictions, speed and travel time conversions, data format, data storage and accessibility and data quality compatibility.
4. Conduct a feasibility study to assess the possibility of enabling states and local operating agencies to submit real time operations data to FHWA. The study should consider if a new data portal is needed or if TMAS is feasible for that function.

APPENDIX A. Research Data Exchange (RDE) Datasets

Table A.1 describes each of the nine data environments available through the Research Data Exchange (RDE). The data available on the RDE is free for use by researchers, etc. Conditions of use include documenting the source of the data and citing the RDE website as part of the source.

Table A.2 lists the corresponding data sets and data environment meta files that pertain to the data environment, including identification of the data file format. The last column in Table A.2 identifies the data elements captured (or to be captured by the dataset) that are potentially applicable for use with national datasets. It does not include the entire list of data elements in the dataset, only those that are most applicable to national datasets. The majority of the data available as noted in Table A.2 pertains to speed, travel time, and location of vehicles in terms of latitude/longitude/elevation. Some occupancy data may also be available. Certain datasets also provide weather related information at the weather station site as indicated in Table A.2. Since the datasets are collected for a trial period only, their potential for integration with current national datasets is limited to perhaps using the data on a pilot basis to further investigate the technology tools and processes needed for such integration. This is an endeavor that is worth exploring as part of the continued development of the Data Business Plan for the U.S. DOT Office of Operations.

Table A.1 RDE Data Environments (Source: http://rde.indrasoft.net)

Data Environment	Description
FDOT Orlando ITS World Congress	The Florida Department of Transportation (FDOT) data environment contains data recorded by Vehicle Awareness Devices (VADs) on Lynx transit buses in Orlando FL. The VADs started operation in September 2011 and continued operation during the ITS World Congress in October 2011. The contents of the recorded data include the required components of the J2735 Basic Safety Message (BSM).
Leesburg VA Vehicle Awareness Device	The files in this data environment were produced by the Vehicle Awareness Device (VAD) installed on one test vehicle over a two month period. Activities included numerous repetitive trips in and around Leesburg VA and one long road trip from Ann Arbor, MI to Leesburg, VA by way of eastern Indiana. The VAD installed in the test car is identical to the VADs installed in over 2800 vehicles participating in the Safety Pilot Model Demonstration in Ann Arbor, MI.
NCAR 2009	See the Vehicle Infrastructure Initiative Proof of Concept data environment for a description of the Michigan Test Bed and the data collected there in 2008. In April 2009 a second set of trials was conducted at the Michigan Test Bed, directed by the National Center for Atmospheric Research (NCAR). These trials used a smaller set of vehicles, and concentrated on collecting data during periods of rainy or snowy weather. RSE data for the NCAR 2009 tests were available for nine days in April 2009. The data in this data environment consists of RSE and OBE data for the six days with the most good data.
NCAR 2010	See the Vehicle Infrastructure Initiative Proof of Concept data environment for a description of the Michigan Test Bed and the data collected there in 2008. In late January through early April 2010 a third set of trials was conducted at the Michigan Test Bed, again directed by the National Center for Atmospheric Research (NCAR). These trials used a small set of vehicles, similar to the trials in 2009, and concentrated on comparing atmospheric data from vehicle-mounted sensors to data from a nearby fixed weather observing station. The 2010 data selected for inclusion in this data environment consists of RSE and OBE data for the six days with the most good data.

Data Environment	Description
Pasadena	The Pasadena data environment covers the diverse roadway network in and around the City of Pasadena, California. The data was collected in 2011 during the months of September and October. The data environment includes a variety of data sets including network data (highway network file), demand data (trip tables), network performance data (link volumes, turn volumes, speeds and capacity), work zone data, weather data, Closed Circuit Television (CCTV) camera data, and Changeable Message Sign (CMS) data. Data from simulations are included where there are no sensors, and to provide forecasts.
Portland	The Portland data environment provides the following data: a) Freeway data consisting of two months of data from dual-loop detectors deployed in the main line and on-ramps of a Portland-area freeway (I-205); (b) Incident data from the Oregon Department of Transportation Advanced Traffic Management System database and planned event data from the ODOT Trip-Check Traveler Information Portal information web site; c) Weather data from two sources: NOAA data and Remote Weather Information System (RWIS) station data; d) Three types of arterial data: 1) Volume and occupancy data from four single loop detectors on 82nd Ave., 2) Signal phase and timing data for 32 signals along the 82nd Avenue corridor, 3) Travel times on 82nd Ave., computed from data collected by two Bluetooth readers; and e) Transit data provided from TriMet, the Portland-metro area transit agency, including schedule, stop event and passenger counts data for both bus and light rail. The data collection period for all datasets is September 15, 2011 through November 15, 2011.
San Diego	The San Diego data environment contains: a) One year of raw and cleaned data for over 3,000 traffic detectors deployed along 1,250 lane miles of I-5 in San Diego, including 30-second raw reports and 5-minute, hourly, and daily aggregations; b) Cleaned and geographically referenced data for over 1,500 incidents and lane closures for the two sections of I-5 that experienced the greatest number of incidents during 2010; c) Complete trip (origin-to-destination) GPS "breadcrumbs" containing latitude/longitude, vehicle heading and speed data, and time for individual in-vehicles devices updated at 3-second intervals for 10,000 trips taken during 2010; and d) Weather data from seven weather stations in the San Diego area.
Seattle	This set of data files contains the following data for the six months from May 1 2011 to October 31 2011: Raw and cleaned data for traffic detectors deployed by Washington Department of Transportation (WSDOT) along I-5 in Seattle. Data includes 20-second raw reports and 5-minute aggregations. Incident response records from the WSDOT's Washington Incident Tracking System (WITS). Estimated highway corridor travel times every 5 minutes. A record of all messages and travel times posted on WSDOT's Active Traffic Management signs and conventional variable message signs on I-5. Loop detector volume and occupancy data from arterials parallel to I-5, estimated travel times on arterials derived from Automatic License Plate Reader (ALPR) data, and arterial signal timing plans. Scheduled and actual bus arrival times from King County Metro buses and Sound Transit buses. Incidents on I-5 during the six month period. Seattle weather data for the six month period. A dataset of GPS breadcrumb data from commercial trucks described in the documentation is not available to the public because of data ownership and privacy issues.

Data Environment	Description
Vehicle Infrastructure Initiative Proof of Concept	The first major set of trials conducted at the Michigan Test Bed was the Proof of Concept (POC) trials during 2008. The POC trials featured fifty-two RSEs within 45 square miles, 27 vehicles configured with OBEs, and a Dedicated Short-Range Communications (DSRC) network. The testing program had three major phases: subsystem test, system integration and test, and public and private applications test. The public application testing portion of the POC trials were conducted during August 2008. RSE data for the public application tests were available for eight days in August 2008. The data in this data environment consists of RSE and OBE data for the middle six of these days. These six days were chosen for inclusion in the data environment because the first and last days had much higher number of duplicate records and questionable data values.

Table A.2 RDE Datasets and Metadata Files – FDOT Orlando ITS World Congress (Source: http://rde.indrasoft.net)

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
FDOT Orlando ITS World Congress	VAD data in csv format	2011-09-01/ 2011-10-22	These data files come from VADs installed in Lynx buses operating in Orlando during September and October 2011. The files have been converted from pcap format to csv format. Purpose: Test the capability of VAD to capture and store data in the form of the J2735 Basic Safety Message, as a prototype for larger scale tests such as Basic Safety Model Deployment and beyond.	Speed Latitude/Longitude/Elevation of vehicle
FDOT Orlando ITS World Congress	VAD data in pcap format	2011-09-01/ 2011-10-22	These data files come directly from VADs installed in Lynx buses operating in Orlando during September and October 2011.	Same as above

Meta Files (file type):
FDOT Orlando ITS World Congress Metadata documentation (doc)

Table A.3 RDE Datasets and Metadata Files – Leesburg Virginia Vehicle Awareness Device (Source: http://rde.indrasoft.net)

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
Leesburg VA Vehicle Awareness Device	Leesburg VAD data in pcap (packet capture) format	2012-10-18/ 2012-12-19	These data files come from a VAD installed in one test vehicle driven in the Leesburg VA area during the period from October 18 through December 19 2012. The file names denote the year, date, and start time of the data collection. The data files are in pcap (packet capture, compressed binary) format. Gives researchers an early sample of the large dataset being collected for the **Safety Pilot Model Deployment.** Researchers are encouraged to develop their own tools to extract data from the binary pcap files and format the data in a useful form. A network analysis tool such as WireShark® is required to convert the file from binary format into a usable format.	Longitude along axis of travel; Latitude and Elevation; Time (Hour, Minute, Second) Turning direction of vehicle Year, Month, Day of data capture Trailer weight data element within the vehicle Data dataframe Vehicle type data element within the vehicle Data dataframe. As defined in J2735, the constant value 4 indicates a passenger car
Leesburg VA Vehicle Awareness Device	Sample formats for VAD data	2012-10-22/ 2012-10-22	These data files come from a VAD installed in one test vehicle driven in the Leesburg VA area during one trip on October 22, 2012. The original pcap format is included, as well as seven different ways the data could be presented.	Same as above
Leesburg VA Vehicle Awareness Device	VAD data in csv format	2012-10-18/ 2012-12-19	These data files come from a VAD installed in one test vehicle driven in the Leesburg VA area during the period from October 18 through December 19 2012. The file names denote the year, date, and start time of the data collection. The data have been converted from pcap (compressed binary) format to a csv (comma separated value) format.	Same as above

Meta Files (file type):
Leesburg VAD Metadata documentation (doc)

Vehicle Awareness Device specification (pdf)

Table A.4 RDE Datasets and Metadata Files – NCAR 2009 (Source: http://rde.indrasoft.net)

Data Environment	Data Sets	Start/End Date	Description (including Purpose where noted)	Data Elements Captured – (which may be applicable to national datasets)
NCAR 2009	OBE Event Data	2009-04-06/ 2009-04-23	These files contain event data extracted from OBE log files for each day of the NCAR 2009 trials. The events include generating a snapshot, connecting to an RSE, attempting to send a message, successfully completing message transmission, and failing to transmit a message. The files are in CSV format. **Purpose:** The purpose of the data set is to provide multi-modal data and contextual information (weather and incidents) that can be used to research and deploy applications for the USDOT DMA program.	Event data extracted from OBE log files for each day of the NCAR 2009 trials- Events include: generating a snapshot, connecting to an RSE, attempting to send a message, successfully sending message, failing to send a message, when the OBE terminated connection to the RSE
NCAR 2009	OBE Snapshots Files	2009-04-06/ 2009-04-23	These files contain data extracted from OBE log files for each day of the NCAR 2009 trials. Each record in the file is a snapshot that appeared in the OBE log file. The data fields in the snapshot are present in comma-separated value format. The INFO 028 message in the OBE log file is always followed by a snapshot. The record indicates whether the snapshot is "start/stop" or "periodic." The snapshot file contains the contents of each snapshot appearing in the OBE log files. The first 4 fields in each record identify the OBE log file and the line number in the file at which the snapshot occurred. The remaining fields contain all the data from the snapshot.	TBD
NCAR 2009	OBE Trajectory Files	2009-04-06/ 2009-04-23	These files contain data extracted from OBE log files for each day of the NCAR 2009 trials. The files contain latitude/longitude data and x-y data in feet for each second of each vehicle's trajectory, as well as the vehicle speed in meters per second and a timestamp. The files are in CSV format.	Vehicle ID (which will indicate vehicle type) Speed of vehicle Latitude and Longitude of vehicle

Data Environment	Data Sets	Start/End Date	Description (including Purpose where noted)	Data Elements Captured – (which may be applicable to national datasets)
NCAR 2009	RSE Parsed Data	2009-04-06/ 2009-04-23	The data in these files have been parsed from raw XML format to CSV format. File contains all messages received by all RSEs. Each message header and each snapshot appears on one line, and individual values are separated by commas. There is one file for each date.	TBD
NCAR 2009	RSE Parsed Process Data	2009-04-06/ 2009-04-23	These files contain parsed data received by the RSE during the trials. The processing of the parsed data consisted of (a) deleting duplicate messages and snapshots and (b) adding flags to indicate erroneous or suspicious data values. Flags may appear for the following types of values: speed, lapsed time between snapshot recording and transmission, location of OBE when the message was transmitted, and air temperature.	Speed Location Air temperature
NCAR 2009	RSE XML Files	2009-04-06/ 2009-04-23	Each zip file contains all the RSE data collected in one day for the NCAR 2009 trials. When the file is unzipped, there is a directory for each RSE. Inside each RSE directory is one file for each message received by that RSE on that day. The files are in XML format, following the J2735 standard.	TBD
NCAR 2009	Testbed Description	2009-04-06/ 2009-04-23	The Nodes and Links file lists all the nodes (intersections) and links in the Michigan test bed, and the Nodes and Links Map depicts them in a KML file to use with Google Earth. The RSE location files depict the location of the RSEs in three formats. The Vehicle ID file lists the vehicles used in each of the three sets of trials.	Location (Nodes and Links) Vehicle ID Vehicle type (i.e., Nissan Altima, etc.)

Data Environment	Data Sets	Start/End Date	Description (including Purpose where noted)	Data Elements Captured – (which may be applicable to national datasets)
NCAR 2009	Weather Data	2009-04-06/ 2009-04-23	These files contain weather data collected from two weather stations in the testbed area during the period of the trials. (Weather Data for the NCAR 2009 Trial Period)	Data fields collected Station Date Time Dewpoint temperature Relative Humidity Atmospheric pressure Atmospheric temperature Wind direction Wind speed Precipitation rate

Meta Files (file type):
NCAR 2009 Metadata Documentation (doc)
NCAR OBE event file documentation (xls)
NCAR OBE file documentation (doc)
NCAR OBE Vehicle 2009 IDs (xls)
NCAR RSE documentation (doc)
NCAR RSE file documentation (xls)
NCAR weather file documentation (doc)

Table A.5 RDE Datasets and Metadata Files – NCAR 2010 (Source: http://rde.indrasoft.net)

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
NCAR 2010	OBE Event	2010-01-28/ 2010-03-29	These files contain event data extracted from OBE log files for each day of the NCAR 2010 trials. The events include generating a snapshot, connecting to an RSE, attempting to send a message, successfully completing message transmission, and failing to transmit a message. The files are in CSV format. The purpose of this data set is to provide multi-modal data and contextual information (weather and incidents) that can be used to research and develop applications for the USDOT Dynamic Mobility Applications (DMA) program.	Event data extracted from OBE log files for each day of the NCAR 2010 trials- Events include: generating a snapshot, connecting to an RSE, attempting to send a message, successfully sending message, failing to send a message, when the OBE terminated connection to the RSE
NCAR 2010	OBE Snapshots Files	2010-01-28/ 2010-03-29	These files contain data extracted from OBE log files for each day of the NCAR 2010 trials. Each record in the file is a snapshot that appeared in the OBE log file. The data fields in the snapshot are present in comma-separated value format. The INFO 028 message in the OBE log file is always followed by a snapshot. The record indicates whether the snapshot is "start/stop" or "periodic". The snapshot file contains the contents of each snapshot appearing in the OBE log files. The first 4 fields in each record identify the OBE log file and the line number in the file at which the snapshot occurred. The **remaining fields contain all the data from the snapshot.**	TBD
NCAR 2010	OBE Trajectory Files	2010-01-28/ 2010-03-29	These files contain data extracted from OBE log files for each day of the NCAR 2010 trials. The files contain latitude/longitude data and x-y data in feet for each second of each vehicle's trajectory. As well as the vehicle speed in meters per second and a timestamp. The files are in CSV format.	Vehicle ID (which will indicate vehicle type) Speed of vehicle Latitude and Longitude of vehicle

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
NCAR 2010	RSE Parsed Data	2010-01-28/ 2010-03-29	The data in these files have been parsed from raw XML format to CSV format. It contains all messages received by all RSEs. Each message header and each snapshot appears on one line, and individual values are separated by commas. There is one file for each date.	TBD
NCAR 2010	RSE Parsed Process Data	2010-01-28/ 2010-03-29	These files contain parsed data received by the RSE during the NCAR 2010 trials. The format is the same as for the parsed RSE data. The processing consisted of (a) deleting duplicate messages and snapshots and (b) adding flags to indicate erroneous or suspicious data values. Flags may appear for the following types of values: speed, lapsed time between snapshot recording and transmission, location of OBE when the message was transmitted, and air temperature.	Speed Location Air temperature
NCAR 2010	RSE XML Files	2010-01-28/ 2010-03-29	Each zip file contains all the RSE data collected in one day for the NCAR 2010 trials. When the file is unzipped, there is a directory for each RSE. Inside each RSE directory is one file for each message received by that RSE on that day. The files are in XML format, following the J2735 standard.	TBD
NCAR 2010	Testbed Description	2010-01-28/ 2010-03-29	The Nodes and Links file lists all the nodes (intersections) and links in the Michigan test bed, and the Nodes and Links Map depicts them in a KML file to use with Google Earth. The RSE location files depict the location of the RSEs in three formats. The Vehicle ID file lists the vehicles used in each of the three sets of trials	Location (Nodes and Links) Vehicle ID Vehicle type (i.e., Nissan Altima, etc.)

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
NCAR 2010	Weather Data	2010-01-28/ 2010-03-29	These files contain weather data collected from two weather stations **in the testbed area** during the period of the trials. Weather Data for the NCAR 2010 Trial Period	Data fields collected Station Date Time Dewpoint temperature Relative Humidity Atmospheric pressure Atmospheric temperature Wind direction Wind speed Precipitation rate

Meta Files (file type):
NCAR 2010 Metadata Documentation (doc)
NCAR OBE event file documentation (xls)
NCAR OBE file documentation (doc)
NCAR OBE Vehicle 2010 IDs (xls)
NCAR RSE documentation (doc)
NCAR RSE file documentation (xls)
NCAR Weather file documentation (doc)

Table A.6 RDE Datasets and Metadata Files – Pasadena (Source: http://rde.indrasoft.net)

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
Pasadena	01 Network Definition (12 files)	2011-09-01/ 2011-10-31	The 01Network data set includes the Pasadena Highway Network file and Highway detector location file in ArcGIS format. The Highway Network is based on a NAVTEQ Q4/2010 sourced network for the City of Pasadena, California. The purpose of the data set is to provide multi-modal data and contextual information (weather and incidents) that can be used to research and develop applications for the USDOT Dynamic Mobility Applications (DMA) program	Highway Network data Demand data **Network performance data** Work zone data Weather data CCTV camera data Changeable message sign data **The following elements apply for the designated link and the reverse link:** From/To Node Number, Node Latitude, Node Longitude for link **Length of link** Description of transportation system (HOV, SOV, etc.) **Number of lanes** Free flow speed (mph) **Functional class** Detector type code: city system detector, freeway mainline, HOV, on-ramp, off-ramp, Freeway-to-freeway Lat/Long of start and end nodes
Pasadena	02 Census Block Groups (4 files)	2011-09-01/ 2011-10-31	The 02CensusBlockGroups data set includes the Census Block Group shape file. The Mygistics real-time model classifies the traffic analysis zones (TAZ) into two groups: internal ones and external ones. The internal TAZ location and boundary are directly imported from the Census Block Group 2010 data; the external TAZ are aggregates from block groups at the model area cordons.	2010 Census state FIPS code 2010 Census county FIPS code 2010 Census tract code 2010 Census tabulation block number 2010 Census functional status 2010 Census land area (square meters) 2010 Census water area (square meters) 2010 Census functional status

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
Pasadena	03 Mobile Sightings	2011-09-01/ 2011-10-31	The 03MobileSightings data set includes two hour sample raw mobile sightings data. Mobile sightings data logs the interaction of AirSage mobile device with the wireless network, and is the basis for generating vehicle origination/destination matrices. Each time a mobile device interacts with the network, a data record is generated by the network switching equipment on the Sprint network. **U.S. DOT currently does not have the rights to distribute this data set.**	Date and time of sighting Lat/Long of sighting location Speed in km/hr Distance between this sighting and consecutive one based on latitude/longitude in meters
Pasadena	04 Hourly Origin-Destinations (144 files)	2011-09-01/ 2011-10-31	The 04HourlyOD data set includes hourly trip tables for two vehicle types (SOV and HOV) and three day types (weekday, weekend and game day). The OD tables are referenced by Census Block Groups. There are a total of 760 Block groups in the Pasadena area and 13 external zones resulting in a 773 by 773 trip matrix after adding external zones.	Trips from Origin Zone to Destination Zone #1 Trips from Origin Zone to Destination Zone #2
Pasadena	05a City of Pasadena Link and Turn Volume Data (SQL format) – (184,984 files)	2011-09-01/ 2011-10-31	The City of Pasadena Arterial System provides traffic volumes in 5-minute intervals from loop detectors on 17 locations on city arterials.	Year, Month, Day, Time of data collection Observed speed in km/hour Occupancy expressed as a percentage
Pasadena	05b City of Pasadena Link and Turn Volume Data (Text format) – (5,982 files)	2011-09-01/ 2011-10-31	The City of Pasadena Arterial System provides traffic volumes in 5-minute intervals from loop detectors on 17 locations on city arterials.	Occupancy Speed VMT Vehicle Hours Traveled (VHT) Travel time Delay – Vehicle hours of delay

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
Pasadena	05c PeMS 5 min Link and Turn Volumes (SQL format)	2011-09-01/ 2011-10-31	The Performance Measurement System (PeMS) provides observed traffic counts data for the freeway system using 516 loop detectors. This data set provides volumes aggregated to 5 minutes.	Occupancy Speed VMT VHT Travel time Delay - Vehicle Hours of Delay
Pasadena	05d PeMS 30 sec Link and Turn Volumes (SQL format)	2011-09-01/ 2011-10-31	The Performance Measurement System (PeMS) provides observed traffic counts data for the freeway system using 516 loop detectors. This data set provides volumes every 30 seconds.	Lane count Loop count Occupancy Flow Status
Pasadena	05e PeMS 5 min Link and Turn Volumes (Plain text format)	2011-09-01/ 2011-10-31	The Performance Measurement System (PeMS) provides observed traffic counts data for the freeway system using 516 loop detectors. This data set provides volumes aggregated to 5 minutes.	Occupancy Speed VMT VHT Travel time Delay - Vehicle Hours of Delay
Pasadena	05f PeMS 30 sec Link and Turn Volumes (SQL format)	2011-09-01/ 2011-10-31	The Performance Measurement System (PeMS) provides observed traffic counts data for the freeway system using 516 loop detectors. This data set provides volumes every 30 seconds.	Lane count Loop count Occupancy Flow Status

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
Pasadena	05g Simulated Link Volumes (SQL format)	2011-09-01/ 2011-10-31	The Mygistics National Traffic Model incorporates live feeds for HOV freeway link volume count data generated by infrastructure-based detectors and sourced from PeMS. This field records a separate volume value for the HOV lanes contiguous to mixed use lanes. The Model simulates in near-real time link volume for all links that are not covered by infrastructure-based detectors. In addition, the Model simulates in near-real time intersection turning movement volumes for all nodes within the geographic coverage area. The model simulates predicted link volumes for a 30 minute forecast horizon to support algorithms that require forecast traffic data.	Volume for HOV lanes contiguous to mixed use lanes Intersection turning movements Predicted link volumes for 30-min forecast horizon
Pasadena	05h Simulated Turn Volumes (SQL format) – (5,937 files)	2011-09-01/ 2011-10-31	The Mygistics National Traffic Model incorporates live feeds for HOV freeway link volume count data generated by infrastructure-based detectors and sourced from PeMS. This field records a separate volume value for the HOV lanes contiguous to mixed use lanes. The Model simulates in near-real time link volume for all links that are not covered by infrastructure-based detectors. In addition, the Model simulates in near-real time intersection turning movement volumes for all nodes within the geographic coverage area. The model simulates predicted turning movement volume for a 30 minute forecast horizon to support algorithms that require forecast traffic data.	Volume for HOV lanes contiguous to mixed use lanes Intersection turning movements Predicted link volumes for 30-min forecast horizon

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
Pasadena	05i Simulated Link Volumes (Plain Text format)	2011-09-01/ 2011-10-31	The Mygistics National Traffic Model incorporates live feeds for HOV freeway link volume count data generated by infrastructure-based detectors and sourced from PeMS. This field records a separate volume value for the HOV lanes contiguous to mixed use lanes. The Model simulates in near-real time link volume for all links that are not covered by infrastructure-based detectors. In addition, the Model simulates in near-real time intersection turning movement volumes for all nodes within the geographic coverage area. The model simulates predicted link volumes for a 30 minute forecast horizon to support algorithms that require forecast traffic data.	Volume for HOV lanes contiguous to mixed use lanes Intersection turning movements Predicted link volumes for 30-min forecast horizon
Pasadena	05j Simulated Turn Volumes (Plain Text format)	2011-09-01/ 2011-10-31	The Mygistics National Traffic Model incorporates live feeds for HOV freeway link volume count data generated by infrastructure-based detectors and sourced from PeMS. This field records a separate volume value for the HOV lanes contiguous to mixed use lanes. The Model simulates in near-real time link volume for all links that are not covered by infrastructure-based detectors. In addition, the Model simulates in near-real time intersection turning movement volumes for all nodes within the geographic coverage area. The model simulates predicted turning movement volume for a 30 minute forecast horizon to support algorithms that require forecast traffic data.	Volume for HOV lanes contiguous to mixed use lanes Intersection turning movements Predicted link volumes for 30-min forecast horizon

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
Pasadena	05k Simulated Link Volumes (VISUM format)	2011-09-01/ 2011-10-31	The Mygistics National Traffic Model incorporates live feeds for HOV freeway link volume count data generated by infrastructure-based detectors and sourced from PeMS. This field records a separate volume value for the HOV lanes contiguous to mixed use lanes. The Model simulates in near-real time link volume for all links that are not covered by infrastructure-based detectors. In addition, the Model simulates in near-real time intersection turning movement volumes for all nodes within the geographic coverage area. The model simulates predicted link volumes for a 30 minute forecast horizon to support algorithms that require forecast traffic data.	Volume for HOV lanes contiguous to mixed use lanes Intersection turning movements Predicted link volumes for 30-min forecast horizon
Pasadena	05l Simulated Turn Volumes (VISUM format)	2011-09-01/ 2011-10-31	The Mygistics National Traffic Model incorporates live feeds for HOV freeway link volume count data generated by infrastructure-based detectors and sourced from PeMS. This field records a separate volume value for the HOV lanes contiguous to mixed use lanes. The Model simulates in near-real time link volume for all links that are not covered by infrastructure-based detectors. In addition, the Model simulates in near-real time intersection turning movement volumes for all nodes within the geographic coverage area. The model simulates predicted turning movement volume for a 30 minute forecast horizon to support algorithms that require forecast traffic data.	Volume for HOV lanes contiguous to mixed use lanes Intersection turning movements Predicted link volumes for 30-min forecast horizon
Pasadena	06a Link Capacity (SQL format)	2011-09-01/ 2011-10-31	The 06LinkCapacity_Speed data set includes link capacity and speed data based on Mygistics Real-Time Model. From the basis of a priori estimation of 24/7 network flow patterns including link capacities, the Real-Time Model adjusts the link capacity from live data feeds such as construction work zone and incident events based on traffic engineering principles. The link capacities are estimated from fusing both the real-time simulation of network flows with live data feeds such as spot speed from detector stations.	NAVTEQ Network Link ID Time of simulated step Direction to/from node Speed

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
Pasadena	06b Link Speed (SQL format)	2011-09-01/ 2011-10-31	The 06LinkCapacity_Speed data set includes link capacity and speed data based on Mygistics Real-Time Model. From the basis of a priori estimation of 24/7 network flow patterns including link capacities, the Real-Time Model adjusts the link capacity from live data feeds such as construction work zone and incident events based on traffic engineering principles. The link speeds are estimated from fusing both the real-time simulation of network flows with live data feeds such as spot speed from detector stations.	NAVTEQ Network Link ID Time of simulated step Direction to/from node Speed
Pasadena	06c Link Capacity (Plain Text format)	2011-09-01/ 2011-10-31	The 06LinkCapacity_Speed data set includes link capacity and speed data based on Mygistics Real-Time Model. From the basis of a priori estimation of 24/7 network flow patterns including link capacities, the Real-Time Model adjusts the link capacity from live data feeds such as construction work zone and incident events based on traffic engineering principles. The link capacities are estimated from fusing both the real-time simulation of network flows with live data feeds such as spot speed from detector stations.	NAVTEQ Network Link ID Time of simulated step Direction to/from node Speed
Pasadena	06d Link Speed (Plain Text format)	2011-09-01/ 2011-10-31	The 06LinkCapacity_Speed data set includes link capacity and speed data based on Mygistics Real-Time Model. From the basis of a priori estimation of 24/7 network flow patterns including link capacities, the Real-Time Model adjusts the link capacity from live data feeds such as construction work zone and incident events based on traffic engineering principles. The link speeds are estimated from fusing both the real-time simulation of network flows with live data feeds such as spot speed from detector stations.	NAVTEQ Network Link ID Time of simulated step Direction to/from node Speed

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
Pasadena	06e Link Capacity (VISUM format)	2011-09-01/ 2011-10-31	The 06LinkCapacity_Speed data set includes link capacity and speed data based on Mygistics Real-Time Model. From the basis of a priori estimation of 24/7 network flow patterns including link capacities, the Real-Time Model adjusts the link capacity from live data feeds such as construction work zone and incident events based on traffic engineering principles. The link capacities are estimated from fusing both the real-time simulation of network flows with live data feeds such as spot speed from detector stations.	NAVTEQ Network Link ID Time of simulated step Direction to/from node Speed
Pasadena	06f Link Speed (VISUM format)	2011-09-01/ 2011-10-31	The 06LinkCapacity_Speed data set includes link capacity and speed data based on Mygistics Real-Time Model. From the basis of a priori estimation of 24/7 network flow patterns including link capacities, the Real-Time Model adjusts the link capacity from live data feeds such as construction work zone and incident events based on traffic engineering principles. The link speeds are estimated from fusing both the real-time simulation of network flows with live data feeds such as spot speed from detector stations.	NAVTEQ Network Link ID Time of simulated step Direction to/from node Speed
Pasadena	07a Turn Capacity (SQL format)	2011-09-01/ 2011-10-31	The Intersection Turning Movement Capacity data file includes the turn capacities computed for each intersection turning movement in the network file. Capacity computations follow the guidelines of the Highway Capacity Manual (HCM) for both signalized and unsignalized intersections. For the Pasadena network, each intersection was coded with lane geometry detail as well as control type and priority movement.	Time of simulated step Origin node ID To node ID Current turn capacity in vehicles/hour

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
Pasadena	07b Turn Delay (SQL format)	2011-09-01/ 2011-10-31	Intersection turn delay describes the average delay vehicles experience when they pass through an intersection.	Time of simulated step Origin node ID To node ID Current turn delay 15-minute and 30- minute forecast turn delay
Pasadena	07c Turn Capacity (SQL format)	2011-09-01/ 2011-10-31	The Intersection Turning Movement Capacity data file includes the turn capacities computed for each intersection turning movement in the network file. Capacity computations follow the guidelines of the Highway Capacity Manual (HCM) for both signalized and unsignalized intersections. For the Pasadena network, each intersection was coded with lane geometry detail as well as control type and priority movement.	Time of simulated step Origin node ID To node ID Current turn capacity in vehicles/hour
Pasadena	07d Turn Delay (Plain text format)	2011-09-01/ 2011-10-31	Intersection turn delay describes the average delay vehicles experience when they pass through an intersection.	Time of simulated step Origin node ID To node ID Current turn delay 15-minute and 30- minute forecast turn delay
Pasadena	07e Turn Capacity (VISUM format)	2011-09-01/ 2011-10-31	The Intersection Turning Movement Capacity data file includes the turn capacities computed for each intersection turning movement in the network file. Capacity computations follow the guidelines of the Highway Capacity Manual (HCM) for both signalized and unsignalized intersections. For the Pasadena network, each intersection was coded with lane geometry detail as well as control type and priority movement.	Time of simulated step Origin node ID To node ID Current turn capacity in vehicles/hour

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
Pasadena	07f Turn Delay (VISUM format)	2011-09-01/ 2011-10-31	Intersection turn delay describes the average delay vehicles experience when they pass through an intersection.	Time of simulated step Origin node ID To node ID Current turn delay 15-minute and 30- minute forecast turn delay
Pasadena	08a WorkZone (SQL format) – (8,087 files)	2011-09-01/ 2011-10-31	The 08WorkZone data set includes lane closure information due to work zone events. The Mygistics National Traffic Model incorporates live data feeds for work zone event alerts from Caltrans Lane Closure System. The test data set includes text files extracted from the Caltrans Lane Closure System, in 5 minutes increments, for the months of September and October 2011.	Closure ID number Start date End date Beg County End County Route number Begin Milepost Begin direction End milepost End direction Facility type (on ramp, mainline, off ramp) Total number of lanes available
Pasadena	08b WorkZone (Plain Text format)	2011-09-01/ 2011-10-31	The 08WorkZone data set includes lane closure information due to work zone events. The Mygistics National Traffic Model incorporates live data feeds for work zone event alerts from Caltrans Lane Closure System. The test data set includes text files extracted from the Caltrans Lane Closure System, in 5 minutes increments, for the months of September and October 2011.	Closure ID number Start date End date Beg County End County Route number Begin Milepost Begin direction End milepost End direction Facility type (on ramp, mainline, off ramp) Total number of lanes available

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
Pasadena	09 Incident data (13,043 files)	2011-09-01/ 2011-10-31	The 09Incident data set includes information on traffic accidents sourced from the Regional Integration of Intelligent Transportation Systems (RIITS). Incident data from RIITS includes information such as time and location of the incident, severity, involved emergency response teams, etc. The data from RIITS was collected for 1-minute increments for two months.	Date/Time Lat/Long Jurisdiction City Postmile where event occurred Type Event Severity Affected Lanes Lane count – total lanes available Vehicle type and counts
Pasadena	10 Weather data (18,412 files)	2011-09-01/ 2011-10-31	The 10Weather data set includes weather data collected from Weather Central and the National Oceanic and Atmospheric Administration (NOAA). Weather data are forecasted to 120 hours (5 days) into the future and are available to be queried by geocode (latitude/longitude) road segment data.	Lat/Long of weather station Date Time Reporting Station Code City State Temperature Temperature string – (in Fahrenheit and centigrade) Temperature_f (Fahrenheit) Temperature_c (Centigrade) Dew Point Relative Humidity Wind Chill Heat Index Wind Direction Wind Direction Degrees Wind Speed Wind Gusts

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
				Atmospheric pressure High temp today (Fahrenheit degrees) Low temp today (Fahrenheit degrees) Precipitation today (in inches) Snow Depth (in inches) Visibility (in miles) Altimeter (altitude at the reporting station location) High temp yesterday (Fahrenheit degrees) Low temp yesterday (Fahrenheit degrees) Sky conditions Feels like (felt air temp – Fahrenheit degrees) Sunrise – local time Sunset – local time Daylight – indicates daylight or darkness
Pasadena	11 CCTV Snapshots – (3,820,731 files)	2011-09-01/ 2011-10-31	The 11CCTVSnapshots data set includes still image data collected through CCTV feeds. One still image for every minute for each camera location through CCTV feeds sourced from Caltrans Freeway Performance Measurement System (PeMS) is captured and archived within the data environment.	Still images from CCTV feeds – one image per minute
Pasadena	12 CMS Data – (12,988 files)	2011-09-01/ 2011-10-31	The 12CMS data set includes the CMS sign text feeds sourced from Caltrans Freeway Performance Measurement System (PeMS). Changeable message signs (CMS) display messages which can be incident/delay related, warning drivers to take specific defensive actions such as accident ahead/merge left/lane closed, or can be advisory; e.g., dense fog/slow vehicles ahead, request motorist assistance as for child abduction alerts, or current travel times between freeway segments. Caltrans has deployed six CMS within the project area. The data is updated every 5 minutes.	Agency Name Message ID TimeStamp – Date/Time of report dmsCurrentMessage – Post mile where the event occurred first/second/third lines of the message

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
Pasadena	13 Detector Influence (144 files)	2011-09-01/ 2011-10-31	The 13DetectorInfluenceFactor data set includes information on each link and turn describing its relative distance from an infrastructure based detectors providing observed data. The test data set includes observed as well as simulated volume and speed data. A detector influence factor is calculated for each link and turning movement depending on its relative distance from an infrastructure based detector providing observed data. The relative distance incorporates actual path travel distance from the closest detection site as well as the number of intersections traversed along that path.	From node To node Unique link ID Influence of a detector on the observed volume (in percent) Via node ID
Pasadena	14a Signal Phase data (SQL format) – (28 files)	2011-09-01/ 2011-10-31	The 14SignalPhaseData data set includes City of Pasadena signal phase data. The test data set includes the real signal and phasing data from the City of Pasadena. This data set includes the signal head state change events such as green start and green end times. These events are used to compute the green split for each 5-minute increment when the data are available.	Time stamp System ID Device Type Event type
Pasadena	14b Signal Phase data (Plain text format)	2011-09-01/ 2011-10-31	The 14SignalPhaseData data set includes City of Pasadena signal phase data. The test data set includes the real signal and phasing data from the City of Pasadena. This data set includes the signal head state change events such as green start and green end times. These events are used to compute the green split for each 5-minute increment when the data are available.	Time stamp System ID Device Type Event type

Meta Files (file type):
Pasadena Data Handbook (pdf) and Pasadena Metadata documentation (doc)

Table A.7 RDE Datasets and Metadata Files – Portland (Source: http://rde.indrasoft.net)

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
Portland	Arterial Bluetooth Data	2011-09-15/ 2011-11-15	The Bluetooth travel times file contains matched travel times between pairs of Bluetooth detectors. The Bluetooth stations file provides metadata about the location of the Bluetooth stations. The purpose of this data is to provide multi-modal data and contextual information (weather and incidents) that can be used to research and develop applications for the USDOT DMA program.	Travel time between detectors Lat/long of the station in the Bluetooth stations file Travel time in the Bluetooth Travel Times data file
Portland	Arterial Detector Data	2011-09-15/ 2011-11-15	This is the primary loop detector data table. It contains one-minute volume, occupancy, speed, and data quality flags for the arterial loop detector data.	Volume Occupancy Speed Lane (in which detector is located)
Portland	Arterial Detectors, Intersection s, and Stations	2011-09-15/ 2011-11-15	The Arterial Detectors file contains metadata for each singe dual-loop detector in the arterial data set. The Arterial Intersections file contains metadata for each intersection in the arterial data set. The Arterial Stations file contains metadata for each station. A station is a set of detectors at a particular location, for example the detectors in all lanes at a particular location.	Metadata for single dual-loop detector Metadata for each intersection in the arterial data set and latitude/longitude of the intersection Metadata for each station (where a station is a set of detectors at a location) and latitude/longitude of the station
Portland	Arterial Signal Phase and Timing Data	2011-09-15/ 2011-11-15	The primary signal timing and phase data table contains bit flags for phases that are currently displaying green, yellow, pedestrian call and vehicle call indications. The 82nd Avenue Timing Plans zip file contains pdf files of signal timing plans for each intersection.	Bit flags for signal phases when green, yellow, pedestrian calls, vehicle calls, intersection ID Signal timing plans for each intersection

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
Portland	Freeway Detectors and Stations	2011-09-15/ 2011-11-15	The Freeway Detectors file contains metadata for each detector in the data set. A detector is defined as a single dual-loop detector. The Freeway Stations file contains metadata for each station in the data set. A station is a set of detectors at a particular location, for example all mainline detectors at a location, or all on-ramp detectors at a location. The Highways file contains metadata describing highways in the Portland-Vancouver metropolitan region. The data set focuses on I-205 NB and SB; other highways are included for reference purposes.	Metadata for freeway detectors and stations Highways file contains metadata describing highways in Portland-Vancouver metro region. (Highway Id, Highway Name, etc.)
Portland	Freeway Incidents	2011-09-15/ 2011-11-15	This file describes incidents from the ODOT incident database.	Incident ID Detection ID Impact type ID County code ID Primary Route Primary (route) milepost Secondary (route) milepost Direction of roadway (northbound, southbound, etc.)
Portland	Freeway Loop Data – 15 min	2011-09-15/ 2011-11-15	This file contains 15-minute aggregations of the freeway loop detector data.	Start time Volume Speed Occupancy VMT VHT Delay Travel time

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
Portland	Freeway Loop Data – 1 hr	2011-09-15/ 2011-11-15	This file contains 1-hour aggregations of the freeway loop detector data.	Start time Volume Speed Occupancy VMT VHT Delay Travel time
Portland	Freeway Loop Data – 20 seconds	2011-09-15/ 2011-11-15	This file contains 20-second speed, occupancy, volume and data quality flags from the freeway loop detectors.	Speed Occupancy Volume
Portland	Freeway Loop Data – 5 min	2011-09-15/ 2011-11-15	This file contains 5-minute aggregations of the freeway loop detector data.	Start time Volume Speed Occupancy VMT VHT Delay Travel time

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
Portland	Freeway Planned Events	2011-09-15/ 2011-11-15	This file contains planned ODOT activities along roadways, primarily construction and maintenance events.	State highway name Link name (e.g., US 101) Start Milepoint End Milepoint Start Lat/Long End Lat/Long Start date End date Highway direction
Portland	Light Rail shapes	2011-09-15/ 2011-11-15	This dataset contains ESRI shapefiles for the light rail (MAX) lines and stops.	ESRI shapefiles for light rail (MAX) lines and stops
Portland	Transit Bus Stops	2011-09-15/ 2011-11-15	The Transit Bus Stop Event file contains a record for each time a bus goes past a bus stop. The Transit Bus Schedule Stop Time file presents bus schedule information. The Transit Stops file provides descriptions of the transit stops.	Time – when bus goes past a stop Bus schedule information Descriptions of transit stops
Portland	Transit MAX Light Rail Stops	2011-09-15/ 2011-11-15	The Transit MAX Stop Event file records MAX (light rail) stop events. There is one record for each time a light rail train stops at a station. The Transit MAX Scheduled Stop Time file provides MAX schedule information. The Transit MAX Stop Event APC file provides automatic passenger counter (APC) records. The MAX Stop Data Event file combines stops data with schedule data to demonstrate reliability.	Time – when light rail train stops at a station Light rail train schedule Passenger count

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
Portland	Weather	2011-09-15/ 2011-11-15	The RWIS file provides data from fixed Remote Weather Information System (RWIS) locations within the state of Oregon. The PDX files provides Quality Controlled Local Climatological data (QCLCD) Weather from NOAA	**RWIS data –** (station) Location name Latitude/Longitude Current temp Wind direction Wind speed Precipitation Humidity Surface water depth Surface water temp Dewpoint **PDX data –** Climatological data weather from NOAA

Meta Files (file type):
Portland Arterial Data Documentation (pdf)
Portland Freeway Data Documentation (pdf)
Portland Metadata Documentation (doc)
Portland Ramp Meter Plans (zip)
Portland Transit Data Documentation (pdf)

Table A.8 RDE Datasets and Metadata Files – San Diego (Source: http://rde.indrasoft.net)

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
San Diego	Freeway Data – 30 sec.	2010-01-01/ 2010-12-31	These data come directly from the Performance Measurement System (PeMS), containing detector data as reported every 30 seconds. Each line contains the timestamp and station ID followed by flow and occupancy for each lane.	Time stamp Station ID Lane "N" flow – number of veh passing over detector during sample period Lane "N" occupancy
San Diego	Freeway Data – 5 min.	2010-01-01/ 2010-12-31	These data come from PeMS, containing the standard PeMS roll-up of raw detector data. Information on the algorithms used to process raw detector data is provided in the Freeway documentation. The PeMS system has the ability to compute speed for sensors that don't report speed, like the detectors in this data set. Traditionally speed has been computed by using a g-factor in combination with the flow and occupancy. The g-factor is a value that represents the effective length of the vehicle. It is a combination of the average length of the vehicles in the traffic stream and the tuning of the loop detector itself. PeMS estimates a g-factor for each loop for every 5 minutes over an average week to provide accurate speed estimates. The algorithm has been tested and validated against ground truth data from double loop detectors and floating cars. Note that we currently do not impute for ramps (on-ramps, off-ramps, freeway-to-freeway connectors, collector-distributors, etc.), only for mainline and HOV detectors.	Time stamp Station ID Freeway (ID) Direction of travel Station Type Total Flow Average Occupancy Average Speed Lane "N" flow Lane "N" average occupancy Lane "N" speed

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
San Diego	Freeway Data - Daily	2010-01-01/ 2010-12-31	These data come from PeMS, containing the daily totals for each active station on the given day. At the end of each day, PeMS summarizes hourly values into daily totals in order to facilitate long term trend reporting. The delay metrics are a measure of the amount of additional time spent by the vehicles on a section of road due to congestion. This is the difference between the travel time at a non-congestion speed and the current speed. In the provided data, we compute the delay for a number of different thresholds so that we can accommodate different definitions of delay. The formula for this is simply D = F * (TT - TT_t) = F * (L/V - L/V_t). In these formulas, TT is the travel time, TT_t is the travel time at the threshold speed, F is the flow, and L is the length of the segment. V is the average speed during the reporting period and V_t is the threshold speed indicated in the column header. Note that by definition, delay can never be negative. Note that for delay, you have to specify a threshold. This threshold is considered to be the definition of congested traffic. This...	Timestamp Station ID Freeway (ID) Direction of travel Station type Total flow Delay - Average delay over the station length wrt to the following thresholds in mph: 35, 40, 45, 50, 55, and 60 mph

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
San Diego	Freeway Data - Hourly	2010-01-01/ 2010-12-31	These data come from PeMS, containing the hourly totals for each active station on the given day. At the end of each hour, PeMS summarizes 5-minute values into hourly totals in order to facilitate reporting long term trend reporting. The delay metrics are a measure of the amount of additional time spent by the vehicles on a section of road due to congestion. This is the difference between the travel time at a non-congestion speed and the current speed. In the provided data, we compute the delay for a number of different thresholds so that we can accommodate different definitions of delay. The formula for this is simply D = F * (TT - TT_t) = F * (L/V - L/V_t). In these formulas, TT is the travel time, TT_t is the travel time at the threshold speed, F is the flow, and L is the length of the segment. V is the average speed during the reporting period and V_t is the threshold speed indicated in the column header. Note that by definition, delay can never be negative. Note that for delay, you have to specify a threshold. This threshold is considered to be the definition of congested traffic...	Timestamp Station ID Freeway (ID) Direction of travel Station type Total flow Average occupancy Average speed Average delay over the station length wrt to the following mph: 35, 40, 45, 50, 55, and 60 mph Lane “N” average speed

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
San Diego	Freeway Detector Configura-tion	2010-01-01/ 2010-12-31	This dataset provides the detector configurations in effect for the selected time range indicated by yyyy_mm_dd in the filename. The California postmile system is a label that resets at county lines. The California postmile may also contain a single character prefix (e.g., R or M) indicating that a section of freeway has been renumbered or altered in some way. This prefix is provided by Caltrans and corresponds to their internal naming scheme. It is best to think of the California postmile as a non-numeric label which corresponds to the physical postmile markers along the roadway. Absolute postmiles measure the actual distance down the mainline and do not reset at county boundaries. Unlike the California postmile system, absolute postmiles strictly increase or decrease in one direction. This makes them useful for computing performance measures that require a segment length such as VMT. The files apply to a particular range of time. The beginning of the time period for which a particular metadata file applies is indicated in the filename as follows: Freeways-Metadata-yyyy_mm_dd. The end of the time period for which that metadata file applies is then given by the next consecutive starting time period (or by December 31, 2010 in the...	Station ID Freeway Direction of travel City CA PM – position using California postmile system Abs PM – Absolute postmile of detector station Lat Long Length (miles) segment length covered by the station in miles Lanes – number of lanes at station ALK Grid ID on which the station is located ALK Link ID on which the station is located

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
San Diego	Freeway Incident and Lane Closure Detector Locations	2010-01-01/ 2010-12-31	This metadata files contain the IDs and locations of the sensors along each section of I-5 North and I-5 South for which incidents and lane closures are provided. This metadata can be used to cross-reference incident locations with freeway performance data as well as the mobile dataset. The metadata files apply to a particular range of time. The beginning of the time period for which a particular metadata file applies is indicated in the filename as follows: IncidentsAndLaneClosures-Metadata-[yyyy]_[mm]_[dd]. The end of the time period for which that metadata file applies is then given by the next consecutive starting time period (or by December 31, 2010 in the case of the final file).	Incident ID Start Time Duration Freeway (ID) Direction of Travel CA PM Abs PM Area Location (text description) ALK Grid ID ALK Link ID
San Diego	Freeway Incidents	2010-01-01/ 2010-12-31	Incident descriptions are provided for sections of I-5 North and I-5 South, as indicated by [Freeway][Direction] in the filename. These incident descriptions come from the California Highway Patrol's (CHP) online feed. All incident types (accident, breakdown, congestion, hazard, police, and weather) are included in this dataset. Separate files are provided containing only long incidents, which are defined to be incidents lasting longer than 15 minutes.	Incident ID Start Time Duration Freeway (ID) Direction of Travel CA PM Abs PM Area Location (text description) ALK Grid ID ALK Link ID

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
San Diego	Freeway Lane Closures	2010-01-01/ 2010-12-31	Description: Lane closures are provided for sections of I-5 North and I-5 South, as indicated by [Freeway][Direction] in the filename. This lane closure notices come from the Caltrans Lane Closure System (LCS). LCS is a lane closure request and tracking system that is used by Caltrans District Traffic Managers and contractors to request, review and approve lane closures on the freeway system. Only fully defined, mainline lane closures were included. Beyond that, a lane closure is included if any part of it lies within the desired I-5 postmile range (either 10-25 Southbound or 15-30 Northbound). Lane closures may be matched with freeway data and incidents by comparing the time, postmile, freeway name, and freeway direction fields.	Lane Closure ID Freeway (ID) Direction of Travel Begin (description of begin of lane closure) Begin CA PM Begin Abs PM End (description of end of lane closure) End CA PM End Abs PM Start date End date Length of segment (in miles) of closure Total lanes (in segment of closure) ALK Grid ID ALK Link ID
San Diego	GPS Trips dataset	2010-01-01/ 2010-12-31	These files contain original 2010 ALK GPS data for San Diego Metropolitan Area. Each file is one trip. The data are collected at typically 3-second intervals from users of CoPilot (ALK's in-vehicle navigation product), with their consent to collect and distribute. These data from GPS-receivers are in NMEA sentence format and includes no personal information. ALK has ensured that all user-specific information that could be traced back to a particular individual CoPilot user has been removed from the dataset. Neither ALK nor anyone will be able to trace back the GPS data to the original traveler. The GPS dataset is in standard NMEA-format output by the mobile device.	GPS trip data from GPS receivers in NMEA sentence format

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
San Diego	GPS Trips – Gridded Track Data	2010-01-01/ 2010-12-31	These files are in Gridded GPS track Data (GGD) format from ALK. The files are a cleaned GPS dataset that is map-matched to ALK Digital Maps, and broken into individual trip segments by individual contributors. The only identifier is an integer trip number. An individual trip is assumed to commence at the first location for a new GPS track as well as for any location for which the time since the previous location is greater than 4 minutes. The end of a trip segment is identified as either the last GPS data point for a track or the last GPS point prior to a 4 minute gap. In addition to position, speed, heading, date and time, the data in this file also contain fields that tell where on which link of ALK's digital map network each GPS observation corresponds. The latitude/longitude values in the GGD file are the same as included in the corresponding GPS files.	GPS trips data in Gridded GPS track Data (GGD) format that is matched to ALK Digital Maps Position Speed Heading Date Time

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
San Diego	GPS Trips – one point per link	2010-01-01/ 2010-12-31	OneMon is an ALK format. It stands for One Monument, where Monument refers to the mid-point of a link. OneMon files contain one vehicle record per link, when it crossed the mid-point. It is a subset of GGD data with unique representation for each trip-link combination. When there are multiple observations for the traversal of a link by a single Trip ID (since GPS data is collected every three seconds), only the one closest to the center point of the link is retained and its date and time are interpolated to the time the vehicle would have actually passed the center point. The representative speed value of a Trip ID is computed based on the total travel time along the link and the distance of the link, in order to smooth out the instantaneous speeds over a link. This is done for each trip separately; hence if there are ten trips over that link, there would be ten data-points (same latitudes-longitudes, but different time stamps and speeds). This dataset helps in travel time analysis - by greatly reducing the number of GPS observations to work with for computing travel times over road segments for a single trip.	Subset of GGD data with representation for each trip-link combination

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
San Diego	Grid Map data	2010-01-01/ 2010-12-31	The node mapdata file defines the ALK nodes by their latitude and longitude. These nodes are the endpoints of the ALK links. ALK grids are rectangular and vary in size (area) from 3 square-miles to several hundreds of square-miles. 92% of grids in the ALK Mapdata for San Diego region are less than 53 square-miles in area, and contain about 94% of the links. The link mapdata file defines the ALK Links. Each link is defined by its starting and ending node. The unique identifier for links is the combination of ALK Grid ID and ALK Link ID. The shape mapdata file includes the vertices of the curve that each ALK link follows. The positions generally correspond to the middle line of the road (for example the yellow line in a two-way undivided street) with a margin of error within a few feet. This can be used to map the links.	Lat/Long of ALK nodes Starting and ending nodes for ALK links Shape mapdata file – vertices of the curve that each ALK link follows
San Diego	Hourly Weather data	2010-01-01/ 2010-12-31	These weather data files come from the United States Government's National Oceanic and Atmospheric Administration (NOAA), specifically, the National Climatic Data Center (NCDC) and the National Weather Service (NWS). The data are quality controlled by both NCDC and Weather Source.	Timestamp Temp (Fahrenheit) Dew Point Relative Humidity Visibility Cloud Cover Precipitation Snow Wind direction Wind speed Maximum wind speed

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
San Diego	Maps of Coverage Area	2010-01-01/ 2010-12-31	Several maps of the coverage area are available including: Map (figure) 1 portrays the area covered by the data environment. Interstate highways and state routes for which data are provided include I-5 (NS), I-8 (EW), I-15 (NS), SR 52 (EW), SR 54 (EW), SR 56 (EW), SR 78 (EW), SR 94 (EW), SR 125 (NS), SR 163 (NS), I-805 (NS), and I-905 (W). Map (figure) 2 portrays the area covered by the data set, with speeds on major roads indicated by color coding. This map is typical of the maps produced by PeMS. Map (figure 3) portrays the section of I-5 for which incidents and lane closures are provided. Map (figure 4) displays locations where GPS data was collected from users of CoPilot (ALK's in-vehicle navigation product).	Map data showing interstate highways and state routes in the coverage area, speed data for routes in the coverage area, incidents and lane closures in the coverage area, locations where GPS data was collected from users of CoPilot (in-vehicle navigation product)

Meta Files (file type):
San Diego Freeways Data Dictionary (doc)
San Diego Incidents and Lane Closures Data Dictionary (doc)
San Diego Metadata documentation (doc)
San Diego Mobile Mapdata Data Dictionary (doc)
San Diego Weather Data Dictionary (doc)

Table A.9 RDE Datasets and Metadata Files – Seattle (Source: http://rde.indrasoft.net)

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
Seattle	20-second freeway data	2011-05-01/ 2011-10-31	This data set data consists of six months of raw data collected every 20 seconds from traffic detectors deployed by Washington State Department of Transportation (WSDOT) along I-5 in Seattle. The data includes flow and occupancy. There is one zip file for each day. In the CabinetsInfo_and_LoopsInfo.zip file, the CabinetsInfo file describes the location of the cabinets which contain the loop electronics, and the LoopsInfo file describes each specific loop.	Flow - volume Occupancy Loop ID Location (milepost) of cabinets containing loop electronics Route – name of state route or interstate on which the road equipment cabinet is located
Seattle	Arterial Travel Times	2011-05-01/ 2011-10-31	This data set contains estimated travel times on arterials derived from Automatic License Plate Readers (ALPRs) located on intersections around the city and on some state routes, including SR 522, the arterial that passes around the north end of Lake Washington and serves as one of the diversion routes for the SR 520 and I-90 floating bridges. Matching license plate reads from ALPRs at different intersections allow direct computation of travel times from one intersection to another by subtracting the time of passage at the upstream location from the time of passage at the downstream location. The data set contains travel times on 96 distinct, directional travel segments.	Estimated travel times on arterials

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
Seattle	Expanded 5-minute freeway data	2011-05-01/ 2011-10-31	This data set data consists of six months of highway detector data aggregated to the 5-minute level. The 5-minute aggregation of the freeway loop data is the primary data set WSDOT uses to calculate freeway performance measures. The file has been expanded to include speeds and travel times in addition to flow and occupancy. There is one zip file for each month. In the CabinetsInfo_and_LoopsInfo.zip file, the CabinetsInfo file describes the location of the cabinets which contain the loop electronics, and the LoopsInfo file describes each specific loop.	Flow Occupancy Speed Travel time Location of the cabinets containing loop electronics
Seattle	Freeway Travel Times	2011-05-01/ 2011-10-31	This data set data contains travel times, computed every five minutes for northbound and southbound travel on the HOV lanes and regular lanes of I-5. The corridor travel times are traditionally computed for use by WSDOT in its freeway performance reporting activities. Travel times are computed with the 5-minute data that pass the quality assurance tests.	Travel times – 5-min intervals for northbound and southbound HOV lanes and regular lanes of I-5
Seattle	Incident Data	2011-05-01/ 2011-10-31	This data set contains descriptions of all incidents that occurred on the relevant section of I-5 during the six month period, taken from the Washington Incident Tracking System (WITS) database.	Incident response records - Incident ID Start time Location How many lanes blocked Response
Seattle	King County Transit AVL Data	2011-05-01/ 2011-10-31	This data set contains scheduled and actual bus arrival times from King County Metro buses. The bus arrival information has been extracted from the KCM Speed and Reliability Analysis (SandRA) database. These 'post processed' data come from two independently operating KCM vehicle location systems.	Scheduled and actual bus arrival times from King County metro buses and Sound Transit buses- Bus routes Bus stop location identification Arrival time of buses at those stops

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
Seattle	Original 5-minute freeway data	2011-05-01/ 2011-10-31	This data set data consists of six months of highway detector data aggregated to the 5-minute level. The 5-minute aggregation of the freeway loop data is the primary data set WSDOT uses to calculate freeway performance measures. This level of aggregation provides sufficient detail to identify the onset of congestion while limiting the amount of data handling required to develop those performance measures. The data includes flow and occupancy. There is one zip file for each month. In the CabinetsInfo_and_LoopsInfo.zip file, the CabinetsInfo file describes the location of the cabinets which contain the loop electronics, and the LoopsInfo file describes each specific loop.	Flow Occupancy Location of cabinet containing the loop electronics
Seattle	Seattle Sensys data	2011-05-01/ 2011-10-31	This data set contains data from arterials parallel to I-5. The Sensys traffic detectors are operated by the City of Seattle Department of Transportation (SDOT).The data gathered by these sensors are collected by SDOT at 1-minute intervals. The collected data consist of volume, lane occupancy, and vehicle speed. The csv file 'SeattleCabinets' contains data describing the location of specific data collection points. The second csv file 'SeattleSensor' provides details about the specific movement being observed by each detector/sensor. Each detector references a cabinet using the 'CabinetID' variable. The actual volume data are stored in the 'SeattleData' csv file, which includes the variable 'SensorNum' which is used as a key along with the CabinetID variable to identify a unique data collection sensor.	Volume Speed Lane occupancy Cabinet ID
Seattle	Seattle Timing Plans	2011-05-01/ 2011-10-31	This data set contains timing plans for signals on arterials parallel to I-5, provided by the City of Seattle. The timing plans are provided as PDF files that researchers can use as desired. Separate PDF files are provided for each signalized intersection.	Timing plans for signals on arterials parallel to I-5

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
Seattle	Seattle Transit Rail data	2011-05-01/ 2011-10-31	Sound Transit is a regional transit authority operating long distance (regional) bus, light rail, and commuter rail services in King, Pierce, and Snohomish counties. The Seattle area data set includes schedule data for the two currently operating train systems that serve the downtown Seattle area. The two train services are the Central Link light rail train (LRT) and the Sounder commuter rail train.	Schedule data for two train systems serving downtown Seattle
Seattle	Variable Message Signs	2011-05-01/ 2011-10-31	The “ATM” data file in this data set contains a record of all messages and travel times posted on WSDOT’s Active Traffic Management signs on I-5. The WSDOT is currently conducting a pilot project of active traffic management (ATM) northbound on I-5, south of Seattle. The ATM pilot project currently consists of a series of gantry-mounted, overhead, lane-specific signs that enable adjustable, lane-specific variable speed limits to be posted, as well as the display of selective lane controls (lane closure alerts) and variable length messages that provide notification of incidents and slow traffic conditions downstream. This “VMS” file data file includes data on all of the information posted on WSDOT dynamic message signs within the I-5 study area boundaries that are not included in the Active Traffic Management data set. There are approximately 33 sign locations, some of which were in use during only part of the 6-month data collection period. This data set indicates when a message was posted on a sign and when that message was either changed or removed.	Data on all of the information posted on the WSDOT dynamic message signs within the I-5 study area boundaries that are not included in the Active Traffic Management data set.

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
Seattle	Weather Station Data	2011-05-01/ 2011-10-31	This data set contains Seattle weather data for the six month period. The weather data set comes from the following National Oceanic and Atmospheric Administration (NOAA) weather stations in the region: SeaTac Airport (southern end of Seattle metropolitan area), Boeing Field (just south of downtown Seattle ‘ next to the ATM corridor) , University of Washington Atmospheric Sciences Department (just north of downtown Seattle), Paine Field (Everett, Washington, north of Seattle), and Renton (south east end of Lake Washington).	Seattle weather data for the six month period (May – Oct 2011)

Meta Files (file type):
Seattle Data Documentation (doc)
Seattle Metadata Documentation doc)

Table A.10 RDE Datasets and Metadata Files – Vehicle Infrastructure Initiative Proof of Concept (Source: http://rde.indrasoft.net)

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
Vehicle Infrastructure Initiative Proof of Concept	OBE Event Files	2008-08-21/ 2008-08-26	These files contain event data extracted from OBE file for each day of the POC trials (data files were not available for 8/22/08 and 8/27/08). The events include generating a snapshot, connecting to an RSE, attempting to send a message, successfully completing message transmission, and failing to transmit a message. The files are in CSV format.	Event data – generating a snapshot, connecting to an RSE, attempting to send a message, etc.
Vehicle Infrastructure Initiative Proof of Concept	OBE Snapshots	2008-08-21/ 2008-08-26	These files contain data extracted from OBE log files for each day of the POC trials. OBE log files were not available for 8/22/08 and 8/27/08. Each record in the file is a snapshot that appeared in the OBE log file. The data fields in the snapshot are present in comma-separated value format.	Snapshot that appear dint he OBE log file
Vehicle Infrastructure Initiative Proof of Concept	OBE Trajectories	2008-08-21/ 2008-08-26	These zip files contain data extracted from OBE log files for each day of the POC trials. OBE log files were not available for 8/22/08 and 8/27/08. The files contain latitude/longitude data and x-y data in feet for each second of each vehicle's trajectory. The files are in CSV format.	Lat/Long and x-y data (in feet) for each second of each vehicle's trajectory

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
Vehicle Infrastructure Initiative Proof of Concept	Paramics Simulation Data	2008-08-21/ 2008-08-26	These simulated RSE snapshot files have been provided by Francois Dion and Ralph Robinson at the University of Michigan Transportation Research Institute (UMTRI). They have constructed a model of the Michigan Testbed with the Paramics Simulation modeling tool. The model simulates morning rush hour in the testbed area, and simulates snapshot generation and transmission to RSEs. The data files included in the data environment include documentation, node and link input data files, and output files containing the snapshots that would be received by each modeled RSE. If you use this data for any reason you are bound by the RDE's Terms of Use and must give acknowledgment to the contributors of this data.	Simulated snapshots and transmission to RSEs. Node and link input data files Output files containing snapshots
Vehicle Infrastructure Initiative Proof of Concept	RSE Parsed Data	2008-08-21/ 2008-08-26	The data in these files have been parsed from raw XML format to CSV format. Each message header and each snapshot appears on one line, and individual values are separated by commas. There is one file for each date, containing all messages received by all RSEs.	Message headers and snapshots
Vehicle Infrastructure Initiative Proof of Concept	RSE Parsed Process	2008-08-21/ 2008-08-26	These files contain parsed data received by the RSE during the POC trials. The format is the same as for the parsed RSE data. The processing consisted of (a) deleting duplicate messages and snapshots and (b) adding flags to indicate erroneous or suspicious data values. Flags may appear for the following types of values: speed, lapsed time between snapshot recording and transmission, location of OBE when the message was transmitted, and air temperature.	Messages and snapshots

Data Environment	Data Sets	Start/ End Date	Description (including Purpose where noted)	Data Elements Captured (which may be applicable to national datasets)
Vehicle Infrastructure Initiative Proof of Concept	RSE XML files	2008-08-21/ 2008-08-26	Each zip file contains all the RSE data collected in one day for the POC trials. When the file is unzipped, there is a directory for each RSE. Inside each RSE directory is one file for each message received by that RSE on that day. The files are in XML format, following the J2735 standard.	Messages received for each RSE for each day of the data collection trial period
Vehicle Infrastructure Initiative Proof of Concept	Testbed Description	2008-08-21/ 2008-08-29	The Nodes and Links file lists all the nodes (intersections) and links in the Michigan test bed, and the Nodes and Links Map depicts them in a KML file to use with Google Earth. The RSE location files depict the location of the RSEs in three formats. The Vehicle ID file lists the vehicles used in each of the three sets of trials.	Nodes/Links in the Michigan test bed Vehicle ID
Vehicle Infrastructure Initiative Proof of Concept	Weather	2008-08-21/ 2008-08-26	This file contains weather data collected from the testbed area during the period of the POC.	Weather station location Dewpoint temp Relative humidity Atmospheric pressure Atmospheric temperature Wind direction Wind speed Precipitation rate

Meta Files (file type):
OBE Event File Documentation (xls)
OBE File Documentation (doc)
OBE Vehicle 2009 IDs (xls)
RSE documentation (doc)
RSE file documentation (xls)
Weather File Documentation (doc)
VII PoC Metadata Documentation (doc)

APPENDIX B. Stakeholder Interview Guide for the Speed Data Test Pilot

1. What are the business needs your office has for speed data?
    a. Safety programs
    b. Freight movement
    c. Speed by type of vehicle
    d. Congestion measures
    e. Work Zone Management
    f. Noise abatement
    g. Prior speed program (1990s)
2. What Federal mandates are there for collecting and reporting speed/travel time data?
3. Are MAP-21 requirements going to change these mandates? In what way?
4. What speed elements does your office need to collect for your use and reporting?
    a. Speed Limit (Critical MIRE Element)
    b. Truck Speed Limit (Value Added MIRE Element)
    c. Nighttime Speed Limit (Value Added MIRE Element)
    d. 85^{th} Percentile Speed (Value Added MIRE Element)
    e. 80^{th} percentile speed
    f. 95^{th} percentile speed
    g. Mean Speed (Value Added MIRE Element)
    h. Ramp Advisory Speed Limit (Critical MIRE Element)
5. What data quality requirements does your database have?
6. Can a different set of requirements for continuous real time data be considered?
7. Are there any restrictions on sharing your data with other Federal offices or agencies or the public?
8. Do you see opportunities to coordinate your office's data activities with other offices?
9. What do you see as benefits of that coordination?
10. Are there technical problems in merging your data with other speed databases?
11. Do you see any institutional issues in merging your database with other speed databases?
12. Does your office require speed data to be in geo spatial format?
13. What are your future plans for acquiring speed data?
14. Do you see benefits in having a Travel Data Working Group reporting to the U.S. DOT Mobility Data Coordination Group that focuses on resolving technical and institutional issues associated with speed data?
15. Is your office willing to participate in the Travel Data Working Group?

APPENDIX C. FHWA Speed Monitoring Data Collection Summit

In November 2009, the FHWA Office of Policy and Management sponsored a Speed Monitoring Data Collection Summit in Tampa, Florida to discuss the future of speed data collection in the U.S., including current speed data collection practices and the need for additional speed data collection sites within each State. The following states participated in the summit (PA, GA, CA, MT, AZ, ID, OH, MN, TX, VA, IN, NY, ME, FL, CO, WA, and MD) along with FHWA, CUTR, and Federal safety staff.

Findings from a survey of State DOT speed data collection practices were presented, which found that nearly all States (45 states) are currently collecting speed data. The majority of states use a speed bin size of 5 mph, although a few states use bins under 5 mph. The first speed bin varied widely among states and included bins as low as <10, <15, and <20 mph. The majority of states used first speed bins of <30 or <40 mph. The last speed bin also varied, with the majority of states using a bin of >85, >90, or other mph. The majority of states are collecting speed data at a time interval of 60 minutes, and data is stored on a per lane basis. The survey indicated that they would like support from FHWA in the form of standards, software, and resources for speed data collection. Speed data programs in Florida, New York, Ohio, and Pennsylvania were discussed in detail, including practices related to data collection, binning schemes, and reporting methods.[16]

There was an interest among participants in standardizing speed data collection procedures, and the group came to a consensus on the following common database structure for collecting and storing speed data:[17]

- By lane;
- Every 15 minutes (preferred); every 1 hour (acceptable);
- In 5 mph bins;
- First bin ≤ 20 mph;
- Report in 5 mph increments;
- Last bin at least 85+ mph; and
- Identify count location by latitude/longitude.

There was also interest in FHWA developing a national speed database. Once this database is in place, it would be relatively easy for States to link speed data with other roadway inventory data elements.

FHWA's plan for implementing the speed data summit findings includes the following:[18]

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[16] H. Desai. Establishing a National Travel Time Reliability Information System. Presented at the Northwest Traffic Data Workshop: Successful Strategies in Data Collection, Analysis and Use, Seattle, Washington, July 2009.

[17] K. Matias. FHWA – Pooled Funds Speed Summit. Presented at the 2010 Traffic Monitoring Workshop, New York State DOT, February 23, 2010.

[18] *Ibid.*

- A draft Speed Data chapter was developed for the Traffic Monitoring Guide in February 2010.
- Speed data requirements were added to the Traffic Monitoring Guide
- Speed data was collected from a few pilot states in Fall 2010.
- FHWA will continue to develop and refine procedures for conducting speed data quality control checks. The following data quality concepts will be considered based on customer and business needs for the speed data:
  - Accuracy – The measure of degree of agreement between a data value or sets of values and a source assumed to be correct.
  - Timeliness – The degree to which data values or a set of values are provided at the time required or specified.
  - Completeness – The degree to which the data values are present in the attributes (data fields) that require them.
  - Validity – The degree to which data values satisfy acceptance requirements of the validation criteria or fall within the respective domain of acceptable values.
  - Coverage – The degree to which data values in a sample accurately represent the whole of that which is to be measured.
  - Accessibility – The relative ease with which data can be retrieved and manipulated by data consumers to meet their needs.

A future Travel Monitoring Analysis System (TMAS) version (v3.0) will require states to submit speed data to FHWA via the web and provide the following functionality related to speed data: upload of speed data, quality control, reporting, exporting, GIS based tools and views, and data aggregation/merging.[19]

[19] S. Jessberger. Speed Data Collection and Format. Presented at 2012 Highway Information Seminar (HIS) Breakout Session 2: What's New with Traffic Monitoring, Arlington, Virginia, October 2012.

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