ITS BENEFITS: DATA NEEDS
2003 UPDATE

September 2003

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Introduction

The United States Department of Transportation's (U.S. DOT's) Joint Program Office (JPO) for Intelligent Transportation Systems (ITS) actively collects information regarding the impact of ITS projects on the operation of the surface transportation network. ITS evaluation is an ongoing process. Significant knowledge is available for many ITS services, but gaps in this knowledge also exist.

To aid the distribution of the information collected, the JPO sponsors the maintenance of the ITS benefits database on the internet. The database, which documents impacts of ITS identified in both U.S. and international evaluations, conference papers, and other reports, is available by visiting www.benefitcost.its.dot.gov.

This is the third in a series of reports documenting the results of a periodic assessment of the state of knowledge regarding the impacts of each of the many types of ITS applications. This assessment has been referred to as the "Data Needs" effort since stakeholders are asked to identify their most important needs for benefits data. This report presents the results of a web-based survey taken in the early summer of 2003. The survey asked participants to rate the importance of continued evaluation of implementations in each of the ITS application areas. To make a broad variety of ITS stakeholders aware of the survey, it was announced at the 2003 ITS America Annual Meeting and via several electronic newsletters.

The gaps in the knowledge of ITS impacts identified by the Data Needs effort help identify where little data have been collected regarding a particular ITS service. The lack of benefits data in an ITS service area indicates where more evaluation may be needed to understand the full impacts of the service. The Data Needs effort is intended to assist the JPO and researchers in establishing which knowledge gaps are considered to be the most important and in determining where limited evaluation resources may provide the most advantage.

For more information on the types of ITS implementations considered under each application area discussed in this report, and a summary of the information contained in the Benefits Database as of January 2003, refer to the FHWA report:

Intelligent Transportation Systems Benefits and Costs: 2003 Update. FHWA Report (FHWA-OP-03-075). June 2001.

The report is available via the ITS JPO's electronic document library (Document No. 13772, www.itsdocs.fhwa.dot.gov//JPODOCS/REPTS_TE/13772.html).

Appendix B also contains brief descriptions of the application areas. These definitions were provided for survey respondents' consideration in determining their ratings of the need for additional research in each application area.

REPORT ORGANIZATION

The following sections of this report present the results of the survey. A brief discussion of the survey and responses received is followed by presentation of the survey results.

Survey Overview

The 2003 Data Needs survey was the first to use a series of web-based survey forms to allow ITS stakeholders to provide input regarding ITS evaluation priorities. Survey participants were asked to rate ITS application areas based on their assessment of the importance of conducting further evaluation in that area of ITS implementation. 113 application areas were presented in the survey, however respondents were not required to respond to each area. The "questions" for each application area were grouped into 13 program areas, and respondents where presented with the opportunity to rate the need for evaluation in each of the areas related to their indicated areas of expertise/interest. The 13 program areas contained in the survey were the following:

- Arterial Management Systems
- Transit Management Systems
- Emergency Management Systems
- Traveler Information Systems
- Crash Prevention and Safety
- Road Weather Management
- Intermodal Freight

- Freeway Management Systems
- Incident Management Systems
- Electronic Payment Systems
- Information Management
- Roadway Operations and Maintenance
- Commercial Vehicle Operations

Also presented in the survey forms for each program area was a listing of the ITS integration links related to that particular program area. These links describe the interaction between ITS applications, representing the sharing of information important to the safe and efficient operation of the transportation system. Survey respondents were also asked to rate the importance of filling the gaps in benefits information regarding these integration links.

The survey instructions, as presented online, are listed in Appendix A. The ratings used for the importance of filling the gaps in benefits information ranged from 1 to 5, as defined below:

> 1 – None
> 2 – Little
> 3 – Medium
> 4 – Medium High
> 5 – Very High

Appendix A contains an example survey form for the Arterial Management program area, which is representative of the format used for each of the other program areas. To assist respondents in rating each integration link and application area, the survey form provides two links to related information. One link provides a definition of the application area or integration link, the other a link to the relevant portion of the ITS benefits database, providing a listing of summaries of

related evaluations. These links were intended to ensure that respondents understood what they were rating and had an opportunity to see the information already available in the benefits database before making their assessment.

Tables in the following sections of this report present the results of the survey for each of the 113 application areas and 34 integration links. The survey also allowed respondents to indicate if they were aware of additional evaluation data that should be incorporated into the ITS benefits database. Respondents indicated positively in many of the application areas; obtaining this information will help strengthen the contents of the database.

Survey Results

RESPONSE OVERVIEW

Fifty-seven individuals from the U.S. transportation community responded to the online survey. This analysis focuses on the responses from within the U.S, excluding the one response received from abroad.

Participants were asked to identify the type of organization they are associated with, to indicate their perspective when completing the survey; Table 1 contains the number of respondents identifying with each type of organization. Many respondents worked for government agencies, while several others worked for the private sector. Few individuals working in research and academia responded to the survey.

Table 1. *Survey Participants' Organizations*

Organization Types	Responses
Federal Government	21
State Government	10
Local Government	10
Consultant	9
ITS Industry/Industry Society	1
Research/Academia	2
"Other" Responses	
Contractor/Integrator	1
Manufacturing	1
MPO/Regional Planning	1
Regional Public Transit	1
TOTAL	**57**

Participants were also asked to identify one or more stakeholder groups with which they identify. These responses, shown in Table 2, also provide an indication of the perspectives of survey respondents. Note that respondents can identify with one or more of the groups listed. Most respondents share the perspective of working with ITS for highways or public transportation, while a significant number work with commercial vehicles and freight transportation. Respondents also identify with a number of other specializations that may be impacted by ITS deployment.

Table 2. *Survey Participants' Stakeholder Groups*

Stakeholder Groups	Responses
ITS/Telematics	37
Highways	33
Public Transportation	22
Enforcement	2
Emergency Response	4
Toll Collection	4
Commercial Vehicles / Freight Transportation	10
"Other" Responses	
Architecture and Standards	1
Hydrology & Hydraulics	1
Information Technology	1
ITS Planning	1
Parking	1
Road Construction	1
Security	1
Traffic Engineering	1
Transportation Planning	1

ITS APPLICATION AREAS

Table 3, on the following pages, shows the survey results from the ITS application areas. The application areas are sorted by the average rating, with the highest score being at the top of the table. This 2003 survey provided respondents with additional flexibility in responding; each had the ability to provide ratings for those ITS application areas most relevant to their areas of interest. Since not all respondents rated each application area, the average rating presented in Table 3 was calculated by dividing the total score by the applicable number of responses.

The survey results do not indicate a single program area that is in greatest need of additional evaluation. Instead, a number of important applications from several different program areas appear near the top of Table 3. This may be due to the respondents' ability to rate appropriate subsets of application areas with which they are familiar, causing the key research interests within the various program areas to receive higher ratings. Scanning the ranked list of average ratings does not indicate a clear break between those application areas of keen interest to the respondents and those where further evaluation was deemed less important. Rather, the ratings

follow a relatively smooth trend from a strong interest in further research to areas with lower interest.

Despite this lack of a clear break between areas of strong interest and those where many respondents did not indicate interest in further research, there are some clear leaders within given ITS program areas. For example, freight tracking appears as an area of strong interest among the various intermodal freight applications of ITS. Also, in the area of transit applications, respondents placed strong interest in research into ITS for planning purposes, in-vehicle surveillance, and service improvements through enhanced service coordination and dynamic routing/scheduling, while more proven concepts such as automated vehicle location and computer aided dispatch systems did not appear as strong research interests. Similar distinctions can be made in the other ITS program areas, with areas of strong research interest to surveyed stakeholders appearing near the top of Table 3.

Table 3. *Survey Responses for ITS Application Areas*

Application Area	Overall Average	Total Responses	Benefits DB Entries (as of 6/16/03)
Intermodal Freight > Freight Tracking	4.333	6	1
Emergency Management> Response & Recovery > Response Management	4.091	11	1
Transit Management> Fleet Management > Planning	4.063	16	0
Crash Prevention & Safety > Highway Rail Crossing Systems	4.000	4	5
Crash Prevention & Safety > Pedestrian Safety	4.000	4	0
Road Weather Management > Surveillance, Monitoring, and Prediction > Road Surface	4.000	19	4
Arterial Management > Traffic Control > Traffic Surveillance	3.952	21	3
Arterial Management > Information Dissemination	3.905	21	4
Commercial Vehicle Operations > Safety Assurance > Safety Information Exchange	3.900	10	4
Road Weather Management > Information Dissemination	3.895	19	6
Transit Management> Transit Demand Management > Service Coordination	3.875	16	1
Incident Management > Information Dissemination	3.818	22	7
Incident Management > Clearance & Recovery > Investigation	3.818	22	1
Transit Management> Safety and Security > In-Vehicle Surveillance	3.800	15	1
Roadway Operations and Maintenance > Information Dissemination	3.765	17	2
Incident Management > Clearance & Recovery > Temporary Traffic Control	3.762	21	0

Application Area	Overall Average	Total Responses	Benefits DB Entries (as of 6/16/03)
Crash Prevention & Safety > Road Geometry Warning Systems > Ramp Rollover Warning	3.750	4	3
Crash Prevention & Safety > Road Geometry Warning Systems > Overheight/Overwidth Warning	3.750	4	0
Crash Prevention & Safety > Intersection Collision Warning	3.750	4	1
Transit Management> Transit Demand Management > Dynamic Routing/Scheduling	3.750	16	4
Traveler Information > En-Route Information	3.733	30	9
Emergency Management> Response & Recovery > Evacuation Operations	3.727	11	0
Freeway Management > Special Event Transportation Management > Occasional Events	3.722	18	0
Roadway Operations and Maintenance > Work Zone Management > Temporary Traffic Mgmt.	3.706	17	3
Roadway Operations and Maintenance > Work Zone Management > Temporary Incident Mgmt.	3.706	17	1
Arterial Management > Traffic Control > Advanced Signal Systems	3.700	20	16
Commercial Vehicle Operations > Electronic Screening > Safety Screening	3.700	10	4
Commercial Vehicle Operations > Electronic Screening > Credential Checking	3.700	10	4
Freeway Management > Traffic Surveillance	3.684	19	9
Freeway Management > Information Dissemination	3.684	19	17
Incident Management > Clearance & Recovery > Video	3.667	21	0
Intermodal Freight > Asset Tracking	3.667	6	0
Intermodal Freight > Freight Terminal Processes	3.667	6	1
Intermodal Freight > Freight Highway Connector System	3.667	6	0
Transit Management> Safety and Security > Facility Surveillance	3.667	15	2
Transit Management> Information Dissemination	3.625	16	4
Freeway Management > Lane Management > Emergency Evacuation	3.556	18	0
Freeway Management > Special Event Transportation Management > Frequent Events	3.556	18	0
Incident Management > Surveillance & Detection	3.545	22	20
Incident Management > Mobilization & Response > AVL/CAD	3.545	22	1
Incident Management > Mobilization & Response > Response Routing	3.545	22	2
Crash Prevention & Safety > Road Geometry Warning Systems > Curve Speed Warning	3.500	4	1

Application Area	Overall Average	*Total Responses*	Benefits DB Entries (as of 6/16/03)
Crash Prevention & Safety > Road Geometry Warning Systems > Downhill Speed Warning	3.500	*4*	3
Intermodal Freight > International Border Crossing Processes	3.500	*6*	0
Incident Management > Mobilization & Response > Motorist Assistance Patrols	3.476	*21*	11
Emergency Management> Hazardous Materials Mgmt.	3.455	*11*	1
Traveler Information > Pre-trip Information	3.433	*30*	31
Arterial Management > Traffic Control > Special Events	3.429	*21*	1
Arterial Management > Lane Management > Emergency Evacuation	3.429	*21*	0
Information Management > Data Archiving	3.429	*14*	0
Road Weather Management > Surveillance, Monitoring, and Prediction > Atmospheric Conditions	3.421	*19*	5
Road Weather Management > Response & Treatment > Mobile Winter Maintenance	3.421	*19*	5
Freeway Management > Special Event Transportation Management > Temporary TMCs	3.412	*17*	0
Commercial Vehicle Operations > Credentials Administration > Electronic Registration/Permitting	3.400	*10*	10
Commercial Vehicle Operations > Electronic Screening > Weight Screening	3.400	*10*	6
Commercial Vehicle Operations > Carrier Operations & Fleet Management > AVL/CAD	3.400	*10*	4
Commercial Vehicle Operations > Carrier Operations & Fleet Management > Traveler Information	3.400	*10*	1
Electronic Payment > Multi-use Payment	3.400	*10*	1
Roadway Operations and Maintenance > Asset Management > Infrastructure Management	3.375	*16*	0
Emergency Management> Emergency Medical Services > Advanced Automated Collision Notification	3.364	*11*	1
Arterial Management > Traffic Control > Adaptive Signal Control	3.333	*21*	18
Electronic Payment > Transit Fare Payment	3.333	*21*	6
Road Weather Management > Traffic Control > Signals	3.316	*19*	2
Transit Management> Fleet Management > AVL/CAD	3.313	*16*	12
Traveler Information > Tourism & Events > Travel Services	3.267	*30*	1
Freeway Management > Special Event Transportation Management > Other Events	3.222	*18*	0
Road Weather Management > Response & Treatment > Fixed Winter Maintenance	3.211	*19*	2
Arterial Management > Traffic Control > Emergency Vehicle Preemption	3.200	*20*	4

Application Area	Overall Average	Total Responses	Benefits DB Entries (as of 6/16/03)
Commercial Vehicle Operations > Safety Assurance > Automated Inspection	3.200	10	2
Roadway Operations and Maintenance > Work Zone Management > Lane Control	3.176	17	1
Traveler Information > Tourism & Events > Advanced Parking	3.167	30	0
Road Weather Management > Traffic Control > Variable Speed Limits	3.158	19	4
Electronic Payment > Toll Collection	3.125	8	10
Transit Management> Transit Demand Management > Ride Sharing/Matching	3.125	16	0
Roadway Operations and Maintenance > Work Zone Management > Speed Enforcement	3.118	17	1
Arterial Management > Enforcement > Speed Enforcement	3.095	21	4
Freeway Management > Ramp Control > Ramp Closures	3.056	18	0
Freeway Management > Ramp Control > Ramp Metering	3.053	19	15
Arterial Management > Enforcement > Stop/Yield Enforcement (Red Light Cameras)	3.050	20	14
Arterial Management > Lane Management > Reversible Flow Lanes	3.000	21	0
Arterial Management > Lane Management > Lane Control	3.000	20	0
Commercial Vehicle Operations > Carrier Operations & Fleet Management > On-Board Monitoring	3.000	10	3
Commercial Vehicle Operations > Security Operations > Asset Tracking	3.000	10	0
Crash Prevention & Safety > Bicycle Warning Systems	3.000	4	0
Crash Prevention & Safety > Animal Warning Systems	3.000	4	0
Emergency Management> Emergency Medical Services > Telemedicine	3.000	10	1
Freeway Management > Lane Management > Reversible Flow Lanes	3.000	18	0
Freeway Management > Lane Management > Pricing	3.000	18	1
Freeway Management > Lane Management > Lane Control	3.000	18	1
Intermodal Freight > Drayage Operations	3.000	6	0
Road Weather Management > Traffic Control > Lane Use	3.000	19	1
Traveler Information > Tourism & Events > Electronic Payment	3.000	30	0
Freeway Management > Enforcement > Speed Enforcement	2.944	18	9
Transit Management> Fleet Management > Maintenance	2.938	16	1
Commercial Vehicle Operations > Electronic Screening > Border Clearance	2.900	10	4
Roadway Operations and Maintenance > Asset Management > Fleet Management	2.875	16	0

Application Area	Overall Average	Total Responses	Benefits DB Entries (as of 6/16/03)
Arterial Management > Traffic Control > Transit Signal Priority	2.861	36	15
Arterial Management > Parking Management	2.857	21	1
Transit Management> Safety and Security > Employee Credentialing	2.857	14	0
Freeway Management > Enforcement > Ramp Meter Enforcement	2.833	18	0
Roadway Operations and Maintenance > Work Zone Management > Variable Speed Limits	2.813	16	0
Commercial Vehicle Operations > Credentials Administration > Electronic Funds	2.800	10	2
Freeway Management > Ramp Control > Priority Access	2.778	18	0
Freeway Management > Lane Management > HOV Facilities	2.778	18	1
Freeway Management > Lane Management > Variable Speed Limits	2.778	18	1
Arterial Management > Traffic Control > Variable Speed Limits	2.762	21	0
Arterial Management > Lane Management > HOV Facilities	2.667	21	0
Freeway Management > Enforcement > HOV	2.667	18	0
Roadway Operations and Maintenance > Work Zone Management > Intrusion Detection	2.647	17	0
Transit Management> Safety and Security > Remote Disabling Systems	2.643	14	0
Arterial Management > Traffic Control > Bicycle and Pedestrian	2.524	21	1
Arterial Management > Lane Management > Pricing	2.476	21	0
Commercial Vehicle Operations > Security Operations > Remote Disabling Systems	2.300	10	0

ITS INTEGRATION LINKS

Table 4 depicts the survey results for evaluation of the integration of ITS components, again sorted by average rating. The links used in the survey help describe the types of integration that occur between various applications. Appendix C provides a more thorough discussion of the types of communication and coordination represented by each link. Respondents' ratings indicate that the integration of Incident Management with other ITS components continues to be an area where evaluation is needed. Respondents also indicated interest in evaluations of integration between freeway and arterial management systems, as well as both of those systems communicating with traveler information programs.

Table 4. *Survey Results for Integration Links*

Integration Link	Overall Average	Total Responses	Benefits DB Entries (as of 6/16/03))
Link No. 7: Incident Management to Emergency Management	4.217	23	2
Link No. 8: Incident Management to Freeway Management	4.087	23	4
Link No. 20: Electronic Fare Payment to Transit Management	3.947	19	0
Link No. 13: Freeway Management to Incident Management	3.913	23	4
Link No. 4: Arterial Management to Incident Management	3.846	26	2
Link No. 5: Incident Management to Arterial Management	3.846	26	3
Link No. 2: Arterial Management to Freeway Management	3.833	24	3
Link No. 21a: Emergency Management to Incident Management	3.792	24	0
Link No. 21b: Emergency Management to Incident Management	3.750	24	0
Link No. 11: Freeway Management to Arterial Management	3.720	25	3
Link No. 10: Freeway Management to Traveler Information	3.706	34	14
Link No. 1: Arterial Management to Traveler Information	3.667	36	6
Link No. 27: Electronic Fare Payment intra-component	3.625	8	1
Link No. 6: Incident Management to Traveler Information	3.588	34	14
Link No. 25: Incident Management intra-component	3.550	20	0
Link No. 22: Emergency Management to Arterial Management	3.542	24	4
Link No. 19: Electronic Toll Collection to Electronic Fare Payment	3.375	8	0
Link No. 28: Electronic Toll Collection intra-component	3.375	8	0
Link No. 30: Freeway Management intra-component	3.333	18	0
Link No. 3: Arterial Management to Transit Management	3.303	33	2
Link No. 26: Arterial Management Intra	3.250	20	5
Link No. 14a: Transit Management to Traveler Information	3.194	36	7
Link No. 14b: Transit Management to Traveler Information	3.139	36	3
Link No. 16a: Transit Management to Arterial Management	3.061	33	8
Link No. 29: Transit Management to Incident Management	3.000	32	0
Link No. 9: Incident Management to Transit Management	2.848	33	0
Link No. 12: Freeway Management to Transit Management	2.839	31	0
Link No. 16b: Transit Management to Arterial Management	2.839	31	0

Integration Link	Overall Average	Total Responses	Benefits DB Entries (as of 6/16/03))
Link No. 23: HRI to Incident Management	2.826	23	0
Link No. 17: ETC to Freeway Management	2.750	24	0
Link No. 15a: Transit Management to Freeway Management	2.742	31	0
Link No. 15b: Transit Management to Freeway Management	2.656	32	0
Link No. 24: Highway Rail Intersections to Arterial Management	2.609	23	0
Link No. 18: Electronic Toll Collection to Arterial Management	2.280	25	0

Appendix A

Sample Survey Forms

ITS Benefits - 2003 Data Needs Survey

Survey Instructions

You will be asked to rate the importance of filling gaps in benefits information for specific ITS/telematics application areas. Please consider information in the ITS Benefits Database as well as other sources in making your assessment. Base your rating on where you feel additional data would help fill gaps in the benefits knowledge base and provide the greatest benefit to decision makers, local government agencies, or researchers. Some ITS/telematics application areas include integration links, which you will also be asked to rate. Below is a sample of the form used to gather ratings along with a description of the key sections.

① This column contains the number of summaries on benefits for the particular application area or integration link already in the ITS Benefits Database. The number is linked to the database and clicking on it will provide access to the referenced summaries. You may want to check out these summaries to see if there is sufficient information to make good deployment decisions specific to your situation.

② Please check 'Yes' here if you are aware of data not included in the ITS Benefits Database summaries. We will contact you about the references. Thank you in advance for your help!

③ For each application area or link, select one of these five ratings to indicate the importance of filling the gaps in ITS/telematics benefits information. In making your decision, consider the contents of the ITS Benefits Database, other references not in the database, as well as your own experience. For example, if you need additional information for making decisions, you might

rate the importance of filling the gap as 4 (Medium High) or 5 (Very High).

(4) Provide comments, as needed, to help us better understand the data gaps you identify.

(5) When providing ratings, you may click on the link or application name for a definition.

(6) Click on the X image to clear the rating selection for any application area / integration link.

After selecting the application area(s) with which you are familiar, click the "Submit" button to begin entering your ratings. (You will be able to change your selections by returning to this page at any time during the survey.)

☑ **Arterial Management Systems**

☑ **Freeway Management Systems**

☑ **Transit Management Systems**

☑ **Incident Management Systems**

☑ **Emergency Management Systems**

☑ **Electronic Payment Systems**

☑ **Traveler Information Systems**

☑ **Information Management**

☑ **Crash Prevention and Safety**

☑ **Roadway Operations and Maintenance**

☑ **Road Weather Management**

☑ **Commercial Vehicle Operations**

☑ **Intermodal Freight**

Continue

ITS Benefits - 2003 Data Needs Survey
Arterial Management Systems

Please rate the importance of filling the gap in ITS/telematics benefits information using the form below.

You can review all the summaries in the ITS Benefits Database concerning Arterial Management here. To review the specific summaries for each application or link, click on the number in the "Benefits Database Summaries" column. [The online version of this survey provided definitions for each integration link and application area, linked to the appropriate names in the table below. Also, as described above, the number under "Benefits DB Entries" provided a link to relevant summaries from the Benefits database.]

When you complete the page go on to the next selected application area by clicking the 'Save and Continue' button. You may also go back to the survey instructions to select additional application areas or go back to the 1st page of the survey to edit your background information.

Application Areas	Benefits DB Entries	Are you aware of additional references?	Rate the importance of filling the gap in benefits information for each of the listed application areas.				
			None	Little	Medium	Medium High	Very High
Traffic Surveillance	3	ڤYes	○1	○2	○3	○4	○5
Additional Comments?							
Traffic Control							
Transit Signal Priority	15	ڤYes	○1	○2	○3	○4	○5
Emergency Vehicle Signal Preemption	4	ڤYes	○ 1	○ 2	○ 3	○ 4	○ 5

Adaptive Signal Control	18	☞Yes	○ 1	○ 2	○ 3	○ 4	○ 5
Advanced Signal Systems	16	☞Yes	○ 1	○ 2	○ 3	○ 4	○ 5
Variable Speed Limits	0	☞Yes	○ 1	○ 2	○ 3	○ 4	○ 5
Bicycle and Pedestrian	1	☞Yes	○ 1	○ 2	○ 3	○ 4	○ 5
Special Events	1	☞Yes	○ 1	○ 2	○ 3	○ 4	○ 5
Additional Comments?							
Lane Management							
HOV Facilities	0	☞Yes	○1	○2	○3	○4	○5
Reversible Flow Lanes	0	☞Yes	○1	○2	○3	○4	○5
Pricing	0	☞Yes	○1	○2	○3	○4	○5
Lane Control	0	☞Yes	○1	○2	○3	○4	○5
Emergency Evacuation	0	☞Yes	○1	○2	○3	○4	○5
Additional Comments?							
Parking Management	1	☞Yes	○ 1	○ 2	○ 3	○ 4	○ 5
Additional Comments?							
Information Dissemination	4	☞Yes	○ 1	○ 2	○ 3	○ 4	○ 5
Additional Comments?							
Enforcement							
Speed Enforcement	4	☞Yes	○ 1	○ 2	○ 3	○ 4	○ 5
Stop/Yield Enforcement (Red Light Cameras)	14	☞Yes	○ 1	○ 2	○ 3	○ 4	○ 5
Additional Comments?							

Did we miss an important Arterial Management Application?
If so, please provide your suggestions in the box below.

Appendix B

Definitions of ITS Application Areas

ARTERIAL MANAGEMENT SYSTEMS

Traffic Surveillance	Many of the services possible through arterial management systems are enabled by traffic surveillance and detection technologies, such as sensors or cameras, monitoring traffic flow.
Traffic Control	
Transit Signal Priority	Transit signal priority systems use sensors to detect approaching transit vehicles and alter signal timings to improve transit performance. For example, some systems extend the duration of green signals for public transportation vehicles when necessary.
Emergency Vehicle Signal Preemption	Signal preemption systems for emergency vehicles use sensors to detect an approaching emergency vehicle and provide a green signal to the vehicle.
Adaptive Signal Control	Adaptive signal control systems coordinate control of traffic signals across a signal network, adjusting the lengths of signal phases based on prevailing traffic conditions.
Advanced Signal Systems	Advanced signal systems include coordinated signal operations across neighboring jurisdictions, as well as centralized control of traffic signals which may include some necessary technologies for the later development of adaptive signal control.
Variable Speed Limits	Variable speed limit systems use sensors to monitor prevailing traffic and/or weather conditions, posting appropriate enforceable speed limits on dynamic message signs.
Bicycle and Pedestrian	Pedestrian detectors, pedestrian activated lighted crosswalks, specialized pedestrian signals (e.g., "countdown" WALK/DON'T WALK signals), and bicycle-actuated signals can improve the safety of all road users at signalized intersections and unsignalized crossings.
Special Events	Arterial management systems can also smooth traffic flow during special events with unique operating schemes, incorporating elements such as special traffic signal operating plans, temporary lane restrictions, traveler guidance, and other measures.

Lane Management	
HOV Facilities	Sensors detecting the traffic conditions support the use of dynamic message signs and moveable barriers (e.g., gates) to control the operation of HOV facilities.
Reversible Flow Lanes	Traffic sensors and lane control signs can be used to implement reversible flow lanes allowing travel in the peak direction during rush hours.
Pricing	Traffic sensors, electronic payment, and automated enforcement technologies can support the implementation of congestion pricing strategies, varying the cost of using transportation facilities based on demand.
Lane Control	Lane control signs, supported by surveillance and detection technologies, allow the temporary closure of lanes to avoid incidents or construction on arterial roadways.
Emergency Evacuation	Lane management applications such as reversible flow lanes and lane control can be used to support emergency evacuations. Such plans can also involve the implementation of special traffic signal timing plans, variable speed limits, and other measures.
Parking Management	Parking management systems, most commonly deployed in urban centers or at modal transfer points such as airports, monitor the availability of parking and disseminate the information to drivers, reducing traveler frustration and congestion associated with searching for parking.
Information Dissemination	Organizations operating ITS can share information collected by detectors associated with arterial management systems with road users through technologies within the arterial network, such as dynamic messages signs or highway advisory radio. ITS operators may also send information to in-vehicle devices capable of displaying traveler information. Coordination with regional or multimodal traveler information efforts, as well as freeway and incident management programs, can increase the availability of information on arterial travel conditions.

Enforcement	
Speed Enforcement	Automated enforcement technologies can assist with the enforcement of speed limit compliance. Still or video cameras, activated by detectors, can record vehicles traveling faster than the speed limit.
Stop/Yield Enforcement (Red Light Cameras)	Automated enforcement technologies can assist with the enforcement of traffic signal compliance. Still or video cameras, activated by detectors, can record vehicles traveling through a red signal.

FREEWAY MANAGEMENT SYSTEMS

Traffic Surveillance	Many of the services possible through freeway management systems are enabled by traffic surveillance and detection technologies, such as sensors or cameras, monitoring traffic flow.
Ramp Control	
Ramp Metering	Traffic signals on freeway ramp meters alternate between red and green signals to control the flow of vehicles entering the freeway. Metering rates can be altered based on freeway traffic conditions.
Ramp Closures	Surveillance and control technologies can allow for the temporary closure of freeway ramps to accommodate peak traffic conditions or inclement weather conditions.
Priority Access	Communication between ramp metering signal hardware or ramp closure gates, and emergency or transit vehicles can allow priority access to these vehicles, providing a green signal or opening the gates to allow for passage of the approaching vehicle.
Lane Management	
HOV Facilities	Sensors detecting the traffic conditions support the use of dynamic message signs and moveable barriers (e.g., gates) to control the operation of HOV facilities.
Reversible Flow Lanes	Traffic sensors and lane control signs can be used to implement reversible flow lanes allowing travel in the peak direction during rush hours or for special events.
Pricing	Traffic sensors, electronic payment, and automated enforcement technologies can support the implementation of congestion pricing strategies, varying the cost of transportation facilities based on demand.
Lane Control	Lane control signs, supported by surveillance and detection technologies, allow the temporary closure of lanes to avoid incidents on freeways.
Variable Speed Limits	Variable speed limit systems use sensors to monitor prevailing traffic and/or weather conditions, posting appropriate enforceable speed limits on dynamic message signs.
Emergency Evacuation	Lane management applications such as reversible flow lanes and lane control can be

	used to support emergency evacuations. Such plans can also involve the implementation of special traffic signal timing plans, variable speed limits, and other measures.
Special Event Transportation Management	
Occasional Events	Special event transportation management systems can help control the impact of congestion at locations hosting large events, such as fairgrounds, stadiums, or convention centers. In areas with occasional or one-time events, portable equipment such as dynamic message signs or portable lane control signs can help smooth traffic flow.
Frequent Events	Special event transportation management systems can help control the impact of congestion at locations hosting large events, such as fairgrounds, stadiums, or convention centers. In areas with frequent events, permanent dynamic message signs, large changeable destination signs or other lane control equipment can be installed.
Other Events	Portable ITS equipment such as dynamic message signs can help meet unique circumstances surrounding one-time special events or unusual events at customary event locations that require extra traffic management.
Temporary TMCs	Major events may require the creation of temporary traffic management centers or satellite locations for existing TMCs, often using portable TMC technologies. These centers can help coordinate traffic management activities associated with the event.
Information Dissemination	Organizations operating ITS can share information collected by detectors associated with freeway management systems with road users through technologies within the freeway network, such as dynamic messages signs or highway advisory radio. ITS operators may also send information to in-vehicle devices capable of displaying traveler information. Coordination with regional or multimodal traveler information efforts, as well as arterial and incident management programs, can increase the availability of information on freeway travel conditions.

Enforcement	
Speed Enforcement	Automated enforcement technologies can assist with the enforcement of speed limit compliance. Still or video cameras, activated by detectors, can record vehicles traveling faster than the speed limit.
HOV	Automated enforcement technologies can assist with the enforcement of high occupancy vehicle (HOV) restrictions. Enforcement personnel can trigger recording technology, such as cameras, to record vehicles in violation of the requirements.
Ramp Meter Enforcement	Automated enforcement technologies can assist with the enforcement of ramp metering compliance. Still or video cameras, activated by detectors, can record vehicles traveling through a red signal.

TRANSIT MANAGEMENT SYSTEMS

Safety and Security	
In-Vehicle Surveillance	Video cameras monitor the interior of buses or train cars. Wireless communication can make images available to transit dispatch or transit management centers. Microphones and transmitters can also enable audio surveillance. Automatic vehicle location systems often incorporate silent alarm features, allowing operators to report problems and vehicle location to dispatchers.
Facility Surveillance	Video and audio surveillance technologies can be deployed to enhance the security of train stations, bus depots, and transit stops.
Employee Credentialing	A variety of identification and access control systems can help maintain the security of public transportation management and support facilities.
Remote Disabling Systems	Transit vehicles in distress can be remotely shutdown via wireless communication and control, typically from dispatch centers.
Transit Demand Management	
Ride Sharing/Matching	Computer database and internet technologies can facilitate ride sharing and carpool matching services.
Dynamic Routing/Scheduling	Automatic vehicle location, combined with dispatching and reservation technologies facilitate the implementation of flexible public transportation routing and scheduling.
Service Coordination	Vehicle monitoring and communication technologies facilitate the coordination of passenger transfers between vehicles or transit systems.
Fleet Management	
AVL/CAD	Automatic vehicle location and computer aided dispatch systems facilitate the management of transit operations, providing up-to-date information on vehicle locations to assist transit dispatchers as well as inform travelers of bus status.
Maintenance	Maintenance monitoring technologies allow for the automatic collection and reporting of vehicle maintenance information. Information can be uploaded at the end of a run, or while in

	service via wireless communication.
Planning	A variety of technologies, including records from AVL/CAD systems and automatic passenger counter systems, can assist in the planning of new and modified transit services.
Information Dissemination	Transit agencies can disseminate both schedule and system performance information to travelers through a variety of applications, in-vehicle, wayside, or in-terminal dynamic messages signs, as well as the internet or wireless devices. Coordination with regional or multimodal traveler information efforts can also increase the availability of this transit schedule and system performance information.

INCIDENT MANAGEMENT SYSTEMS

Surveillance & Detection	Traffic surveillance, through sensors or cameras, combined with incident detection algorithms and transportation management center staff confirmation, assist with the identification of incidents on the roadway network. These sensor and camera networks also enable the confirmation of traveler reported incidents and assist with the determination of appropriate response actions.
Mobilization & Response	
AVL/CAD	Automated vehicle location and computer aided dispatch systems assist emergency dispatchers in locating and assigning appropriate responders to incidents that occur throughout a response area, including those that occur on the transportation system.
Response Routing	Response routing systems assist responders in identifying the quickest safe route to incident locations. Advanced systems may incorporate information on current traffic congestion, allowing responders to avoid traffic delays.
Motorist Assistance Patrols	Motorist assistance patrols, occasionally initiated prior to the emergence of ITS technologies, are now frequently incorporated into traffic management systems. These patrols typically consist of specially equipped vehicles and trained staff that can assist stranded motorists, help clear minor incidents and assist with the safe management of traffic around major incident scenes.
Information Dissemination	Organizations operating ITS can share information concerning ongoing incidents with road users through technologies deployed as part of incident management programs, such as dynamic messages signs or highway advisory radio. ITS operators may also send information to in-vehicle devices capable of displaying traveler information. Coordination with regional or multimodal traveler information efforts, as well as arterial and freeway management programs, can also increase the availability of incident-related information.
Clearance & Recovery	
Investigation	Several technologies are available to speed the

	investigation of incident scenes and record necessary information for later analysis.
Video	Video imaging can assist with data collection at incident scenes and speed the reopening of travel lanes.
Temporary Traffic Control	Temporary traffic control devices, such as portable message signs and lane control signs, help ensure the safety of incident responders and provide for the safe travel of vehicles around the incident site.

EMERGENCY MANAGEMENT SYSTEMS

Hazardous Materials Mgmt.	Computer software, vehicle identification technologies, and tracking devices can facilitate the management of hazardous materials transportation.
Emergency Medical Services	
Advanced Automated Collision Notification	Advanced automated collision notification systems use vehicle-mounted sensors and wireless communication to notify emergency personnel and provide them with valuable information on the crash, including location, crash characteristics, and possibly relevant medical information regarding the vehicle occupants.
Telemedicine	Telemedicine systems provide a link between responding ambulances and nearby emergency medical facilities, enabling doctors to advise emergency medical personnel regarding treatment of patients en-route to the hospital.
Response & Recovery	
Evacuation Operations	Evacuation operations often require a coordinated emergency response involving multiple agencies, various emergency centers, and numerous response plans. Various communication technologies can support the management of evacuations, which may also include a variety of traffic and transit management activities.
Response Management	Response management may include the tracking of emergency vehicle fleets using automated vehicle location (AVL) technology and two-way communications between emergency vehicles and dispatchers. Integration with traffic and transit management systems enables emergency information to be shared between public and private agencies and the traveling public.

ELECTRONIC PAYMENT SYSTEMS

Toll Collection	Electronic toll collection (ETC) supports the collection of payment at toll plazas using automated systems to increase the operational efficiency and convenience of toll collection. Systems typically consist of vehicle-mounted transponders identified by readers located in dedicated and/or mixed-use lanes at toll plazas.
Transit Fare Payment	Electronic transit fare payment systems, often enabled by smart card or magnetic stripe technologies, can provide increased convenience to customers and generate significant cost savings to transportation agencies by increasing the efficiency of money handling processes and improving administrative controls.
Multi-use Payment	Multi-use payment systems can make transit payment more convenient. Payment for bus, rail, parking, and other public or private sector goods and services can be made using transit fare cards at terminal gates, or on check-out counters and phone booths of participating merchants located near transit stations. Multi-use systems may also incorporate the ability to pay highway tolls with the same card.

TRAVELER INFORMATION

Pre-trip Information	A variety of applications support pre-trip traveler information programs. Typically regional and/or multimodal in nature, these programs may include 511 telephone information systems, internet website, TV and radio programs, and/or traveler information kiosks.
En-Route Information	Regional and/or multimodal traveler information programs intended for travelers en-route to their destinations may make use of 511 telephone systems, in-vehicle devices, radios, or other wireless devices such as pagers and PDAs.
Tourism & Events	
Travel Services	Tourism and event-related travel information focuses on the needs of travelers in areas unfamiliar to them. Information services could include electronic yellow pages, incorporating lodging reservations systems and directions to points of interest.
Advanced Parking	Parking management systems, including availability and directional guidance posted on dynamic message signs, may be deployed at major tourist destinations.
Electronic Payment	Custom electronic payment systems, using technologies such as magnetic stripe cards or smart cards, can facilitate traveler's payment for travel and other services at tourist destinations.

INFORMATION MANAGEMENT

Data Archiving	Data archiving is the collection, storage and distribution of ITS data for transportation planning, administration, policy, operation, safety analyses, and research. Data archiving systems make use of a variety of software, database, and electronic data storage technologies.

CRASH PREVENTION & SAFETY

Road Geometry Warning Systems	
Ramp Rollover Warning	Ramp rollover warning systems use roadside detectors and electronic warning signs to warn drivers, typically those in commercial trucks and other heavy vehicles, of potentially dangerous speeds in approach to freeway ramps.
Curve Speed Warning	Curve speed warning systems use roadside detectors and electronic warning signs to warn drivers, typically those in commercial trucks and other heavy vehicles, of potentially dangerous speeds in approach to curves on highways.
Downhill Speed Warning	Downhill speed warning systems use roadside detectors and electronic warning signs to warn drivers, typically those in commercial trucks and other heavy vehicles, of potentially dangerous speeds in approach to downhill grades.
Overheight/Overwidth Warning	Overheight/Overwidth warning systems use roadside detectors and electronic warning signs to warn drivers of vehicles that are too tall or wide to pass under bridges or through tunnels.
Highway Rail Crossing Systems	Highway rail crossing systems use detectors, electronic warning signs and automated enforcement technologies to warn roadway traffic of approaching trains and discourage drivers from violating railroad crossing traffic controls.
Intersection Collision Warning	Intersection collision warning systems use sensors to monitor traffic approaching dangerous intersections and warn vehicles of approaching cross traffic, via roadside or in-vehicle signage.
Pedestrian Safety	Pedestrian safety systems can help protect pedestrians by automatically activating in-pavement lighting to alert drivers as pedestrians enter crosswalks. Other systems include "countdown" pedestrian traffic signals, and pedestrian detectors that extend the "Walk" phase for pedestrians needing more time to cross a street.

Bicycle Warning Systems	Bicycle warning systems can use detectors and electronic warning signs to identify bicycle traffic and notify drivers when a cyclist is in an upcoming segment of roadway to improve safety on narrow bridges and tunnels.
Animal Warning Systems	Animal warning systems typically use infrared or other detection technologies to identify large animals approaching the roadway, and alert drivers by activating flashers on warning signs located upstream of high frequency crossing areas. These systems may also activate in-vehicle warning devices.

ROADWAY OPERATIONS & MAINTENANCE

Information Dissemination	Information dissemination technologies such as dynamic message signs or highway advisory radio can be deployed temporarily, or existing systems can be updated periodically to provide information on work zones or other highway maintenance activities. ITS operators may also send this information to in-vehicle devices capable of displaying traveler information.
Asset Management	
Fleet Management	Several applications help state DOTs with asset management, including fleet tracking applications such as automated vehicle location and computer aided dispatch systems, as well as handheld computers supporting data entry and reporting from the field.
Infrastructure Management	Automated data collection systems can assist transportation agencies in monitoring the condition of highway infrastructure.
Work Zone Management	
Temporary Traffic Mgmt.	ITS applications in work zones include the temporary implementation of traffic management applications such as components of arterial and freeway management systems. These temporary systems can be stand-alone implementations, or they may supplement existing systems in the area during construction.
Temporary Incident Mgmt.	Incident management programs may be temporarily implemented or existing programs supplemented to facilitate the safe clearance of incidents that occur in the area of work zones.
Lane Control	Lane control signs, portable dynamic message signs, and other applications assist work zone managers in notifying drivers of changing lane configurations within work zones.
Variable Speed Limits	Variable speed limit systems use sensors to monitor working conditions, traffic and/or weather conditions within work zones, posting appropriate enforceable speed limits on dynamic message signs.
Speed Enforcement	Automated speed detection in work zones can enable automated ticketing of vehicles exceeding posted speed limits when combined with automatically triggered vehicle

	identification technologies such as photographs, still or video digital imaging, or license plate recognition. Some systems transmit images of offending vehicles to police officers downstream of the work zone where enforcement can be carried out more safely.
Intrusion Detection	Intrusion detection systems monitor work zones and alert highway workers and drivers when vehicles or construction equipment enter sensitive sections of the work area, such as those where personnel are actively working.

ROAD WEATHER MANAGEMENT

Surveillance, Monitoring, and Prediction	
Road Surface	Road weather management systems rely on surveillance data to facilitate decisions on maintenance strategies and driver advisories. Road surface sensors detect the presence of ice and water on the road surface that could affect travelers or road maintenance decisions.
Atmospheric Conditions	Road weather management systems rely on surveillance data to facilitate decisions on maintenance strategies and driver advisories. Environmental sensor stations can be used to monitor air temperatures, precipitation, as well as the presence of fog, smoke or other conditions that could affect travelers or road maintenance decisions.
Information Dissemination	A variety of roadside technologies, such as dynamic messages signs and highway advisory radio, can be used to provide travelers with weather-related travel information. Weather specific internet sites and phone information lines may also be implemented. ITS operators may also send information to in-vehicle devices capable of displaying traveler information. Coordination with regional or multimodal traveler information efforts like 511, as well as arterial, freeway and incident management programs, can increase the availability of information on weather conditions along roadways.
Traffic Control	
Variable Speed Limits	Variable speed limit systems use sensors to monitor prevailing traffic and/or weather conditions, posting appropriate enforceable speed limits on dynamic message signs.
Signals	Traffic signal timing plans can be adjusted to accommodate reduced travel speeds during inclement weather.
Lane Use	Surveillance and control technologies can allow for the temporary closure of dangerous sections of roadway during inclement weather.
Response & Treatment	
Fixed Winter Maintenance	Technologies such as anti-icing systems on

	bridges can provide automatic winter maintenance activities in specific locations in need of special attention.
Mobile Winter Maintenance	Use of a variety of technologies, including weather information services, automatic vehicle location for maintenance vehicles, and on-board devices monitoring equipment and chemical application can assist road maintenance managers in coordinating effective response to weather emergencies such as winter storms and widespread flooding.

COMMERCIAL VEHICLE OPERATIONS

| **Credentials Administration**	
Electronic Funds	Various electronic data exchange methods can facilitate business and the transfer of registration fees, etc. between carriers and agencies.
Electronic Registration/Permitting	Electronic registration and permitting can improve the time required for states to approve permits. Internet applications and other electronic means can facilitate the exchange of credentials data between agencies and carriers.
Safety Assurance	
Safety Information Exchange	Safety information exchange programs assist the safe operation of commercial vehicles, providing inspectors with electronic access to carrier and vehicle safety information from previous inspections.
Automated Inspection	Automated inspection equipment can be implemented to remotely test commercial trucks for faulty equipment, such as non-functioning brakes.
Electronic Screening	
Safety Screening	In-vehicle transponders can communicate with inspection stations to pre-screen trucks for safety records.
Border Clearance	In-vehicle transponders can communicate with customs check points to pre-screen trucks for safety records, border clearance, and proper credentials.
Weight Screening	In-vehicle transponders can communicate with weigh stations to pre-screen trucks for compliance with weight regulations. Weigh-in-motion (WIM) scales can be used for more efficient weight screening.
Credential Checking	In-vehicle transponders can communicate with weigh stations and customs check points to pre-screen trucks for proper credentials.
Carrier Operations & Fleet Management	
AVL/CAD	Automated vehicle location and computer aided dispatch systems can assist carriers with scheduling and tracking of vehicle loads.
On-Board Monitoring	On-board sensors can monitor cargo and alert

	drivers and carriers of potentially unsafe conditions for the cargo being transported, such as elevated temperatures in a refrigerated trailer.
Traveler Information	Targeted traveler information systems can help carriers choose alternate departure times, avoid traffic, and arrive on time.
Security Operations	
Asset Tracking	ITS can be used to ensure the security of motor carriers. Asset tracking can improve the safety and security of drivers and vehicles by installing technologies that can monitor the location and condition of fleet assets (e.g., trailers, cabs, and trucks) in real-time.
Remote Disabling Systems	ITS can be used to ensure the security of motor carriers. Remote disabling systems can be installed to prevent unauthorized operation and assist in asset recovery.

INTERMODAL FREIGHT

Freight Tracking	Freight tracking applications can monitor, detect, and communicate freight status information such as condition and location of goods while ensuring containerized cargo remains sealed within shipping containers while en-route.
Asset Tracking	Asset tracking technologies can monitor the location, identity and status of mobile or stored freight containers, chassis, or other transportation assets in real-time.
Freight Terminal Processes	ITS freight terminal processes can improve the efficiency of freight transfers or freight storage by activating transponder tags to track cargo containers within the terminal as they are processed and sealed for transfer or storage.
Drayage Operations	ITS for drayage operations can promote the efficient loading, unloading, sorting, and transfer of cargo by implementing automated systems and robotics to optimize limited dock and port space.
Freight Highway Connector System	ITS applications that optimize traffic control and coordinate transfers near intermodal ports of entry can streamline increased freight movement on the nation's freight highway connector system.
International Border Crossing Processes	At international border crossings, automating tax revenue transactions and faster, more efficient verification of cargo manifest information can reduce delays associated with multi-agency processes.

Appendix C

Definitions of Metropolitan Integration Links
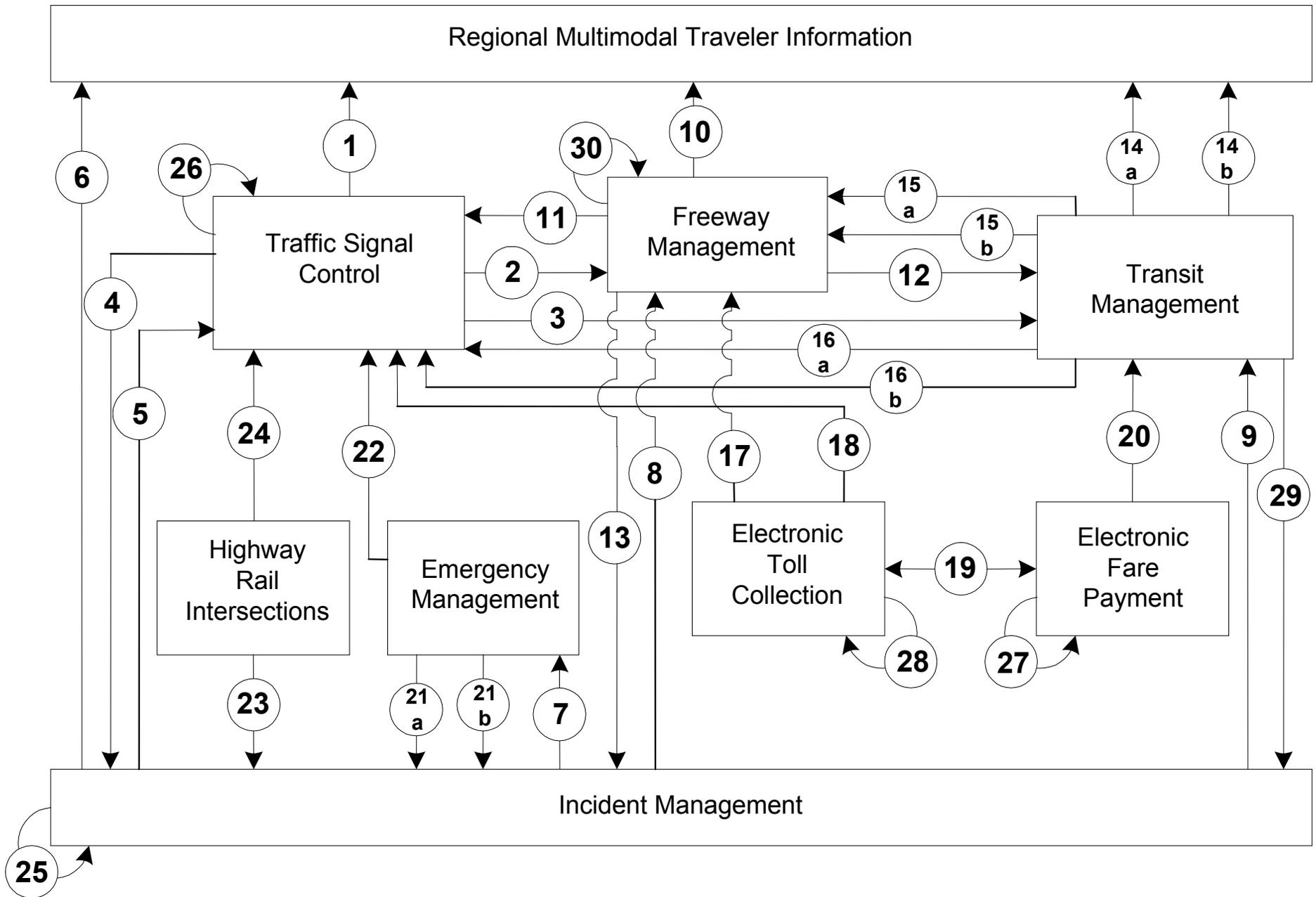
Link 1: Arterial Management to Regional Multimodal Traveler Information: Arterial travel time, speed and condition information are displayed by Regional Multimodal Traveler Information media.

Link 2: Arterial Management to Freeway Management: Freeway Management Center monitors arterial travel times, speeds, and conditions using data provided from Arterial Management to adjust ramp meter timing, lane control or HAR in response to changes in real-time conditions on a parallel arterial.

Link 3: Arterial Management to Transit Management: Transit Management adjusts transit routes and schedules in response to arterial travel times, speeds, and conditions information collected as art of Arterial Management.

Link 4: Arterial Management to Incident Management: Incident Management monitors real-time arterial travel times, speeds, and conditions using data provided from Arterial Management to detect arterial incidents and manage incident response activities.

Link 5: Incident Management to Arterial Management: Arterial Management monitors incident severity, location, and type information collected by Incident Management to adjust traffic signal timing or provide information to travelers in response to incident management activities.

Link 6: Incident Management to Regional Multimodal Traveler Information: Incident location, severity and type information are displayed by Regional Multimodal Traveler Information media.

Link 7: Incident Management to Emergency Management: Incident severity, location and type data collected as part of Incident Management are used to notify Emergency Management for incident response.

Link 8: Incident Management to Freeway Management: Incident Severity, location, and type data collected by Incident Management are monitored by Freeway Management for the purpose of adjusting ramp meter timing, lane control or HAR messages in response to freeway or arterial incidents.

Link 9: Incident Management to Transit Management: Transit Management adjusts transit routes and schedules in response to incident severity, location, and type data collected as part of Incident Management.

Link 10: Freeway Management to Regional Multimodal Traveler Information: Freeway travel time, speed and condition information are displayed by Regional Multimodal Traveler Information.

Link 11: Freeway Management to Arterial Management: Freeway travel time, speeds, and conditions data collected by Freeway Management are used by Arterial Management to adjust arterial traffic signal timing or arterial VMS messages in response to changing freeway conditions.

Link 12: Freeway Management to Transit Management: Transit Management adjusts transit routes and schedules in response to freeway travel times, speeds, and conditions information collected as part of Freeway Management.

Link 13: Freeway Management to Incident Management: Incident Management monitors freeway travel time, speed, and condition data collected by Freeway Management to detect incidents or manage incident response.

Link 14a: Transit Management to Regional Multimodal Traveler Information: Transit routes, schedules, and fare information are displayed on Regional Multimodal Traveler Information media.

Link 14b: Transit Management to Regional Multimodal Traveler Information: Transit schedule adherence information is displayed on Regional Multimodal Traveler Information media.

Link 15a: Transit Management to Freeway Management: Freeway ramp meters are adjusted in response to receipt of transit vehicle priority signal.

Link 15b: Transit Management to Freeway Management: Transit Vehicles equipped as probes are monitored by Freeway Management to determine freeway travel speeds or travel times.

Link 16a: Transit Management to Arterial Management: Traffic signals are adjusted in response to receipt of transit vehicle priority signal.

Link 16b: Transit Management to Arterial Management: Transit vehicles equipped as probes are monitored by Arterial Management to determine arterial speeds or travel times.

Link 17: Electronic Toll Collection to Freeway Management: Vehicle equipped with electronic toll collection tags are used as probes and monitored by Freeway Management to determine freeway travel speeds or travel times.

Link 18: Electronic Toll Collection to Arterial Management: Vehicle equipped with electronic toll collection tags are used as probes and monitored by Arterial Management to determine arterial travel speeds or travel times.

Link 19: Electronic Toll Collection to Electronic Fare Payment: Transit operators accept ETC issued tags to pay for transit fares.

Link 20: Electronic Fare Payment to Transit Management: Rider ship details collected as part of Electronic Fare Payment are used in transit service planning by Transit Management.

Link 21a: Emergency Management to Incident Management: Incident Management is notified of incident location, severity and type by Emergency Management to identify incidents on freeways or arterials.

Link 21b: Emergency Management to Incident Management: Incident Management is notified of incident clearance activities by Emergency Management to manage incident response on freeways or arterials.

Link 22: Emergency Management to Arterial Management: Emergency Management vehicles are equipped with traffic signal priority capability.

Link 23: Highway-rail intersection to Incident Management: Incident Management is notified of crossing blockages by Highway-rail intersection to manage incident response.

Link 24: Highway-rail intersections to Arterial Management: Highway-rail intersection and Arterial Management are interconnected for the purpose of adjusting traffic signal timing in response to train crossing.

Link 25: Incident Management intra-component: Agencies participating in formal working agreements or incident management plans coordinate incident detection, verification and response.

Link 26: Arterial Management intra-component: Agencies operating traffic signals along common corridors sharing information and possible control of traffic signals to maintain progression on arterial routes.

Link 27: Electronic Fare Payment intra-component: Operators of different public transit services share common electronic fare payment media.

Link 28: Electronic Toll Collection intra-component: Electronic Toll Collection agencies share a common toll tag for the purpose of facilitating "seam less" toll transactions.

Link 29: Transit Management to Incident Management: Transit agencies notify Incident Management agencies of incident locations, severity and type.

Link 30: Freeway Management intra-component: Agencies operating freeways within the same region share freeway travel time, speeds and condition data.