EnableATIS Strategy Assessment

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16. Abstract

Enabling Advanced Traveler Information Systems (EnableATIS) is the traveler information component of the Dynamic Mobility Application (DMA) program. The objective of the EnableATIS effort is to foster transformative traveler information applications and strategies that fully utilize enhanced data sources enabled from connected vehicle research broadly and the DMA program specifically. The foundational approach for the EnableATIS effort was defined and documented 2011-2012, and defines a high-value federal role in facilitating market-driven development of transformative traveler information applications. Further, in late 2012, EnableATIS sponsored initiated two exploratory basic research studies on advanced methods and technologies to infer disaggregate traveler behavior data. With the two exploratory research efforts underway, an EnableATIS strategy meeting was held in Washington DC on November 13 to assess whether the foundational assumptions from 2011 May 2012 were still valid and to identify high-value, near-term federal actions consistent with EnableATIS goals. This document captures the discussion and insights from the strategy session, validates the original vision and objectives of the EnableATIS effort, and outlines a range of potential, high-value federal actions that build on current research work.

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Executive Summary

The Dynamic Mobility Application (DMA) program seeks to identify, develop, and deploy applications that leverage the full potential of connected vehicles, travelers and infrastructure to enhance current operational practices and transform future surface transportation systems management. Enabling Advanced Traveler Information Systems (EnableATIS) is the traveler information component of the DMA program. The objective of the EnableATIS effort is to foster transformative traveler information applications and strategies that fully utilize enhanced data sources enabled from connected vehicle research broadly and the DMA program specifically.

The foundational analysis for the EnableATIS effort has been well-defined in previous documents, including the Operational Concept and Market Readiness reports (May 2012). This foundational approach has defined a high-value federal role in facilitating market-driven development of transformative traveler information applications. Consistent with a federal role facilitating research in the market, unique among DMA bundle development efforts, the EnableATIS effort did not follow a process of application concept development, prototyping and demonstration. Instead, in late 2012, EnableATIS initiated two exploratory basic research studies on advanced methods and technologies to infer disaggregate traveler behavior data.

With the two exploratory research efforts underway, an EnableATIS strategy meeting was held in Washington DC on 13 November 2013 to assess whether the foundational assumptions from May 2012 were still valid and to identify high-value, near-term federal actions consistent with EnableATIS goals. In attendance were USDOT program stakeholders and members of the Noblis DMA technical support services team. The objectives for the strategy session were to:

- Review key tenets and opportunities identified in the EnableATIS Operational Concept development work
- Assess current state of public sector and private sector traveler information markets relative to the Operational Concept findings
- Identify near-term potential to realize EnableATIS transformative goals, describe underlying challenges
- Discuss the nature of an effective federal role in helping to achieve these goals
- Within the ATIS and ITS marketplaces, several trends are changing the landscape:
- A reduction in available resources combined with increased appetite for data and information and the proliferation of private sector ATIS services is causing the public sector to reassess its role across the ATIS value chain. While the public sector has traditionally taken the lead in data collection and deploying systems to disseminate traveler information, there is a growing realization that agencies need to consolidate services and rely more heavily on the private sector.
- The increase in demand for pervasive traveler information services is providing a strong marketplace for the private sector to fund the development of innovative technologies and applications for both data collection and end-user telematics.
- The emergence of connected and autonomous vehicles, along with crowdsourcing applications, is changing the perception about traveler information systems – how data is sourced, fused, and shared between system users and managers.

Today, the fundamental assumptions of the operational concept are still valid but the Federal Role is shifting. The goal to improve transportation system mobility and safety by better informing agency operational strategies as well as individual user decisions requires a more Robust environment that seeks a better balance between system and user optimal conditions. In the current Laissez-Faire environment, the marketplace will continue to evolve around the growing focus of the private sector to develop products and services that aid system users. There is strong incentive for private sector investment in applications and services focused on the end user and in data collection and analytics. There is less incentive and greater risk for the private sector to invest in services that support the elements of the value chain related to system management.

The Federal Government can adopt a stronger leadership role in supporting these outcomes by expanding public-private partnerships and providing incentives that foster innovative research. New models, algorithms, and systems that support an integrated dynamic mobility environment between system users and managers will result in evolving the current landscape toward the more Robust concept and achieve the objectives of the EnableATIS program.

1 Introduction

1.1 Background

Enabling Advanced Traveler Information Systems (EnableATIS) is a high priority application area of the United States Department of Transportation (USDOT) Dynamic Mobility Applications (DMA) Program. EnableATIS seeks to accelerate transformative changes in the provision of multi-modal traveler information in order to increase mobility and trip planning. EnableATIS promotes multimodal, end-to-end trip planning, increased data collection, fusion, and sharing, predictive analytics, and intelligent decision support to create an operational environment that provides personalized information services to users.

This strategy session builds upon previous activities sponsored by USDOT to assess the state of ATIS including the 2009 Workshop on Identifying Traveler Information Research Needs to Achieve All Roads-All Modes-All the Time and two Enable ATIS reports released in 2012 - the Operational Concept and Market Readiness Assessment. These reports outlined the vision and goals of the program and identified the next steps for USDOT to research, demonstrate and advance the objectives of EnableATIS. In a potential next phase of EnableATIS, USDOT is seeking to initiate transformative activities leading to new prototypes and model deployments consistent with the goals of EnableATIS

The foundational analysis for the EnableATIS effort is documented in the Operational Concept and Market Readiness reports. This foundational approach defines a high-value federal role in facilitating market-driven development of transformative traveler information applications. Consistent with a federal role facilitating research in the market, unique among DMA bundle development efforts, the EnableATIS effort did not follow a process of application concept development, prototyping and demonstration. Instead, in 2012, EnableATIS sponsored two exploratory basic research studies on advanced methods and technologies to infer disaggregate traveler behavior data.

1.1.1 Strategy Session

With the two exploratory research efforts underway, an EnableATIS strategy meeting was held in Washington DC on 13 November 2013 to assess whether the foundational assumptions from 2011 were still valid and to identify high-value, near-term federal actions consistent with EnableATIS goals. The morning session included a series of presentations and discussions to frame the state of the practice. During the afternoon session, the participants engaged in an exercise to frame a set of desired outcomes and research questions to guide the evolution of EnableATIS initiatives.
The purpose of this document is to summarize the material presented and insights gained from group discussion, to capture group consensus related to goals and objectives, and to identify potential high-value, near-term federal actions and strategies consistent with EnableATIS objectives.

Table 1-1: EnableATIS Strategy Session Agenda

Agenda	Times
Welcome/Introductions/Objectives (Bob Rupert)	9:00-9:15 am
EnableATIS OpCon Review (Karl Wunderlich)	9:15-9:45 am
EnableATIS prototypes (Matt Cuddy)	9:45-10:00 am
Deployment Trends: Public Sector Traveler Info (Jeff Adler)	10:00-10:30 am
Break	10:30-10:45 am
Private Sector Traveler Information Market Trends (Jon Bottom)	10:45-11:15 am
Lessons Learned from UK deployments (Craig Nelson)	11:15-11:45 am
Lunch/Discussion	11:45 am-1:00 pm
Near-Term Scenario Planning Exercise (Karl Wunderlich)	1:00-2:30 pm
Wrap-Up and Next Steps (Bob Rupert/Karl Wunderlich)	2:30-2:45 pm
Adjourn	2:45 pm

Table 1-2: EnableATIS Strategy Session Participants

Name	EnableATIS Role	Affiliation
Kate Hartman	DMA Program Lead	ITS JPO
Bob Rupert	Enable ATIS Bundle Lead	FHWA Office of Operations
Gene McHale	DCM Program Modal Lead	FHWA R&D
Matt Cuddy	EnableATIS Research Support	Volpe Center
Karl Wunderlich	EnableATIS Technical Support Lead	Noblis
Meenakshy Vasudevan	EnableATIS Technical Support Team	Noblis
Phil Tarnoff	EnableATIS Technical Support Team	Consultant
Jeff Adler	EnableATIS Technical Support Team	Open Roads Consulting
Jon Bottom	EnableATIS Technical Support Team	Steer Davies Gleave
Craig Nelson	EnableATIS Technical Support Team	Steer Davies Gleave

2 EnableATIS Objectives and Status

This section covers the objectives and current status of the EnableATIS effort as presented at the time of the 13 November Strategy Session (presentations by Bob Rupert, FHWA and Karl Wunderlich, Noblis). The intent of this section is to provide a brief summary on these topics derived from the Operational Concept document, plus insights gained from discussion at the Strategy Session. In addition, this section covers EnableATIS research efforts underway at the University of Minnesota and MIT (presentation by Matt Cuddy, Volpe Center).

2.1 The EnableATIS Operational Concept

As described in the EnableATIS Operational Concept document, EnableATIS is unique among DMA bundle development efforts. Five other DMA bundles are actively prototyping one or more application bundles based on Concepts of Operations and System Requirement documents completed in 2013. EnableATIS is not developing a specific application or system, but rather seeks to have a positive influence in a complicated and emerging traveler information market that is undergoing rapid technological change. This leads to some level of uncertainty about future roles for agencies, in particular at the federal level, relative to the next generation of traveler information services. Since a strong federal role was not foreseen in application prototyping for traveler information, the DMA program opted to explore EnableATIS at the Operational Concept level rather than a Concept of Operations. The Operational Concept describes the broad traveler information market and external influences that are rapidly re-shaping technologies and market interactions in traveler information provision. Further, the Operational Concept describes two operational scenarios (*laissez faire* and *robust*), defining two different relationships between public sector agencies and the market, with correspondingly different federal roles and potential actions on the part of the DMA program.

2.1.1 Background, Vision and Objectives

The EnableATIS bundle of connected vehicle/connected traveler application concepts grew out of the DMA candidate concept development effort initiated in 2010, that included a stakeholder prioritization exercise at the December 2010 Mobility Workshop held in the Washington DC metropolitan area. One of the key pieces of feedback from that workshop was the strong stakeholder interest in traveler information and the expectation among stakeholders that transformative applications based on new connected vehicle/traveler data could have significant and near-term impact. In fact, the “Next Generation ATIS” application concept was the highest rated application for potential impact among roughly 40 application concepts considered. The level of interest was high but this interest was tempered by some uncertainty about an appropriate federal role in facilitating the development of new transformative applications.

As a result, in 2011, the DMA program launched an Operational Concept development effort (led by Kimley-Horn and Associates) to conduct more detailed stakeholder interaction as well as market and technology research. Key products of that effort included a vision statement and three transformative goals for Enable ATIS.

Vision Statement

Enable ATIS is a transformative concept of the traveler information community that will:

- Improve transportation system mobility and safety by better informing agency operational strategies as well as individual user decisions
- Foster multi-source data and information integration and delivery that will transform the user experience on the transportation network
- Advance planning, engineering and research with new forms of data about traveler behavior and response to transportation operations
- Promote development of dynamic and transformative applications for real-time, multi-modal, and traveler information partnerships

Transformative Goals

1. EnableATIS will transform the user experience on the transportation network. Future traveler information systems will intuitively provide users with trip, location and mode specific information to empower real-time decision making.
2. As a result of EnableATIS, transportation networks will experience measurable gains in performance, including mobility, safety and efficiency.
3. A more robust traveler information suite of capabilities will be enabled through a rich and multisource data environment that leverages public sector system and operations data, and transportation network operations and user data from privately operated systems.

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The Enable ATIS concept development effort also produced a Market Readiness Assessment document that took a closer look at stakeholder feedback regarding near-term potential to act on the EnableATIS vision and achieve the associated transformative goals.

Specific items identified as high-value elements of a desired end state for future traveler information systems included:

- multimodal integration
- facilitated sharing of data
- end-to-end trip perspectives
- use of analytics and logic to generate predictive information specific to users

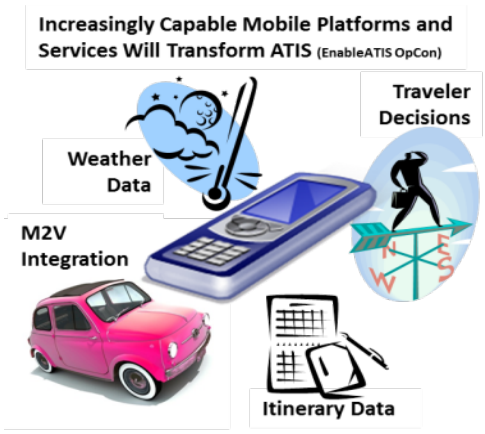

Figure 2-1: EnableATIS Summary Graphic, Mobility Workshop Event (May 2012)
(Source: Noblis)

Figure 2-1 highlights some examples of transformative data elements provided as part of a connected vehicle/connected traveler environment. For example, a mobile device (e.g., smartphone) stand-alone or integrated with a vehicle (Mobile-2-Vehicle integration) might act as a platform to provide new data on the surrounding environment (e.g., weather data), disaggregate traveler decision data, and vehicle/traveler itinerary data. A key observation from the concept development phase of EnableATIS resides in the conjecture that these new forms of data, made available rapidly and broadly among many travelers and vehicles in the system will enable new forms of traveler information services that meet the three EnableATIS objectives.

2.1.2 Operational Scenarios

The two operational scenarios are summarized below.

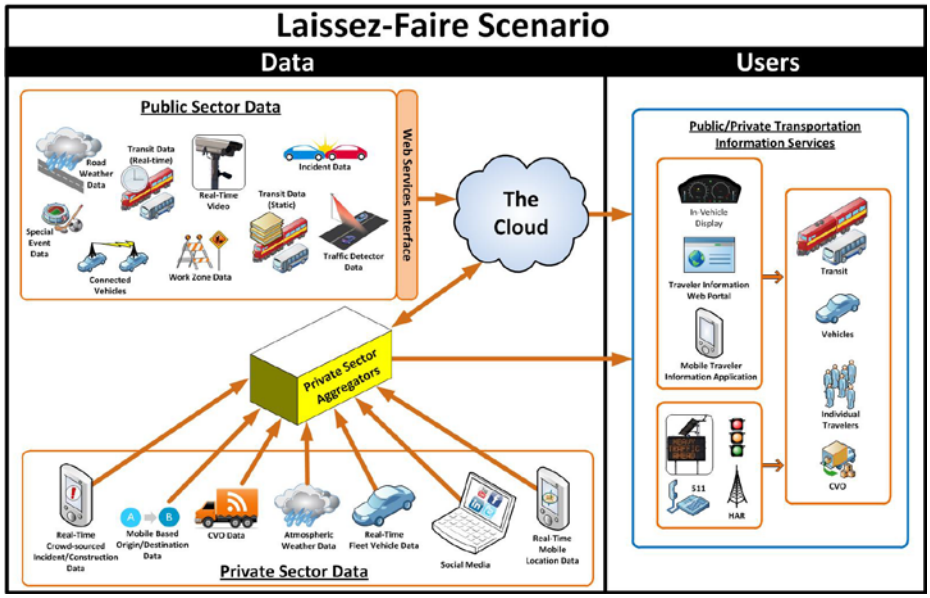

Figure 2-2: Laissez-Faire EnableATIS Operational Scenario

(Source: Kimley Horn, from FHWA-JPO-12-052)

Figure 2-2 represents the laissez-faire operational scenario. This is seen as an incremental build out over time, assuming an increasing (but not ubiquitous) level of data and data aggregation, and continued innovation in delivery mechanisms. There is minimal concerted effort by USDOT to influence the market; rather this first scenario illustrates how traveler information services and partnership would potentially evolve given advances that are happening in today's environment.

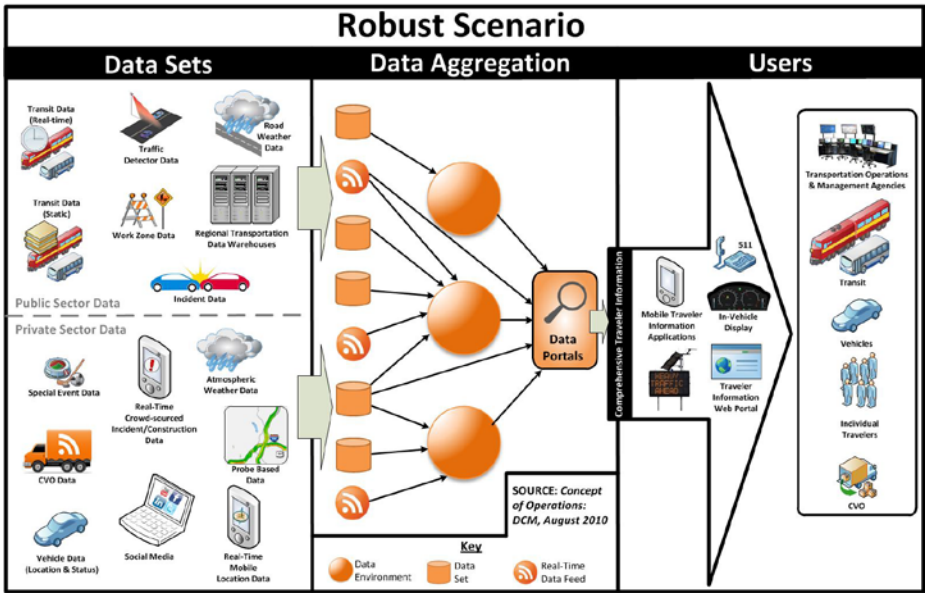

Figure 2-3: Robust EnableATIS Operational Scenario
(*Source: Kimley Horn, from FHWA-JPO-12-052)*

Figure 2-3 summarizes the robust operational scenario. Here, there is active leadership in certain roles by both public and private stakeholders. This scenario assumes a comprehensive, multisource and multimodal data environment from which to enable a multitude of traveler information services. This scenario represents a desired end state, strong collective interaction. This operational scenario is presented as being more likely to deliver on the transformative objectives of EnableATIS.

2.1.3 Federal Role

The two operational scenarios offered in the Operational Concept document are potential end-states, but the robust scenario is identified as a preferred outcome, closer to the goals of EnableATIS. As stated earlier, direct application development at the federal level is not considered an appropriate role for the DMA program in facilitating the preferred robust end state.

Five key roles (not necessarily federal) were identified to facilitate the emergence of the desired end state operational scenario. However, the federal role supporting in each area was identified:

- **Facilitate Vision and Coalition Building**. Because of the federal position in coalition building, federal leadership in this aspect was seen as high-value.
- **Lead and Support for Public Private Partnering.** A federal role in providing guidance to state and local transportation agencies was identified.
- **Sponsor Fundamental Research and Research Initiatives.** The DMA program can assist by independently and in partnership with TRB, sponsoring and coordinating research initiatives.
- **Innovate and Implement Technology.** A federal role was identified to assist in fostering innovation and to ensure that markets and populations are not significantly under-served in information services.
- **Operate and Manage Systems.** Here, a federal role is identified in moving innovations into operational practice and to act as a steward of data and data standards.

The Strategy session participants generally felt the vision, objectives and roles from the 2012 Operational Concept still pertained, although actions potentially taken by the program should be revisited. A complete discussion of this is provided below in Section 5.

2.2 EnableATIS Exploratory Research Initiatives

In late 2012, the DMA program initiated two exploratory basic research studies on advanced methods and technologies to infer disaggregate traveler behavior data. This section summarizes the material presented by Matt Cuddy (Volpe Center) at the strategy session. The objectives of the effort were to advance the state of the art in mobility data capture by casting a wide net for innovative devices and applications that could routinely generate or infer critical new forms of data seen as the foundational element of the EnableATIS concept. Although stakeholders agreed that new forms of data could have transformative properties, it was unclear how readily available these data might practically be. Therefore, the broad agency announcement (BAA) released in 2012 called for devices with these attributes:

- More effective and flexible tools for acquiring travel decision data
- Multimodal & portable
- Measures physical environment and/or
- Infers traveler itinerary and/or
- Manages communications network utilization

The result of the BAA solicitation was two projects, both focused primarily on bullet items one (decision data), two (portability), and four (inferring itinerary data). Sections 2.2.1 and 2.2.2 summarize the two projects, their technical approach, objectives, and delivery schedule.

2.2.1 MIT – CloudCar

The MIT CloudCar research effort has two elements, one related to connected vehicle capture and the second related to inferring traveler mode from smartphone data. In the connected vehicle element, the CloudCar concept leverages a low-cost cellular-enabled OBD-II port reader to direct vehicle data directly to a cloud-based archive. The cloud based archive can be accessed in real-time within a data rights-sensitive environment. More information can be obtained at www.cloudcar.mobi.

The second element is a connected traveler application (Mobility as a Service) that records user motion and can infer mode of travel.

The goal of the effort is to evaluate mobile versus vehicle-based data collection and demonstrate alternative approaches for managing data rights. Given the low cost of the devices and applications, results from this effort will assist in understanding in more detail the feasibility and potential value of larger-scale naturalistic studies combining connected vehicle and traveler data.

An initial prototype is expected in June 2014 and the project will be complete in June 2015.

2.2.2 University of Minnesota – SmarTrac

The University of Minnesota SmarTrac research effort focuses on inferring traveler mode and destination from smartphone data. However, this effort also includes an aspect related to self-learning on the part of the application to infer traveler trip purpose based on historical information on typical

travel and activity patterns. This aspect of the project employs machine learning techniques as well as patterns of strategic and tactical user input. Over time, the application learns to recognize trip type, purpose and nature and records that inferred data on the smartphone.

The goal of the effort is to advance self-learning research and assess the accuracy of these methods to infer traveler mode (walk, bike, transit vehicle). Results from this effort will assist in understanding how unobtrusive data capture methods can be included in larger scale, naturalistic studies specifically attempting to capture and make available disaggregate travel itinerary and purpose data.

An initial prototype is expected in December 2013 and a project demonstration will be complete in December 2014.

3 Deployment Trends and Challenges

This section is a synthesis of the presentations made by Jeff Adler and Jon Bottom regarding the public and private sector deployment trends. The intent of this section is to reflect on recent trends in ATIS, most notably, the pronounced shift in roles and responsibilities between public agencies and the private sector. As the ATIS industry undergoes transformative changes in how data is collected and information is disseminated, this session provided an opportunity to reassess the assumptions and findings from previous foundational analyses, including the Operational Concept and Market Readiness Reports.

3.1 Overview of ATIS

Traveler information should be defined broadly, to include information about individual trips and the paths they take, about travel at the network level, and about travelers themselves. Such information is of value not only to individuals planning their trips, but also to network operations managers and to planners and marketers. Although the information provided to travelers is typically about travel conditions on the path(s) under consideration, or a specific path recommendation, the generation of such information may involve the collection and processing of data on travel patterns and levels across the network, and even data about how travelers are interacting with the ATIS.

Information that is collected, processed and disseminated by an Advanced Traveler Information System (ATIS) has the potential to:

- Improve end user decision-making, both by individual travelers making independent travel choices, as well as by groups of travelers acting in a more coordinated fashion, such as a fleet of commercial vehicles under centralized dispatching or the participants in a Transportation Management Association (TMA);
- Improve transportation systems management and operations including freeways, arterials, managed lanes, tollways, and transit systems. Traveler information can assist in integrated corridor management by improving the coordination and synergy between transportation system components; and
- Provide valuable data on travel patterns and traveler characteristics to third parties such as planners or marketing groups.

In the context of ATIS, the term “information” is used to cover descriptive, predictive, and prescriptive information sought by travelers and system operators to assist in pre-trip and enroute decision making and roadway system management. The first two categories focus on the current and anticipated conditions in the transportation network; the latter is focused on the traveler’s activity or trip.

- Descriptive information includes real-time traffic conditions (e.g. link travel times, delays, or the presence of an incident on a particular route) or status of transit services (e.g., bus arrival times).
- Predictive information is based on the fusion of real-time and historical data and attempts to inform travelers of what conditions are likely to be experienced in the near future

- Prescriptive information includes recommendations to end users regarding route and mode choice options. This information is focused more about the trip than the travel conditions.

Conventionally the traveler information processing data stream has been thought of in terms of a one-way open loop flow, starting with raw data collected and aggregated from network sensors and possibly other sources such as cell phone, Bluetooth or GPS devices, probe vehicles or crowd sourcing. The different data sources are then fused and processed into an estimate of the prevailing (or possibly forecast future) state of travel conditions over the network. Depending on the processing method, this state estimation may also entail determining the volumes and patterns of trips flowing over the network. The processed results are then made available to end users for incorporation in their decision-making, but in ways that remain unknown to the information provider.

In contrast, emerging ATIS concepts ("ATIS 2.0") envision a two-way flow, in which the information provided to end users is customized to their individual travel needs and preferences, and the way the information is used by travelers (for example, a request for information concerning a particular origin-destination [OD] pair) becomes another type of data to be incorporated in subsequent traveler information production. This would have the advantages of providing end users with information that is more customized and relevant to their particular travel needs. This also benefits transportation management and operations by supplying vital data regarding individual traveler locations, preferences, and behaviors to improve the quality of network state estimates and predictions thereby enabling active management of demand and flow through the transportation network.

A final form of information available from ATIS is information about travelers themselves. Marketers and planners are interested in knowing the socio-economic characteristics and trip purposes of people at particular network locations (passing in front of a billboard, for example, or using a particular facility such as a toll road), and this information can be collected or inferred from the raw data used by ATIS, or from travelers' use of ATIS itself.

The following sections describe recent ATIS trends affecting the public and the private sector, and assess their likely impacts on the EnableATIS vision presented above.

3.2 Public Sector Trends

This section follows Jeff Adler's briefing slides from the strategy session. The focus of this section is to highlight the changing attitudes among public sector agencies as it relates to ATIS. The combination of decreasing operating budgets and the rapid proliferation of new technologies for data collection and dissemination from the private sector is forcing public agencies to reconsider their traditional role as the owner and primary source for traveler information.

3.2.1 A Tool for Traffic Management

ATIS is an essential tool for the public sector to support transportation systems management and operations (TSM&O). Providing travelers with access to accurate, reliable, and easy to understand pre-trip and en-route traveler information can influence travel choice behavior demand and improve system performance. The benefits of making real-time information available to travelers have been well documented.

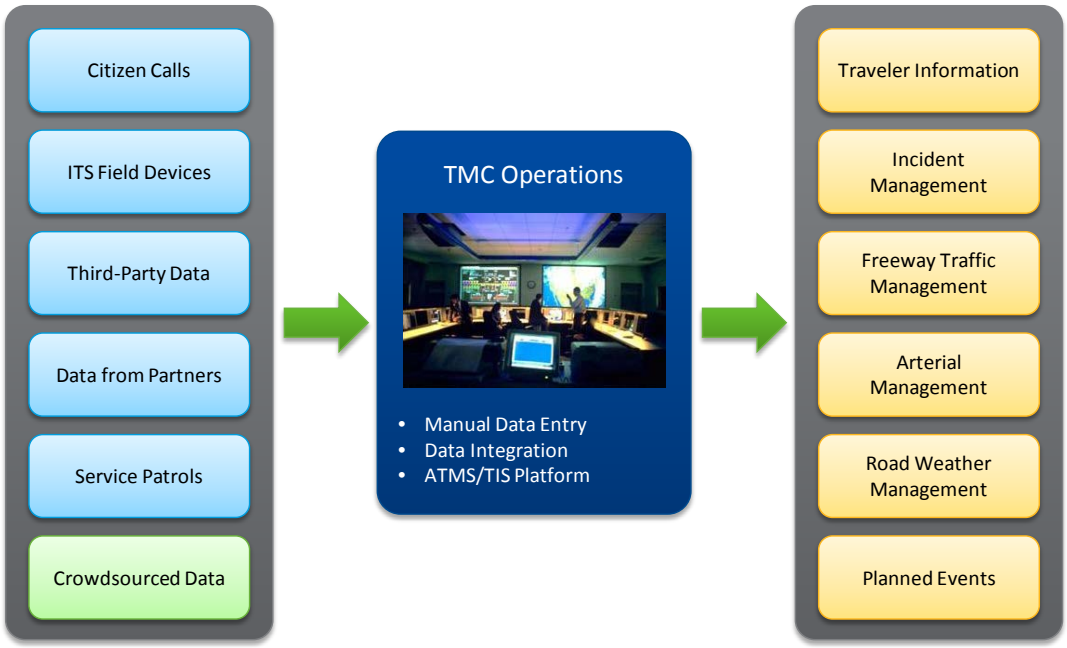

Figure 3-1: TMC Data Flow
(Source: Noblis/Open Roads)

Public sector agencies have traditionally positioned themselves to own and manage the entire traveler information value chain including data collection, data fusion, translating data into traveler information, and disseminating this information to the traveling public.

- Traffic Management Centers / Freeway Management
  - Information: Incidents, planned events, road conditions, travel times, parking information
  - Technologies: Dynamic Message Signs (DMS), Highway Advisory Radio (HAR), 511 telephony and websites, social media
- Transit Operations
  - Information: Schedules, arrival times, parking information
  - Technologies: Message Boards, Telephony, mobile apps

One of the perceived values for having system operators control the dissemination of traveler information is the desire to influence travel choice behavior towards a "system optimal" state. For example, a key component of incident management is the coordinated the use of DMS, HAR, lane control signals, traffic signals, and ramp meters to distribute traffic along operator preferred diversion paths. This ability of agencies to manage how and where information is disseminated provides some level of control over evolving traffic patterns.

In recent years, the landscape for traveler information services has changed and the traditional role that public agencies have played is being questioned. The proliferation of third-party data services and traveler information systems has increased the market penetration of pre-trip and en-route traveler information. Crowdsourcing technologies have fostered an increase in the quality and amount of data readily available. With the emergence of connected and/or autonomous vehicles on the horizon, it is not difficult to imagine traditional roadside ATIS technologies becoming obsolete.

3.2.2 The Changing Landscape

Profound changes in technology along with a reduction in public sector funding are influencing a changing ATIS landscape. Technological evolution (which has resulted in low-cost computing, mobile devices, data storage, and GPS services) has enabled the private sector to assume dominance in controlling the ATIS value chain. Furthermore, budget constraints are forcing the public sector to rethink how it allocates funds to TSM&O and, in particular, how much should be spent on traveler information services in light of the emergence of private sector services.

3.2.2.1 *Mobile Applications / Personal ATIS*

The increased market penetration rate of mobile and personal devices along with the proliferation of navigation and traveler information applications have created a dynamic marketplace for traveler information services. More than ever, travelers are relying on third-party traveler information services rather than services provided by the public sector.

3.2.2.2 *Third-Party Data Collection Services*

While public agencies are still the primary source for incident and planned event data, transit schedule and vehicle location data, and parking data, there has been tremendous growth in data services offered by the private sector. The application of active and passive crowdsourcing has supported the rise of third-party traffic data providers (e.g., INRIX, Here, TomTom, Airsage) and the availability of new data sources for data traditionally gathered by public agencies such as weather, pavement condition, and incidents.

3.2.2.3 *Increase in Demand for Personalized Real-time Information and Services*

The wide-spread distribution of mobile devices and apps has increased the appetite of the traveling public for real-time information. Sparked by navigation systems and apps that provide comprehensive trip planning, there is ever expanding demand for personalized, accurate, and reliable traveler information. Public agencies have focused data collection efforts on first providing full coverage of freeways and critical corridors. Data on arterials and state/local routes is currently limited but is becoming a point of emphasis.

No longer is it sufficient to base traveler information on current conditions but the market is embracing big data and predictive analytics that integrate real-time and historical data. As data collection expands across all links and modes, there is an increased emphasis on multi-modal, end-to-end trip planning. In addition to more accurate and reliable information, the next evolution in ATIS is the emergence of intelligent technologies that can learn traveler behavior and provide more personalized travel planning advice.

3.2.2.4 *Connected/Autonomous Vehicles*

The emergence of connected/autonomous vehicles will further alter the ATIS landscape by changing both data collection and data dissemination. The public sector realizes that the question is no longer “if” connected/autonomous vehicles will become a reality but “when” the transformation will take place.

3.2.3 Deployment Trends

In response to the changing landscape and the pressures of reduced budgets, the public sector is reconsidering its role as it relates to ATIS.

3.2.3.1 *Data Collection, Processing, and Management*

State agencies understand their valuable role in collecting data and making sure accurate and timely data is being shared with the traveling public. While some of the data needs may be filled by the private sector, public agencies are the primary source for much of the data that is required to support ATIS, such as information about work zone, traffic incident, or special event restrictions. Three tends have emerged as it relates to data management:

Public sector agencies are well aware of the increased demand for data and are actively seeking to expand data collection to provide more coverage including arterials and local roadways, parking, transit and other modes, and incorporating data available from partner agencies.

As the amount of available data increases, public agencies are focusing on how to effectively manage the inflow, outflow, and storage of their data. There is a growing movement among public sector agencies to develop Open Data portals or Data Hubs to make their data more readily accessible to business partners, stakeholders, and the development community.

Data sharing between public sector agencies along with the integration of data from third party sector sources has elevated the need for improved data fusion and the value of improved analytics.

- Reconciling data from multiple sources: When agencies seek to combine multiple sources of traffic data for a roadway segment or multiple agency reports for the same incident they need to apply fusion algorithms to reconcile the data to generate accurate information
- Predictive Analytics: The growth of data repositories makes it possible for agencies to mine historical data and use predictive analytics to make inferences about emerging traffic conditions.

3.2.3.2 *Technology Applications*

The public sector is continually attempting to keep up with technology innovations that enhance ATIS. Throughout the past decade, public agencies were early adopters of technologies to promote a variety of traveler information services including 511 telephony and websites; websites and mobile apps to support multi-modal trip planning and provide real-time transit vehicle location information, and parking information systems. In light of the changing landscape, public agencies are looking for more cost-effective ways to use technology to enhance their ATIS capabilities:

To offer travelers ATIS that provide comprehensive end-to-end trip planning across time, space, and modes, public agencies are seeking ways to consolidate services and applications.

- Multimodal trip planning – many public agencies, especially those with strong public transit systems, continue to push the envelope in creating a single access point that incorporates a broad spectrum of multi-modal trip planning capabilities
- Corridor-based information – Following in the footsteps of the I-95 corridor coalition, the demand for corridor-based information has increased the number of multi-state coalitions that pool resources to create applications that extend across jurisdictions

The public sector is becoming increasingly aware of the opportunity to harness the power of social media and crowdsourcing to support TSM&O. Crowdsourcing has emerged as a low-cost approach to generate data by enlisting or encouraging citizens to participate in data collection and verification.

Today, any equipped person or vehicle can serve as a data collector or data source. Social media applications like Facebook and Twitter offer new ways to quickly disseminate information.

3.2.3.3 *Increased Role of the Private Sector and Outside Organizations*

The most significant trend among public agencies is the growing sentiment that components of the ATIS value chain services should be outsourced to the private sector. Public agencies have recognized the increased role of the private sector to provide critical data needed to generate real-time traveler information. Third-party data providers have made significant inroads in selling traffic data to support TSM&O activities.

Fusing and analyzing big data is an area that the private sector and non-agency organizations has excelled at. The work by Google to integrate transit data and the Regional Integrated Transportation Information System (RITIS) from the University of Maryland are examples of successful initiatives to normalize and fuse data from many state agencies.

In recognition that many travelers are using private sector systems and applications for traveler information services, public agencies are scaling back activities to deploy ATIS.

- Scaling back of 511 Services: Several state DOT's have started to question the long-term costs of developing, operating, and maintaining 511 systems (state-sponsored telephony, websites, and mobile apps). There have been discussions to consider eliminating components of their systems and/or scale back the annual budget for operating, maintaining, and enhancing these systems.
- Mobile applications: The private sector is better equipped to keep up with changing technologies, especially as it relates to developing and maintaining mobile applications. The public sector is moving toward embracing the notion of Open Data and making data more readily available to the developer community to spur innovation.

3.2.4 Challenges

The public sector is facing several challenges as its role to support EnableATIS is evolving in response to the changing landscape.

3.2.4.1 *Systems Management and Operations*

The ability of TMCs to effectively manage freeway operations and reroute drivers around incidents and planned events is more challenging in an environment where drivers are relying on private sector ATIS. When DMS and/or HAR were the primary source of information, TMC operators had more control to influence driver behavior. It is significantly more difficult to attain "system optimal" conditions in an environment that effectively operates as a competitive, non-cooperative game between drivers who have varied levels of access to information. Without the ability to directly influence the information being shared with travelers, TMCs will increasingly need to develop predictive analytics and active traffic management strategies to manage operations. It will also be necessary to develop strategies to cope with potential problems caused by high levels of market penetration for ATIS-related devices such as the possibility that too many vehicles divert to facilities with inadequate capacity in the presence of an incident.

3.2.4.2 *Data Governance and Management*

As the emphasis shifts in the public sector from information provision to data governance and management, agencies need to develop the skills and policies required to support these activities.

- Support the development of the infrastructure and technical capabilities to fuse, store, and utilize data from multiple disparate sources and develop proficiency in data analytics and large database management techniques.
- Create and manage Open Data portals to share data, broadly, including with the developer and practitioner communities
- Develop and expand efforts to improve data validation while ensuring data quality, integrity, and the privacy and security of data

3.2.4.3 *Overcoming Institutional and Operational Barriers*

Transformative ATIS programs require increased sharing of data and partnering between public agencies and with private sector partners. It also requires adapting to more agile, dynamic approaches to systems engineering.

- The public sector needs to continue working to reduce barriers that prevent integration and embrace best-practices for standards based data exchange.

The public sector needs to become more comfortable with open innovation models. Today, most public sector contracts are closed-end with fixed deliverables and schedules. The software development community has moved toward agile development and changes to the systems engineering approach should be considered to embrace a more dynamic process.

3.2.5 Summary

There is a rapidly changing landscape for public agencies as it relates to ATIS. A reduction in available resources combined with increased appetite by the public and companies for data and information and the proliferation of private sector ATIS services is causing the public sector to reassess its role across the ATIS value chain. While the public sector has traditionally taken the lead in data collection and deploying systems to disseminate traveler information, there is a growing realization that agencies need to consolidate services and rely more heavily on the private sector.

The public sector is accepting their role in aggregating and sharing data to empower the developer community to develop innovative ATIS applications. Public agencies are reducing their spending on developing and operating ATIS services, including 511 systems and mobile applications, and are focusing their efforts toward data management, system management, and governance. Through increased cooperation between agencies and partnerships with the private sector, the public sector is helping to create comprehensive real-time data repositories to support multi-modal end-to-end ATIS.

3.3 Private Sector Perspective

This section follows Jon Bottom's briefing slides from the session.

3.3.1 Overview

The private sector can play a major role in providing data and analytics to support all of the activities mentioned above. For this to happen, the proper incentives must exist in the marketplace. However, government can catalyze the development of the market in a variety of ways, for example by establishing standards, promoting R&D or sponsoring high-impact demonstration projects. It is perhaps less appropriate for government itself to develop the systems that provide travel information to end users, as private sector firms have shown that they can be very effective at doing this.

3.3.2 Deployment Trends

The private sector traveler information industry includes a growing number of general travel and traffic data providers. These firms aggregate a variety of types of raw travel data and filter the data into estimates of prevailing travel conditions (or in some cases forecasts of future conditions), which are then the basis of information messages disseminated to users, either directly or via third-party data re-packagers. Some firms disseminate raw unprocessed data, others maintain historical files and still others provide origin-destination data. This industry sub-sector is characterized by strong economies of scale and barriers to entry. These result from a number of causes, including the considerable hardware and software resources needed to efficiently process very large volumes of raw data, particularly in real-time; the agreements (sometimes exclusionary) made with public sector agencies that generate some of the raw data; and the benefits in terms of data quality resulting from having available large amounts of diverse data types relevant to travel condition estimation.

Several firms have emerged that develop and deploy innovative specialized technology for data collection or analytics. As one example, AirSage has established agreements with Verizon Wireless and Sprint to access anonymous raw data on cell phone movements, and has developed proprietary algorithms to process this data into estimates of travel times or aggregate OD volumes between suitably-defined geographic zones and over particular time periods. The algorithms also attempt to infer trip purpose (for example journey to work) and traveler characteristics (for example area visitor or resident) from the raw data. As another example, a number of firms have technologies for anonymously identifying Bluetooth devices inside passing vehicles and recognizing a given device at different locations and times, thus enabling estimates of point-to-point travel times and volumes. These specialized firms tend to focus on collecting and processing a single type of data and so may miss out on the data enrichment opportunities that result from combining multiple distinct data types, as is done by the larger data aggregators.

At the same time, larger and more general information provision and communications technology firms have come to recognize the value of being able to provide traveler information along with their other information offerings, and so have acquired travel information firms. Examples of this include the recent acquisition by Google of Waze (still under antitrust review), and of Navteq by Nokia (now Here). Microsoft in turn has announced its intent to acquire Nokia's mobile devices division in 2014, presumably bringing Navteq's mapping and traveler information capabilities to its smart phones and to Bing. These companies tend to monetize their services indirectly, for example via targeted advertising on a travel information web site.

Notwithstanding the availability of online multi-modal travel information from large information providers at no cost to end users, transportation agencies sometimes prefer to develop and deploy their own custom websites or other information platforms. Agencies may want to present unique presentations of different travel data sources, or simply to control the message that travelers receive when they search for information related to the agencies. There is a vibrant market of smaller firms

developing specific online ATIS applications, particularly for public transit agencies or in the area of integrated multimodal information.

3.3.3 Opportunities

Developments currently in process will provide opportunities to enhance the quality and value of ATIS in the future.

3.3.3.1 *New and More Diverse and Informative Sources of Data will Become Available*

The government's connected vehicle program, with components of vehicle –to-vehicle and vehicle-to-infrastructure communications, will provide a wealth of real-time vehicle position, movement and performance data that ATIS should be able to exploit to develop improved traveler information. Increased market penetration of mobile cellular, GPS and Bluetooth devices are currently making available increasing amounts of traveler and vehicle location data that, with required guarantees of anonymity where appropriate, can be tracked and used to better understand travel patterns. Increasingly capable smart phones and other smart mobile devices will allow a more personalized and detailed interaction between end users and traveler information providers, serving both to collect data on traveler intentions and actions, as well as to present information to users in a relevant, safe, and actionable way.

3.3.3.2 *Technology Evolution*

Continued improvements in the hardware, software and algorithmic capabilities that are being developed to address the growing needs of Big Data in general can be expected to apply to the specific processing requirements of traveler information systems as well. Large aggregators such as INRIX develop proprietary IT solutions for the fusion and processing of their diverse data sources, while more specialized firms can sometimes meet their key data processing needs using off-the-shelf software, including open source packages such as Hadoop. Both of these application types are likely to be able to take advantage of broader industry advancements in processing and analyzing large and diverse data sets.

As mentioned, increasingly capable smart phones and other smart mobile devices will make it possible for traveler information providers to interact more effectively with end users, enhancing the relevance of the provided information to users and at the same time obtaining detailed user-level data that can be incorporated in improved travel information generation.

3.3.4 Challenges

As private sector firms continue the development of traveler information services, they will confront a number of challenges.

3.3.4.1 *Data Collection and Fusion*

The effort for collecting, fusing and processing increasing amounts of increasingly diverse data in real time requires a large cost commitment and can be a barrier to entry for smaller firms. Very significant hardware and software capabilities are needed to do this and in fact the magnitude of these requirements constitutes a barrier to entry for new firms wanting to perform travel data aggregation, as noted above. Development of predictive travel information is an even more challenging computational problem that will need to be solved in real time in order to be useful.

3.3.4.2 *Privacy Concerns*

Privacy and anonymity concerns surrounding some types of potentially very useful raw travel data will need to be successfully addressed by the industry. Having access to data on individual traveler behavior will enable the development of better estimates and forecasts of travel information, and also allow more customized information to be provided to end users. The constraints on access to and use of such data are sometimes ill-defined. Traveler information firms will need to find and maintain a careful balance in a changing legal and societal environment.

3.3.4.3 *Understanding Traveler Behavior*

Current understanding of how travelers obtain and use information in making travel decisions is very primitive, and will need to be considerably improved as systems that provide predictive or individually customized travel information are increasingly deployed. This will require a sustained program of data collection, research and communication of results to the industry.

Improved capabilities for collecting information from users as they receive and respond to actual traveler information in real time will enable the design and deployment data collection and research efforts that will lead to an improved understanding of traveler use of information, and to better methods for generating accurate, relevant traveler information.

As travel information systems based on predictions of future travel conditions are increasingly deployed, the reactions of travelers to the predictions that they receive will significantly affect the future travel conditions themselves. Predictions that do not factor in travelers' reactions to the predictions will likely be invalidated by those reactions, becoming self-defeating prophecies. Approaches for addressing this issue have been explored in academic research, but are far from ready for deployment on a large scale. While this issue is general and does not only concern private sector ATIS trends, practical solutions to this problem will need to be developed in order for predictive traveler information systems to be ready for effective deployment by the private sector.

3.3.4.4 *Monetizing ATIS*

Lastly, the challenge of private sector providers of traveler information will be to find effective ways to monetize the value of the information and services that they provide.

3.3.5 Summary

The private sector traveler information industry is characterized by considerable concentration among a few data aggregation and provision firms, and by an additional set of more specialized firms offering specialized travel data collection and processing technologies, or that develop custom information dissemination platforms. There are substantial barriers to entry for new data aggregation firms, and also a trend for large general information providers to acquire ATIS in order to offer traveler information along with their other offerings. The business model of these general information providers relies on indirect revenue generation from sales of targeted advertising, rather than direct sale of the traveler information itself to end users or data re-packagers.

There is increasing reliance by traveler information firms on the smart use of available general data sources – anonymous cell phone or Bluetooth data, crowd-sourced data, data from probe vehicles – and less on dedicated fixed data collection equipment such as loop detectors. Firms that have developed specialized technologies to process specific types of data tend to work with those data

types to the exclusion of other more general data, even when a data fusion effort combining the different data types might lead to better quality traveler information.

A better understanding of how people incorporate traveler information in their decision-making would increase the relevance of the information to end users, and allow better predictions of network-level travel flows and conditions as these are affected by information itself.

3.4 Impacts on the EnableATIS Vision

As described above, the ATIS marketplace is experiencing transformative changes. The private sector, building on substantial contributions from the research community and input from USDOT, has been responsible for introducing many of these changes and expanding the range of ATIS offerings that are available. In response, the role of the public sector is also changing, with agencies focusing more on core data management and governance activities and on using ATIS products of the private sector, but generally reducing their activities related to data collection and to developing specific end-user applications.

These developments are generally consistent with the Operational Concept's Laissez Faire scenario, and somewhat less so with the Robust scenario. Public agencies interact synergistically with the private sector as producers of raw data and consumers of processed data, but government's role in guiding the advancement of ATIS is indirect rather than direct. The private sector has demonstrated innovation and dynamism in developing offerings that progress the current state of ATIS and provide value to a range of users. With budget constraints heavily affecting the public sector, it is sensible for government agencies to avoid duplicating activities that the private sector has shown itself capable of undertaking efficiently.

Nonetheless, it is the sense of the Noblis EnableATIS technical support team that government – and particularly the Federal government – can positively influence the pursuit and attainment of the EnableATIS vision and transformative goals. The final sections of this document describe a strategic planning exercise carried out by the technical support team to characterize and rank outcomes, and to identify research opportunities, in order to elucidate the definition of an appropriate Federal role. First, however, the next chapter provides a description of ATIS developments in the UK, where the central government has had a more robust role in guiding and promoting the growth of the market.

4 Lessons Learned from the UK

To provide a different perspective on the state of ATIS, Craig Nelson provided a review of traveler information systems in the United Kingdom. Due to its smaller size and greater dependence on multi-modalism, the ATIS environment in the UK more closely resembles the "Robust" operational scenario. The national support for multi-modal trip planning offers some interesting lessons for the EnableATIS program.

4.1 Introduction

This chapter will provide an overview of traveler information systems in the UK and the lessons that can be learned from their development and operation. This includes:

- National trip planners and information systems
- Roads based information systems and websites
- Data management
- Real-time information systems

Since 2004, the UK has had a national door-to-door multi-modal trip planner that has been through various phases of development, including the introduction of a bicycle trip planner. The UK also has a centralized passenger information system for the national rail network and for users of the UK's trunk roads and motorways. Local and regional gaps are normally filled by local government-funded systems or private sector companies.

4.2 Overview

4.2.1 Traveler Information in the UK and its Organization

Since 2000, and due to investment from the Government, the UK has pushed forward with developing data standards, systems and public-facing platforms for the provision of electronic transportation information. Much of what has been developed could be labelled as advanced, especially the deployment of real-time information systems and use of interactive websites to broadcast traveler information. Much of what has been developed over the past ten years or so has been publicly-funded (but delivered by the private sector), but we are seeing more third party providers entering the market since previously unavailable data has been made open by the UK Government.

The UK currently has three publicly-funded key web resources that publish national traveler information: Transport Direct (for national door-to-door trip planning), Traffic England/Wales/Scotland (for live roadway traffic information) and National Rail Enquiries (for national rail trip planning and station information). Much of the data that is published has been collected by regional or localized systems or Intelligent Transport Systems infrastructure. Efforts are being made to add value to ITS investments and to make technology more visible to the traveling public.

4.2.1.1 ***Public Transportation***

The British public has a number of options when planning a door-to-door trip using ATIS technologies. The better systems are publicly-funded, but it should be noted that Google is slowly integrating UK transit data into its Google Maps trip planning application. The national transit trip planning website, Transport Direct, was made live in 2004 and built on the work carried out by Traveline to provide impartial travel advice via the web and telephone. More detail on this relationship is provided in section 4.4.2 of this chapter. In short, it is easy to plan a door-to-door public transit trip via the web or via a call center, no matter where one lives in the UK. The quality of responses will vary, but generally the UK is good at providing this type of information to the public. In addition to national and regional systems, there are also local trip planners and information portals that provide location-specific information and that normally come under the umbrella of a local government website or a branded sustainable travel campaign.

Real-time information is found in many UK towns and cities and is seen by travelers as an easy way to understand complicated bus schedules. Many websites and apps give a simple countdown to bus departures for a specific stop, using AVL technologies fitted to vehicles. Transit operators are also investing in AVL systems in order to better manage their fleets.

Figure 4–1 Transport Direct Web Portal

(Source: Noblis/Steer Davies Gleave, from public website: http://www.transportdirect.info)

4.2.1.2 *Road Transportation (Including Freight)*

The UK has a broad range of ITS deployments for monitoring traffic on the national strategic road network (SRM) and local road networks. The UK Highways Agency (HA) is responsible for the monitoring of the SRM and individual local/regional government authorities look after local roads.

Local authorities deploy their own ITS for road network management. These systems will normally utilize CCTV, traffic management systems (such as SCOOT) and in some cases AVL to capture real-time snap shots of road conditions and provide the public with information. Many ITS systems will be Urban Traffic Management and Control (UTMC) compatible, through the adoption of the UTMC technical guidelines for ease of system integration and compatibility with neighboring systems.

Traditionally, the ITS deployed nationally and regionally do not communicate with one another, but this is changing as more open data standards are adopted and non-proprietary systems are deployed. The SRM is controlled and managed by a series of Regional Control Centers and the National Traffic Control Center. These control centers then provide information to roadside information systems (such as roadside Variable Message Signs), the emergency services, the media (TV and radio), social media and official websites. There are also a number of data feeds that can be accessed from the HA for incorporation into websites, trip planners and apps.

The big push for ITS in the UK at the moment is 'Smart Motorways'. This system, which automatically opens motorway shoulders to traffic when main lane volumes are high, uses detector technologies and overhead VMS to control speeds and actively manage traffic at peak times, similar to active traffic management in the US.

Figure 4–2 Smart Motorways Technology
(Source: UK Highways Agency - from http://www.highways.gov.uk/our-road-network/managing-our-roads/improving-our-network/smart-motorways/ under Open Government License)

4.2.1.3 *Cycling and Walking*

The UK has two bicycle trip planning resources – Transport Direct and Cycle Streets. Cycle Streets is a national not-for-profit trip planner that uses data sourced from Open Street Map. This means that the community can contribute to the underlying trip planning network and see this contribution appear in trip planning results where gaps occur, something which the Transport Direct system does not offer

(and has been criticized for). Cycle Streets offers an API for third party developers to integrate with existing trip planners. This has been used effectively in Swindon Borough, City of York and Warwickshire County, among others.

Walking trip planners are light on the ground, but are offered by Walkit.com and Cloudmade (an open data broker that also has a walking route engine).

4.2.2 Trends

4.2.2.1 *Real-time Information and Transit Management*

As previously mentioned, real-time information for public transit is popular in the UK. Up to 2012, 44 local authorities had invested in real-time information systems for buses, with over 17,500 vehicles equipped with AVL technologies. Approximately 10,000 bus stops are equipped with digital countdown displays, with the majority being found in London. With the proliferation of smartphone technology it should be remembered that many people will access real-time information via apps and mobile websites – 33 local authorities are now providing real-time information via the mobile web.

In addition, transit operators (private) are using AVL systems to manage their fleets more effectively. Where previously operators were averse to investing in AVL technology (they didn't see passenger information as a cost effective way to increase patronage and grow revenues), they now see the business case for putting equipment onto their vehicles and into depots for the purposes of managing their business better.

For further information on UK trends in real-time information, as well as useful funding insights, please consult the Public transport technology in the United Kingdom: Annual Survey 2012.

4.2.2.2 *Open Data*

In line with the rise of real-time information systems deployment has been the release of real-time data in standardized formats. The UK NextBuses API provides a single data feed for all real-time 'equipped' bus stops in the UK (providing that the local authority has arranged for a data feed of their own), enabling bus stops to offer real-time departure information. This system, which is free for use, works by sending a NaPTAN code to NextBuses, which then returns the next bus departure times for that stop in XML format. NextBuses uses the CEN SIRI standard for real-time information data exchange. The release of this data has allowed a number of smartphone apps and websites to be developed.

4.2.2.3 *Third Party Apps*

Third party apps for trip planning and access to real-time information are popular in the UK, as they are in the US. In London, where real-time and trip planning data was made 'open' to developers, a number of best-selling iOS and Android apps have been released. They include Buschecker and CityMapper.

4.3 Data Production and Management

4.3.1 Static Transit Data

Static transit data underpins the main traveler information systems in the UK. Since 2000 there has been an emphasis on developing standardized formats for the sharing and exchange of data.

In the UK bus services are run by private operators under competitive contracts to local authorities. This means that a single town or city may have two or more operators competing on multiple routes. By law, a bus operator must provide a local authority (plus other government organizations) with a bus registration document 56 days ahead of a new service starting or an existing service being amended. This bus registration is normally a paper-based document that provides the geographical route, timing points and a schedule.

The local authority is then responsible for turning the registration document into public information, normally via a scheduling software application such as Routewise. The schedule data is then passed, on a weekly basis, to the regional Traveline center and Transport Direct for inclusion in electronic trip planners. It is also passed to the real-time information system deployment (if available). Lastly, it may be used to produce static timetables for presentation at bus stops and interchanges.

With regard to rail information, each regional Train Operating Company in the UK provides National Rail Enquiries (as well as Traveline and Transport Direct) with its schedule information. This is imported into the NRE trip planner for rail-specific trip details.

4.3.2 Real Time Data

Transit real-time systems sometimes operate in isolation, although there is often a need for 'cross-border' information sharing between two systems, such as when a bus leaves one county and arrives in another. The SIRI standard allows for such integration and has been used with varying degrees of success in the UK.

Real-time transit information systems were kick started by a GBP 20 million (around $32 million) UK government investment in local deployments, as part of the Transport Direct program.

4.3.3 Open Data

In 2010 the Government made two key data sets available as open data – the Traveline National Dataset (which is updated weekly) and the NaPTAN database of all bus stops and intermodal connection points. Previously this data was not available for free to download. The datasets have been used to create smartphone apps and web applications.

The data.gov.uk website provides national snapshots of key datasets, all available for free.

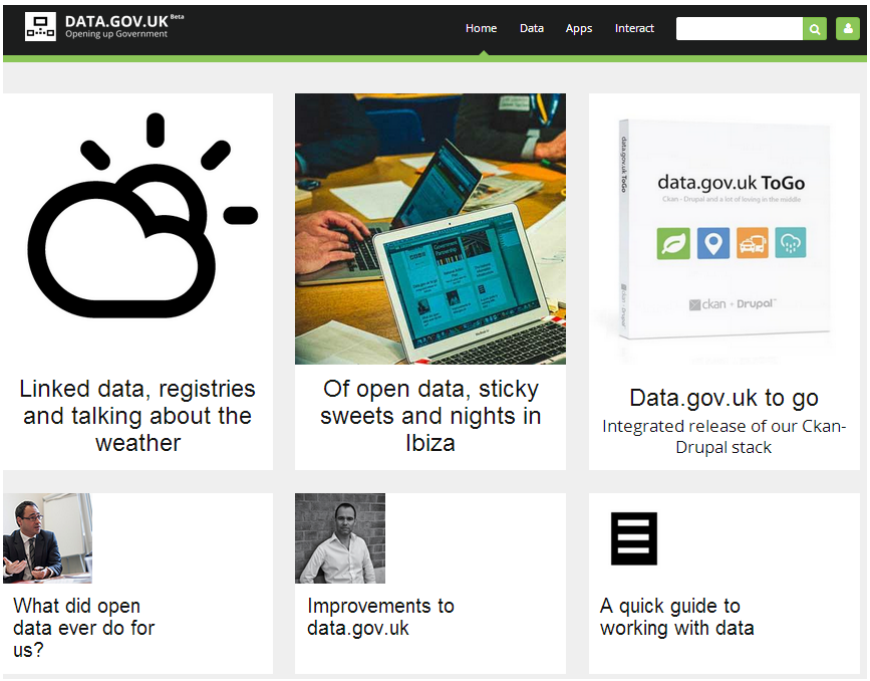

Figure 4–3 UK's Open Data website
(Source: Noblis/Steer Davies Gleave, from public website http://www.data.gov.uk)

4.4 UK Key Information Providers and Approaches

4.4.1 Traveline

Transit trip planning is available across 11 regions of the UK and has been so since 2000. Each trip planner is linked to a call center, for the provision of impartial transportation advice, and is run in partnership with UK local authorities and transit operators. Local authorities pass data to Traveline on a weekly basis, based on bus registration documents provided to them by local bus operators. The organization that runs the regional planner imports and publishes the new data sets.

Trip planning is available via a web-based trip planner and a call center. There are also localized apps available for trip planning and real-time information access. Each Traveline region shares its schedule data with Transport Direct for national door-to-door trip planning.

Due to differing levels of data quality in each region, results will vary in accuracy, but Traveline is generally thought of as a trusted information resource in the UK. One of the main issues is associated with the bus registration process. Often this registration arrives at a local authority in paper format and has to be digitized – this is where double data entry errors can occur. Electronic Bus Registration (EBSR), which uses the TransXchange data format, is available for bus operators to send their registrations electronically, but it has not been extensively adopted (by 2010 only 21% of all registrations were done via EBSR).

Traveline started making its data set publicly accessible, in the guise of the National Transport Data Set, in 2010. Each region also has a licensed trip planner API for the use of third party developers. This has been used by local authorities to create locally-focused multi-modal trip planners and apps.

4.4.2 Transport Direct

In 1998, the UK government announced that a national multi-modal traveler information system would be developed by 2000. The project, known as the Transport Direct Program, sought to provide door-to-door trip planning for anywhere in the British Isles, including transit and driving routes. In addition to the development of a public front end, a data project was set up to provide the system with the required information to power the trip planner. This involved the establishment of a number of data standards, including a data exchange format for schedule information (TransXchange), a national standard for the exchange of public transport access point information and naming (NaPTAN) and a server-to-server real-time information CEN standard (SIRI).

Transport Direct also broadcasts information provided by the Highways Agency, for road travel information.

The Transport Direct Portal was launched in 2004 and offered national multi-modal (public transit and driving) trip planning for Great Britain, using data sourced from the Traveline regions and the national roadway network. In 2009 a bicycle planner was added to the portal. The project, developed by ATOS Origin and the UK Department for Transport, cost over GBP 55 million (around $89 million) of public money to develop, with the portal costing GBP 5.9 million (around $9.5 million). The portal has approximately 1.5 million user sessions every month.

4.4.3 National Rail Enquiries

National Rail Enquiries is a website, run by the Association of Train Operating Companies (ATOC), that provides national station-to-station and postcode-to-postcode rail trip planning, as well as live departure information, links to ticketing and station information. NRE also licenses its data feeds for departure information and trip planning – previously there was a charge, but we understand that it is now free and not as restricted. NRE also provides data to Transport Direct and Traveline to include in their trip planners. Previously, ATOC decided to switch off a free to use API, impacting the developers of apps that used the data to provide trip planning information. This caused outcry within the developer community as they then had to sign up to a paid for service.

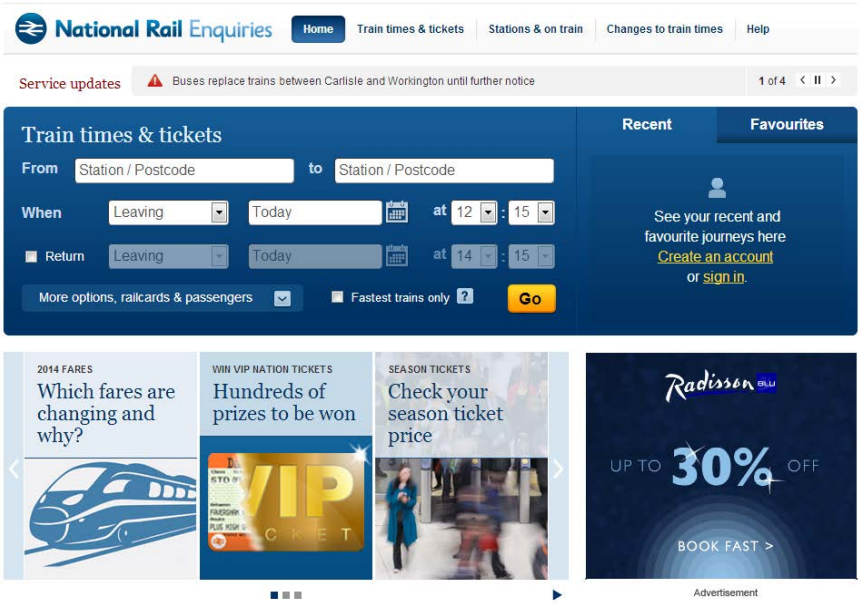

Figure 4–4: National Rail Enquires Website

(Source: Noblis/Steer Davies Gleave, from public website http://www.nationalrail.co.uk)

4.4.4 The Highways Agency

As previously noted, the Highways Agency collects information about the current operational state of the SRN, using traditional ITS systems technologies. This allows the Agency to have strategic control of the network, and using historical data, enables it to predict traffic movements and adjust accordingly. Much of the information is disseminated via broadcast media (in particular via radio stations) and the web. Separate websites are provided for England, Wales and Scotland and each of them uses real-time data collected by ITS and presents it to the general public for trip planning. There is also data on known disruptions to the network, such as upcoming events, road works or intersection closures. Information is generally presented to the public by interactive map, but the system does not offer dynamic trip planning (where a route can be planned that avoids congestion or disruption).

Data feeds are available for incorporation into websites, apps and trip planners. The Travel West website and trip planner use HA data to indicate if a chosen route could be delayed by road works and disruption.

4.4.5 Local and Regional Governments

Local and regional government organizations provide locally-focused public transit, parking and roads information, and, in some cases, more detailed information about cycling and walking. There are three ways that local authorities may provide this information – via their existing local government website; via a dedicated branded multi-modal information portal or via a mobile app/website. In more recent years, local governments have moved towards the last two options in order to make information more accessible, with private firms being contracted to design and deliver the projects. The websites are often user-focused and provide key information on different modes. Some websites focus on providing information about sustainable transportation options, such as Swindon Travel Choices. Some authorities in the UK are solely responsible for transportation, such as Transport for London – they have their own information websites, with a primary focus on public transit trip planning.

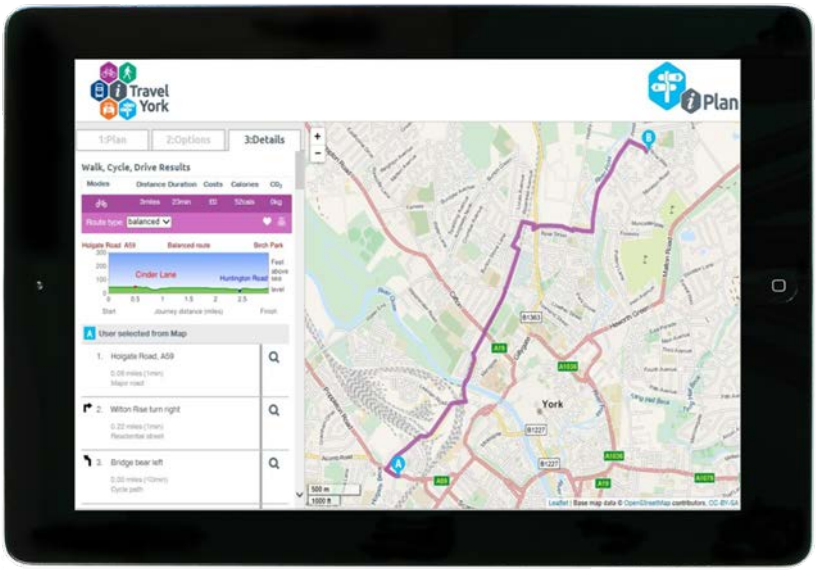

Figure 4–5: iTravel York Multimodal Trip Planner
(Source: Noblis/Steer Davies Gleave)

4.4.6 Private Sector Information Providers

The main, or most widely used, private sector provider of ATIS in the UK is probably TomTom, the GPS manufacturer. TomTom heavily promotes its dynamic GPS system that routes drivers around congested areas, as well as their iOS and Android apps. Apple and Google also provide mapping and route planning services in England. Google does not have full coverage of English bus operations, so there are considerable gaps in where trip planning can be carried out. Google does use road data to provide real-time congestion information, as well as to indicate whether a trip will be delayed.

INRIX is also active in the UK, and offers a roadway information and route planning service to subscribers (mainly freight operating companies).

4.4.7 Social Media and Crowd Sourced Information

The use of social media for advanced information provision is still in its infancy in the UK, but it does hold great potential. It has largely been embraced by rail operating companies and National Rail to communicate with their customers – in particular when they are en route. Many travelers have taken to Twitter to either complain about a service (they will often mention the operator in the tweet) or to ask about a particular trip plan. Travelers can also follow a particular Twitter account for their regular commute or operator (such as https://twitter.com/SW_Trains) – this will be used to warn of delays and, importantly, tell travelers why their trip is delayed. Social media thus performs the function of a public relations tool and a travel information service, as well as being highly cost effective.

Social media can also be used to gather information on the roadway network, particularly in areas where there may be no ITS sensor technology or where systems are slow to report incidents. A pilot project in Scotland used Twitter to capture information about rural road conditions during the winter – this actually built up a small community of local people who were willing to share information about road conditions (often closed due to snow) with other people.

Bus operators are also using Facebook to promote services and to communicate with their customers. Facebook is particularly useful for communicating with the younger demographic – especially large University towns where information about student passes and other promotions can be disseminated. Bus operators also want to make their brands 'cool' with the traveling public, and social media and real-time information (especially via an app) are proving to be useful platforms for this purpose.

Social media was heavily used during the London 2012 Summer Olympic Games as a travel demand management tool. It was used to make people aware of how busy London's network would be and to encourage the use of other modes.

4.4.8 Upcoming Big Data Projects and Innovation Agencies

The discussion so far has centered on individual systems collecting information and disseminating it via portals or dedicated web services. The next big step will be integrating all of this data, making sense of it, and providing dynamic information systems that link together different modes and sources of information. For example, how will road conditions and the prevailing weather affect a commute trip? Is there a viable public transport alternative?

In the UK, the city of Manchester appears to be a leading innovator in this area. The city collects a huge amount of data via its ITS, AVL and through social media. Manchester is currently in the process of developing a system that brings together all the data streams (as well as data streams from neighbors) and makes sense of them. Manchester then makes this data available to developers to create trip planners, apps and websites. The city already has an open data repository, so has a history of opening up useful data streams to developers.

The UK also has an 'innovation agency' called the Technology Strategy Board. It offers funding for innovative projects, including the use of open and 'big' data. Often, competitions are run and attract submissions from public organizations and private sector firms. More can be found out at this website: https://www.innovateuk.org/

4.5 Takeaways

The key takeaways are as follows:

- The UK follows the 'robust' operational scenario, but with an increasing focus on making data available to third parties for innovative developments. Much of the ground work, especially with regard to public transit information, was kick started by central government policy and funding opportunities for local government.
- UK government policy led directly to the creation of readily available electronic transportation information, including the Transport Direct project and the Transport Direct portal. Whilst a centrally managed system would be of benefit to the US, the logistics and day to day organization would be cost-prohibitive and technically complicated. Regional focus may be the best approach. The Transport Direct project, as a cost effective entity, is increasing being brought into focus especially with the rise in the private sector and players such as Google. Like 511 in the US, its role may have peaked.
- Much of the information provision in the UK is 'one-way'. The person has to seek the information, rather than have it 'pushed' to them. Twitter has provided a useful platform for this type of information exchange, but UK systems, in the most part, are not two way.

- The Highways Agency (which is a national entity) manages the motorway and trunk road ITS and any information that is produced from that data, using their own systems. Steps are being made to integrate this system with others, but currently it is only the Transport Direct portal that presents information on a publically accessible centralized information website.
- The 'Smart Motorways' project is not aligned or integrated with any national information system, in that it doesn't provide information as part of a journey plan, for example. Road speed data on motorways is made available to developers and third parties.
- Data standards and open data are key for national projects, especially with regard to data exchange principles. This should be considered when discussing EnableATIS and will be important to its take up across the US, especially where multi-state coordination is required – as part of a corridor, for example.
- Real-time information appears to be effective at getting people on to buses – more people are seeing apps as useful tools for using public transit. Investment by the UK government kick-started this push for real-time information. Nearly half of all UK local authorities now have an operational system. This ties in well with the vision for EnableATIS – for making better use of real time information.
- Bus operators are now seeing AVL as a useful way of monitoring their fleets and improving the way that their businesses are run. It would be worth exploring attitudes amongst transit agencies to this as it can become an important tool for monitoring usage.

Social media crowd sourcing has become a 'go to' tool for communicating with customers in real time. It was used very successfully during the London 2012 Olympic Games. It should become a core element of EnableATIS.

5 Strategic Assessment

5.1 Purpose

In support of the EnableATIS program goals, the vision of the two operational scenarios, and the discussion of public and private sector trends, the attendees of the strategic planning meeting participated in an exercise to develop a roadmap for enabling transformative outcomes or opportunities for ATIS. The participants were tasked with developing a framework to characterize the federal role for supporting EnableATIS opportunities:

- Identifying desirable outcomes or opportunities wherein traveler information provision might be transformed for the better
- Rating each outcome in terms of relative potential impact (high, medium, low) and overall risk (high, medium, low).

Characterizing the federal role needed to support achievement of the desired outcomes including funding research activities and addressing any challenges.

5.2 Outcomes

The group identified eight outcomes in support of transformative ATIS. For each outcome, the group assessed the impact and risk based on the following definition:

- ***Goal:*** Which of the transformative goals would be met by this outcome
  - EnableATIS will transform the user experience on the transportation network. Future traveler information systems will intuitively provide users with trip, location and mode specific information to empower real-time decision making.
  - As a result of EnableATIS, transportation networks will experience measurable gains in performance, including mobility, safety and efficiency.
  - A more robust traveler information suite of capabilities will be enabled through a rich and multisource data environment that leverages public sector system and operations data, and transportation network operations and user data from privately operated systems.
- ***Impact***: The ability (High, Medium, Low) of this outcome to support the vision statement and meet the goals of the EnableATIS program (as summarized in chapter 2).
- ***Risk***: Assessing the inherent risk (High, Medium, Low) of expending effort to achieve this outcome but failing to meet the program goals.

The outcomes have been rank-ordered based on “Impact” and “Risk” with High Impact – Low Risk being the optimal result.

Table 5-1: Desired Outcomes for a Transformative EnableATIS program

Rank	Outcome	Description	Goal	Impact	Risk
1	User Optimal	Travelers experience personalized and optimized services improving their mobility in exchange sharing position, transactional and decision data generated by interaction with the new services	a	High	Low
2	System Optimal	Traveler use of ATIS services generates data that when combined with multi-source (private and public) connected traveler/vehicle data transforms transportation system management.	b	High	Medium
3	Improved Analytics	Integration of disaggregate connected traveler/vehicle data will improve data fusion, prediction, and feedback control.	b,c	High	Medium
4	Overshift Control	Dynamic control systems and algorithms are in place to leverage connected traveler data effectively to mitigate or eliminate collective over-shift control effects, even at high-market penetration rates	b,c	High	High
5	End-to-End Trip Planning	True end-to-end multi-modal trip planning and real-time information services are deployed seamlessly across multiple jurisdictions (state and local), modes and platforms speeding widespread deployment	a,c	Medium	Low
6	Intelligent Services	Self-learning systems widely found on apps/devices to learn traveler behavior over time to improve application effectiveness (user perspective) and accumulate longitudinal data (manager perspective)	a,b,c	Medium	Medium
7	Manager Influence	Public sector agencies can effectively, accurately and consistently influence the display of data throughout the market, including private sector applications.	b,c	Medium	High
8	Improved HMI	New forms of ATIS are deployed that improve the human-machine interface (HMI) including reducing driver distraction effects.	a,c	Low	Low

5.3 Relating Desired Outcomes to DMA Decision Chain

The vision of the Dynamic Mobility Applications program is to expedite the development, testing, commercialization, and deployment of innovative mobility applications, fully leveraging both new technologies and federal investment to transform transportation system management, to maximize the productivity of the system and enhance the mobility of individuals within the system. To model various program hypotheses and illustrate the data and decision flow within a connected transportation system, the following framework was developed.

On the far left side of Figure 5–1, there is a column of System Users, who represent the travelers, drivers and workers who directly utilize the transportation system and seek traveler information services to guide their decision making. At the far right of Figure 5–1 are the System Managers, who

control a particular aspect of the system and are responsible for ensuring the safe and efficient operation of their element of the complete system. ATIS is one of the primary elements of the ITS toolbox that support transportation systems management and operations. This framework depicts an integrated system by which System Users and System Managers can be connected by technologies that deliver data and information, the communication systems that serve as the conduit for data and information flow, and the operational data environments that provide the models and tools for aggregating data transforming data into information and decision support.

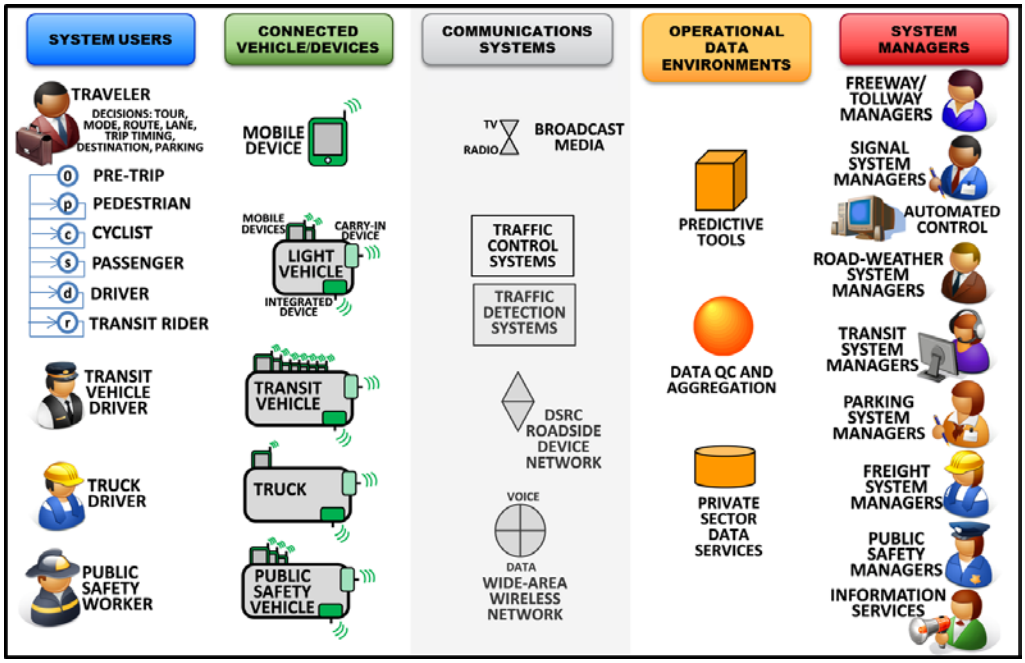

Figure 5–1 DMA Decision Chain Framework
(Source: Noblis)

The Laissez Faire operational environment favors a "User Optimal " condition as there are stronger market incentives to develop innovative end-user products that provide personalized information services. There are limited incentives for application developers to be concerned with system performance and the needs of the system managers. System users are mainly concerned with optimizing their travel experience, even at the expense of other travelers.

As market penetration rates for ATIS devices increases, travel patterns become more chaotic as a greater number of system users adjust their routes in response to congestion. This inevitably leads to a decrease in network performance as system managers cannot reliably predict traffic flows and efficiently allocate traffic across the network.

In moving from the Laissez Faire environment toward a more Robust environment requires acknowledging and supporting the efforts of system managers who strive to achieve better system performance by introducing some level of prediction, control, and feedback into the ATIS delivery process. Figure 5–2 shows a version of the framework which includes a complete decision value chain as part of a cooperative environment in which system managers influence how and what information is disseminated to system users to promote system performance and achieve performance metrics. This requires participation by users to provide data on their travel patterns and

preferences which, in turn, feeds the models and services that help system managers monitor and manage system performance.

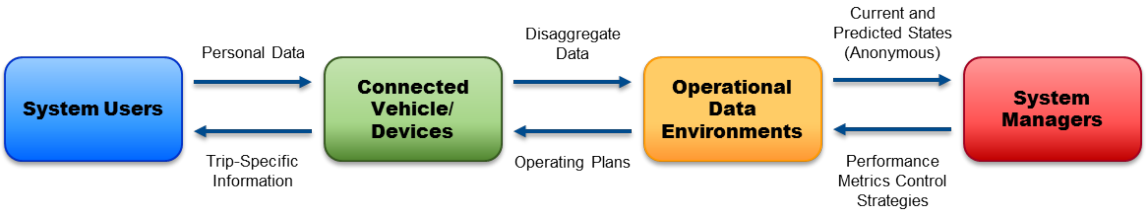

Figure 5–2 ATIS Decision Value Chain
(Source: Noblis/Open Roads)

5.3.1 *Data Flow from Users to Managers*

1. System users subscribe to information services and provide personal data on travel choice and preferences
2. Data is quality checked and aggregated then used to drive tools and services
3. Current and predicted state information is used by system managers to assess network performance and operate their systems

5.3.2 Information Flow from Managers to Users

1. System Manager specify performance metrics they are trying to achieve and the control strategies to be imposed on the system to acThankujehieve these metrics
2. The tools and services create operating plans to incorporate the metrics and strategies into traveler information services to be pushed out to the travelers
3. Personalized, trip-specific information is delivered to individual system users

This framework is useful for illustrating how the eight outcomes for the EnableATIS program correlate with improving the core steps in the supply chain

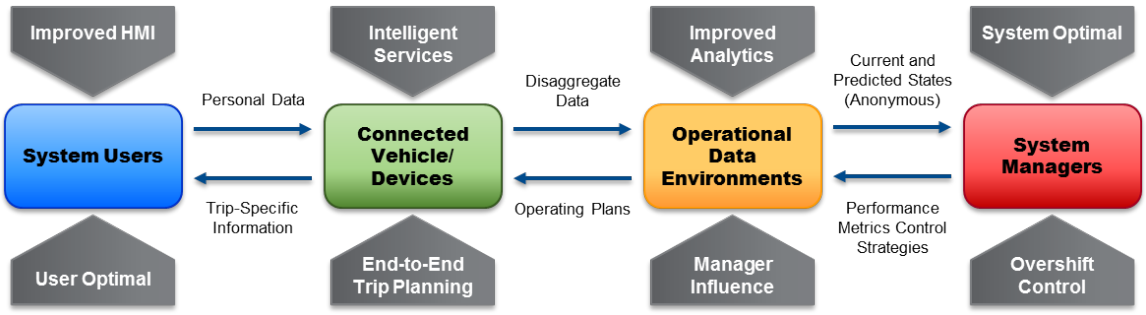

Figure 5–3 Outcomes Across the ATIS Decision Value Chain *(Source: Noblis/Open Roads)*

5.4 Federal Role

Based on the prevailing trends in the public and private sectors cited earlier in the study and the success of governments in other counties, such as the UK, to introduce centralized services that aid the ATIS marketplace, the Federal Government can effect transformative changes by supporting the

development of a cooperative value chain and promoting those activities that the Laissez Faire nature of the marketplace would not encourage. There is strong incentive for the private sector and research communities to focus on areas in which there is high demand and potential profits for products and services – such as user applications, devices and interfaces, and data services. This marketplace will continue to evolve and grow. Alternatively, the marketplace is weaker for services that are consumed by system managers. The cost of entry is high, demand is low, and there are more barriers to overcome.

The Operational Concept identified five core roles that the Federal Government could play in supporting transformative research and activities to Enable ATIS.

1. Facilitate Vision and Coalition Building.
2. Lead and Support for Public Private Partnering.
3. Sponsor Fundamental Research and Research Initiatives.
4. Innovate and Implement Technology.
5. Operate and Manage Systems

State governments have less funding to invest in new technologies and services and are looking to the private sector to offer lower cost solutions. As the power of ATIS continues to shift from system manager to third-party providers, the Federal Government can play a central role to build the vision, support private-public partnerships, and support research that will solidify the system optimal position in the value chain.

5.4.1 Facilitate Vision and Coalition Building

Developing a cooperative value chain requires the participation of public and private sectors. While public-private partnerships are evolving naturally in the marketplace, the Federal Government should assume a leadership role to offer guidance and incentives to accelerate this process. Activities that would fall under this umbrella include:

- Expanding support for state and corridor coalitions to pool resources to invest in new services and research
- Supporting innovative public-private partnerships including data sharing programs
- Creating testbed and demonstration programs that require public-private cooperation

5.4.2 Sponsor Fundamental Research and Research Initiatives

In pursuit of the desired transformative outcomes, there are several opportunities for fundamental research. Table 5–2 presents a sample of opportunities and identifies the federal influence for sponsoring and spearheading these efforts.

- “Strong” - Indicates that the Federal government should consider taking a lead role in sponsoring, promoting, and funding this effort
- “Moderate” – Indicates that the Federal Government should support this effort but in a secondary role
- “Weak” – Indicates that this research or activity is likely to evolve and be strongly supported by private interests

Table 5-2: Research Opportunities and Federal Influence

ID	Research Opportunities	Federal
System Optimal	Integrating new data sources into conventional TSM&O models and algorithms	Strong
	Creating new TSM&O tools that exploit big data	Strong
User Optimal	Advanced methods and technologies for improved user service provision	Weak
Overshift Control	New models that predict and manage overshift	Strong
Improved Analytics	Development of predictive analytics methods	Weak
	Assessment of predictive methods to address system manager needs in information provision	Strong
End-to-End Trip Planning	New multi-modal trip planning apps	Moderate
	Data fusion methods and algorithms for processing and archiving data from multiple sources	Moderate
	User privacy and policy for sharing data	Strong
Intelligent Services	Self-adapting ATIS to improve user mobility	Weak
	Self-learning algorithms and business intelligence models to capture and process longitudinal data	Moderate
Improved HMI	Improved in-vehicle and mobile applications	Weak
	Human factor/distraction studies	Strong
Manager Influence	Promoting public-private partnerships	Moderate
	Data governance/market facilitation	Moderate

5.5 Summary

Transformative changes to the current state of ATIS are needed to move the marketplace to a more robust operating environment. This section defined eight outcomes that, when achieved, would bring us closer to realizing the vision of the EnableATIS program.

The fundamental challenge is to support an integrated, connected decision chain that includes the provision of comprehensive traveler information services to optimize the user experience while improving the efficacy and efficiency of transportation system management. This emerging service architecture for a transformative EnableATIS program requires applications, infrastructure, and data environments that link system managers to system users.

While the public sector, private sector, and research communities are actively engaged in developing components of this service architecture, the marketplace is following the laissez-faire operational scenario. There is strong incentive for private sector investment in applications and services focused on the end user and in data collection and analytics. There is less incentive and greater risk for the private sector to invest in services that support the elements of the value chain related to system management. The Federal Government should adopt a stronger leadership role in supporting these outcomes by expanding public-private partnerships and providing incentives that foster innovative research.

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APPENDIX A. List of Acronyms

Acronym	Meaning
ATIS	Advanced Traveler Information System
AVL	Automatic Vehicle Location
BAA	Broad Agency Announcement
DCM	Real-Time Data Capture and Management Program
DMA	Dynamic Mobility Applications Program
DMS	Dynamic Message Sign
EnableATIS	Enabling Advanced Traveler Information Systems
GPS	Global Positioning Systems
HAR	Highway Advisory Radio
IT	Information Technology
ITS	Intelligent Transportation System
NRE	National Rail Enquiries
OD	Origin-Destination
TMC	Traffic Management Center
TSM&O	Transportation System Management and Operations
USDOT	United States Department of Transportation
UTMC	Urban Traffic Management and Control

APPENDIX B. Glossary

Big Data: Collection of data sets so large and complex that it becomes difficult to process using on-hand database management tools or traditional data processing applications

Data Capture and Management (DCM): Effort to standardize and streamline data formats to support aggregation of multi-source information into comprehensive regional and traveler specific uses.

Dynamic Mobility Applications (DMA): USDOT Program Focus Area which identifies bundles of regional information applications applying to freight, transit, weather, traffic, safety, and other types of data capture opportunities. Mobility applications focus on real-time uses of data to support system operations and traveler decision making.

Human-Machine Interface (HMI): The user interface for ATIS. The goal is to produce a user interface which makes it easy and efficient for travelers to seek and acquire traveler information.

Laissez-Faire Operational Scenario: An incremental build out of ATIS over time, assuming an increasing (but not ubiquitous) level of data and data aggregation, and continued innovation in delivery mechanisms. There is minimal concerted effort by USDOT to influence the market.

The National Public Transport Access Code (NaPTAN): NaPTAN is the standard UK data format for the exchange of bus stop information. In other words, a unique ID. It was developed as part of the Transport Direct program for improving digital passenger information in the UK. The data can be downloaded for free.

The National Public Transport Access Code (NaPTAN): The standard UK data format for the exchange of bus stop information, in other words, a unique ID. It was developed as part of the Transport Direct program for improving digital passenger information in the UK.

Open Data: The idea that certain data should be freely available to everyone to use and republish as they wish, without restrictions from copyright, patents or other mechanisms of control.

Robust Operational Scenario: This scenario assumes a comprehensive, multisource and multimodal data environment from which to enable a multitude of traveler information services. This scenario represents a desired end state, strong collective interaction and seen as more likely to deliver on the transformative objectives of EnableATIS.

Transportation System Management and Operations (TSM&O): An integrated program to optimize the performance of the existing infrastructure though implementation of multi-modal, cross-jurisdictional systems, services, and projects. These systems, services, and projects are designed to preserve capacity and improve security, safety, and reliability of transportation systems.

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