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USDOT Integrated Corridor Management (ICM) Initiative

High-Level Requirements for the US-75 Integrated Corridor in Dallas, Texas

April 30, 2008
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High-Level Requirements for the US-75 Integrated Corridor in Dallas, Texas

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Submitted by:

DART in association with City of Dallas, Town of Highland Park, North Central Texas Council of Governments, NTTA, City of Plano, City of Richardson, TxDOT, City of University Park

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16. Abstract
This document is intended as a listing and discussion of the high-level Requirements for the US-75 Integrated Corridor Management System (ICMS) in Dallas. This document describes what the system is to do (the functional requirements), how well it is to perform (the performance requirements), and under what conditions (non-functional and performance requirements). This document does not define how the system is to be built; that is the providence of the design document. This document pulls together requirements from a number of sources including but not limited to the Concept of Operations and constraints identified by the agencies. This document sets the technical scope of the system to be built. It is the basis for verifying the system and sub-systems when delivered via the Verification Plan. The purpose of the US-75 ICMS is to implement a multi-modal operations decision support tool enabled by real-time data and live video pertaining to the operation of freeways, arterials, tollways, and public transit. The US-75 ICMS will be a multi-agency, de-centralized operation which will utilize a set of regional systems to integrate the operations of the corridor.

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1. Introduction

This document is intended as a listing and discussion of the high-level Requirements for the US-75 Integrated Corridor Management System (ICMS) in Dallas. This document describes what the system is to do (the functional requirements), how well it is to perform (the performance requirements), and under what conditions (non-functional and performance requirements). This document does not define how the system is to be built; that is the providence of the design document. This document pulls together requirements from a number of sources including but not limited to the Concept of Operations and constraints identified by the agencies. This document sets the technical scope of the system to be built. It is the basis for verifying the system and sub-systems when delivered via the Verification Plan.

1.1. System Purpose

The purpose of the US-75 ICMS is to implement a multi-modal operations decision support tool enabled by real-time data and live video pertaining to the operation of freeways, arterials, tollways, and public transit. The system will be shared between information systems and people involved in transportation operations and emergency response in the US-75 Corridor. The US-75 ICMS is intended to provide improved integration of operation procedures, including procedures that take advantage of the data and video sharing capabilities of the US-75 ICMS and facilitate improved emergency response, and traveler information.

1.2. System Scope

The US-75 ICMS will be a multi-agency, de-centralized operation which will utilize a set of regional systems to integrate the operations of the corridor. Currently, the agencies within the corridor have some cooperation and integration. The following figure provides an overview of the current systems, and level of integration. As discussed in our Concept of Operations, the US-75 corridor operations will be de-centralized with DalTrans as the corridor central coordination point. At the DalTrans Transportation Management Center (TMC) there will be one dedicated operator for the corridor, who will insure the corridor agencies are responding to requests, and will monitor the overall performance of the corridor.

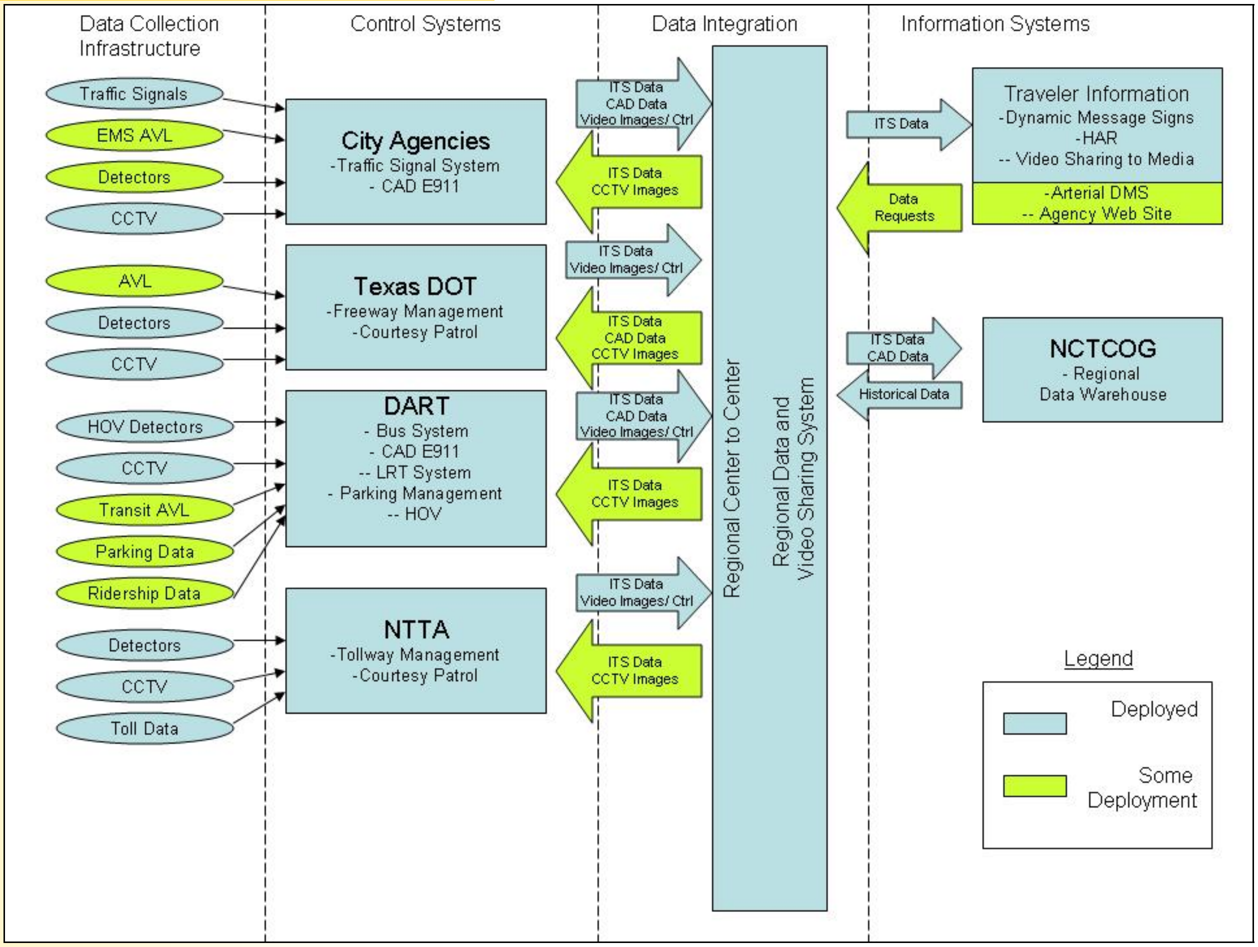

Figure 1.2-1 US-75 Corridor Systems - Before

Once the systems described in the concept of operations, and this requirements document are deployed and integrated among the agencies, the new ICMS as shown in the figure below will be operational.

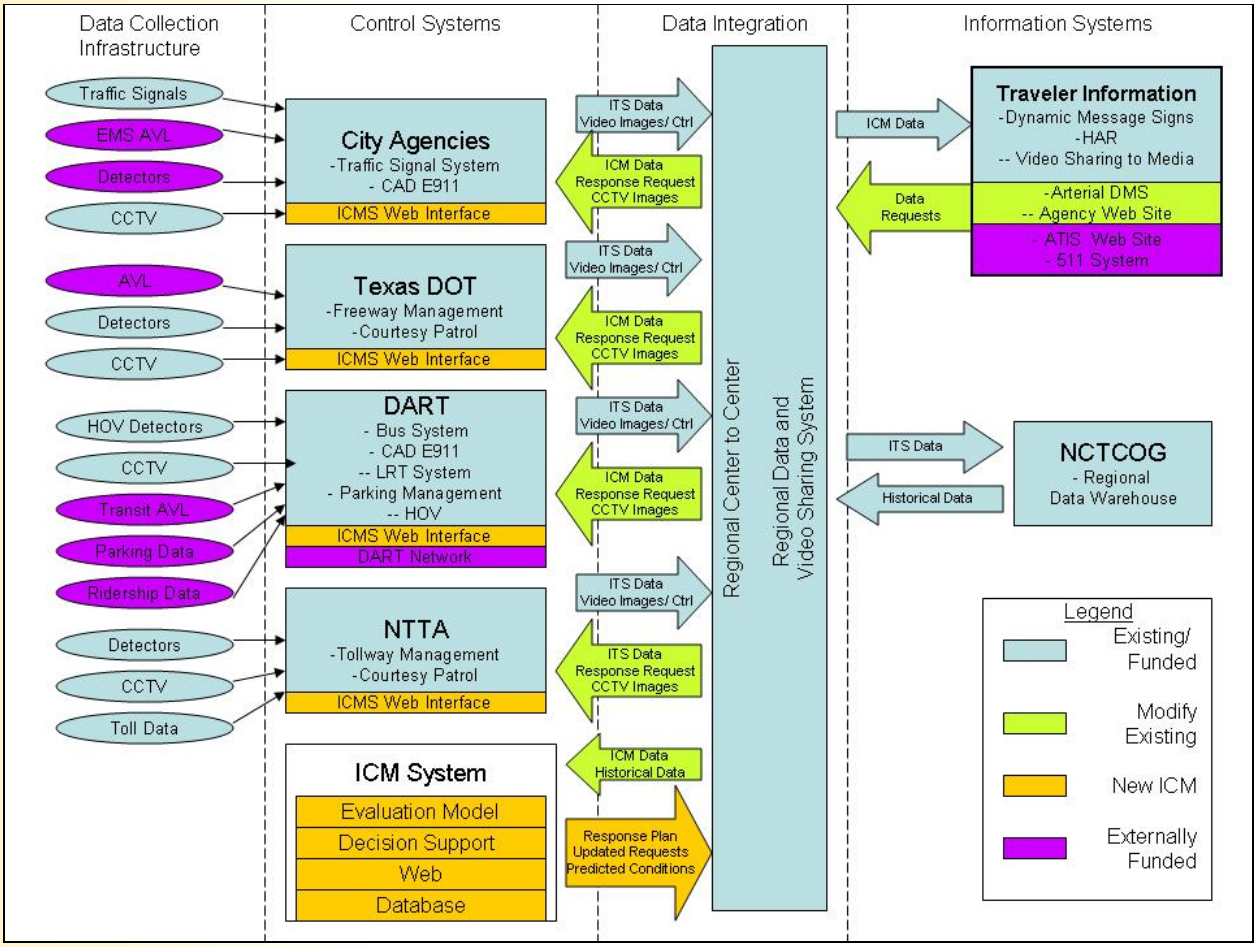

Figure 1.2-2 US-75 Corridor Systems - After

The "ICMS" will operate as a multi-modal operations decision support tool with a cooperative network of agencies which will operate the corridor in a coordinated manner to reduce congestion of the network, and improve the movement of people and goods within the corridor. The ICM System will consist of 4 new subsystems: an ICM Database, an Evaluation Model subsystem; a Decision Support subsystem; and a Web subsystem. The ICM Database will store the data within the ICM System; this data will come from historical data provided by the Regional Data Warehouse, current network data provided by the ICM Agencies in the corridor, and output data from the Decision Support subsystem including response plans and predictive conditions of the network. The Evaluation Model will be used as a tool to evaluate the overall performance of the corridor. The Decision Support subsystem will be used as a tool for coordination or responses to events, evaluation of current network conditions, and prediction of network conditions in order to proactively manage the corridor. Lastly, the Web subsystem will be a tool which will allow the viewing, reporting, and sending of ICM data. The Web subsystem will provide an "ICMS Web Interface" for approved users to interact with the ICM data, and provide a data feed of current network conditions to the regional ATIS.

1.3. Definitions, acronyms, and abbreviations

- ATIS – Advanced Traveler Information System
- ATMS – Advanced Transportation Management System
- ARDT – Arterial Detection Subsystem
- CAD – Computer Aided Dispatch
- CCTV – Closed Circuit Television
- Con Ops – Concept of Operations
- DalTrans – Dallas Transportation Management Center
- DART – Dallas Area Rapid Transit
- DMS – Dynamic Message Sign
- DNT – Dallas North Tollway
- DSS – Decision Support Subsystem
- ETC – Electronic Toll Collection
- HOV – High Occupancy Vehicle
- ICM – Integrated Corridor Management
- ICMS – Integrated Corridor Management System
- INFR – Infrastructure
- ISP – Information Service Provider
- ITS – Intelligent Transportation System
- LBJ – Lyndon Bayne Johnson
- LRT – Light Rail Transit
- LRV – Light Rail Vehicle
- MS/ETMC - Message Sets for External TMC to TMC Communication
- MOD – Corridor Model
- NCTCOG – North Central Texas Council of Government
- NTTA – North Texas Tollway Authority
- P&R – Park & Ride
- PARK – Parking Management
- PDA – Personal Data Assistant
- PGBT – President George Bush Turnpike
- RTC – Regional Transportation Council
- TMDD - Traffic Management Data Dictionary
- TRE – Trinity Railway Express
- TxDOT – Texas Department of Transportation

2. References

This section identifies all needed standards, policies, laws, concept of operations, and other reference material that supports the requirements.

The following references were used in developing the Requirements for the US-75 Integrated Corridor Management System.

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2.1. System Overview

The US-75 Corridor is a major north-south radial corridor connecting downtown Dallas with many of the suburbs and cities north of Dallas. It contains a primary freeway, continuous frontage roads, a light-rail line, transit bus service, park-and-ride lots, major regional arterial streets, toll roads, bike trails, and significant intelligent transportation system (ITS) infrastructure.

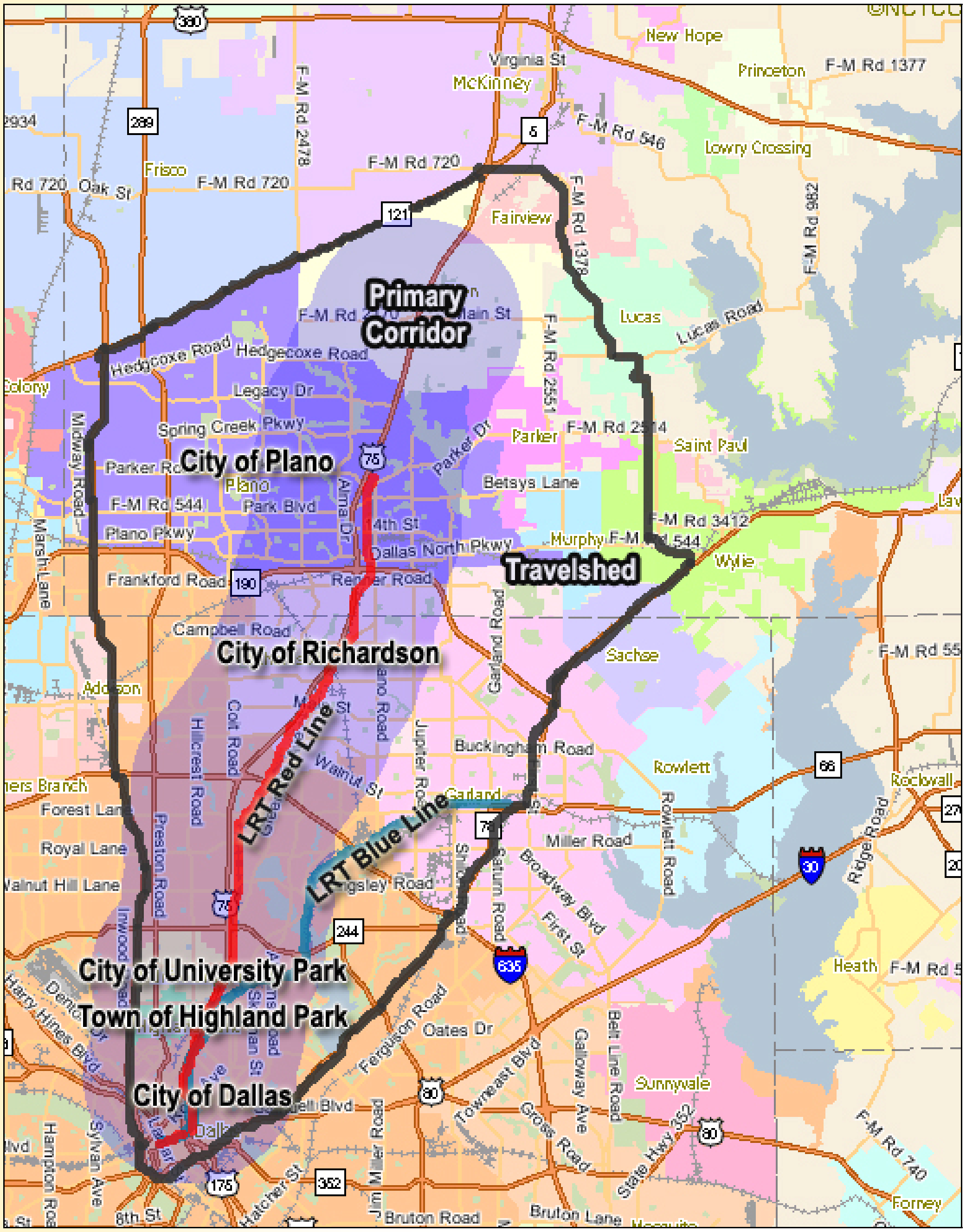

Figure 2.1-1 US-75 Integrated Corridor (Source: NCTCOG website dfwmaps.com)

3. General System Description

Keeping in mind the vision of the ICM project, “Operate the US-75 Corridor in a true multimodal, integrated, efficient, and safe fashion where the focus is on the transportation customer”, the management and operations of the corridor and the ICM will be a joint effort involving all the stakeholders. To effectively manage and operate the ICM concept, the US-75 Steering Committee recommended the creation of a central corridor decision-making body. This body – designated as the US 75 ICM Subcommittee – will consist of leadership level representatives from each of the stakeholders in the US-75 Corridor. Due to the number of agencies involved in ITS and traffic operations in the Dallas – Fort Worth Region, the subcommittee is envisioned to be a subcommittee of the Regional ITS Steering Committee. The membership will consist of members from each of the corridor agencies; however, membership will be on a rotational basis so that the size doesn’t become too large.

The daily operation of the corridor will be coordinated through the existing arrangements and information will be exchanged through the center-to-center project, along with a Decision Support Subsystem which will distribute response plan requests and utilize the center-to-center interface to communicate to the various agency systems. The central point of coordination for the corridor will be the DalTrans facility, with TxDOT, Dallas County, and DART co-located at the facility.

All operations among corridor networks and agencies (e.g., activation of specific ICM strategies) will be coordinated via the Decision Support Subsystem. The US 75 ICM Subcommittee will investigate and prepare corridor response plans and rules-based response procedures for various scenarios that can be expected to occur within the US-75 Corridor. The chairman of the committee will be responsible, with the other agency/service operations officers, for configuring the subcommittee with respect to its functions and staffing for all hours of operations. Staff will be assigned by the corridor stakeholders to support daily operations, develop response plans, and analyze system deficiencies and needs, and general administration. Performance measurement and monitoring will be the responsibility of the US 75 ICM Subcommittee. The agency/service members, led by the chairman, will be accountable to the centralized decision-making body and make reports as the decision-making body designates.

Communications, systems, and system networks will be integrated to support the distributed corridor command center beyond DalTrans. Voice, data, video, information, and control will be provided to all agencies based on the adopted protocols and standards for the sharing of information and the distribution of responsibilities. The ICM will support the virtual nature of the corridor by connecting the member agency staff on a real-time basis via communications and other ITS technologies. While all the ICM operational strategies will be available for use, it is envisioned that only a subset of these strategies will be activated at any one time, depending on the operational conditions and events within the corridor.

The US 75 ICM Subcommittee, working with NCTCOG will conduct desktop scenario sessions to prepare, train and refine response plans for incidents, special events, weather, and evacuations. All the agency/service operations officers and staff will know their respective roles and responsibilities for any of the various situations the corridor may face and will be aided by the Decision Support Subsystem. Moreover, agency operations officers will be able and authorized to improvise as situations may dictate.

Traveler information via websites, DMS, and through the media and ISPs will be corridor-based, providing information on corridor trip alternatives complete with current and predicted conditions. Travelers will access or be given real-time corridor information so they can plan or alter their trips in response to current or predicted corridor conditions. Each traveler will be able to make route and modal shifts between networks easily due to integrated and real-time corridor information, integrated fare/parking payment system, and coordinated operations between networks. Using one network or another will be dependent on the preferences of the traveler, and not the nuances of each network. Travelers will be able to educate themselves about the corridor so they can identify their optimal travel alternatives and obtain the necessary tools to facilitate their use of corridor alternatives when conditions warrant.

The US-75 Corridor will be an integrated transportation system – managed and operated collectively – to maximize its efficiency to corridor travelers. All corridor assets will be attuned to obtain the goals and objectives of the corridor, as well as the goals of each individual traveler as their preferences prescribe. The corridor users will recognize the US-75 Corridor as a multimodal, integrated, efficient, and safe transportation system that provides them with multiple viable alternatives that they can select based on their specific travel circumstances and needs.

The operations and coordination of the corridor will utilize a Decision Support Subsystem as part of the daily operation of the corridor, and will be coordinated through the existing arrangements between the agencies with information exchanged through the center-to-center project. The center-to-center interface is an ITS standards based system utilizing the TMDD and MS/ETMC. The Decision Support Subsystem will distribute response plan requests and utilize the center-to-center interface to communicate to the various agency systems.

Figure 3-1 is a high-level framework on how the system will interface to the various agencies. The system would utilize existing Center-to-Center standards based communication infrastructure. It would also be able to have direct connections to agencies not on the Center-to-Center network. The existing systems of each member agency would share ITS data with the corridor, and the Decision Support Subsystem would recommend responses to all affected agencies.

The Decision Support Subsystem would be initially populated by response plans developed by the US-75 ICM Subcommittee utilizing the models developed for the corridor analysis and strategy selection. The decision support subsystem would evaluate conditions against the response plans, and recommend new response plans as network conditions and responses are evaluated.

The US-75 ICM Subcommittee will meet on a regular basis to do post-incident analysis and review any modification to response plans to improve the efficiency of the corridor. The Decision Support hardware and software will be hosted and maintained at the DalTrans facility.

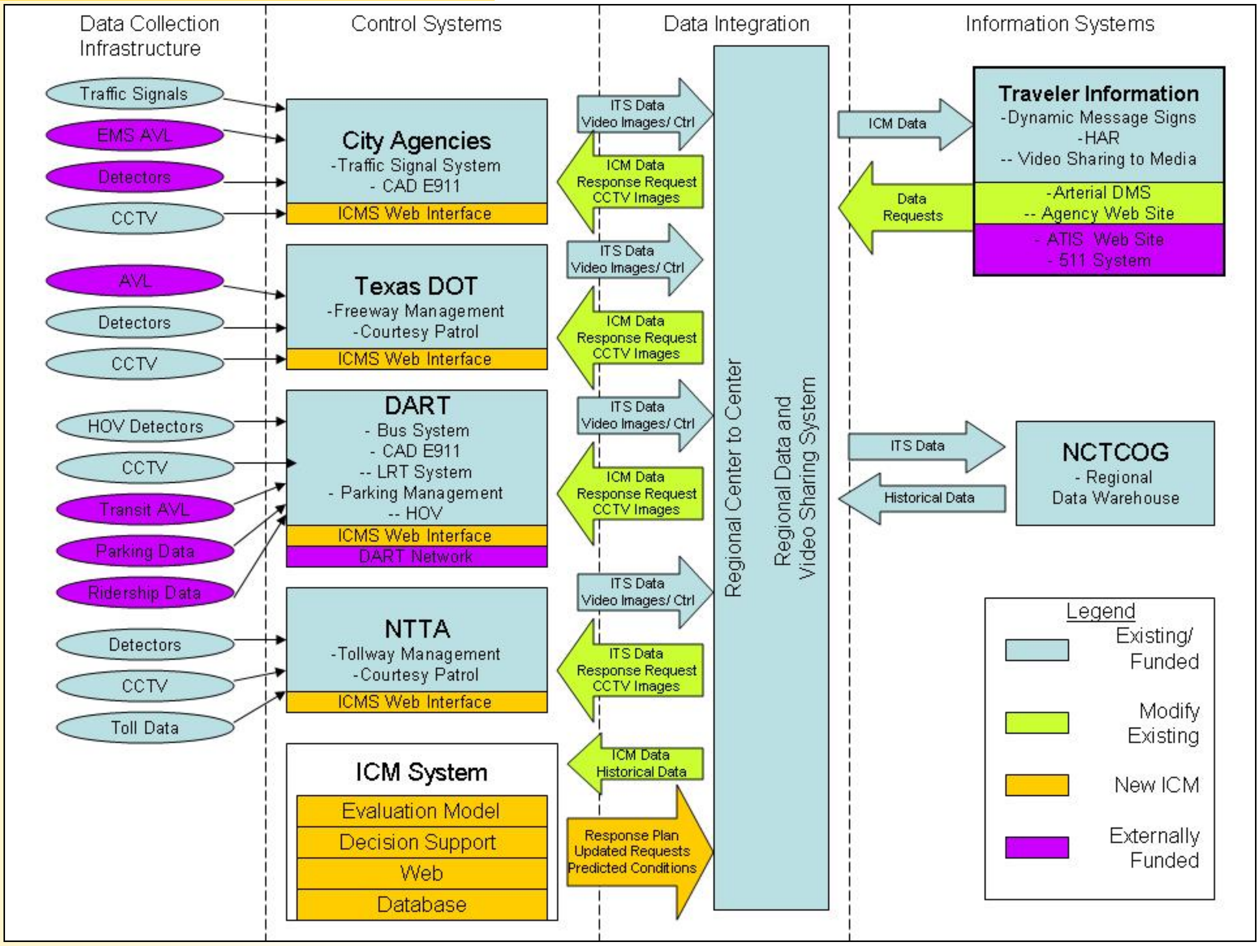

Figure 3-1 High-Level Integrated Corridor Management System Concept

The Decision Support Subsystem (DSS) will send response plan requests via the center-to-center interface to communicate to the various agency systems. The regional center-to-center interface is an ITS standards based interface, utilizing the Traffic Management Data Dictionary (TMDD) and the Message Sets for External TMC to TMC Communication (MS/ETMC). For instance, if TxDOT has an incident on the US-75 freeway, when the operator at the Daltrans facility inputs data in their ATMS incident management subsystem, the information from this subsystem would send basic information on the incident (such as location, number of lanes, severity) to the DSS via the regional Center-to-Center communication system. The DSS would then query its database based on this criteria, and select pre-approved response plans. The DSS would send the response plan recommendations to all affected agencies, and a notification to the regional ATIS. The agencies in the corridor would accept or modify the recommended response, based on current conditions within their network. As the conditions of the incident change, and the ATMS system is updated, the DSS would also be notified and send out updated responses, if needed. In addition, the DSS will send out updated responses based on other criteria. For instance, if an incident was occurring during the peak hours, and extended beyond. One potential response during the peak could be to increase the number of Light Rail Vehicles (LRV) in operation. If a certain time of day was reached before any updates were provided, the DSS may send DART an update that notifies them that additional LRT are not required.

3.1. System Performance Measures

Taking into account the vision, goals, and current conditions within the Corridor, the US-75 Steering Committee discussed "success" targets for several of the performance measures, their main concern was if the target was realistic, could be measured, and if enough data would be available. These "Performance Measures Success Thresholds," listed in Table 3.1-1, provide an indication that the corridor goals have been achieved. The listed performance levels/thresholds are long-term targets that reflect the future vision of how the corridor will operate. Upon deployment of the ICM, any movement toward the thresholds will indicate that ICM is having the desired effect. As data is collected in the next phase, and models developed the targets will be validated and goals adjusted to ensure realistic and achievable targets are used.

Table 3.1-1 Corridor Performance Measure Targets

Performance Measure	Performance Measure Success Threshold
Travel Time Index	Reduce Index by 2% per year
Travel Time	Light Rail – reduce travel time by 20% in downtown corridor Bus - reduce travel time by 20% in downtown corridor
Corridor Throughput	Increase overall throughput – increase person/trips per hour by 2% Increase throughput during incident – increase person/trips per hour by 2%
Clearance time for an Incident (based on Jurisdiction and Corridor)	Emergency Responder Training - 75% of agencies trained on Incident Management response.
Response time	Response to Incidents - target is consistent response between jurisdictions (within 5 minutes)
Revenue/ Cash machine Tickets for Transit	Increase in Ticket purchases during major incidents/ events – 10%
Parking Lot Volume at Transit locations	Parking Lot Capacity – 90% utilization
Ridership per vehicle (Transit)	Increase of ridership – 2% (year to year increase)
Queue wait time at intersections	Percentage of time stopped at intersections – reduce by 10% during peak period
Provide ATIS information to public on incident	Information to Regional ATIS – 10 minutes
Public Perception	Public Perception – Awareness of ICM and perceived benefits (survey based)
ICM Response Plan deployment	ICM Response Plan activated - 95% of plans were deployed correctly

The performance measures and targets discussed above focus on assessing the overall effectiveness of the ICM and corridor operations for purposes of needs identification and improvement selections. Such parameters, however, are not conducive to day-to-day assessments of alternatives by travelers and are not sensitive to quickly changing conditions within the corridor.

Data collection for the performance measures (i.e., overall assessment) and operations measures will be identical, using the information collected by each of the individual network systems. However, their respective processing may be different. As mentioned previously, one of the focuses of the corridor is to utilize mesoscopic models to evaluate the strategies and assist with prioritization both as part of the Decision Support subsystem and the Evaluation Model subsystem.

3.2. System Context

Simply put, the Integrated Corridor Management concept seems to be a strong fitting solution for the Dallas US-75 Corridor. The needs and goals and related transportation operations within the Corridor, will only be met through a coordinated operation of the individual transportation networks.

The US-75 Corridor consists of multiple independent networks:

- Freeway
- Managed High-Occupancy Vehicle Lanes
- Tollway
- Arterials
- Bus
- Light Rail

Each of these corridor networks are experiencing congestion to some extent during peak hours. “Integrated Corridor Management” focuses on the operational, institutional, and technical coordination of multiple transportation networks and cross-network connections comprising a corridor. Moreover, ICM can encompass several activities which address the problems and needs identified in the previous section (e.g., integrated policy among stakeholders, communications among network operators and stakeholders, improving the efficiency of cross-network junctions and interfaces, real-time traffic and transit monitoring, real-time information distribution, congestion management, incident management, public awareness programs, and transportation pricing and payment).

The US-75 Steering Committee has identified multiple areas and strategies that would assist in operating the corridor in a more efficient and safe manner which in turn would have a positive impact to the overall economy of the region. The first major area deals with information sharing both with the public and among agencies. Currently the region has an ITS Standards based Center-to-Center program with a couple of the agencies integrated. This sharing of information could be used for better informing the public of the operations of the corridor and the availability and impact of different modes. The corridor could provide comparative travel time across modes, so that travelers can make informed decisions about trips they are about to make, this would include the ability to collect and distribute arterial travel time data via various media including through 3rd party ISPs, websites, and subscription services for phones and PDAs.

One of the areas multiple agencies identified that is needed is pre-planned response plans and a decision support tool to assist with the on-going operations of the corridor. This decision support tool would be integrated with the various agencies, and provide multi-agency responses to scenarios.

One of the deficiencies that needs to be addressed – and a specific attribute of the Regional ITS Architecture – involves the exchange and sharing of real-time data. With real-time data and video among the networks, each network could monitor the conditions of adjacent networks to anticipate when travelers may shift to their network and take appropriate actions. Moreover, real-time condition information would provide the foundation for corridor-wide traveler information. The corridor has solutions for both of these deficiencies – the current center-to-center project is used by some of the agencies within the corridor, but further expansion to all of the corridor agencies is needed. A Regional Data and Video Communication System is currently being designed that would serve as the central distribution point for sharing video among corridor agencies. Currently several cities, DART, and TxDOT share some of their video images.

Another element of ICM that is needed is outreach and marketing to the public and major employers within the corridor. Currently, many travelers utilize the regional website and 3rd Party ISPs (including Media) to find out about current conditions. One of the strategies identified by the stakeholders is outreach to major employers to provide customized traveler information to them; this could then be used as a potential way to allow diversion of travelers to use their overflow parking.

Another potential element of ICM involves enhanced mobility opportunities, including shifts to alternate routes and modes. Currently, any shifts that do occur are based on traveler knowledge and past experience. Using integrated real-time information, the various networks working as a corridor could influence traveler network shifts; especially promoting, when appropriate, shifts to the light rail network with its unused capacity. The one problem with influencing a shift to rail is the parking shortage. Parking notification could be used to direct travelers to available parking; or in some situations temporary parking may be instituted to handle the new demand.

Current and new DMS deployed among the networks could be operationally integrated and messages could be used to provide travelers condition information on all corridor networks so that each traveler can take appropriate action if one or more of the corridor's network's performance is compromised. More can be done with corridor trip travel times to influence traveler shifts, or staggering of the start of travel. For special events, the DMS could be used to direct event attendees to specific event corridor transportation services.

Clearly, there is great potential to enhance current and near-term operations by implementing selected ICM and cross-network strategies. All of these enhancements would not be possible from an independent network operational perspective. The potential strategies identified above indicate that further investigation and design concerning integrated corridor management is warranted.

3.3. System Modes and States

In order to get a better understanding of the overall ICM System, each of the agencies was analyzed to determine a before and after of its systems, interfaces, and data requirements for the ICMS.

3.3.1. City of Dallas

Dallas is the largest city in the urban area with a population of 1,210,390 – making it the 9th largest city in the United States, 3rd largest in Texas, covering 384 square miles. The City of Dallas municipal agency employs over 12,000 workers, with over 5,400 dedicated to public safety (police and fire). The Dallas Independent School District is comprised of 180 public elementary and middle schools and 37 public high schools. In addition, the metro area has 17 two-year and technical/trade colleges, 4 public four-year colleges and universities, and 17 private colleges and universities. Dallas is one of the top convention cities in the country, with 3,700,000 conference attendees per year. The City of Dallas also has two airports.

The City operates and maintains 1,300 traffic signals (most of which are in coordinated arterial signal systems); and 37 arterial Dynamic Message Signs (DMS), and 35 roadside cameras. There are 62 miles of bike & jogging trails and 500 miles of street bicycle routes. The Dallas Police Department provides incident management on all facilities within the City of Dallas except the HOV lanes and tollways.

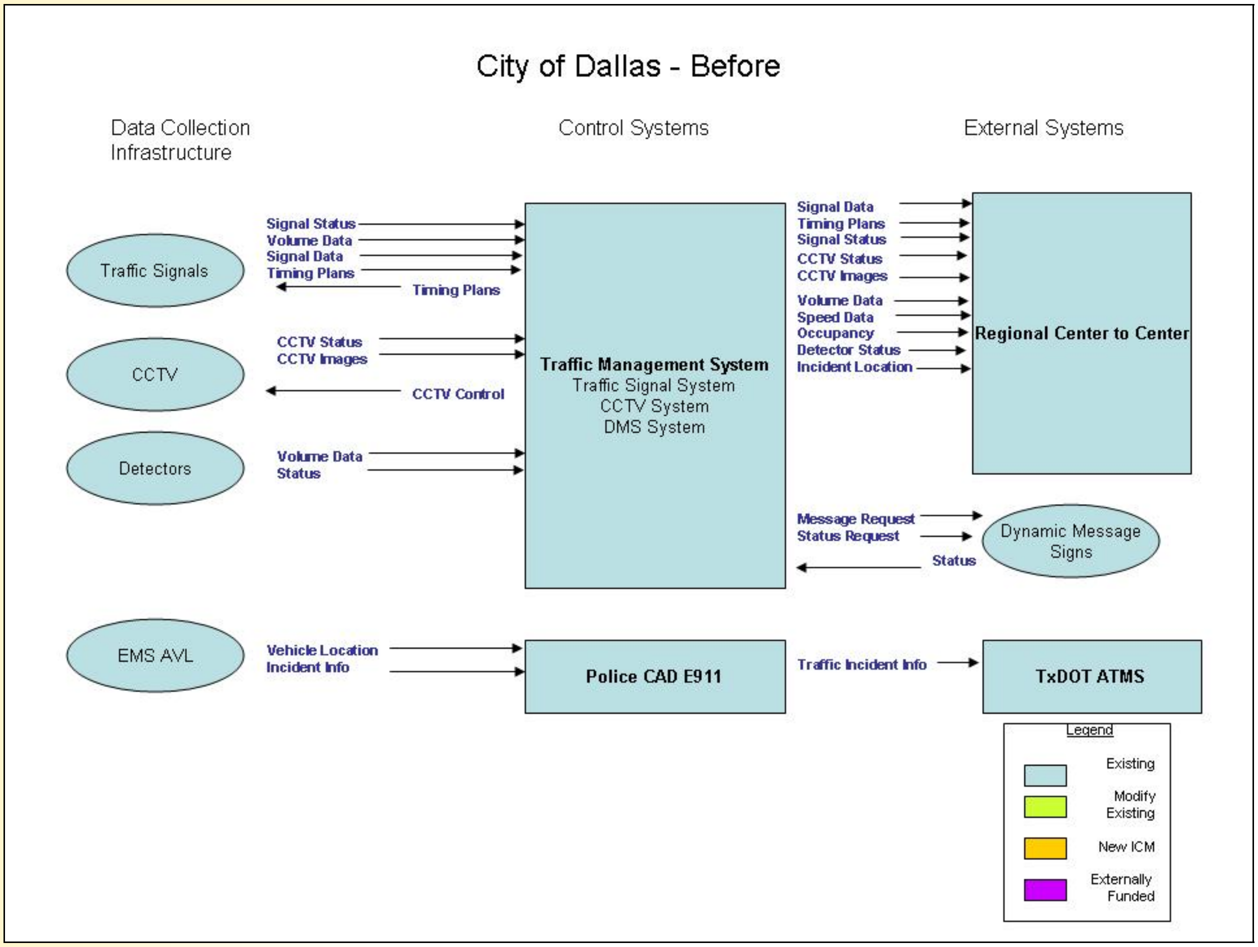

Figure 3.3-1 City of Dallas Systems - Before

As part of the ICM Deployment, several new linkages will be required. These include integration with the Decision Support Subsystem, and providing additional data to the corridor partners. The other main focus of the City of Dallas is to increase its data collection and dissemination capabilities in order to improve the corridor's operation.

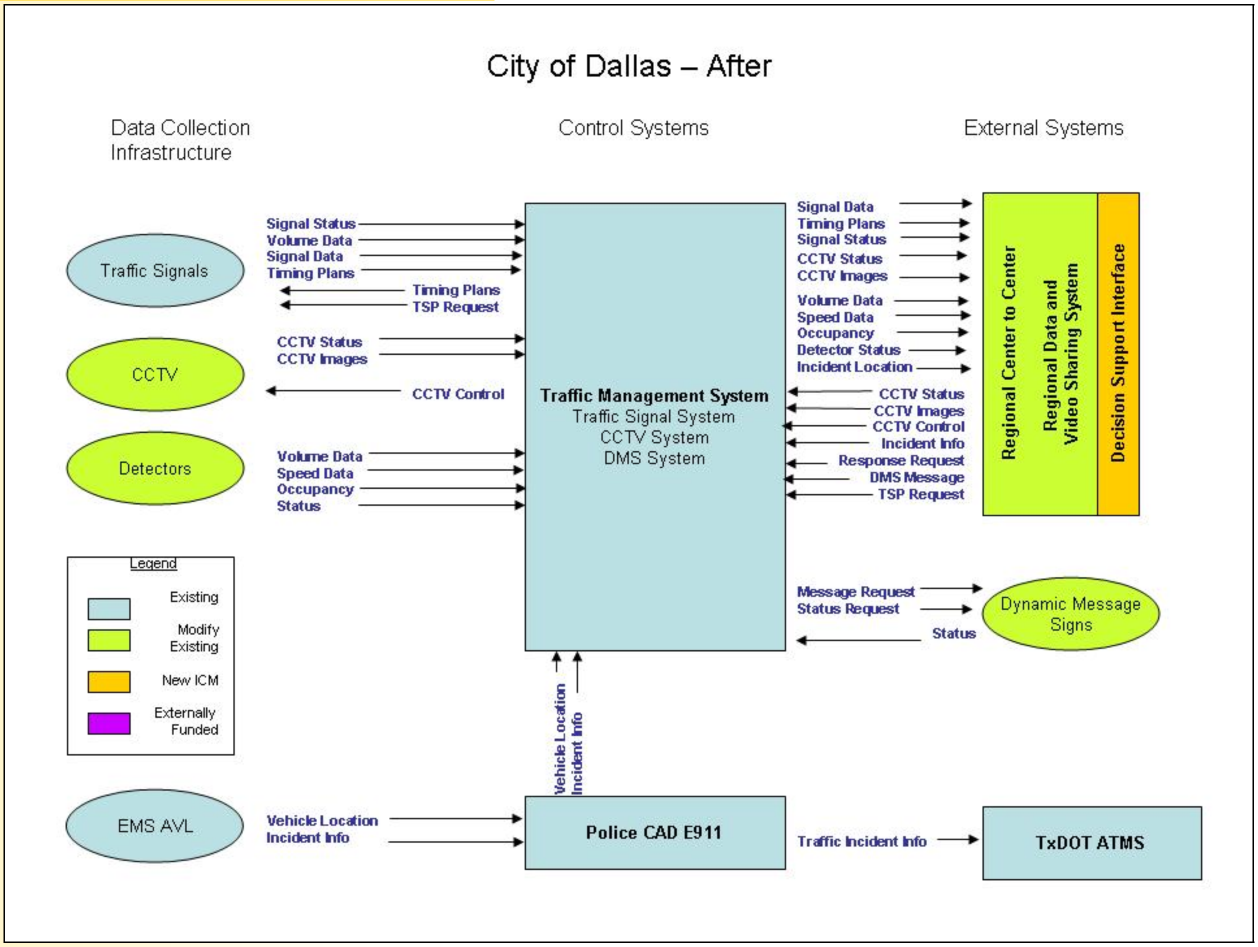

Figure 3.3-2 City of Dallas Systems - After

Additions to Systems and Infrastructure

In order to fill the infrastructure needs of the City and to have a completed data collection network, and traveler information system; additional detectors, DMS, and CCTV were identified as the largest need for the City. These will allow the ICMS to better monitor and predict traffic related issues within the corridor.

The following locations for additional CCTV were identified:

- Coit & Frankford
- Coit & IH 635
- US 75 & Forest
- US 75 & Royal
- US 75 & Walnut Hill
- US 75 & Park
- US 75 & Southwestern
- US 75 & Lovers
- US 75 & Mockingbird
- US 75 & Knox/Henderson
- US 75 & Blackburn/Haskell
- Peak & Ross
- Greenville & Mockingbird

- Greenville & Lovers
- Greenville & Park
- Greenville & Walnut Hill
- Greenville & Royal
- Greenville & IH 635
- Greenville & Restland
- Floyd & Restland
- Hillcrest & Arapaho
- Hillcrest & Beltline
- Hillcrest & Spring Valley
- Hillcrest & Alpha
- Hillcrest & IH 635
- Hillcrest & Forest
- Hillcrest & Loop 12 (Northwest Hwy.)
- Preston & Spring Valley
- Preston & Alpha
- Preston & IH 635
- Preston & Loop 12 (Northwest Hwy.)
- DNT & Royal
- DNT & Loop 12 (Northwest Hwy.)
- DNT & Lovers
- DNT & Mockingbird
- DNT & Wycliff
- Skillman & Mockingbird
- Skillman & Walnut Hill
- Skillman & IH 635
- Abrams & Forest
- Abrams & IH 635
- Forest & IH 635
- Forest & Audelia
- Abrams & Royal
- Abrams & Loop 12 (Northwest Hwy.)
- Shadybrook & Loop 12 (Northwest Hwy.)
- Boedeker & Loop 12 (Northwest Hwy.)
- DNT & Loop 12 (Northwest Hwy.)

The following locations for additional DMS were identified:

1. SB Hillcrest approaching Arapaho
2. SB Hillcrest approaching IH 635

The following locations for additional Detectors were identified:

- Speed/count detectors in 7 locations on Greenville Avenue, between the major east/west streets that have US-75 access: Mockingbird, Lovers, Caruth Haven, Park, Walnut Hill, Royal, Forest, IH 635;
- Speed/count detectors in 2 locations on Coit Rd., south of IH 635, north of IH 635.

3.3.2. City of Richardson

Richardson has a population of 97,800. The Richardson Police Department provides incident management on all facilities within its city limits except the tollways. The city operates a remote-access automated traffic signal system with over 120 intersections under control, and a count station network of 105 locations.

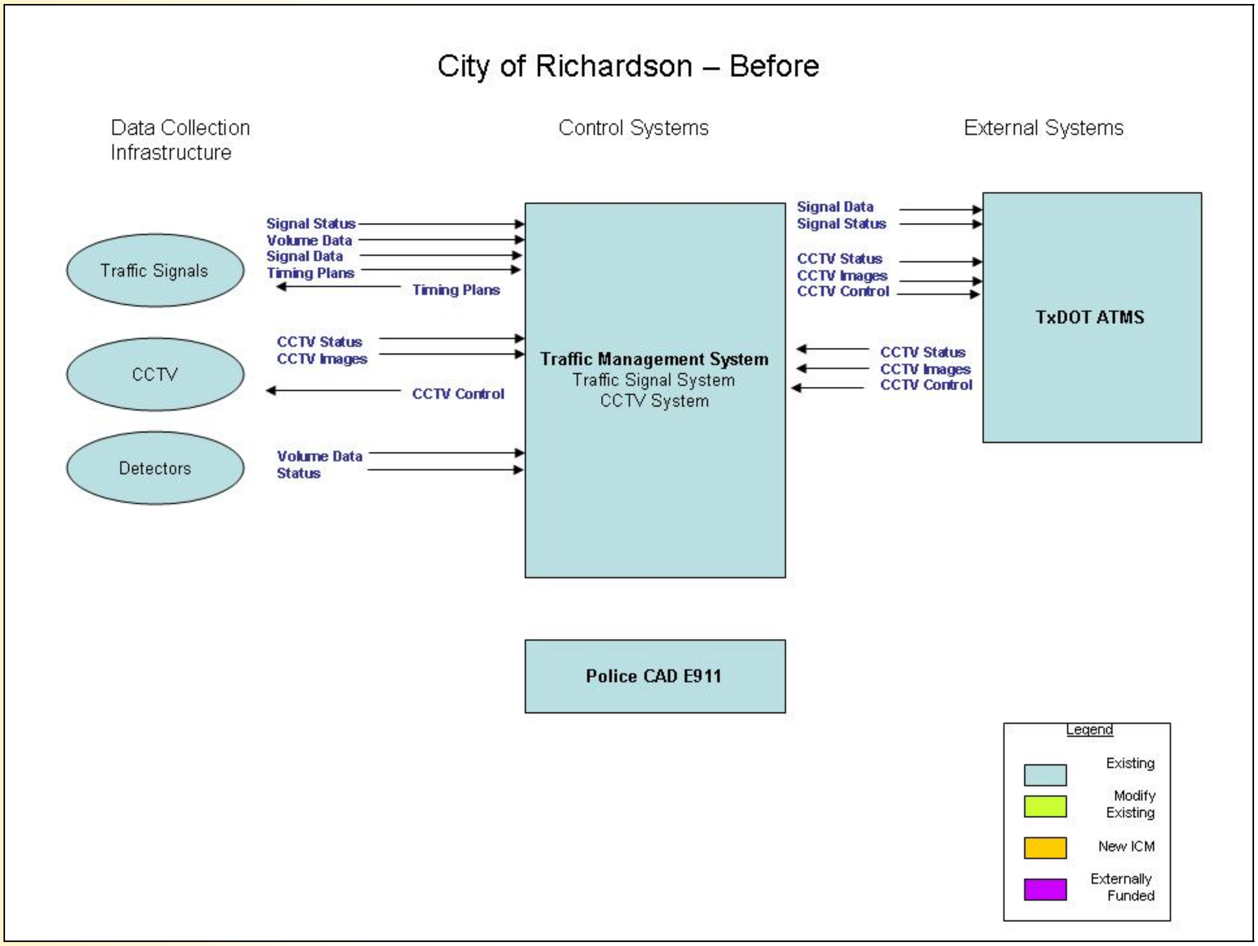

Figure 3.3-3 City of Richardson - Before

As part of the ICM Deployment, several new linkages will be required. These include integration with the Decision Support Subsystem, and providing additional data to the corridor partners. It is assumed that the linkages to the Regional Center to Center, and Data and Video Sharing System will be completed separate from the ICM projects. The other main focus of the City of Richardson is to increase its data collection and dissemination capabilities in order to improve the corridor's operation. The City does need additional DMS in strategic corridor locations, and detection capabilities to monitor the conditions of the arterial network.

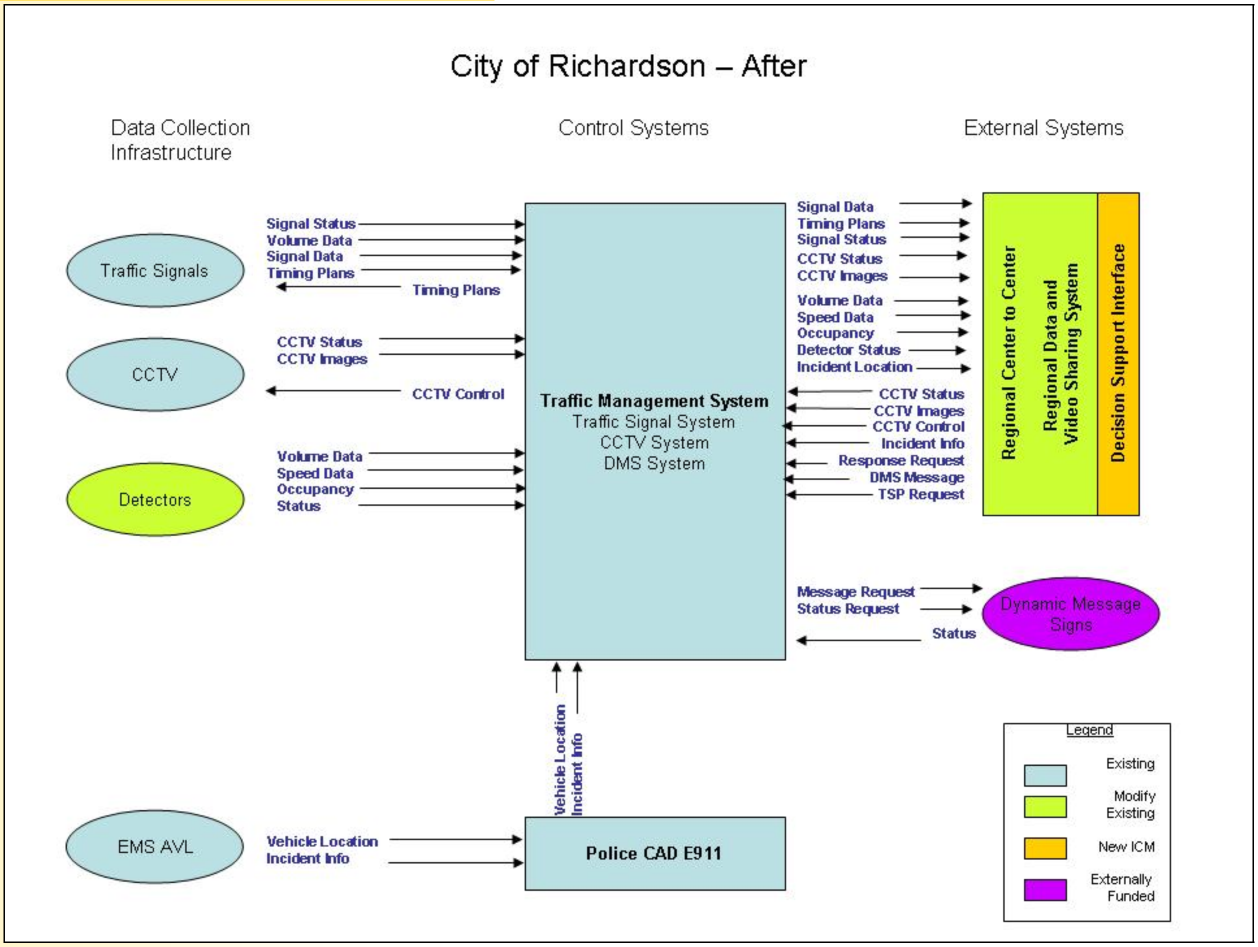

Figure 3.3-4 City of Richardson - After

Additions to Systems and Infrastructure

In order to fill the infrastructure needs of the City and to have a completed data collection network, and traveler information system; additional detectors, and DMS were identified as the largest need for the City. These will allow the ICMS to better monitor and predict traffic related issues within the corridor.

The following locations for DMS were identified:

1. westbound on Centennial at Whitehall
2. westbound on Belt Line at St. Johns
3. westbound on Belt Line at Dorothy
4. westbound on Arapaho at Bowser
5. westbound Campbell at Glenville

The following arterials were identified for arterial detection

1. Coit Road
2. Plano Rd
3. Spring Valley/Centennial
4. Belt Line

3.3.3. City of Plano

As described in the Concept of Operations, Plano is the second largest city in the urban area with a population of 249,000. The Plano Police Department provides incident management on all facilities within its city limits except the tollways. The city operates a remote-access automated traffic signal system with over 196 intersections under control.

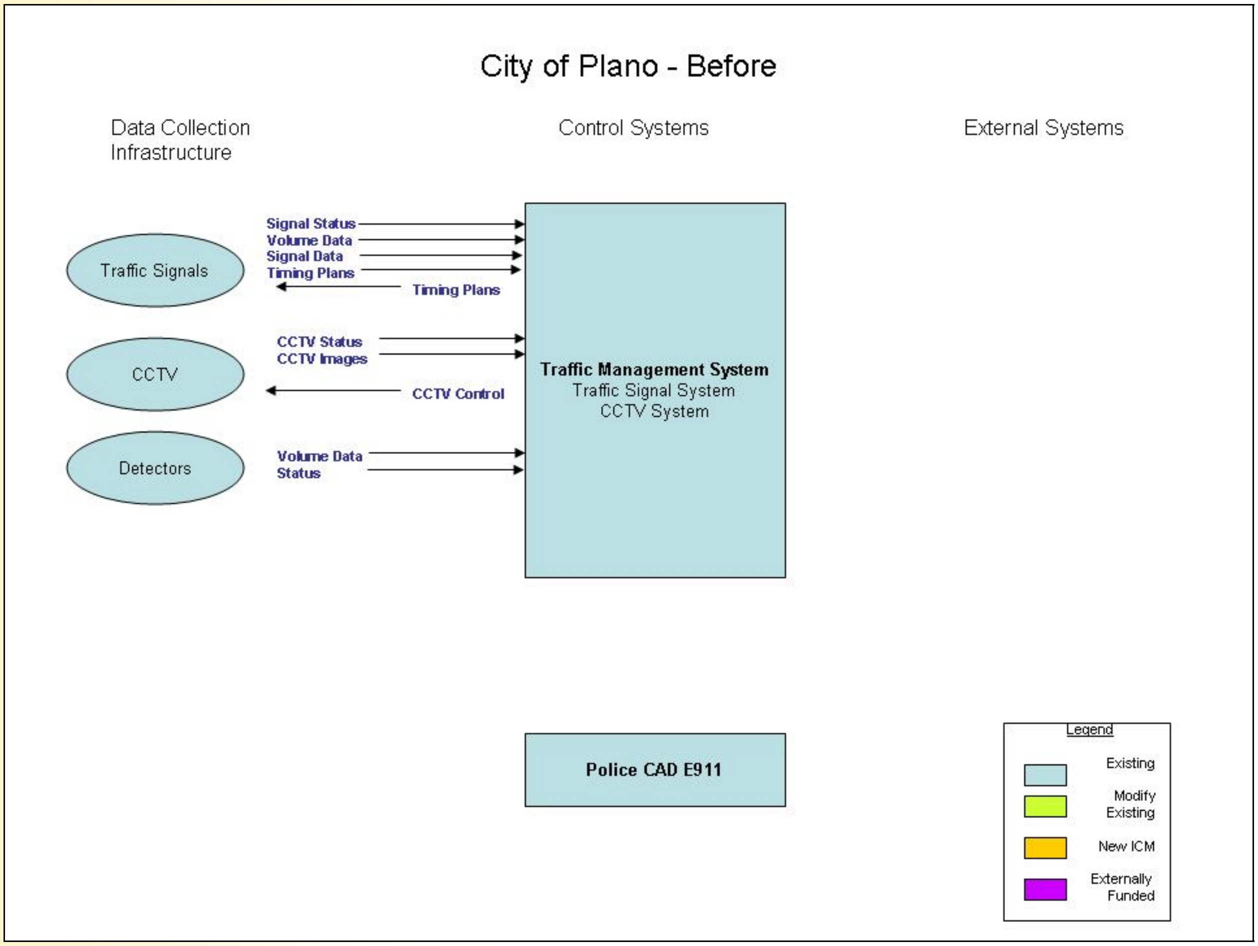

Figure 3.3-5 City of Plano - Before

As part of the ICM Deployment, several new linkages will be required. These include integration with the Decision Support Subsystem, and providing additional data to the corridor partners. It is assumed that the linkages to the Regional Center to Center, and Data and Video Sharing System will be completed. The other main focus of the City of Plano is to increase its data collection and dissemination capabilities in order to improve the corridor's operation. The City does need additional detection capabilities to monitor the conditions of the arterial network.

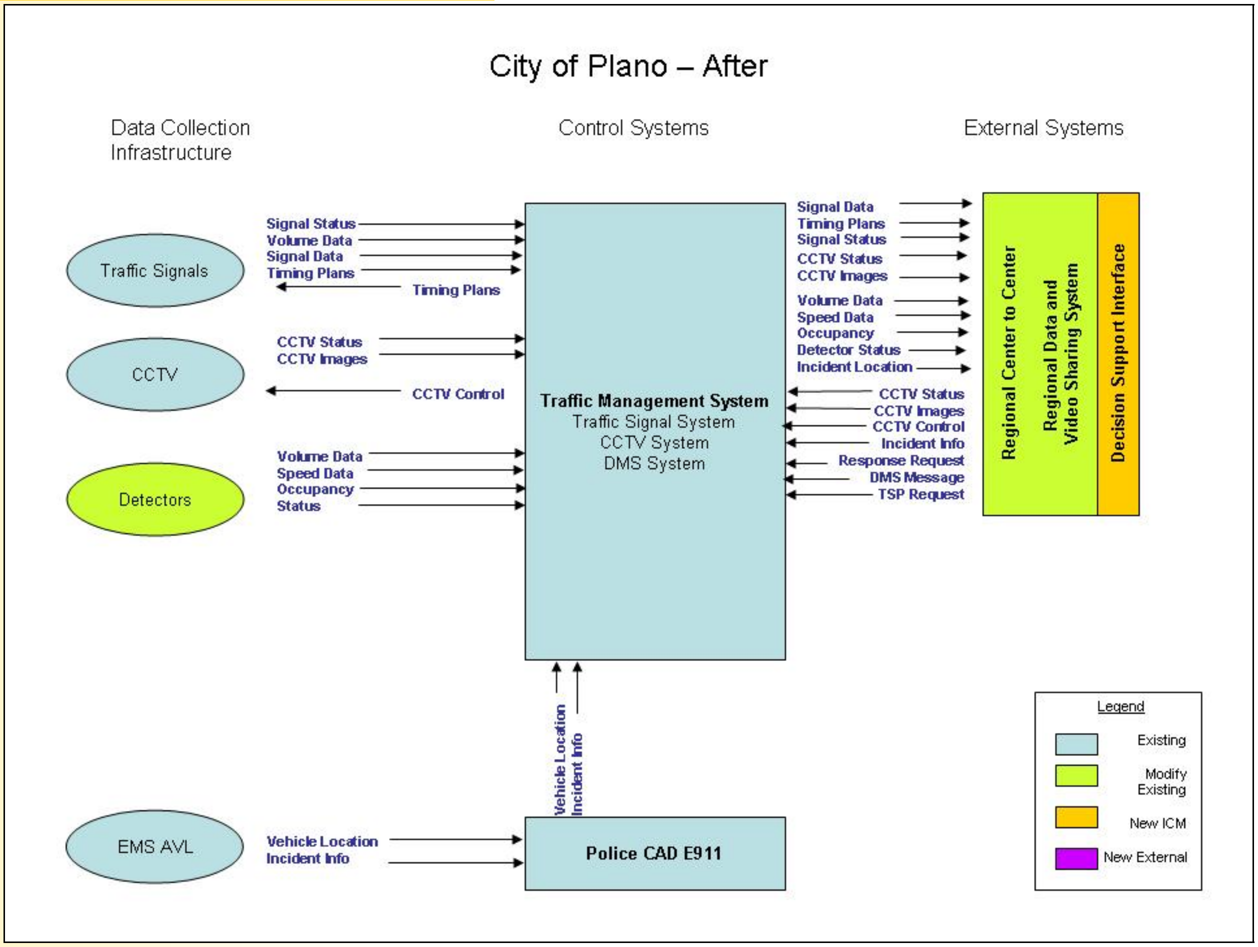

Figure 3.3-6 City of Plano - After

Additions to Systems and Infrastructure

In order to fill the infrastructure needs of the City and to have a completed data collection network, and traveler information system; additional detectors were identified as the largest need for the City. These will allow the ICMS to better monitor and predict traffic related issues within the corridor.

The following arterials were identified for arterial detection

- Jupiter Road-From PGBT to Spring Creek Parkway
- Avenue K from south of Plano Parkway to Legacy Drive
- Alma Drive-From south of Plano Parkway to Legacy Drive

3.3.4. Town of Highland Park

As described in the Concept of Operations, the Town of Highland Park has a population of 8,800 with 13 isolated traffic signals. Although freeway or tollway facilities do not pass through the town, both types of facilities abut the town limits.

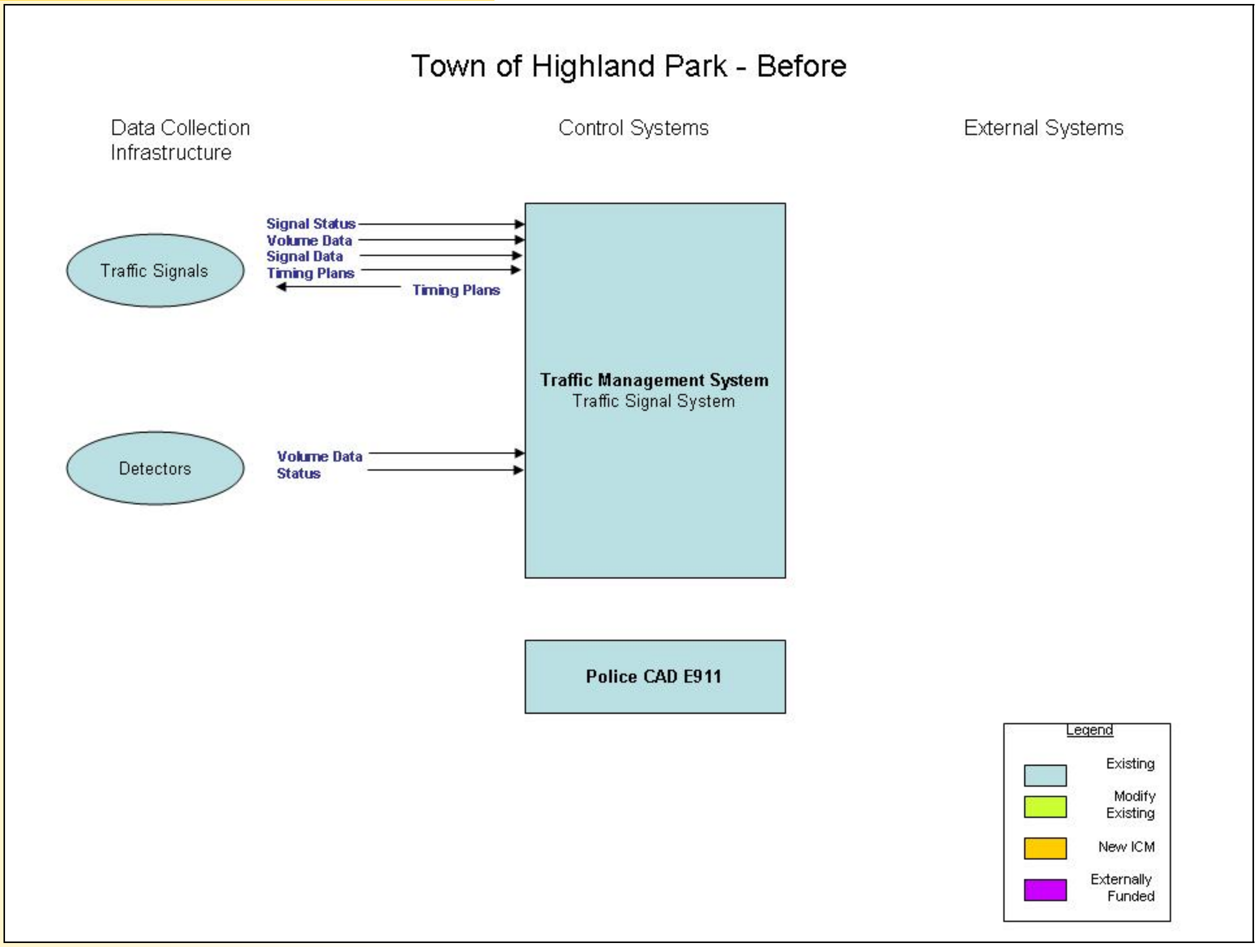

Figure 3.3-7 Town of Highland Park - Before

Since the Town of Highland Park has a small number of devices and routes within the corridor, a minimal deployment of the integrated system will be needed. As part of the ICM Deployment, several new linkages will be required. These include integration with the Decision Support Subsystem, and providing additional data to the corridor partners. It is assumed that the linkages to the Regional Center to Center, and Data and Video Sharing System will be completed. The other main focus of the Town of Highland is to increase its data collection and dissemination capabilities in order to improve the corridor's operation. The City does need additional detection capabilities to monitor the conditions of the arterial network. The main Arterial within the Town which is used by travelers is Mockingbird.

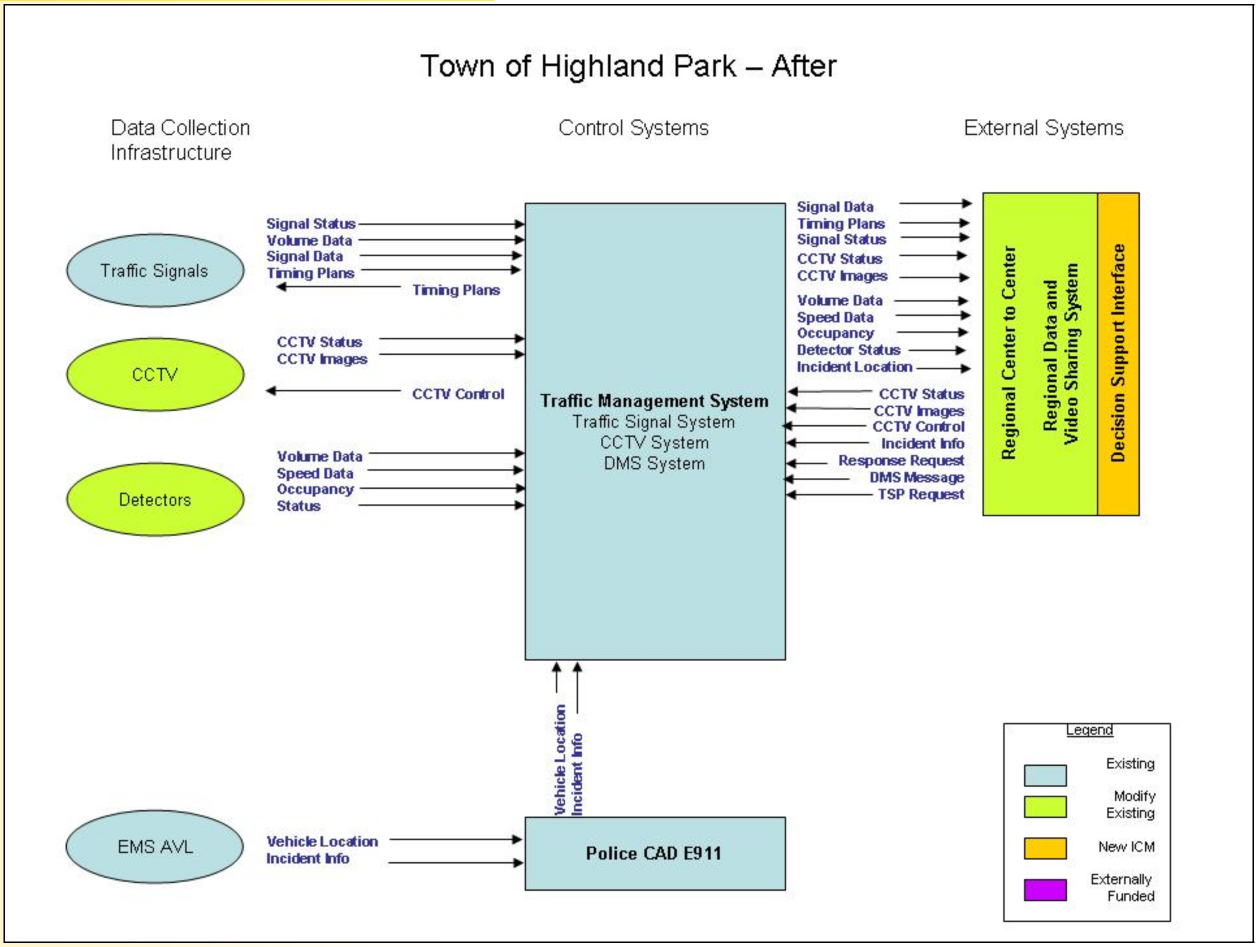

Figure 3.3-8 Town of Highland Park - After

Additions to Systems and Infrastructure

In order to fill the infrastructure needs of the City and to have a completed data collection network, and traveler information system; arterial detection within the city is needed on the major arterial in the city, along with some CCTV along the corridor.

The following arterials was identified for arterial detection and CCTV locations

- Mockingbird

3.3.5. City of University Park

As described in the Concept of Operations, the City of University Park has a population of 23,300 with 33 traffic signals under coordination by three field masters. US-75 runs on the east side of University Park with a majority of the city to the west and a few city blocks to the east. The Dallas North Tollway runs along the western edge of the city.

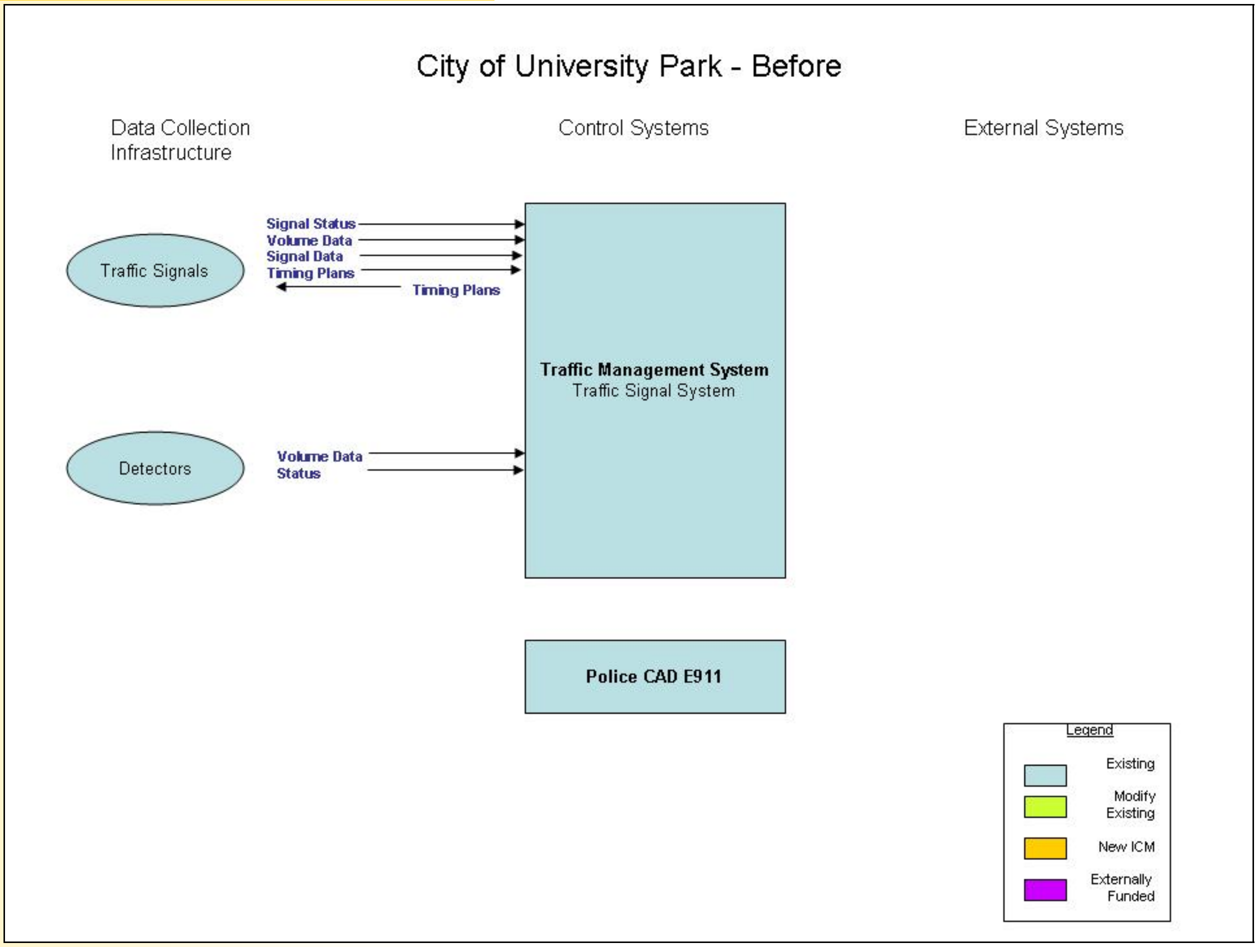

Figure 3.3-9 City of University Park - Before

Since the City of University Park also has a small number of devices and routes within the corridor, a minimal deployment of the integrated system will be needed. As part of the ICM Deployment, several new linkages will be required. These include integration with the Decision Support Subsystem, and providing additional data to the corridor partners. It is assumed that the linkages to the Regional Center to Center, and Data and Video Sharing System will be completed. The other main focus of the City of University Park is to increase its data collection and dissemination capabilities in order to improve the corridor's operation. The City does need additional detection capabilities to monitor the conditions of the arterial network.

Additions to Systems and Infrastructure

In order to fill the infrastructure needs of the City and to have a completed data collection network, and traveler information system; arterial detection within the city is needed on the major arterial in the city, along with some CCTV along the corridor.

The following arterials was identified for arterial detection and CCTV locations

- Lovers Lane

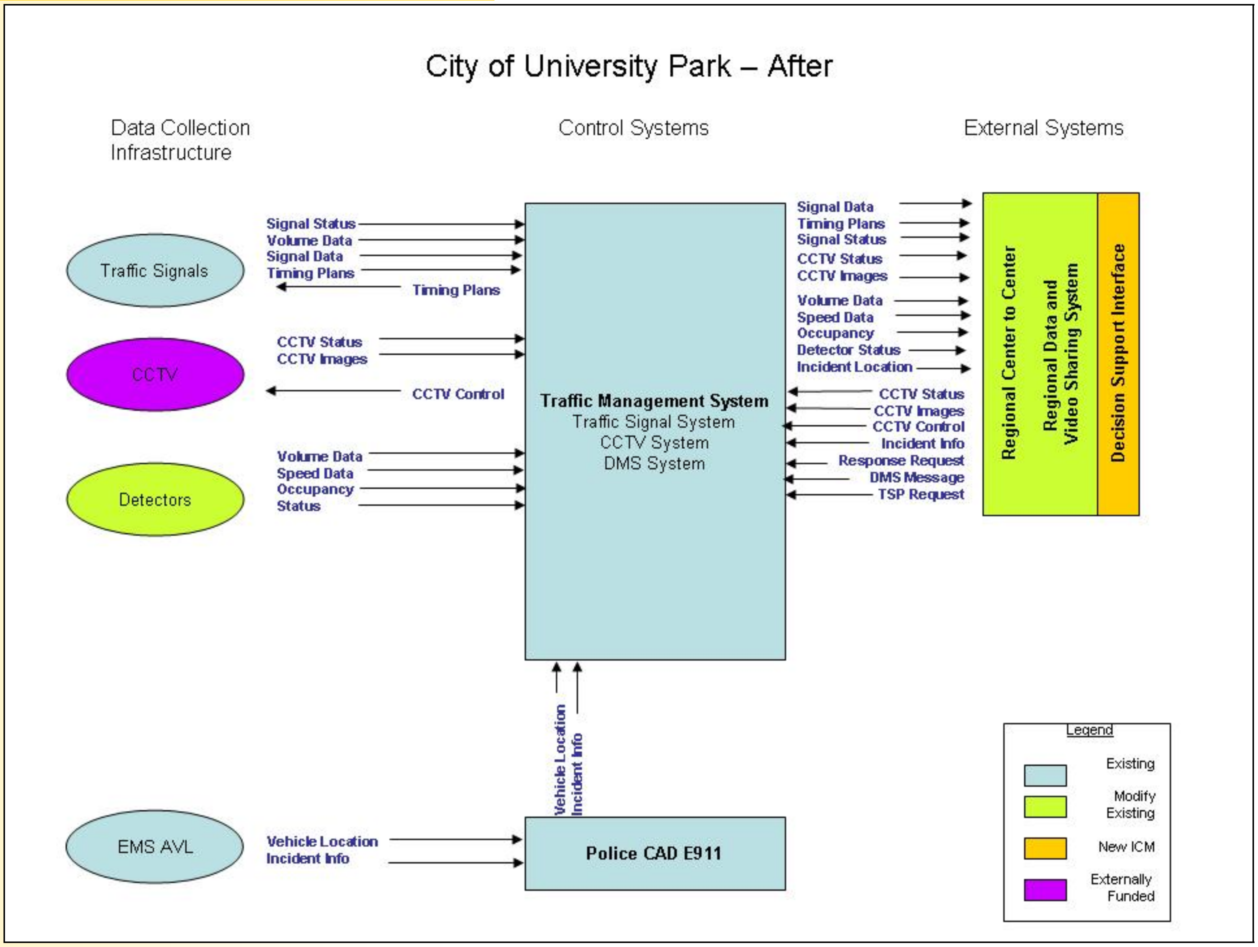

Figure 3.3-10 City of University Park - After

3.3.6. Texas Department of Transportation

As described in the Concept of Operations, the Dallas District of the Texas Department of Transportation (TxDOT) is responsible for the Design, Construction, Maintenance, and Operations of the US and State Highway System in seven counties in north Texas: Dallas, Denton Collin, Rockwall, Kaufman, Ellis and Navarro.

The US-75 Corridor from downtown Dallas passes through two counties (Dallas and Collin Counties) and four TxDOT Area Offices (of which three are located in Dallas County). Those offices being the Central Dallas Area Office, the Northwest Dallas Area Office, the Northeast/Rockwall Area Office, and the Collin County Area Office. These four offices have 318 employees. There are approximately 272 lane-miles of access-managed freeways in the US-75 ICM Corridor. TxDOT monitors most freeways within the Corridor via CCTV, private ISP providers, field units (enforcement and courtesy patrols), and other available sources along all but 14 highway miles in the Corridor.

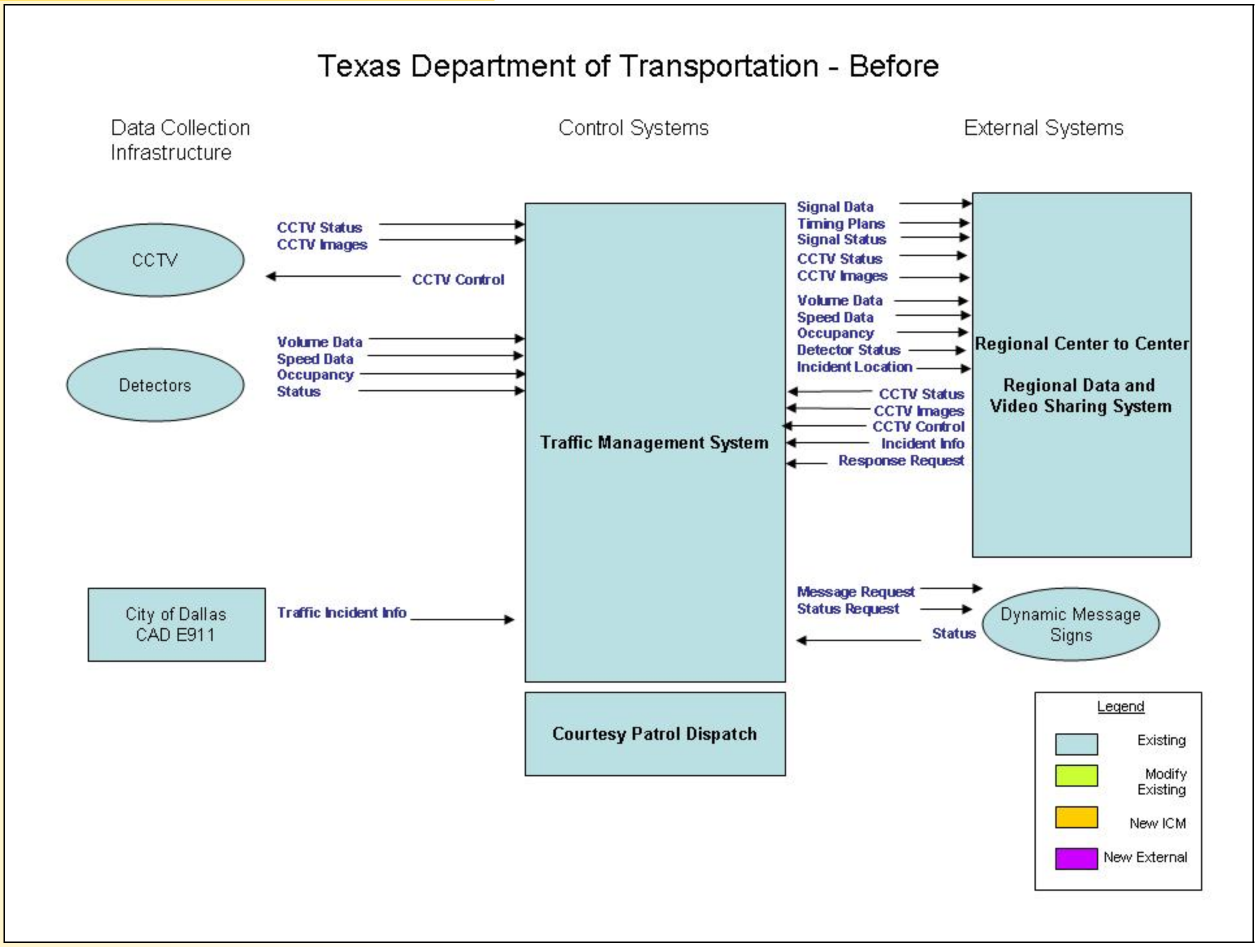

Figure 3.3-11 Texas Department of Transportation - Before

Since much of the TxDOT system is in place, there are only a few new items that are needed for the data requirements of the ICM, and the data distribution needs of the public. These include integration with the Decision Support Subsystem, and providing additional data to the corridor partners. TxDOT does need to deploy ramp meters, but this is not a priority. Two new DMS signs have been identified to fill-in the data distribution of the network, and additional detectors in areas that are currently not covered.

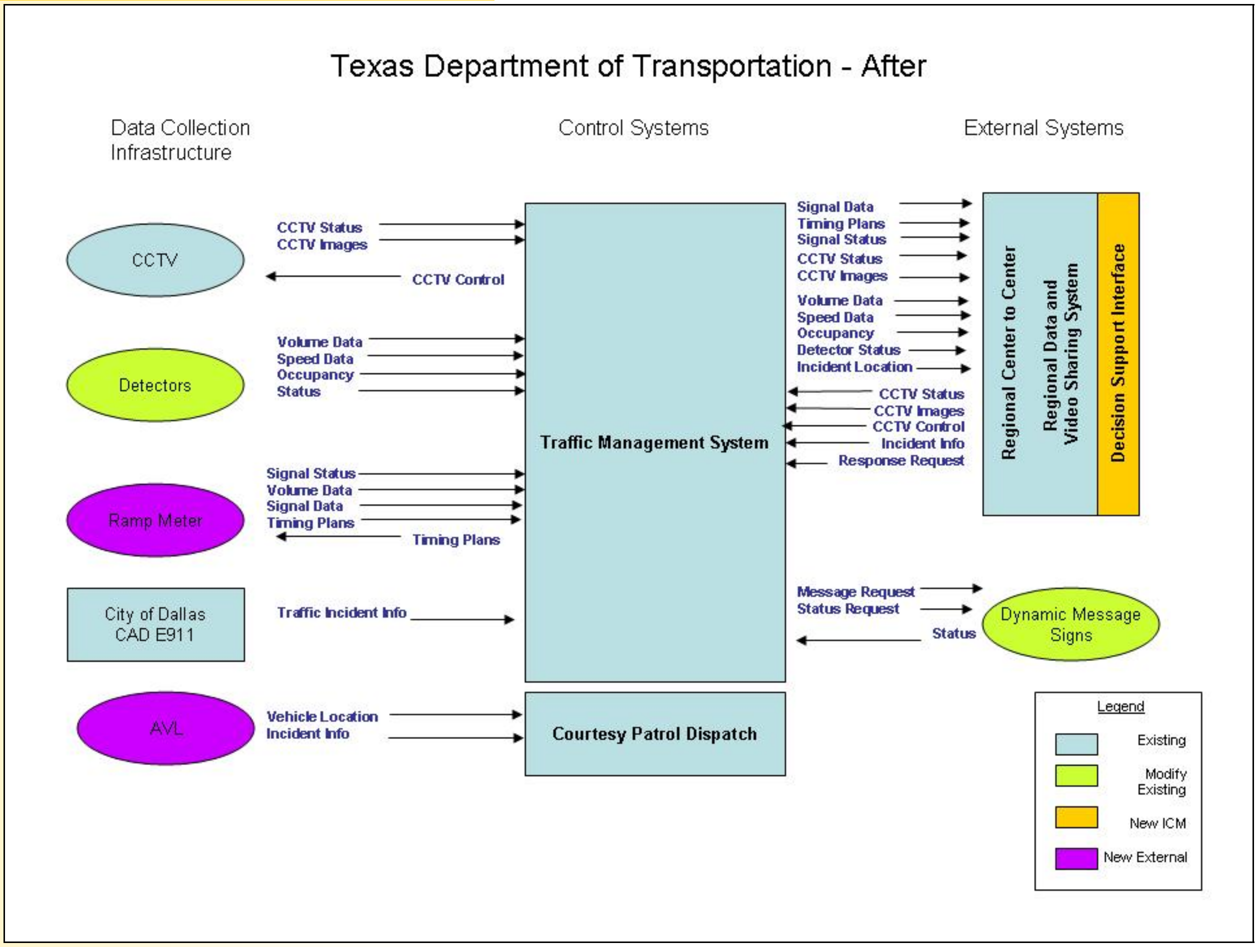

Figure 3.3-12 Texas Department of Transportation - After

Additions to Systems and Infrastructure

In order to fill the infrastructure needs of TxDOT and to have a completed data collection network, and traveler information system; additional detectors, ramp meters, and DMS were identified as the largest need for TxDOT. These will allow the ICMS to better monitor and predict traffic related issues within the corridor.

The additional infrastructure needs are:

- Completion of Ramp Meter sites, already in place along US-75
- Detectors will be need on US 75 particularly north of IH 635
- 2 additional DMS along the 28 mile corridor from downtown Dallas to SH 121

3.3.7. Dallas Area Rapid Transit

As described in the Concept of Operations, Dallas Area Rapid Transit (DART) – a regional transit agency authorized pursuant to Chapter 452 of the Texas Transportation Code – was created by voters and funded with a one-cent local sales tax in 1983. The service area consists of 13 member cities: Addison, Carrollton, Cockrell Hill, Dallas, Farmers Branch, Garland, Glenn Heights, Highland Park, Irving, Plano, Richardson, Rowlett and University Park. DART is governed by a 15-member board appointed by member-city councils based on population. Eight members are appointed by the City of Dallas and seven are appointed by the remaining cities.

Board members serve two-year terms with no limits. Board officers are elected from the board membership and serve one-year terms.

Dallas Area Rapid Transit (DART) provides bus and light rail transit service throughout the Corridor. Currently, DART serves Dallas and 12 surrounding cities with approximately 130 bus routes, 45 miles of light rail transit (DART Rail), 31 freeway miles of high occupancy vehicle (HOV) lanes, and paratransit service for the mobility impaired. DART and the Fort Worth Transportation Authority ("the T") jointly operate 35 miles of commuter rail transit (the Trinity Railway Express or TRE), linking downtown Dallas and Fort Worth with stops in the mid-cities and DFW International Airport. Through 2014, the DART Rail System is slated to more than double in size to 93 miles. Extensions now in development include the 17.5-mile Northwest Corridor serving downtown Dallas, American Airlines Center, the Dallas Medical/Market Center, Love Field Airport, and the cities of Farmers Branch and Carrollton.

The 45-mile DART Rail System provides fast, convenient service to work, shopping and entertainment destinations in Dallas, Plano and Richardson. Free parking is available at most rail stations, and all are served by bus routes timed to make transfers easy. Popular shopping, dining, and entertainment destinations near DART Rail stations within the US-75 Corridor include NorthPark Center and the Upper Greenville Avenue area (Park Lane Station), West Village (subterranean Cityplace Station), Mockingbird Station (Mockingbird Station), the Dallas Museum of Art (St. Paul Station), the historic West End District (West End Station), American Airlines Center (Victory Station), the Dallas Convention Center (Convention Center Station), the Renaissance Hotel and Eisemann Center for the Performing Arts (Galatyn Park Station in Richardson); Downtown Plano, the ArtCentre of Plano, and the Courtyard Theater (Downtown Plano Station).

DART operates all HOV facilities within the Dallas Region, including a Motorist Assistance Patrol on HOV facilities. Buses, motorcycles, vanpools and carpools with two or more occupants are eligible to use DART's 31-mile network off HOV lanes. DART operates HOV lanes on East R. L. Thornton Freeway (I-30) between Downtown Dallas and Jim Miller Road; Stemmons Freeway (I-35E) between LBJ Freeway (I-635) and Round Grove Road; LBJ Freeway between North Central Expressway and Stemmons Freeway; and I-35E/US 67 south of Downtown Dallas. Dynamic Message Signs, lane control signals, changeable message signs, and cameras associated with the HOV lane facilities are operated from the ITS Satellite Control Center at a DART/TxDOT facility. DART's Transit System Plan calls for 116 miles of managed HOV lanes. HOV lanes are jointly planned and designed by DART and the Texas Department of Transportation. DART is responsible for facility management, operation, and enforcement.

3.3.7.1. DART Network

One of the systems beginning to be developed and deployed for DART is the DART Network. The DART Network will integrate the systems within DART into a single data exchange and repository system allowing for the integration of the DART systems and provide a single interface for the Regional Center to Center network.

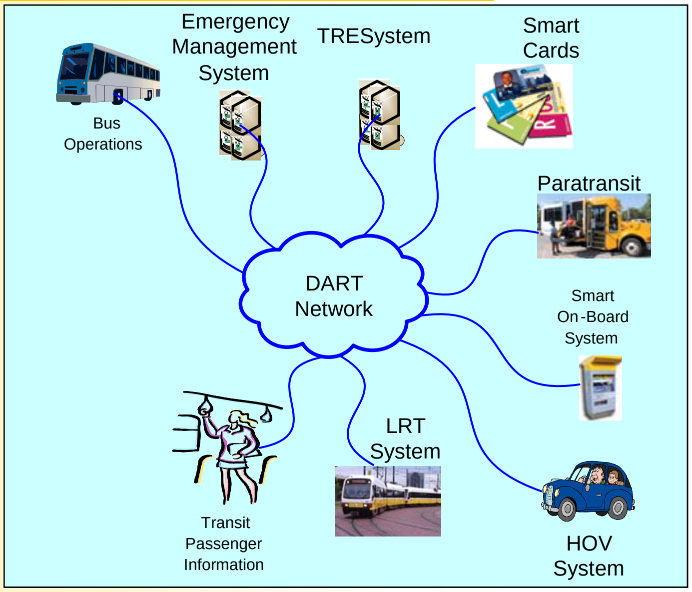

Figure 3.3-13 DART Network (Source: DART)

3.3.7.2. DART Police

The DART Police have the responsibility of providing enforcement and public safety for all of DART services, to include the HOV, Bus, and Light Rail Transit systems. DART Police utilize a Computer Aided Dispatch (CAD) to collect information and dispatch officers in response to incidents.

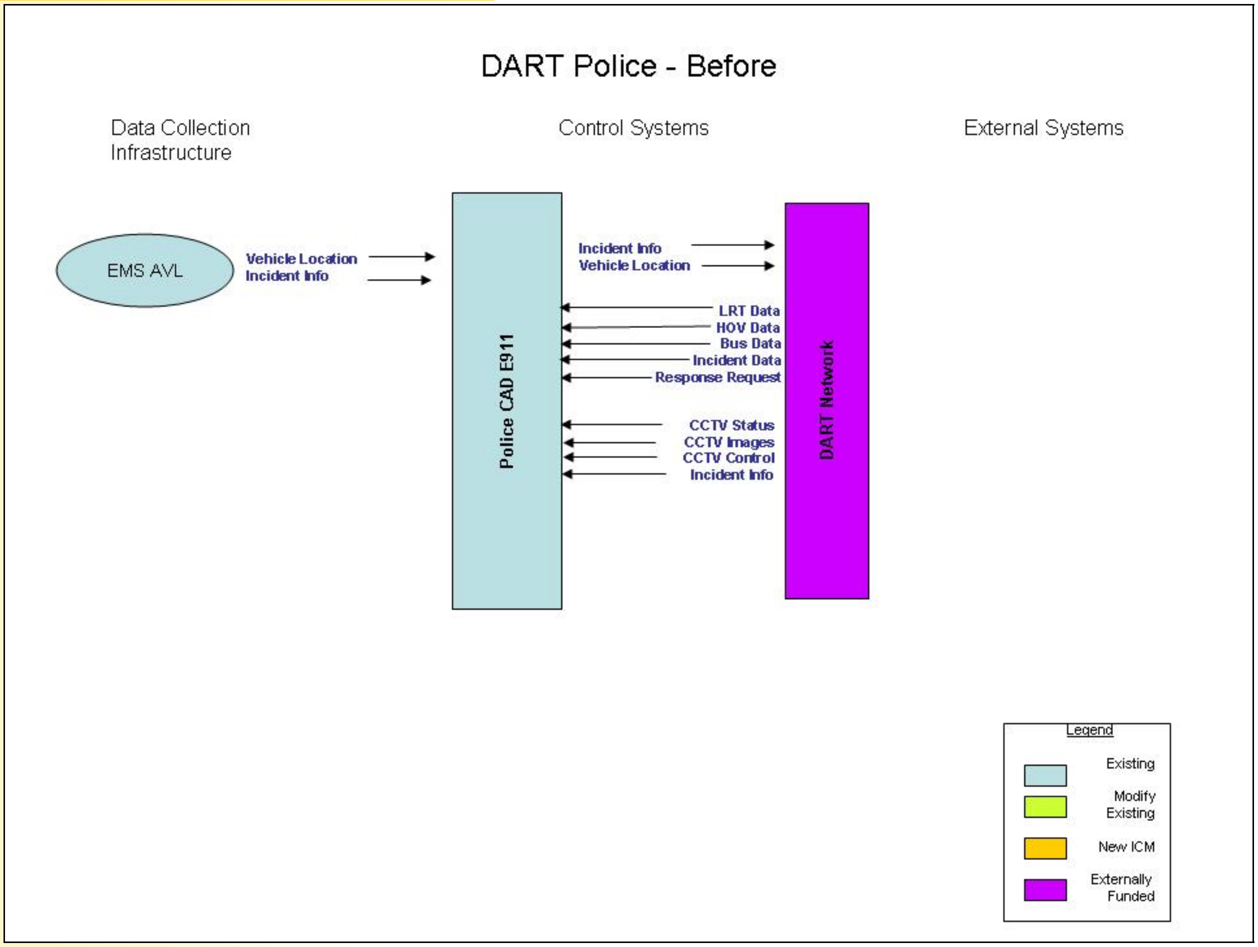

Figure 3.3-14 DART Police – Before

Since the DART police provide the enforcement and assist with incident management in the corridor, they have data on incidents, and locations. For all of the DART systems, the DART Network will be completed and connected to the Regional Center to Center for exchanging data, and for actively managing the corridor.

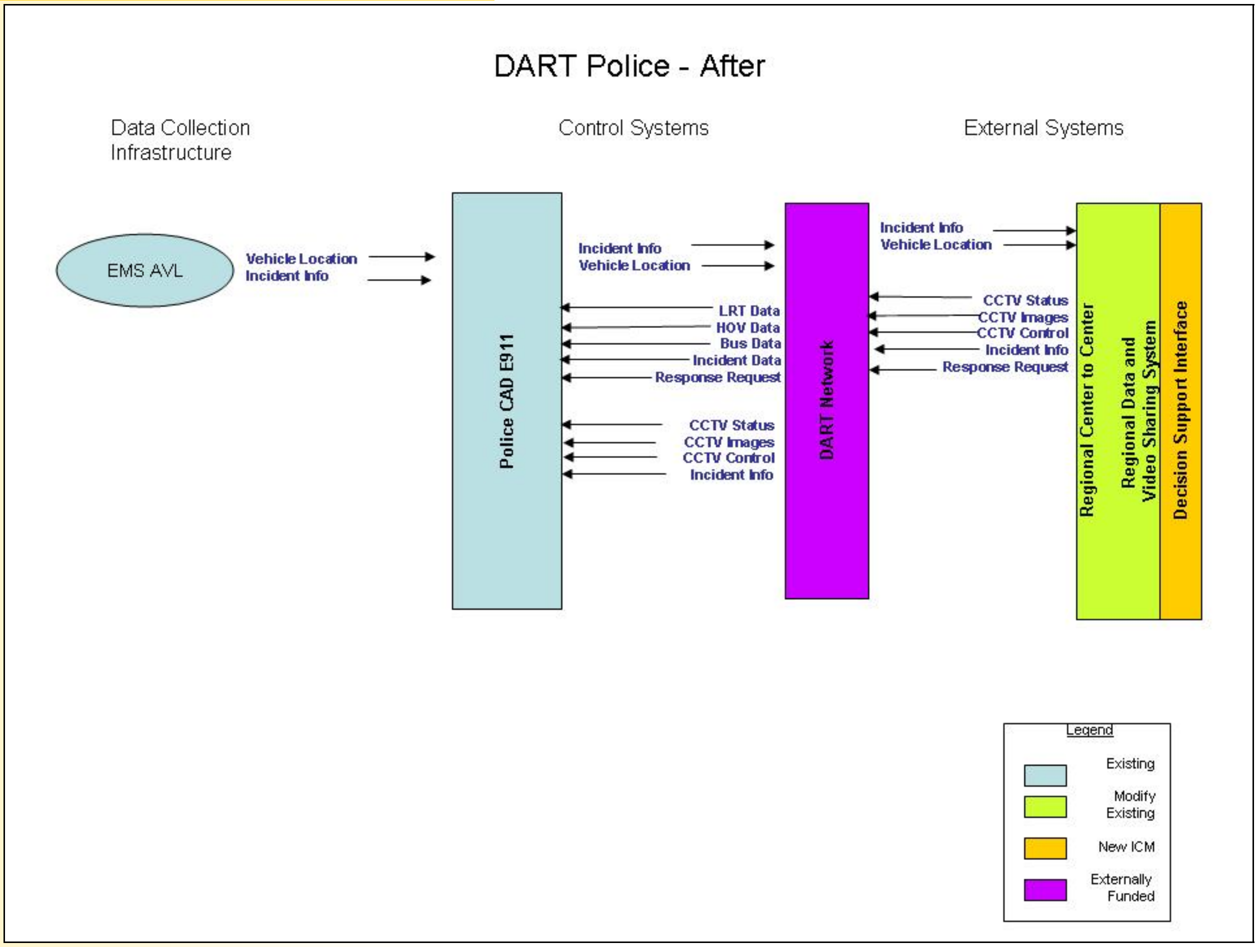

Figure 3.3-15 DART Police – After

3.3.7.3. DART Light Rail

The primary light-rail line within the US-75 Corridor is the Red Line which runs north-south. The portion of the Red Line within the Corridor Boundaries runs from the Downtown Dallas station (Convention Center Station) to the northern-most station (Parker Road Station) in the City of Plano. Between these two endpoints, there are a total of 17 rail stations.

In addition, the Blue Line runs in the US-75 Corridor Influence Area from Downtown Dallas to the Mockingbird Lane Station (approximately three miles). From the Mockingbird Lane Station, the Blue Line runs into the City of Garland. The Blue Line is the eastern-most boundary of the larger Corridor Influence Area and could serve as an alternate rail route into downtown if there were problems with the Red Line.

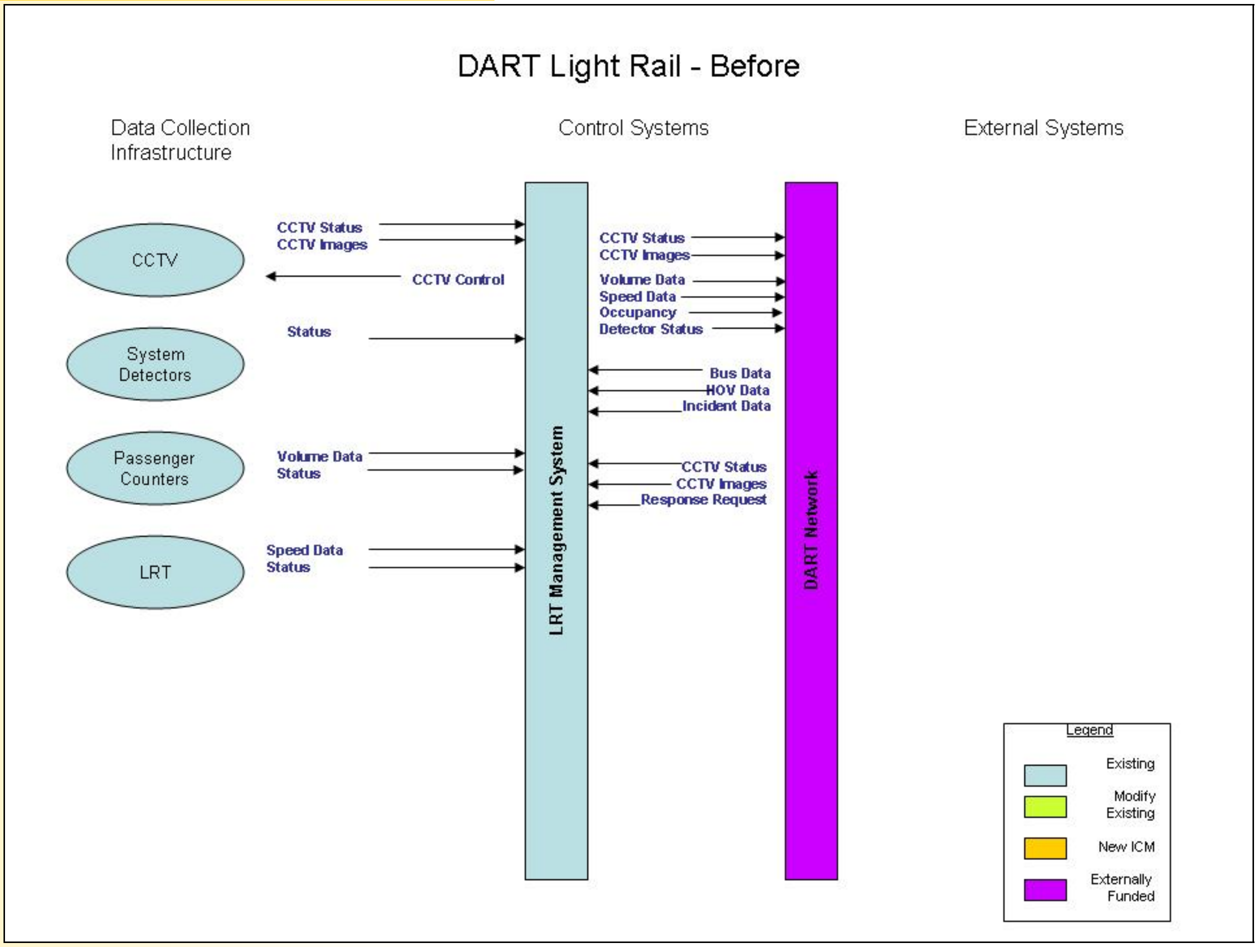

Figure 3.3-16 DART Light Rail - Before

As discussed in the Concept of Operations, the LRT will serve as a major part of the modal shift within the corridor. This includes additional parking, parking management, and providing more real-time information on capacity and volumes of the LRT system. For all of the DART systems, the DART Network will be completed and connected to the Regional Center to Center for exchanging data, and for actively managing the corridor.

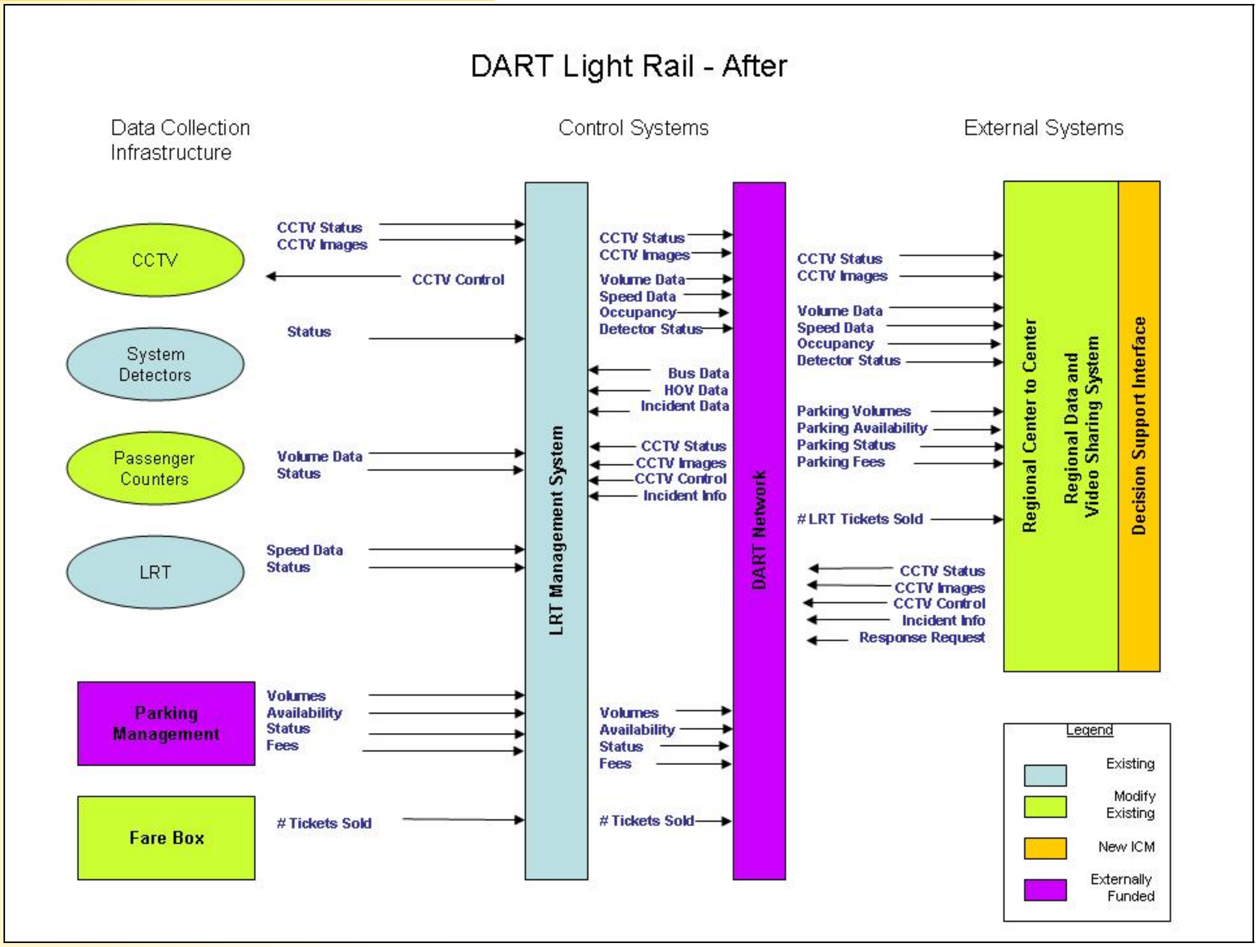

Figure 3.3-17 DART Light Rail – After

3.3.7.4. DART HOV

The US-75 HOV Lane opened for operation in December 2007, the HOV lane is a single concurrent flow lane in each direction separated from the general purpose traffic by a painted buffer area with pylons to provide physical separation. The HOV lane is 15 miles in length (these are new miles being added to the existing 31-mile system) and extends from the northern end of the Corridor (Exchange Parkway and US-75) to the I-635 interchange.

There are three access points in each direction to the HOV lane within the Corridor. The northern end has a slip ramp from the inside lanes of the freeway. Near the I-635 interchange there are “wishbone” type ramps for traffic to enter and exit the facility.

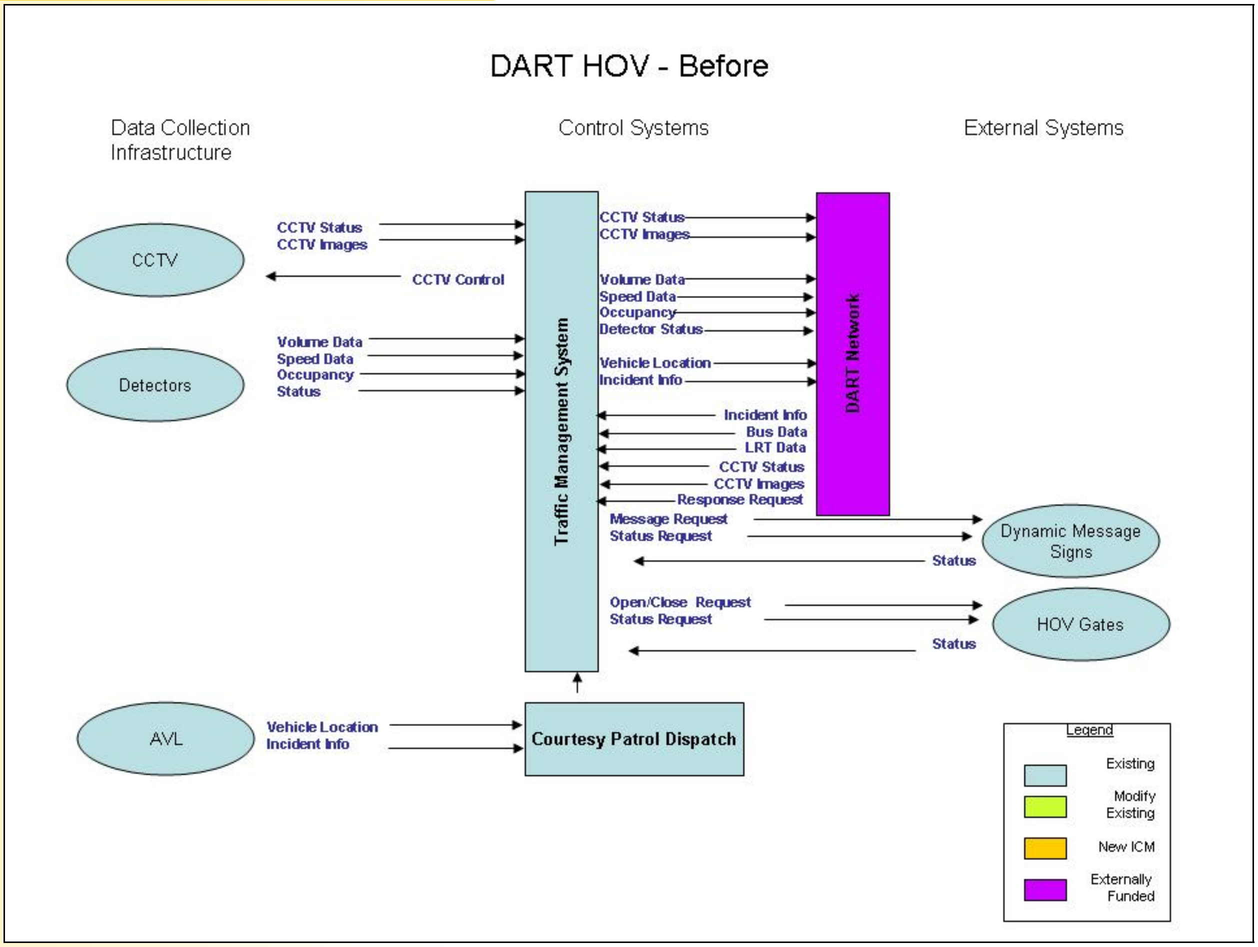

Figure 3.3-18 DART HOV – Before

The DART HOV Operations are co-located at DalTrans with the TxDOT operations. Much of the information provided by the HOV systems is needed for the operations of the corridor. For all of the DART systems, the DART Network will be completed and connected to the Regional Center to Center for exchanging data, and for actively managing the corridor.

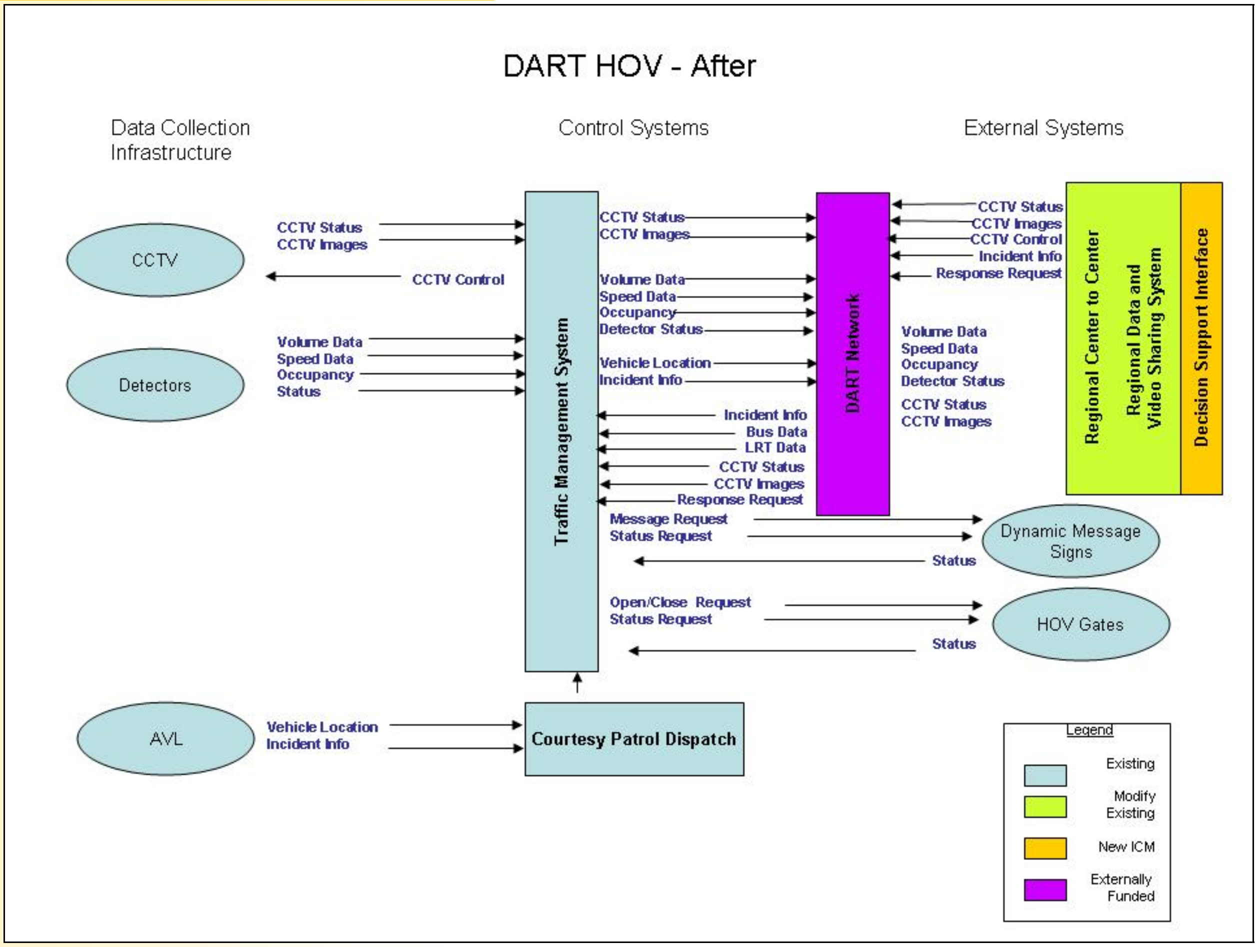

Figure 3.3-19 DART HOV - After

3.3.7.5. DART Bus

The bus transit Network within the US-75 Corridor Boundary consists of various types of services. There is local bus service serving specific areas characterized by frequent stops. In addition, express routes and cross-town routes that serve longer distance trips. Express routes have less frequent stops and generally run on the primary arterials within the Corridor.

There is also a light-rail station feeder bus service. These bus lines transport passengers traveling between light-rail stations. In total, there are 30 express routes and an additional 12 special routes in the US-75 Corridor.

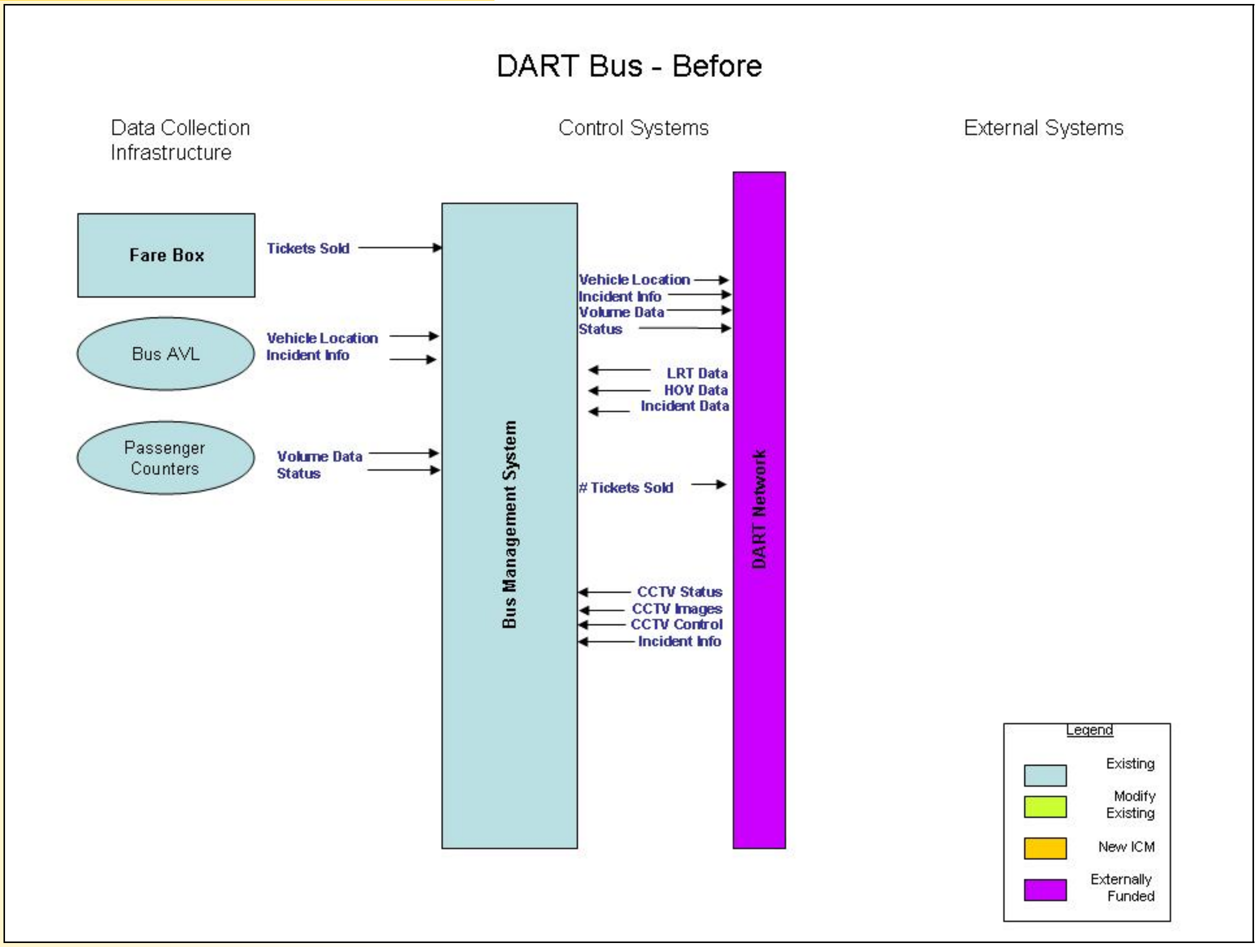

Figure 3.3-20 DART Bus – Before

As discussed in the Concept of Operations, the Bus system will also serve as a major part of the modal shift within the corridor. For all of the DART systems, the DART Network will be completed and connected to the Regional Center to Center for exchanging data, and for actively managing the corridor.

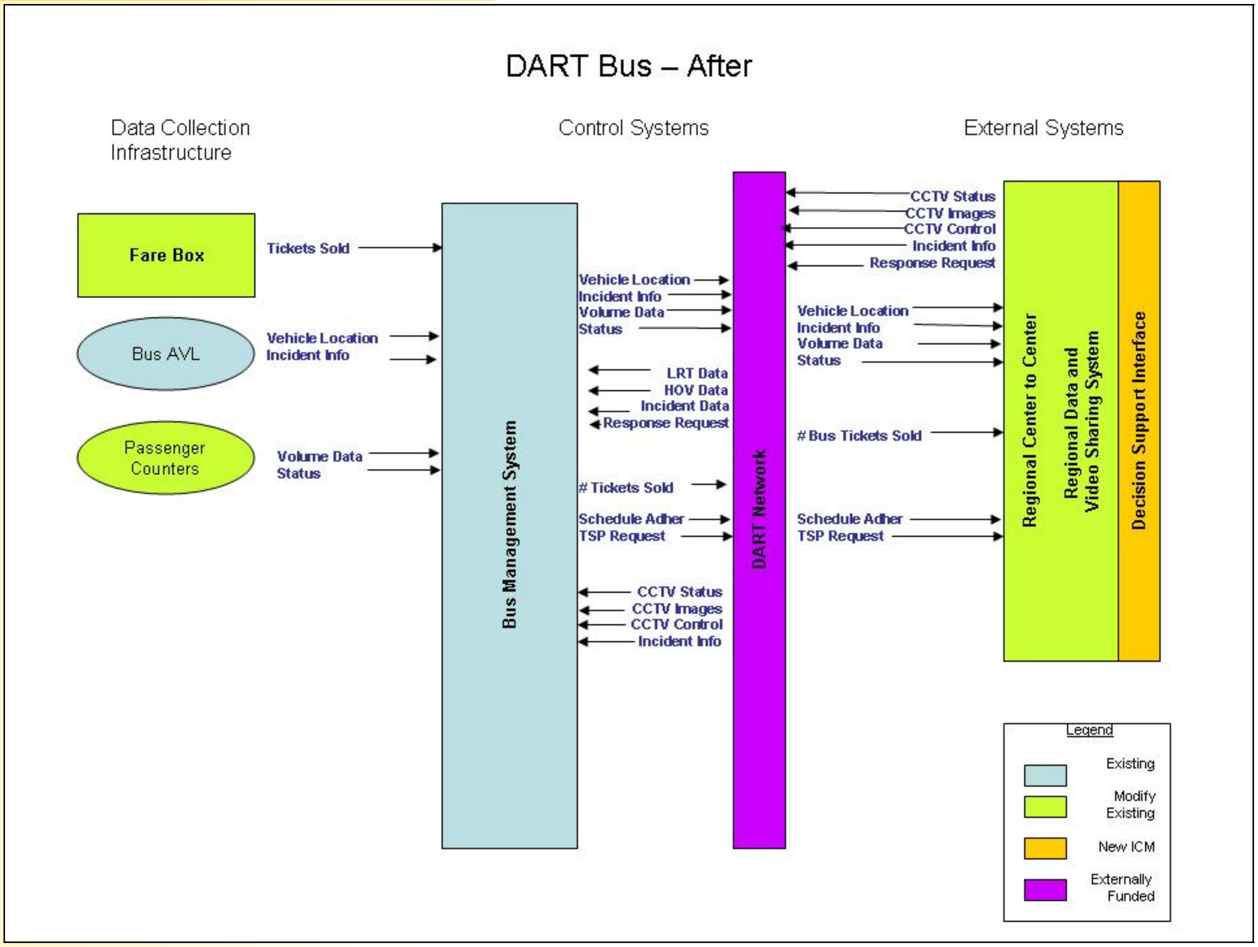

Figure 3.3-21 DART Bus – After

Additions to Systems and Infrastructure
Since a major goal of the ICM is for Modal Shift, DART plays an important role in this effort. In order to improve the data collection of the system, and to provide for the corridor, several new systems and improvements to the infrastructure were identified. These will allow the ICMS to better monitor and predict traffic related issues within the corridor.

New Systems and Infrastructure Identified include:

- Transit Signal Priority
- Passenger Counter System on all Buses
- Passenger Counter System on all Light Rail Transit
- 2 Additional Light Rail Vehicles (LRV)
- Parking Management System
- Fare Box Counters – real-time
- Additional CCTV at Rail Stations, and Parking Lots

3.3.8. North Texas Tollway Authority

The NTTA operates both the President George Bush Turnpike (PGBT) and the Dallas North Tollway (DNT). The PGBT is an east-west toll road that intersects the Corridor in the northern section. The PGBT provides access to several of the north-south arterials to the west as well as the DNT. The DNT is the other major north-south controlled access facility. The north-south arterials and the DNT have the ability to serve as alternate routes to destinations in the US-75 Corridor.

The DNT has three mainline plazas with both high-speed electronic toll collection-only (ETC) lanes, and toll booth lanes that accept either electronic or cash payment. There are also ten ramp access locations that accept both electronic and cash payment.

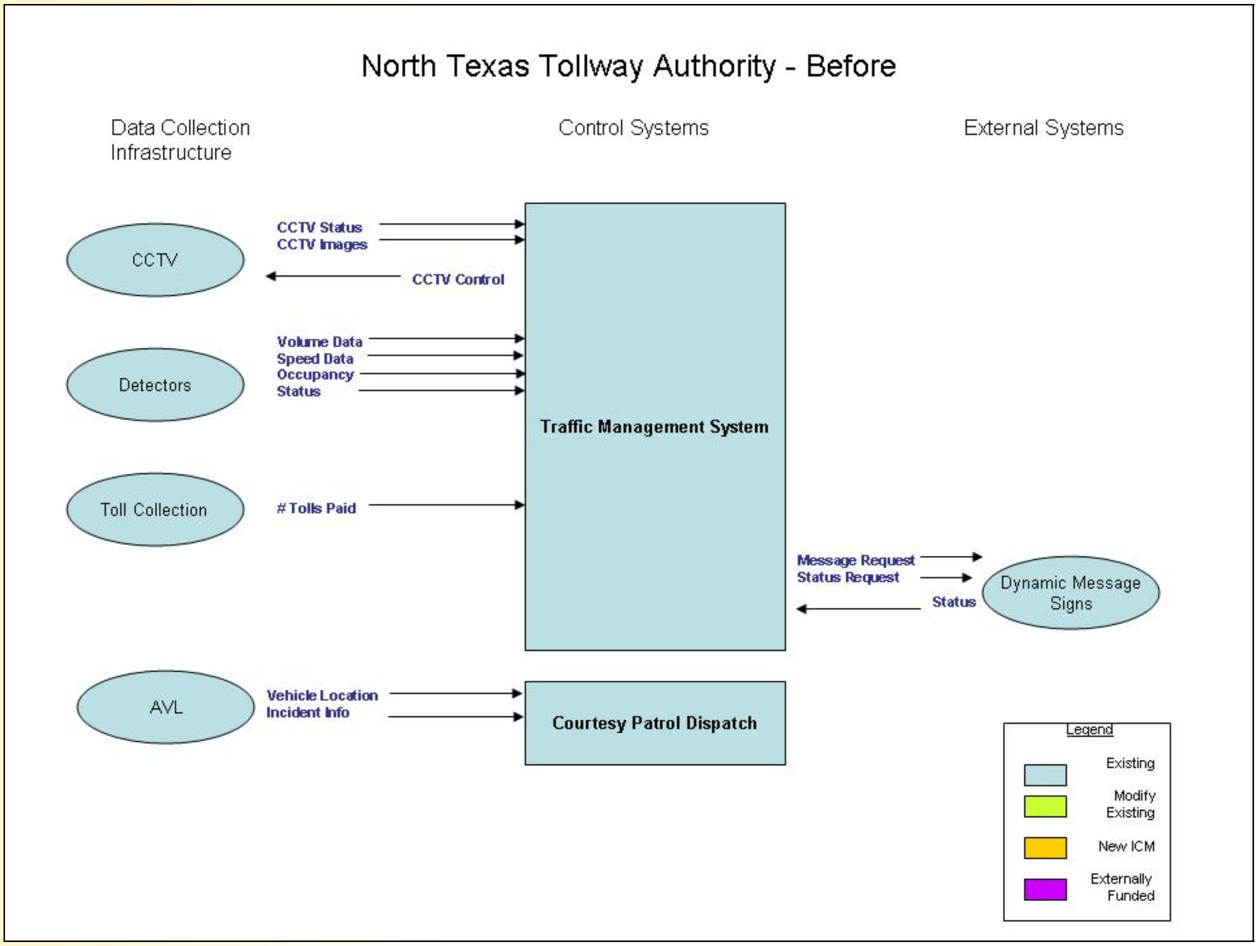

Figure 3.3-22 North Texas Tollway Authority Systems - Before

Additions to Systems and Infrastructure

NTTA has the majority of its infrastructure in place, or planned and funded. For the ICMS, the biggest need is the data sharing and integration with the other agencies within the corridor. It is assumed that NTTA will be connected to the Regional Center to Center and the Regional Data and Video Sharing Systems.

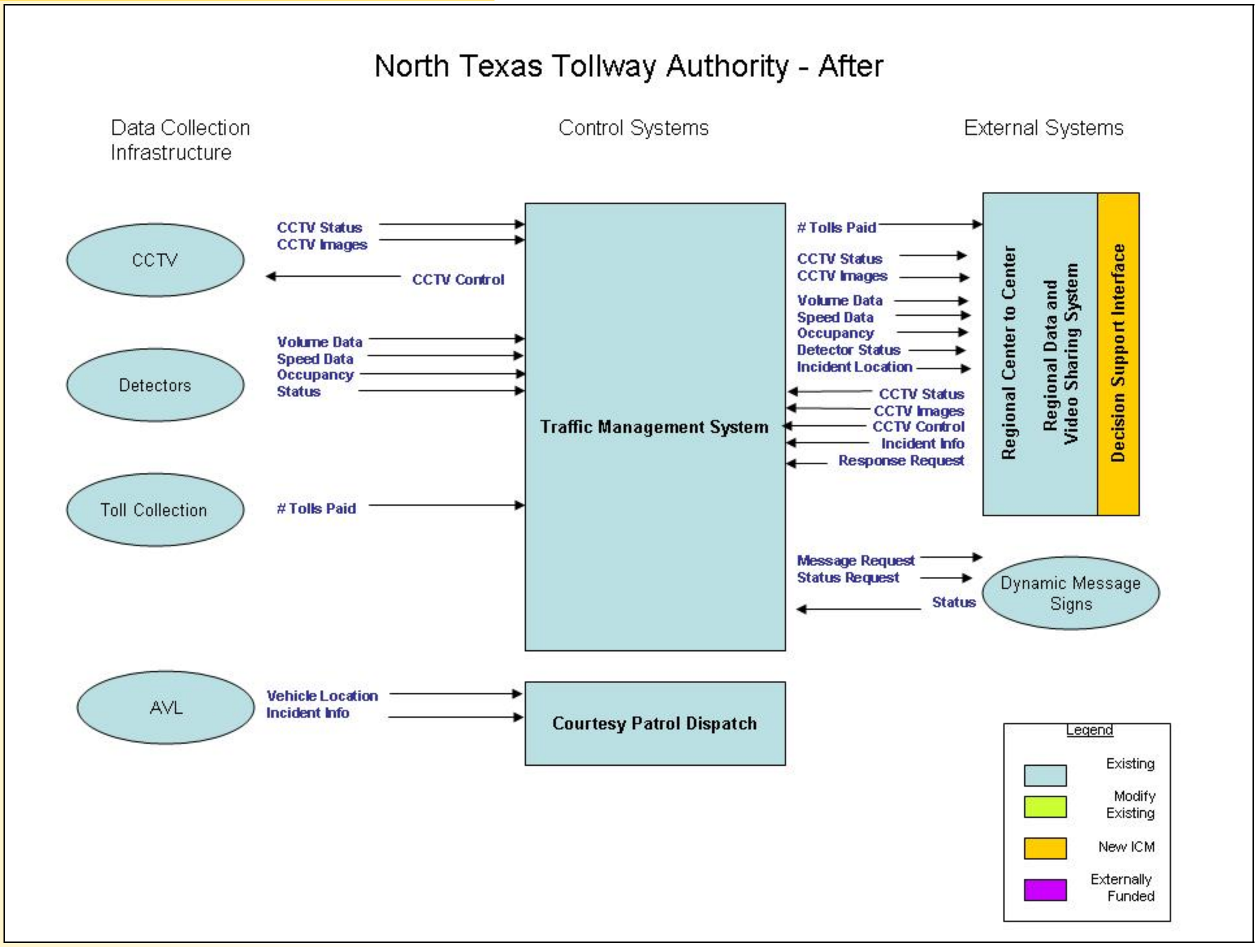

Figure 3.3-23 North Texas Tollway Authority Systems - After

3.3.9. Decision Support Subsystem

As described in the Concept of Operations, the operations and coordination of the corridor will utilize a Decision Support Subsystem as part of the daily operation of the corridor, and will be coordinated through the existing arrangements between the agencies with information exchanged through the center-to-center project. The Decision Support Subsystem will distribute response plan requests and utilize the center-to-center interface to communicate to the various agency systems, as shown below in Figure 3.3-24.

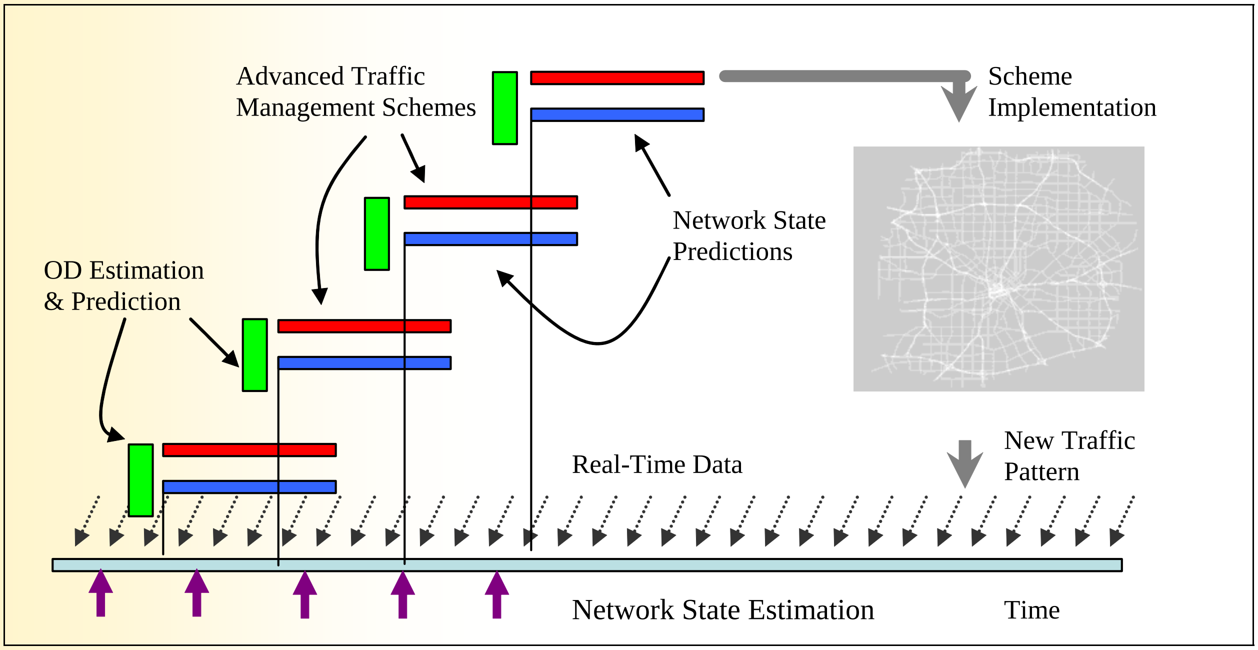

Figure 3.3-24 Decision Support Subsystem Framework

Figure 3.3-25 and 3.3-26, below, show the data flows into and out of the Decision Support Subsystem to create a real-time system which will provide response plan requests, monitor current network conditions, and provide some prediction on future conditions. These capabilities will allow the corridor agencies to be pro-active in responding to current and potential network conditions.

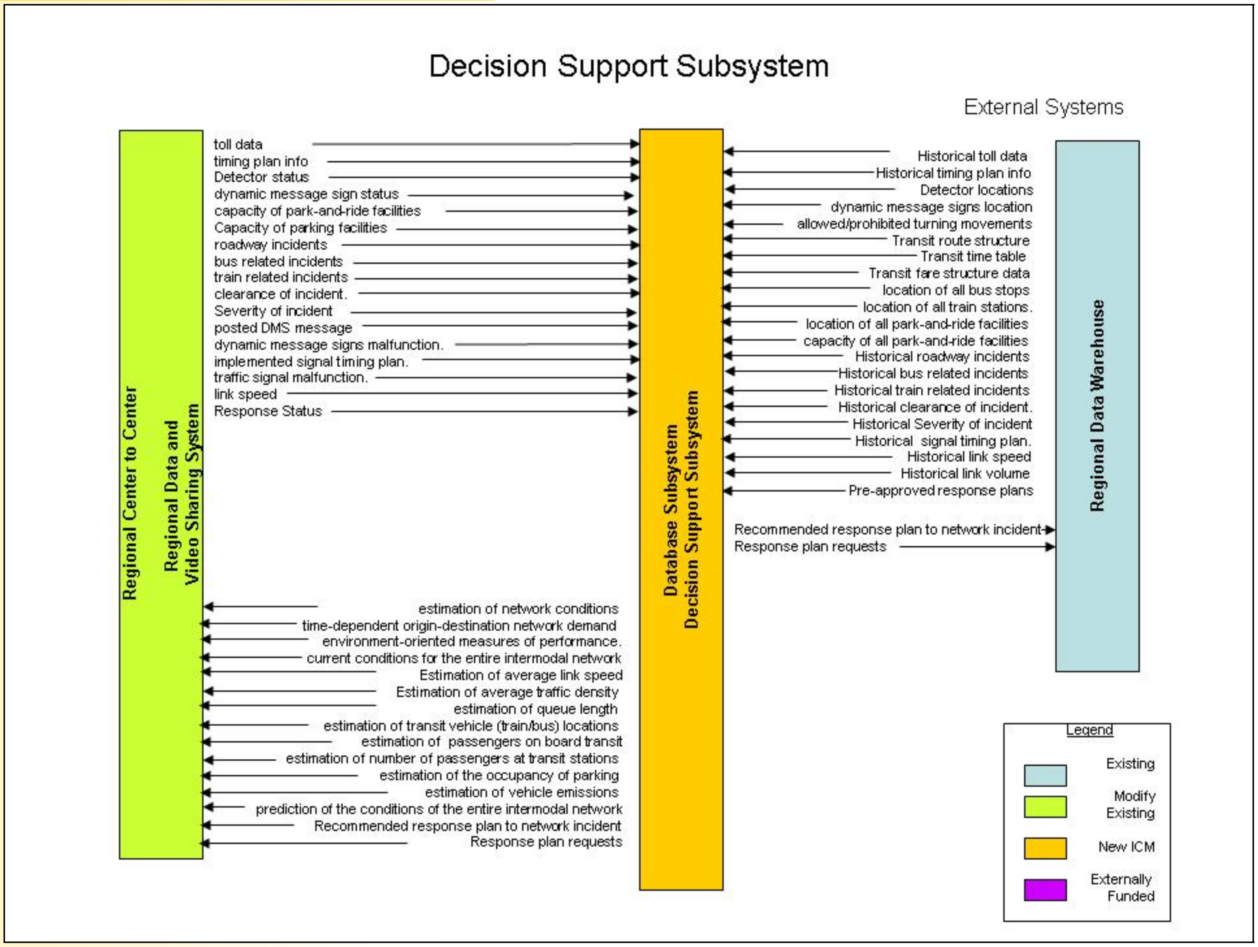

Figure 3.3-25 Decision Support Subsystem

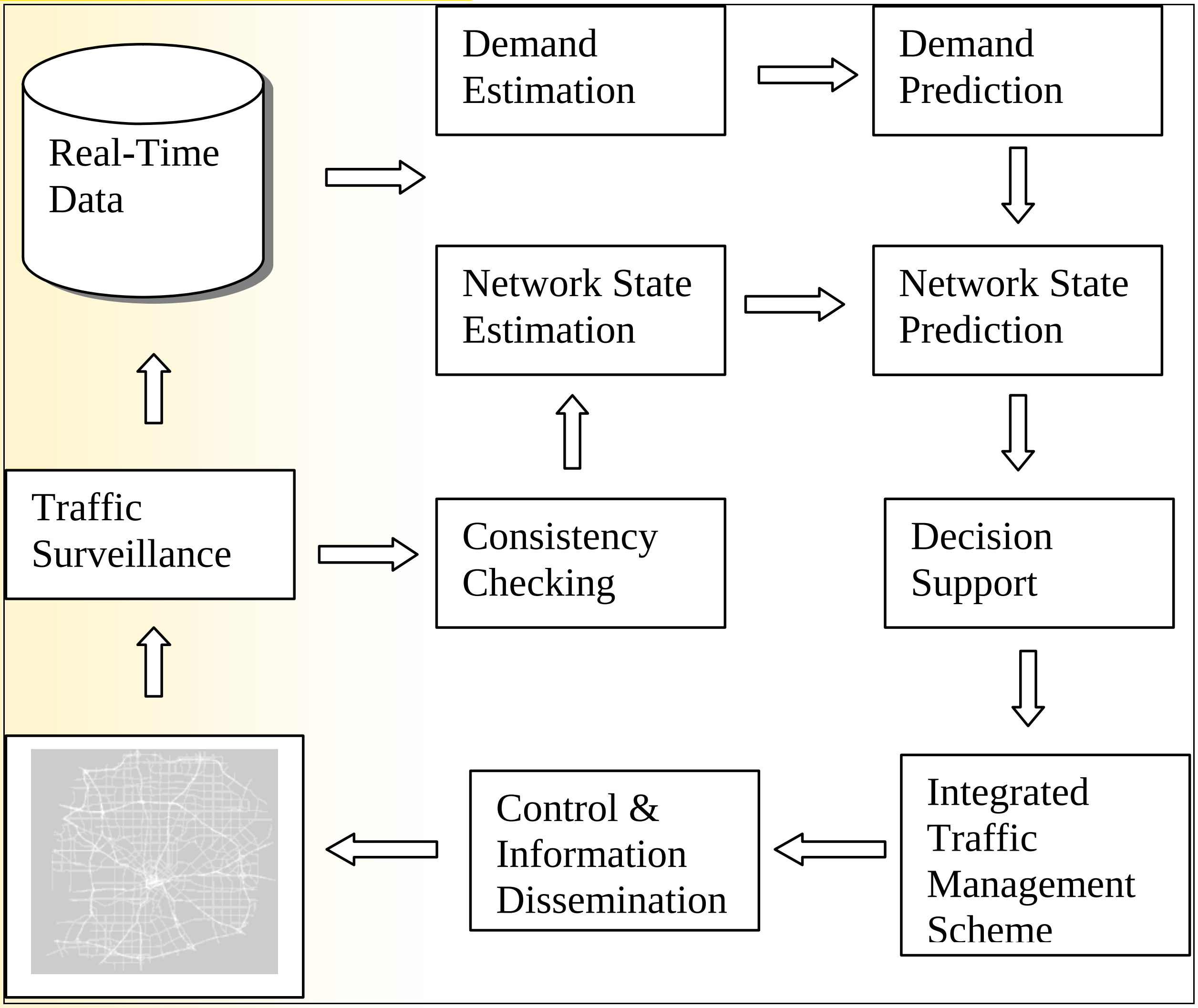

Figure 3.3-26 Decision Support Subsystem Data Flow

A basic functional requirement of real-time traffic management system is to be able to predict the traffic congestion pattern and to develop a real-time integrated management scheme to alleviate this congestion. State prediction of urban traffic networks is a complex process. It requires estimating the current state of the network, predicting the future travel demand over the prediction horizon, and projecting the temporal-spatial traffic evolution as the outcome of demand interaction with the supplied roadway capacities and the adopted control strategies.

Estimating the current state of the network is a data driven operation. A real-time data stream that describes the current state of the different network elements is obtained through a distributed surveillance system. In case of partial network coverage, a supporting network state estimation module is used to provide an estimate of the missing data elements. Predicting the future travel demand over the prediction horizon combines historical origin-destination trip tables and the observed real-time data to estimate the current time-dependent trip tables, and to use this estimation as a basis to predict the future travel demand pattern.

Projecting traffic evolution and associated congestion pattern starts by acquiring a snapshot describing the current state of the entire network and the future origin-destination travel pattern over the prediction horizon. The network state prediction module predicts travelers' mode-route choice decisions as function of the evolving congestion pattern and the adopted control strategies. The anticipated operation performance of the different network elements is captured as the outcome of the travelers' collective decisions. Based on the predicted performance, an efficient traffic management scheme is developed. The scheme integrates several advanced traffic and transit management strategies including real-time adaptive signal control, travelers' information provision strategies, automated incident detection and emergency management systems, dynamic congestion pricing systems, transit vehicle location identification systems, transit and emergency vehicle preemption, real-time transit dispatching systems, etc. Figure 3.3-27, below, shows a sample of the system interface under development by SMU for the ICM project.

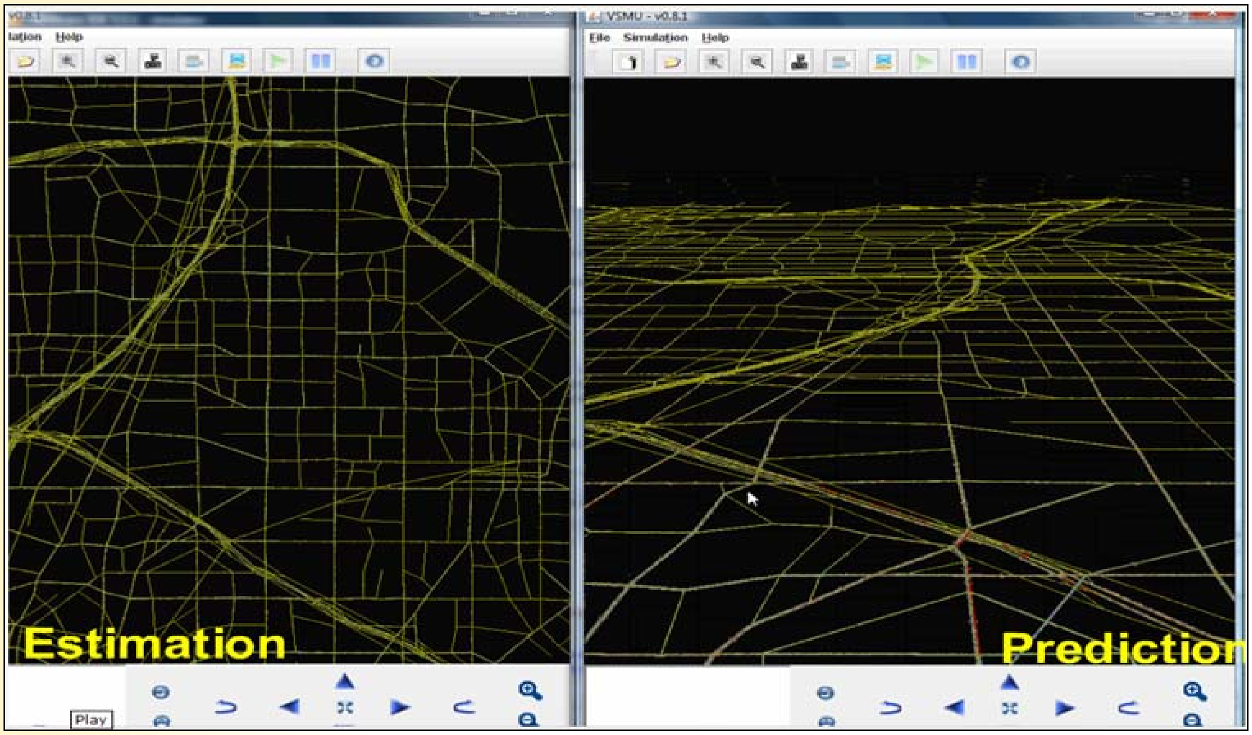

Figure 3.3-27 Decision Support Subsystem Interface (Source: Southern Methodist University)

3.3.10. System Modes

Since the decision support system will be used as an operational tool for the corridor two modes of the system are needed, a production and a test mode. The test mode would be used to verify the system works correctly without modifying or creating false data into the regional systems. The test mode would utilize a set of test data that could be used for verification and testing of the decision support system.

3.4. Major System Constraints

This section summarizes the problems, issues and needs of the individual Networks and the Corridor as a whole. Using the inventory information and other gathered data, coupled with stakeholder discussions, this section addresses operational, technical, and, institutional deficiencies and constraints, As such, it provides insight into the types of problems being faced in the US-75 Corridor.

Within the US-75 Corridor, the challenges in efficient movement of people and goods can be classified in terms of 1) agency coordination, 2) available capacity, and 3) proactive operational and control strategies.

3.4.1. Network Challenges

Agency Coordination: First, the Corridor encompasses multiple modes of transportation and a variety of facilities. It also encompasses multiple operating agencies with various responsibilities for providing transportation services. These operating agencies include five cities, two counties, a state department of transportation, a transit authority, a regional tolling authority, a metropolitan planning organization and a large number of local emergency service providers. While the various agencies generally operate in a cooperative manner, there are limited systems and tools for integrated coordinated operation.

One example where data is exchanged is between Texas Department of Transportation (TxDOT), the Dallas 911 system, and Metro Traffic (one of the local information service providers). The TxDOT Dallas District ITS central system receives traffic incidents from Dallas related to incidents, events, or other actions is accomplished via email or telephone. There is not, however, a Corridor-wide automated mechanism for improved sharing of data, control strategies, and response plans.

For example, a major incident may occur on a freeway and block travel lanes for an hour or more. Drivers may reroute based on information from Dynamic Message Signs (DMS) or from Information Service Providers (ISPs). There exists an opportunity for a modal shift to transit, a travel schedule shift, or a route shift if there is a mechanism in place for the affected agencies to act. Even with recurrent congestion, there exists an opportunity for modal, schedule, or route shifts with exchange of information among agencies along with communication to travelers. Such exchange of information and an action plan can better balance available capacity either in time or space. In either case - recurrent or non-recurrent congestion - agencies would be able to manage travel in a more coordinated manner with improved exchange of information and a coordinated action plan taking into account available capacity from all modes.

During 2005, the TxDOT freeway management system logged over 8,500 incidents on US-75 and over 5,000 incidents on I-635 within the Corridor boundaries. These incidents ranged in severity from debris in the roadway, to stalled vehicles, to major vehicle crashes with multiple lane closures.

Available Capacity: Second, the Corridor represents a highly-developed, urbanized area. As such, there is limited right-of-way remaining to expand the freeway and arterial streets. Therefore, the vehicle capacity is set, and the ability to handle future demand increases relies on moving more people on the given modes and effectively utilizing the existing capacity in real-time as both demand and capacity fluctuate.

Proactive Operational and Control Strategies: Third, maintaining mobility and safety in the Corridor will require proactive operational and control strategies implemented in an integrated manner among the agencies in the Corridor. Whether it is responding to the high travel demand each day or responding to special and planned events in the Corridor, there is a need to coordinate available capacity to match changes in demand. Furthermore, traveler information must be provided to inform users of travel alternatives to maximize their trips.

While the Corridor Stakeholders are in agreement that the principal mobility challenge in the Corridor is the daily traffic demand, there are a significant number of special events at venues in or near the Corridor that add additional challenges for mobility, safety, and wayfinding.

3.4.2. Network Needs

Many of the operational deficiencies within the US-75 Corridor were identified in the Concept of Operations, representing a major problem along most of the networks within the Corridor. Specific examples of additional needs relating to separate Network, as well as the Corridor as a whole are discussed below. These needs were established through a dedicated Corridor Stakeholder interviewing process, as well as by general input throughout the process of developing this Con Ops.

Arterial Network Needs

- Increased communications infrastructure between agency systems/centers, especially for video sharing
- Optimization / retiming of traffic signals – especially on established detour routes within Corridor
- Signal systems that better react to current travel conditions (rather than time-of-day) – i.e., deployment of traffic responsive signal systems along arterials throughout corridor.
- Collection and use of real-time traffic conditions along arterials – volume data is needed along with speed data
- Increase city traffic management office access to 911 / Emergency CAD data to better manage signal system based on incidents effecting traffic on arterials
- Improved incident management policies for incidents on arterials – different than freeways

Freeway Network Needs

- Increased freeway travel data to distribute accurate traveler information
- Increased mediums for distributing freeway traveler information, e.g., automated emailing of incidents based on personalized travel preferences
- Processing accurate freeway travel times
- Increased sharing of existing freeway travel speed data to other agency systems
- Relaying freeway travel times to travelers, specifically on DMS
- Making freeway travel times available to other agencies for operational use and distribution to travelers
- Steaming video to travelers
- Improve ability to delineate the events that will effect highway mobility from within integrated data from 911/Emergency CAD system
- Improve ability for appropriate TxDOT personnel to be alerted by 911/Emergency CAD events that effect transportation system

Transit Network Needs

- Signal priority capability for light rail transit.
- Signal priority for bus transit vehicles (especially near transit centers)
- Increased coordination between DART and Cities for management and public information distribution relating to transit line closures
- Ability to accurately measure bus and rail ridership in real-time

- Need ability to alert (not just broadcast) customers about service disruptions, both pre-trip and en-route (probably via wireless medium, e.g., cell phones or PDAs)
- Need better parking management at park-n-ride facilities, e.g., traveler information about lots being full
- Need for automated payment collection at park-n-ride lots
- Increased information sharing within DART so that bus operators know about problems on rail, and vice-versa

Incident Management / Field Operation Needs

- Increased outreach/education for local police & fire in incident response procedures related to traffic management, i.e., keeping traffic moving where possible
- Increased coordination with incident responders to communicate operational decisions, including between TxDOT maintenance, local police, local fire, towing, and EMS personnel.
- Need for interoperable communication between incident responders of all agencies

Multi-Network Needs

- Getting freeway travel times and incidents to travelers along arterials prior to getting on freeway.
- Additional mediums for distributing travel conditions to travelers en-route, e.g., via cell-phones or PDAs.
- Ability to effectively communicate diversion routes to travelers who may be unaccustomed to alternate routes, e.g., use dynamic trailblazing signage.
- Proven systems for predicting operating conditions in order to make operational decisions.
- Ability to measure mode change when put into affect as traffic management tool
- Increased sharing of video
- Increased sharing of travel conditions along all networks, so that information about problems on one network can be relayed to travelers who seek to transfer from another network
- Access to real-time information about incidents, including what agencies and/or resources are at the incident scene
- Ability to effectively relay travel time and/or delay information for all modes to travelers en-route so that travel decisions can be made
- Need for real-time volume data on all modes, not just flow data
- Integration of existing bus location data (for flow information) to freeway systems
- Public outreach and education to traveling public who's unaccustomed to use of alternate modes of travel, e.g., education program to explain use of park-n-ride lots and transit fare payment options.

Institutional / Coordination Needs

- There is a need for formalized agreements to define data and video sharing protocol between partner agencies.
- There is a need for formalized standard operating procedures for multi-agency shared control of ITS devices through integrated systems
- There currently is no clearly defined and agreed-upon performance measures for determining the effectiveness of multi/cross-network operational management
- There needs to be increased coordination between agencies about what real-time data is being collected and how it can be made available

- Increased focus of Corridor Stakeholders for integration of existing system, rather than deployment of additional non-integrated systems
- Acquiring decision-maker/political support for ICM concepts, specifically the City Councils and RTC

3.5. Assumptions and Dependencies

Since the practice and concepts of ICM are relatively new, several system, technology, and institutional assumptions were made in the development of the requirements. These assumptions may prove false once more is known, and ICM deployment is completed. However, based on the information we currently have on ICM and the corridor, these are our best assumptions.

3.5.1. System Assumptions

- The Regional Center to Center will be sufficient for the data exchange needs of the ICM
- The Regional Center to Center will be fully deployed
- The Regional Data Warehouse will be fully deployed
- The TMDD and MS/ETMC standards deployed as part of the Regional Center to Center will be sufficient in most cases for the data needed for the ICM System
- Communication links between all US 75 stakeholders are completed
- Current deployed infrastructure and systems will be utilized
- This is a research project, so some of the technology and systems deployed may need to be altered once operations have begun
- Current and proposed infrastructure will be sufficient for the data requirements of the ICM, and the real-time Decision Support Subsystem

3.5.2. Technology Assumptions

- Utilize the existing Regional Center to Center system
- Utilize the Regional Video and Data Sharing System
- Existing systems will sufficient for the needs of the system
- DART Network will be deployed
- Regional Data and Video Sharing System will be deployed
- Regional Center to Center plug-in will be deployed for each partner
- Current agency specifications for equipment will be utilized
- Current agency user authorization and authentication practices will be used
- Current agency information technology standards (hardware/ software) will be used
- Decision Support Subsystem will include an API, and web interface for agency's to utilize
- A Regional 511 system will be deployed
- Arterial detection will use both Tolltag readers and point detectors along the recommended arterials

3.5.3. Institutional Assumptions

- An Operator at DalTrans will be the corridor coordinator
- Funding will be available for ICM
- Agencies within the corridor will be willing to optimize the entire corridor, even if it impacts their individual network
- Regional Transportation Council and NCTCOG are supportive of the ICM and will provide funding, when needed

3.6. Operational Scenarios

When deciding upon locations of events that drive operational scenarios for the US-75 ICM Con Ops, it was decided that varying locations would require varying response scenarios depending on both location and time-of-day. In order to capture the various ICM response strategies, the Corridor was divided into multiple sections and directions. Then based on time-of-day, the impact and necessary strategies could be determined. With the time available to the US-75 Steering Committee, a typical location and scenario was chosen for the majority of the scenarios.

The committee also tried to identify incidents that typically occur as frequently as possible, as well look at recurring areas of congestion for daily operations, and high frequency locations for incidents. The US-75 Steering Committee discussed how ICM in the future could be used to improve the efficiency and response of the coordinated response.

3.6.1. Daily Operations

Daily operation is defined as:

- Operations that are not related to a particular incident/event that causes response or management strategies to be carried out, however minor incidents are routine and a part of daily operations.
- Recurring congestion and peak ridership conditions

Operations are not related to a particular incident/event that causes response or management strategies to be carried out; however, minor incidents are routine and a part of daily operations.

- Recurring congestion and peak ridership conditions

Table 3.6-1 below, provides roles and responsibilities for Stakeholders who perform significant functions during Daily Operations within the US-75 ICM Corridor.

Table 3.6-1 Daily Operations Agency Roles and Responsibilities

Stakeholder	Roles and Responsibilities
Texas DOT	**Coverage** • Four-person operational coverage • 24 hours x 7-days/week x 365/year coverage • Freeways and interchanges/ramps with other networks within the "US-75 ICM Influence Area" **Monitoring** • TxDOT CCTV video • Regional CCTV video • Occurrence of incidents that effect travel through 911 and emergency centers • Traffic flow conditions • DalTrans system health and device status • Weather and emergency events • ICM System – incidents/events on other agency networks that may affect highways • Dallas County Sheriff Courtesy Patrol Radio **Coordination** • Coordinate construction and lane closures with TxDOT Districts and municipalities • Coordinate regional events (e.g., sporting events) • Coordinate recurring congestion traffic management with DART HOV, DART Transit, City signal control centers, and NTTA • Coordinate roadside assistance services with Dallas County Sheriff Courtesy Patrol • Coordinate control of "passive devices" with DART HOV, DART Transit, NTTA, and Cities **Information Distribution** • Distribute freeway travel conditions to DFW ATIS and other outlets, including media • Distribute travel messages and advisories using DMS **Maintenance** • Perform routine maintenance • Repair DalTrans system and communication failures • Repair / replace malfunctioning devices

Table 3.6-1 Daily Operations Agency Roles and Responsibilities (Continued)

Stakeholder	Roles and Responsibilities
City of Dallas	**Coverage** • Two-person operational coverage • 12-14 hours x 7-days/week x 365/year coverage • "Significant Arterial" streets in the City of Dallas and within the "US-75 ICM Influence Area" • Partial monitoring coverage responsibility along US-75 within the City of Dallas **Monitoring** • City CCTV video • Regional CCTV video • Occurrence of incidents that effect travel through 911 and emergency centers • Arterial traffic flow conditions • Signal system health and status • Weather and emergency events • ICM System – incidents/events on other agency networks that may affect city arterial travel conditions **Coordination** • Coordinate construction and lane closures with construction and maintenance offices • Coordinate regional events (e.g., sporting events) • Coordinate recurring congestion traffic management with TxDOT, DART HOV, DART Transit, and other city signal control centers – including timing plan changes • Coordinate control of "passive devices" with TxDOT, DART HOV, DART Transit, and other Cities **Information Distribution** • Distribute arterial travel conditions to DFW ATIS and other outlets, including media • Distribute travel messages and advisories using arterial DMS **Maintenance** • Perform routine maintenance • Repair signal system and communication failures • Repair / replace malfunctioning signal intersection equipment

Table 3.6-1 Daily Operations Agency Roles and Responsibilities (Continued)

Stakeholder	Roles and Responsibilities
City of Richardson	**Coverage** • One/two-person operational coverage • 12-14 hours x 7-days/week x 365/year coverage • "Significant Arterial" streets in the City of Richardson and within the "US-75 ICM Influence Area" • Partial monitoring coverage responsibility along US-75 and the President George Bush Turnpike within the City of Richardson **Monitoring** • City CCTV video • Regional CCTV video • Occurrence of incidents that effect travel through 911 and emergency centers • Arterial traffic flow conditions • Signal system health and status • Weather and emergency events • ICM System – incidents/events on other agency networks that may affect city arterial travel conditions **Coordination** • Coordinate construction and lane closures with construction and maintenance offices • Coordinate event management • Coordinate recurring congestion traffic management with TxDOT, DART HOV, DART Transit, and other city signal control centers – including timing plan changes • Coordinate transit signal priority with DART bus and rail centers/systems • Coordinate control of "passive devices" with TxDOT, DART HOV, DART Transit, NTTA, and other Cities **Information Distribution** • Distribute arterial travel conditions to DFW ATIS and other outlets, including media • Distribute travel messages and advisories using arterial DMS **Maintenance** • Perform routine maintenance • Repair signal system and communication failures • Repair / replace malfunctioning signal intersection equipment

Table 3.6-1 Daily Operations Agency Roles and Responsibilities (Continued)

Stakeholder	Roles and Responsibilities
City of Plano	**Coverage** • One/two-person operational coverage • 12-14 hours x 7-days/week x 365/year coverage • “Significant Arterial” streets in the City of Plano and within the “US-75 ICM Influence Area” • Partial monitoring coverage responsibility along US-75 within the City of Plano **Monitoring** • City CCTV video • Regional CCTV video • Occurrence of incidents that effect travel through 911 and emergency centers • Arterial traffic flow conditions • Signal system health and status • Weather and emergency events • ICM System – incidents/events on other agency networks that may affect city arterial travel conditions **Coordination** • Coordinate construction and lane closures with construction and maintenance offices • Coordinate event management • Coordinate recurring congestion traffic management with TxDOT, DART HOV, DART Transit, and other city signal control centers – including timing plan changes • Coordinate transit signal priority with DART bus and rail centers/systems • Coordinate control of “passive devices” with TxDOT, DART HOV, DART Transit, and other Cities **Information Distribution** • Distribute arterial travel conditions to DFW ATIS and other outlets, including media • Distribute travel messages and advisories using arterial DMS **Maintenance** • Perform routine maintenance • Repair signal system and communication failures • Repair / replace malfunctioning signal intersection equipment

Table 3.6-1 Daily Operations Agency Roles and Responsibilities (Continued)

Stakeholder	Roles and Responsibilities
DART	**Coverage** <u>All</u> • One/two-person operational coverage at DalTrans Center • 14 hours x 7-days/week x 365/year coverage at DalTrans Center • 24 hours x 7-days/week x 365/ year coverage at customer service call centers <u>Rail</u> • All Red and Blue Line LRT light-rail routes and stations within the "US-75 ICM Influence Area" <u>HOV</u> • Managed HOV lanes • All HOV lanes along US-75 within the "US-75 ICM Influence Area" • Partial monitoring coverage responsibility along parallel freeway lanes within the "US-75 ICM Influence Area" <u>Bus</u> • All operational bus routes within the "US-75 ICM Influence Area" • Partial monitoring coverage responsibility on arterials and freeways that make up bus routes within the "US-75 ICM Influence Area" **Monitoring** • All • DART CCTV video – stations, HOV, park-n-ride lots, and in-vehicle/train • Regional CCTV video • Occurrence of incidents that effect travel through 911 and emergency centers • Weather and emergency events • ICM System – incidents/events on other agency networks that may affect DART operations <u>Bus</u> • Bus schedule adherence / status • Real-time bus occupancy • Vehicle emergency status (voice communication with operator) <u>Rail</u> • Park-n-ride lot status • Rail schedule adherence / status • Real-time light rail occupancy • Train emergency status (voice communication with operator)

Table 3.6-1 Daily Operations Agency Roles and Responsibilities (Continued)

Stakeholder	Roles and Responsibilities
	<u>HOV</u> • HOV lane traffic flow • Partial monitoring coverage responsibility along TxDOT freeways within "US-75 ICM Influence Area" • DalTrans system health and device status • Dallas County Sheriff Courtesy Patrol Radio **Coordination** <u>All</u> • Coordinate construction, maintenance, and service disruptions with construction and maintenance offices • Coordinate event management • Coordinate recurring congestion traffic management with TxDOT, NTTA, and city signal control centers <u>Bus</u> • Coordinate transit signal priority with city signal control centers/systems • Coordinate transfer protection with DART Rail <u>Rail</u> • Coordinate transit signal priority with city signal control centers/systems • Coordinate transfer protection with DART Bus • Coordinate parking fare payment with NTTA <u>HOV</u> • Coordinate control of "passive devices" with TxDOT, NTTA, and Cities **Information Distribution** • Distribute transit travel conditions to DFW ATIS and other outlets, including media • Distribute travel messages and advisories using transit station, HOV, and parking lot station DMS and PA systems • Provide trip-planning services via website and call center **Maintenance** • Perform routine maintenance • Repair in-vehicle system and communication failures • Repair / replace malfunctioning signal intersection equipment

Table 3.6-1 Daily Operations Agency Roles and Responsibilities (Continued)

Stakeholder	Roles and Responsibilities
North Texas Tollway Authority	**Coverage** • Tollways and interchanges/ramps with other networks within the “US-75 ICM Influence Area” **Monitoring** • CCTV video • Regional CCTV video • Occurrence of incidents that effect travel through 911 and emergency centers • Traffic flow conditions • Weather and emergency events • ICM System – incidents/events on other agency networks that may affect highways **Coordination** • Coordinate construction and lane closures with TxDOT Districts and municipalities • Coordinate regional events (e.g., sporting events) • Coordinate recurring congestion traffic management with DART HOV, DART Transit, City signal control centers, and TxDOT • Coordinate control of “passive devices” with DART HOV, DART Transit, TxDOT, and Cities **Information Distribution** • Distribute freeway travel conditions to DFW ATIS and other outlets, including media • Distribute travel messages and advisories using DMS **Maintenance** • Perform routine maintenance • Repair operational system and communication failures • Repair / replace malfunctioning devices

Table 3.6-1 Daily Operations Agency Roles and Responsibilities (Continued)

Stakeholder	Roles and Responsibilities
Town of Highland Park	**Coverage** • One/two-person operational coverage • 12-14 hours x 5-days/week x 365/year coverage **Monitoring** • City CCTV video • Regional CCTV video • Occurrence of incidents that effect travel through 911 and emergency centers • Arterial traffic flow conditions • Signal system health and status • Weather and emergency events • ICM System – incidents/events on other agency networks that may affect city arterial travel conditions **Coordination** • Coordinate construction and lane closures with construction and maintenance offices • Coordinate event management • Coordinate recurring congestion traffic management with TxDOT, DART HOV, DART Transit, and other city signal control centers – including timing plan changes • Coordinate control of “passive devices” with TxDOT, DART HOV, DART Transit, and other Cities **Information Distribution** • Distribute arterial travel conditions to DFW ATIS and other outlets, including media • Distribute travel messages and advisories using arterial DMS **Maintenance** • Perform routine maintenance • Repair signal system and communication failures • Repair / replace malfunctioning signal intersection equipment

Table 3.6-1 Daily Operations Agency Roles and Responsibilities (Continued)

Stakeholder	Roles and Responsibilities
City of University Park	**Coverage** • One/two-person operational coverage • 12-14 hours x 5-days/week x 365/year coverage **Monitoring** • City CCTV video • Regional CCTV video • Occurrence of incidents that effect travel through 911 and emergency centers • Arterial traffic flow conditions • Signal system health and status • Weather and emergency events • ICM System – incidents/events on other agency networks that may affect city arterial travel conditions **Coordination** • Coordinate construction and lane closures with construction and maintenance offices • Coordinate event management • Coordinate recurring congestion traffic management with TxDOT, DART HOV, DART Transit, and other city signal control centers – including timing plan changes • Coordinate control of “passive devices” with TxDOT, DART HOV, DART Transit, and other Cities **Information Distribution** • Distribute arterial travel conditions to DFW ATIS and other outlets, including media • Distribute travel messages and advisories using arterial DMS **Maintenance** • Perform routine maintenance • Repair signal system and communication failures • Repair / replace malfunctioning signal intersection equipment

ICM Strategies that will be deployed during Daily Operations Conditions include:

- Automated information sharing
- Shared control of “passive” ITS devices
- Information clearinghouse
- A corridor-based traveler information database
- En-route traveler information devices used to describe current operational conditions on another network(s) within the corridor
- Transit signal priority
- Multi-modal electronic payment
- Transit hub connection protection
- Multi-agency/multi-network incident response teams and service patrols

- Accommodate cross-network shifts

The remaining scenarios were developed based on deviation from the baseline of "Daily Operations" – since many of the agencies deal with minor incidents as a routine, they decided that they are a part of daily operations.

3.6.2. Traveler Information

Since all scenarios have some component of traveler information, it was decided to include a discussion and description of the traveler information assets existing and needed for the US-75 ICM and for the region as a whole.

The traveler information capabilities for the US-75 ICM will involve multiple media, and varied capabilities. This includes existing systems for pre-trip planning, in-route traveler information, and general information regarding the transportation network. This element encompasses many different types of information that can be of use to the traveling public. Through the traveler information technologies that we propose to utilize and continue to deploy, information will be provided regarding incidents, congestion, travel times, road conditions, pricing, transit status and parking availability.

For example, when there are incidents, incident information will be provided to minimize adverse impacts and enable the public to make decisions on options for the use of work hubs or work from home alternatives. Transit information alternatives will be provided so that commuters can determine the status of the bus or light rail system and find out about the availability of parking in DART parking lots in the vicinity of LRT stations in order to avoid an incident or congestion.

The delivery methods to be employed in US-75 corridor will consist of:

- Dynamic message signs (DMS) placed at strategic locations
- Interactive traveler information websites that commuters can quickly check each morning or go to anytime for corridor information
- Traveler information service retailers who will take the data collected and provide value-based services for their customers
- A robust 511 phone system that will provide traffic conditions, road conditions, and transit information
- Media partnerships with television and radio formed to provide them with traveler information and camera feeds for rebroadcast
- A personalized traveler alert system that will enable travelers to create route specific alerts based on the parameters they enter
- This component will also feature an in-reach and outreach program to garner support from public and private sector partners

3.6.3. Incident Scenario

When discussing Incident scenarios, the US-75 Steering Committee discussed how multiple locations would require multiple response scenarios depending on location and time of day. Based on time of day and jurisdiction, the impact and necessary strategies would be determined.

Major Traffic Incident – Arterials

Since there are multiple Cities within the corridor, each with different infrastructure and integration – a sample major incident was chosen at a particular intersection where vehicle accidents occur regularly, and have major impact on overall mobility within the Corridor. Each of the five city US-75 ICM Stakeholders, has a primary arterial street that is used during peak hours for public and transit vehicles. Since many of the arterials are collectors or parallel routes to the freeway, many have very high volumes during peak times.

Incident Description:

During the evening peak, an incident occurs at the intersection of Greenville Avenue and Spring Valley Road that closes the intersection for the evening rush. Since it is a parallel route which feeds US-75, it does have some preliminary impact to US-75, as well as overall mobility within the Corridor.

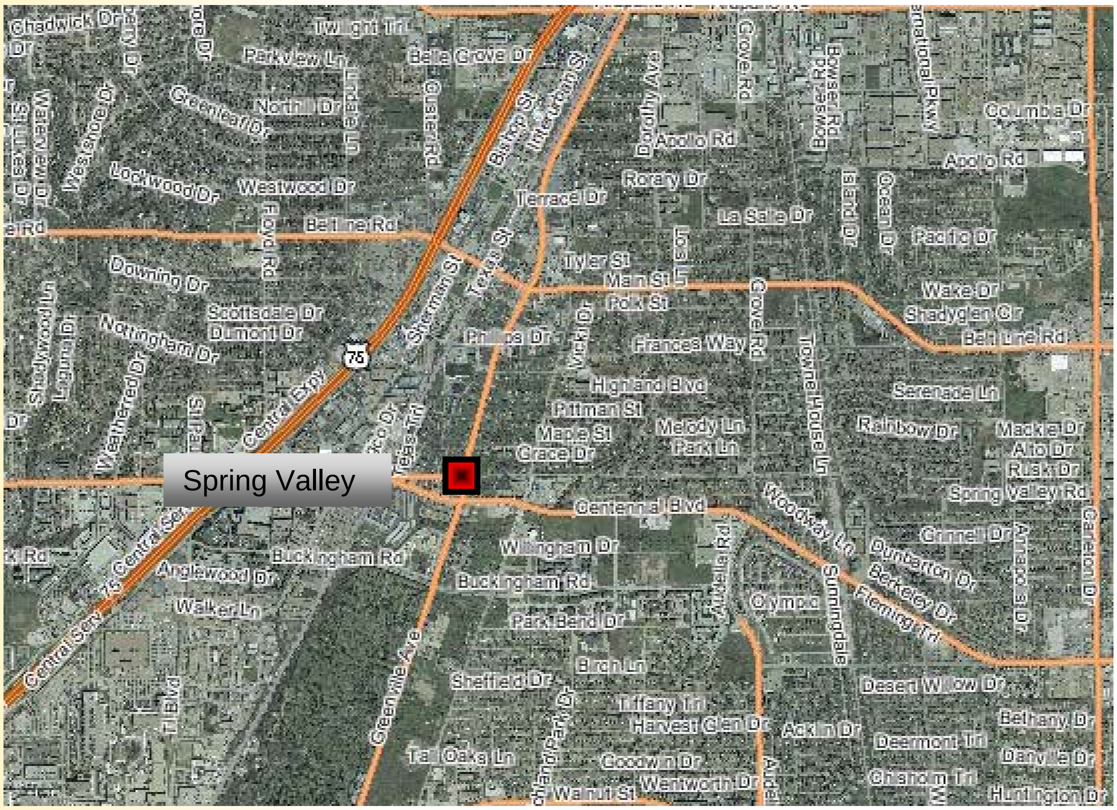

Figure 3.6-1 Incident Location at Intersection of Greenville Avenue and Spring Valley Road (Source: NCTCOG dfwmaps.com)

Assumptions:

- Major parallel route to the freeway, with impact to the corridor
- Multiple bus routes impacted
- Incident does not include any fatalities

Timeline:

4:00 p.m. Incident Occurs, drivers immediately contact E911 to report the incident. Due to integration with the various E911 CAD systems, the corridor agencies are immediately notified of the potential incident (through ICM System alerting subsystems) and approximate location (through ICM System mapping).

4:05 p.m. City of Richardson police arrive on scene and begin initial determination of severity and approximate time for resolution. DART Bus Dispatch is automatically notified by the ICM system of the location, and drivers on affected bus routes are notified.

4:20 p.m. City of Richardson updates ICM System to indicate major incident with a closure of more than 1 hour. The corridor agencies are alerted through ICM alerting subsystem, and a previously approved response plan is recommended by the corridor Decision Support subsystem. Incident data is transferred to the DFW ATIS, resulting in information on the incident being sent to local media, and 3rd party ISPs, along with traveling public through various mediums. TxDOT, DART, and City of Richardson display preliminary information on DMS signs and HAR near the incident. DART displays intersection closure information on the vehicle and bus stop DMS along the affected routes.

4:30 p.m. City of Richardson implements timing plans for diversions around the intersection to parallel routes, and bus priority is implemented for pre-approved diversion routes for DART buses impacted by the intersection closure.

5:00 p.m. Initial clearance of the intersection, restoring traffic flow in all directions, City of Richardson updates ICM System. City of Richardson continues to monitor the traffic flow and change timing plans, if needed. DART and TxDOT remove DMS messages. DART is notified of opening, however, back-up still requires diversion

5:20 p.m. Normal operations, DART bus resumes routes through intersection.

Changes to Baseline Strategies:
The approach the US-75 Steering Committee has taken is to use the Daily Operations as the baseline for the strategies associated with the ICM, and then discuss what changes and additions are needed for the specific scenario. In the following tables, the stakeholders have identified some of the additional roles and responsibilities, and data and infrastructure required to have a corridor based response. In addition, the following changes to strategies were identified:

- Information sharing and distribution
- Operational efficiency at network junctions
- A common incident reporting system and asset management (GIS) system
- Modify transit priority parameters to accommodate more timely bus service and light rail service
- Emergency response signal priority
- En-route traveler information devices used to describe current operational conditions on another network(s) within the corridor

Table 3.6-2 Additional Roles and Responsibilities for Major Arterial Scenario

Stakeholder	Roles and Responsibilities
Texas DOT	**Monitoring** • On-going monitoring of response and flow on arterials and impact to freeway • Monitor freeway traffic flow around affected incident area • Strategies recommended by ICM Decision Support Tool • Strategies being carried out by ICM Stakeholders **Coordination** • Shared use and control of freeway CCTV able to see field conditions at incident scene, and/or traveling conditions around the incident scene • Coordinate traffic management of freeway conditions affected by arterial incident **Information Distribution** • Incident information on freeway DMS
City of Richardson	**Monitoring** • On-going monitoring of incident response and status through voice/data communications and city CCTV • On-going monitoring of flow on arterial network • Strategies recommended by ICM Decision Support Tool • Strategies being carried out by ICM Stakeholders **Coordination** • Coordinate incident response with local public safety, including emergency vehicle signal priority • Coordinate on-site traffic control with City emergency response agencies and traffic control crews • Update signal timings to follow pre-planned response • Enter and/or update incident information in ICM System • Update Strategies being carried out on City arterial network in ICM System • Coordinate arterial management tactics with adjacent cities • Coordinate arterial incident affects on freeway operations with TxDOT, NTTA, and DART • Coordinate arterial management affects on transit operations with DART, including transit signal priority **Information Distribution** • Incident and alternate route information on arterial DMS and HAR • Provide interface to DFW ATIS to transfer incident and alternate route data • Distribute incident and alternate route information to media and local businesses

Table 3.6-2 Additional Roles and Responsibilities for Major Arterial Scenario (Continued)

Stakeholder	Roles and Responsibilities
DART	**Monitoring** • On-going monitoring of response and flow on arterials and impact to HOV and transit networks • Monitor HOV traffic flow and transit vehicle schedule adherence near affected incident area • Strategies recommended by ICM Decision Support Tool • Strategies being carried out by ICM Stakeholders **Coordination** • Shared use and control of "passive devices" for incident response and travel management • Coordinate traffic management of HOV and transit conditions affected by arterial incident, including transit signal priority with cities **Information Distribution** • Incident information on DMS and trip planning services

Major Traffic Incident – Freeway

When deciding upon locations for scenarios multiple locations would require multiple response scenarios depending on location and time of day. In order to capture the various response strategies for a major incident, the corridor was divided into multiple sections and directions. Then based on time of day, the impact and necessary strategies could be determined. With the time available to the US-75 Steering Committee, a typical location and scenario was chosen.

Trying to use a real-world incident, the committee discussed a recent incident on US-75 at the LBJ Freeway. During the early morning hours (approximately 4 a.m.), a northbound commercial vehicle incident closed multiple exit ramps to include the interchange to LBJ. The commercial vehicle lost its load, and required clean-up and hazmat response due to over 50 gallons of diesel being spilled. The City of Plano emergency response arrived first at scene and closed three exit ramps to include the one to LBJ Freeway, a little later the City of Richardson arrived and took over responsibility. The City of Richardson opened a couple of the exit ramps. The TxDOT courtesy patrol assisted with traffic control, and began clean-up of incident. The incident went through multiple phases: initial reaction, clean-up, modifying traffic control, and resumption of normal operations. The US-75 Steering Committee discussed how ICM in the future could be used to improve the efficiency and response of the coordinated response.
Incident Description:

A commercial vehicle jackknifed on southbound US-75 north of the LBJ Freeway interchange at 6 a.m., spilling its load of boxes onto the freeway and closing the freeway in the southbound direction. The jurisdiction of the incident is the City of Richardson.

Figure 3.6-2 Incident Location on US-75 North of LBJ Freeway (Source: NCTCOG dfwmaps.com)

Assumptions:
The assumptions used for this scenario are:

- No Fatalities
- Hazardous materials spill due to at least 50 gallons of diesel fuel spilled
- Long-term closure requiring mode shift, and arterial diversions
- Multiple coordinated responses needed to optimize the corridor

Timeline:
6:00 a.m. Incident Occurs, drivers immediately contact E911 to report the incident
Due to integration with the various E911 CAD systems, the corridor agencies are immediately notified of the potential incident (through ICM System alerting subsystems) and approximate location (through ICM System mapping).

6:10 a.m. City of Richardson police arrive on scene and begin initial determination of severity and approximate time for resolution. TxDOT courtesy patrol and DART Motorist Assistance arrive on scene to assist with traffic control. TxDOT uses video cameras to verify type of incident and number of lanes closed, and notifies ICM partners. TxDOT, DART, and City of Richardson and Plano display preliminary information on their DMS signs north of the incident.

6:20 a.m. City of Richardson updates ICM System to indicate major incident with a closure of more than 4 hours. The corridor agencies are alerted through ICM alerting subsystem, and a previously approved response plan is recommended by the corridor Decision Support

Subsystem. Local wrecker service has been notified, and begins response to assist police with clearing incident.

6:30 a.m. As part of the pre-planned response contained in the corridor Decision Support Subsystem, DART begins preparation for additional light rail and bus bridging for temporary parking. City of Richardson contacts local business close to light rail station to implement pre-agreed temporary parking. City of Richardson and City of Plano implement timing plans for freeway diversions.

7:00 a.m. Temporary parking lots have been started; DMS signs and static trailblazer signs provide direction to motorists to these locations. DART has begun bus bridge between the temporary lots and light rail stations. City of Richardson and City of Plano have implemented bus signal priority.

9:00 a.m. HazMat response has begun to clean-up the fuel spill. The commercial vehicle has been up-righted, and clearance of boxes in roadway has begun.

9:30 a.m. Since majority of rush hour is completed, DART begins to reduce its light rail service back to normal levels.

10:30 a.m. Clearance of boxes has completed, and some capacity is restored to the freeway, interchange ramps have all re-opened.

12:00 p.m. Roadway is back to normal operation.

8:00 p.m. Bus Bridge ends for the temporary parking lots.

Changes to Baseline Strategies:
The approach the US-75 Steering Committee has taken is to use the Daily Operations as the baseline for the strategies associated with the ICM, and then discuss what changes and additions are needed for the specific scenario. In the following tables, the stakeholders have identified some of the additional roles and responsibilities, and data and infrastructure required to have a corridor based response. In addition, the following changes to strategies were identified:

- Information sharing and distribution
- Operational efficiency at network junctions
- A common incident reporting system and asset management (GIS) system
- Modify transit priority parameters to accommodate more timely bus service and light rail service
- Emergency response signal priority
- En-route traveler information devices used to describe current operational conditions on another network(s) within the corridor

Table 3.6-3 Additional Roles and Responsibilities for Major Freeway Scenario

Stakeholder	Roles and Responsibilities
Texas DOT	**Monitoring** • On-going monitoring of response and flow on freeway system **Coordination** • Communication with on-scene emergency response • Communicate any changes to pre-planned response through decision support tool **Information Distribution** • Provide updated information on the incident as time goes by to the corridor ATIS and through center-to-center
City of Richardson	**Monitoring** • On-going monitoring of response and flow on freeway system and impact to arterials • Monitor arterial traffic flow **Coordination** • Communication with on-scene emergency response • Communicate any changes to pre-planned response through decision support tool • Outreach to local business for temporary parking (pre-arranged) • Traffic control for re-directing traffic to overflow parking • Bus signal priority for overflow parking locations **Information Distribution** • Provide updated information on the incident as time goes by to the corridor ATIS and through center-to-center on arterial traffic flow
City of Plano	**Monitoring** • On-going monitoring of response and flow on freeway system and impact to arterials • Monitor arterial traffic flow **Coordination** • Outreach to local business for temporary parking (pre-arranged) • Traffic control for re-directing traffic to overflow parking • Bus signal priority for overflow parking locations **Information Distribution** • Provide updated information on the incident as time goes by to the corridor ATIS and through center-to-center on arterial traffic flow

Table 3.6-3 Additional Roles and Responsibilities for Major Freeway Scenario (Continued)

Stakeholder	Roles and Responsibilities
DART	**Monitoring** • Monitor transit usage, provide additional vehicles (if needed) • Monitor parking availability • Provide shuttle bus service between rail stations and temporary parking lots • Provide connection protection • Monitor bus headways/schedules • Passenger counts **Coordination** • Inform cities when overflow parking is needed • Bus Bridge to overflow parking **Information Distribution** • Provide updated information on the incident as time goes by to the corridor ATIS and through center-to-center on transit capacity • Provide updated information on the incident as time goes by to the corridor ATIS and through center-to-center on parking availability

Major Transit Incident

The US-75 Steering Committee discussed various potential scenarios for disruption of the transit network, and tried to decide upon location, time-of-day, and incident parameters. In order to capture the various response strategies for a major transit incident, multiple transit modes and impacts could be shown. Based on time-of-day, the impact and necessary strategies could be determined. Some of the scenarios discussed included outage due to strikes, train breakdown, rail shutdown, major crime event, surface street intersection incident involving light rail, morning in-bound transit scenario, and evening out-bound transit scenario – each of these would require different strategies and responses. A LRT train hitting a pedestrian during evening peak volume period was decided upon due to: the need to shut both directions of travel down; the relatively high frequency of actual DART LRT pedestrian accidents; and due to the evening peak volume that LRT customers who are already in Dallas not having the option of working from home – as would be the case for a morning peak event.

Incident Description:

A pedestrian is hit by a DART Red Line LRT light-rail train at 4:30 p.m. After reporting the incident to DART dispatch personnel, the train operator is directed to hold the train at the Lovers Lanes station until emergency response arrives. The pedestrian accident leaves the LRT train in a position that is not blocking surface street arterial lanes.

Figure 3.6-3 Incident Location in DART Red Line (Source: NCTCOG dfwmaps.com)

Assumptions:

- Minor impact to arterial network travel conditions, outside of 2 block vicinity of incident
- Little/no impact to freeway travel conditions

Timeline:

4:30 p.m. Train operator radios pedestrian accident to DART dispatch, which then relays incident information and location to City of Dallas 911 dispatch.

4:35 p.m. Train ordered to remain in current location and exact location details are input into ICM System. DART and City of Dallas operators access TxDOT and City CCTV that are able to see incident scene and surrounding arterial network conditions.

4:37 p.m. Responders arrive on scene and begin relaying incident details, which are input into ICM system. DART enters incident information into DFW ATIS, and puts incident information out through vehicle and station DMS and PAs, as well as customer service and web trip planning services.

4:45 p.m. Incident responders relay that investigative operations will likely hold the train at current location and shutting down both directions of Red Line LRT for 2.5 hours. DART dispatch begins coordinating the transfer of Blue-Line LRT customers at the incident scene onto spare DART buses. Additionally, DART references ICM System Decision Support Tool for additional strategies based on modeling. Strategy of adding bus vehicles to adjacent lines, and beginning bus bridges to Red Line LRT are initiated.

5:00 p.m. City of Dallas sees DART bus lines have been increased and begins coordination for increased transit vehicle priority along City arterials.

7:30 p.m. DART verifies real-time ridership data and confirms ICM System Strategy to begin normal reduction in bus service due to time-of-day lower volumes. However, DART keeps the service higher than normal to accommodate for additional travelers using bus due to Red Line closure.

8:15 p.m. Incident investigative operations are finalized and Red Line LRT is reopened for travel. DART updates incident status in ICM System, as well as DFW ATIS.

Changes to Baseline Strategies:
The approach the US-75 Steering Committee has taken is to use the Daily Operations as the baseline for the strategies associated with the ICM, and then discuss what changes and additions are needed for the specific scenario. In the following tables, the stakeholders have identified some of the additional roles and responsibilities, and data and infrastructure required to have a corridor based response. In addition, the following changes to strategies were identified:

- Information sharing and distribution
- Operational efficiency at network junctions
- A common incident reporting system and asset management (GIS) system
- Modify transit priority parameters to accommodate more timely bus service and light rail service
- Emergency response signal priority
- En-route traveler information devices used to describe current operational conditions on another network(s) within the corridor
- Modify transit priority parameters to accommodate more timely bus service
- Modify HOV restrictions (increase minimum number from 2 to 4)
- Increase roadway capacity by using shoulders for traffic (peak periods)
- Add transit capacity (express bus service during peak periods) by adjusting headways and number of buses
- Add temporary new transit service (bus bridge)
- Peak spreading by outreach to media/commuters on ridesharing and telecommuting during closure of the section of rail

Table 3.6-4 Additional Roles and Responsibilities for Transit Scenario

Stakeholder	Roles and Responsibilities
Texas DOT	**Monitoring** • Strategies recommended by ICM Decision Support Tool • Strategies being carried out by ICM Stakeholders **Coordination** • Shared use and control of freeway CCTV able to see field conditions at incident scene, and/or traveling conditions around the incident scene **Information Distribution** • Incident information on freeway DMS

Table 3.6-4 Additional Roles and Responsibilities for Transit Scenario (Continued)

Stakeholder	Roles and Responsibilities
City of Dallas	**Monitoring** • On-going monitoring of incident response and status through voice/data communications and city CCTV • On-going monitoring of flow on arterial network • Strategies recommended by ICM Decision Support Tool • Strategies being carried out by ICM Stakeholders **Coordination** • Coordinate incident response with local public safety, including emergency vehicle signal priority • Coordinate on-site traffic control with City emergency response agencies and traffic control crews • Update signal timings to follow pre-planned response • Update Strategies being carried out on City arterial network in ICM System • Coordinate bus bridge and added bus service with DART **Information Distribution** • Incident information on City DMS
DART	**Monitoring** • Status and location of incident from vehicle and field/maintenance operators through DART System and voice communications • Strategies recommended by ICM Decision Support Tool • Strategies being carried out by ICM Stakeholders **Coordination** • Internal DART coordination between transit dispatch, field operations personnel, maintenance, and customer service offices through DART System • Enter and/or update incident information in ICM System • Coordination with City of Dallas (and other applicable cities) to increase transit signal priority requests • Coordination with City of Dallas public safety for traffic and incident management at incident scene **Information Distribution** • Incident location and status information to DFW ATIS for regional distribution • Coordination with local media and businesses for travel information distribution • Alert notifications and alternate route information through DART trip planning services (both phone and web) • Alert notifications at transit station DMS and PA systems

3.6.4. Weather Event Scenario

The US-75 Steering Committee discussed various potential scenarios for weather events, how likely they could occur, and tried to decide upon specific events that currently occur. In order to capture the various response strategies for different types of weather, the committee discussed how each event impacts their current systems, and how often these events occur. It was also decided that depending on the weather event, location of impacts, and time of day – different responses would be needed. In order to discuss the various potential responses, the following events were discussed:

Rain

Rain does occur frequently, and have a general impact to the flow of traffic; this includes transit, freeway, and arterials, which usually decreases the average speed and decreases throughput of the corridor. Rain also does provide some impact to traffic signal systems in some areas, and reduces the speed of the light rail system. Several locations within the corridor lose power to the traffic signals during heavy rain events, which can cause various response strategies to be implemented (re-routing, police manually doing traffic control, etc.)

The strategies and responses to this scenario would be a subset of minor and major arterial scenarios, minor incidents on transit, and minor incidents on freeways.

Ice

Ice storms do occur a couple times per year on average in Dallas, and have tremendous regional impact. Since these events do not occur often, the agencies within the region do not have the resources (plows, salt trucks, etc.) that some northern locations that routinely have snow and ice would have. This causes various issues and incidents. Many of the businesses in the region will shutdown during ice storms, and in general discourage travel during these events.

Similar to rain, overall speeds decrease significantly and throughput decreases. Also, incidents increase during this time on arterials and the freeway. One interesting side effect is also the impact on transit. The light rail system will sometimes be impacted due to ice that coats the power lines overhead of the vehicle and the contact between the vehicle and the power line is disrupted, causing shutdown of the vehicle. Overall, when discussing responses to this scenario, the committee focused more on the information needed and distributed to the public to try and reduce travelers during these events.

Ozone Alert / Action Day

Dallas is an air quality non-attainment area, and due to the heat during the summer months frequently has ozone alert and ozone action days. Part of the current response is to market heavily through the media, and ATIS systems. The committee also discussed the potential for using the ICM for additional mode shift to include increasing transit usage, and car pooling. Similar to a major freeway incident, temporary parking lots would be needed, to include bus bridges, and signal priority.

Table 3.6-5 Additional Roles and Responsibilities for Weather Event Scenarios

Stakeholder	Roles and Responsibilities
Texas DOT	**Monitoring** • On-going monitoring of response and flow on freeway system **Coordination** • Response requests for minor and major incidents during weather events **Information Distribution** • Update DMS with current information • Update Regional ATIS with current information
City of Dallas	**Monitoring** • On-going monitoring of response and flow on arterial system **Coordination** • Response requests for minor and major incidents during weather events **Information Distribution** • Update DMS with current information • Update Regional ATIS with current information
City of Richardson	**Monitoring** • On-going monitoring of response and flow on arterial system **Coordination** • Response requests for minor and major incidents during weather events **Information Distribution** • Update DMS with current information • Update Regional ATIS with current information
City of Plano	**Monitoring** • On-going monitoring of response and flow on arterial system **Coordination** • Response requests for minor and major incidents during weather events **Information Distribution** • Update DMS with current information • Update Regional ATIS with current information
DART	**Monitoring** • On-going monitoring of response and flow on transit system • On-going monitoring of response and flow on HOV system **Coordination** • Response requests for minor and major incidents during weather events **Information Distribution** • Update DMS with current information • Update Regional ATIS with current information

Table 3.6-5 Additional Roles and Responsibilities for Weather Event Scenarios (Continued)

Stakeholder	Roles and Responsibilities
North Texas Tollway	**Monitoring**

Stakeholder	Roles and Responsibilities
Authority	• On-going monitoring of response and flow on tollway system **Coordination** • Response requests for minor and major incidents during weather events **Information Distribution** • Update DMS with current information • Update Regional ATIS with current information
Town of Highland Park	**Monitoring** • On-going monitoring of response and flow on arterial system **Coordination** • Response requests for minor and major incidents during weather events **Information Distribution** • Update DMS with current information • Update Regional ATIS with current information
City of University Park	**Monitoring** • On-going monitoring of response and flow on arterial system **Coordination** • Response requests for minor and major incidents during weather events **Information Distribution** • Update DMS with current information • Update Regional ATIS with current information
North Central Council of Governments	**Monitoring** • Environmental Sensor Data **Coordination** • Regional Weather Data • Regional Air Quality Data **Information Distribution** • Air Quality Model results • Weather Service Information

4. User Needs

User needs identify the high-level ICM system needs; these user needs are developed to focus on the operational aspects of the ICM, and defining the functional requirements of the proposed ICM system. These needs are based upon the system goals and objectives, and the future operational conditions and scenarios defined in the Concept of Operations.

These needs were established through a dedicated Corridor Stakeholder interviewing process, as well as by general input throughout the process of developing this Concept of Operations. Utilizing the Operational Scenarios from the section above, User Needs were developed. The following needs represent the identified needs of the ICM system.

Table 3.6-1 User Needs for the US-75 Integrated Corridor Management System

Need #	Need Title and Description
1	**Need for improved communication among agencies** – to ensure that actions taken by one corridor agency do not have unintended consequences on the corridor, or other agencies within the corridor, the agencies need to communicate interactively with each other in order to plan and execute actions that are not normal operation procedures. The communication does not have to be continuous, but does need to occur in a timely manner when actions are about to begin.
2	**Need to monitor the status of the physical transportation infrastructure** – The agency operators need to monitor the status of all devices within the. Knowing which devices are operational will enable them to determine which devices can be used to affect change within the corridor.
3	**Need to process information on status of the infrastructure** – The ICM system needs to be able to process all of the relevant data and information it receives from the various agencies within the corridor, in order to provide information to operators and travelers which can be used to make informed decisions on actions to be made.
4	**Need to update conditions of the infrastructure to the public and other agencies** - in order to optimize the corridor operations, the travelers and the agencies need to have up to date information on the current conditions and status of the corridor infrastructure.
5	**Need for interactive trip planning** – to ensure that travelers within the corridor can make informed decisions, the corridor agencies need to provide a way to allow travelers to develop plans for a trip. This could include various media, and multi-modes of travel.
6	**Need for information to travelers** – in order to optimize the trips that a traveler makes, they need to have current information provided to them during trips in order to make informed decisions on the their current route and mode.
7	**Need to have physical infrastructure coverage** – The components for the physical infrastructure (DMS, CCTV, communications network, etc.) within the corridor need to be reliable, available, maintained, extensible, and interoperable. The operators of the corridor need to know the location of all devices and other facilities within the corridor's network, and their purpose and capabilities. If a device is not operating correctly, the operator needs to know whom to contact to fix the device.
8	**Need to collect and store data/ information** – The data/ information collected during daily operations of the corridor needs to be stored for analyzing the effectiveness of the corridor strategies and responses, and for modeling.

Table 4-1 User Needs for the US-75 Integrated Corridor Management System (Continued)

Need #	Need Title and Description
9	**Need to provide pre-agreed incident response plans** – The agencies in the corridor need to have some pre-arranged response plans for incidents within the corridors, these will provide the contacts, roles and responsibilities, and responses for each network within the corridor.
10	**Need to coordinate incident responses among agencies** – The agencies within the corridor need to coordinate responses to incidents such that two agencies are not responding to the same incident, and not inadvertently impacted one another.
11	**Need to provide multi-modal alternatives for travelers** – In order to reduce congestion, and improve efficiency of the entire corridor, multiple modes and routes need to be available to the traveler. These modes choices need to include alternatives for various levels of income and mobility for the traveler.
12	**Need to measure effectiveness of responses** – During the response to an event in the corridor, the operators need to be able to determine if the pre-planned response is effective and if the response if having the intended effect. This includes verifying what conditions exist after implementation of a response. If the operators of the systems determine that their response is not effective, they should be able to change components of their response plans and communicate these changes to the other agencies within the corridor, such that they are not inadvertently impacting the other agencies.
13	**Need to modify responses during event as conditions change** - As an event progresses, the conditions (such as lanes closed, severity, etc.) will change. The operators should be able to modify the current conditions, and communicate with the others within the corridor of the change. The system needs to also request changes to the current responses as the conditions warrant.
14	**Need to request use of infrastructure from third party** - During some major incidents and special events, the current and planned capacity of the infrastructure owned and operated by the agencies may not be sufficient. This requires an interface to multiple third parties (large companies, private parking, van services, etc.) to request service from them or use of their infrastructure during special circumstances.

4.1. Breakdown of User Needs

Once the User Needs were defined and agreed upon by the Steering Committee, a further breakdown of the needs into Functions was developed. The following table is the initial breakdown developed by the committee, and was expanded during the development of the requirements for each system

Table 4.1-1 Breakdown of User Needs

		ICM System Point of View
1	**User Need**	**Need for improved communication among agencies**
	Function	Increase information received from agencies.
	Function	Increase information sent to agencies.
	Function	Consolidate information from all agencies
	Function	Present information to all agencies
	Function	Receive information from all agencies
2	**User Need**	**Need to monitor the status of the physical transportation infrastructure**
	Function	Provide information on status of physical infrastructure
	Function	Provide information on state of physical infrastructure
	Function	Provide status of agency infrastructure to the public
	Function	Provide status of agency infrastructure to all agencies
	Function	Provide comparative status of infrastructure across travel modes
3	**User Need**	**Need to process information on status of the infrastructure in near-real time**
	Function	Update status of agency infrastructure to all agencies
	Function	Update status of agency infrastructure to the public
4	**User Need**	**Need to update conditions of the infrastructure to the public and other agencies in near-real time**
	Function	Update status of agency infrastructure to all agencies
	Function	Update status of agency infrastructure to the public
	Function	Update response plan information to all agencies
	Function	Update response plan information to the public
5	**User Need**	**Need for interactive trip planning**
	Function	Increase information about modes of travel.
	Function	Consolidate information about modes of travel.
	Function	Present information about modes of travel to travelers.
6	**User Need**	**Need for near-real time information for travelers**
	Function	Update information about modes of travel to public
	Function	Update infrastructure status to public
	Function	Distribute information to public through a variety of media
7	**User Need**	**Need to have physical infrastructure coverage**
	Function	Send infrastructure data from all agencies
	Function	Collect information from all agencies
8	**User Need**	**Need to collect and store data/ information**
	Function	Receive infrastructure data from all agencies
	Function	Receive response plan information from all agencies
	Function	Collect response plan requests recommended
	Function	Collect information from all agencies
	Function	Store information from all agencies

Table 4.1-1 Breakdown of User Needs (Continued)

		ICM System Point of View
9	**User Need**	**Need to provide pre-agreed response plans**
	Function	Provide response plan request to all agencies
	Function	Receive response plan from DSS
	Function	Receive response plan request from all agencies
10	**User Need**	**Need to coordinate responses among agencies**
	Function	Provide response plan requests to all agencies
	Function	Receive response plan requests to all agencies
11	**User Need**	**Need to provide multi-modal alternatives for travelers**
	Function	Consolidate information about modes of travel.
	Function	Present information about modes of travel to travelers.
12	**User Need**	**Need to measure effectiveness of responses**
	Function	Receive information from all agencies
	Function	Receive MOE calculations from Model
	Function	Provide information to Model
13	**User Need**	**Need to modify responses during event as conditions change**
	Function	Provide change to response plan requests to all agencies
	Function	Receive change response plan requests from all agencies
14	**User Need**	**Need to request use of infrastructure from third party**
	Function	Present request to third party
	Function	Receive status information from third party

5. User Requirements

Use cases are a technique for capturing the functional requirements of a system. Use cases work by describing the typical interactions between the users of a system and the system itself, by providing a narrative of how a system is used.

Utilizing the scenarios developed during the concept of operations phase of the ICM project, use cases were developed to tie the scenarios together by a common user goal. The goal of the typical user (traveler) is to make a trip from one location to another. This trip requires the user to plan, understand the current conditions of the transportation network, and make changes during the trip if the conditions of the network change. In use case terminology, the users are referred to as actors. An actor is a role that a user plays with respect to the system. Actors might include travelers, agency operators, or the ICM steering committee. Actors carry out use cases. A single actor may perform many use cases; conversely a use case may have several actors performing it.

There are three key things we need to know to describe a use case:

- The actor or actors involved.
- The system being used.
- The functional goal that the actor achieves using the system (the reason for using the system.)

There's a little more to it than that, for example if we were developing a use case for an Automated Teller Machine:

- The actor describes a role that users play in relation to the system. Maybe the cardholder is an advertising executive, but that doesn't interest us. We only care about his relationship to the system.
- The actor is external to the system itself.
- Actors don't have to be people. They can be other systems. For example, the ATM may need to connect to the cardholder's bank. External systems that interact in a use case are also actors.
- The goal must be of value to the actor. We wouldn't have a use case called Cardholder enters PIN because that, by itself, has no value to the cardholder. We don't build ATM's just so people can enter their PINs.

When we are analyzing functional requirements for a system, the key questions we need to ask are; who will be using the system, and what will they be using it to do?

In order to get a more complete understanding of the user needs within the corridor, and identification of functions required, the input from the corridor stakeholders was utilized to develop a preliminary list of needs and functions.

Thus, use cases capture who (actor) does what (interaction) with the system, for what purpose (goal), without dealing with system internals. A complete set of use cases specifies all the different ways to use the system, and therefore defines all behavior required of the system, bounding the scope of the system.

5.1. Actors

In order to understand the process of each use case, the actors (or users of the system) were identified. The following actors would be the main stakeholders and users of the ICM System, in some instances the actors are subsystems of the ICM and would interact with other parts of the ICM.

5.1.1. Traveler

Travelers utilize the transportation network to make trips. They need up to date information on the routes, modes and conditions of the various networks available to make the trip.

5.1.2. ICM Agency

ICM Agencies operate and control the transportation network and supporting facilities within the corridor. This includes enforcement agencies (police, fire, EMS), maintenance, and operators of the corridor networks. Their role is to operate the network in a coordinated fashion to improve the mobility and efficiency of the entire network within the corridor.

5.1.3. Evaluation Model Subsystem

In order to measure the effectiveness of the pre-approved responses, and develop new responses, an Evaluation Model subsystem will utilize the data from ICM Agencies via the Regional Data Warehouse in order to model the corridor and the potential operational responses to improve the efficiency of the overall corridor network.

5.1.4. Decision Support Subsystem

The Decision Support Subsystem (DSS) is an external system to the corridor that is utilized to assist in the response to various incidents within the corridor. The DSS will be utilized as a search tool to assist with the distribution of pre-approved responses to ICM Agencies, and Third Party. The DSS System also includes a real-time Corridor Model which will be used to model the network in real-time, and predict required responses for operating the network.

5.1.5. Third Party Infrastructure

For certain network conditions, a third party is required to provide additional infrastructure (parking, van pools, etc.) for the corridor in order to respond to certain incidents and special events.

5.1.6. Regional Data Warehouse

During the daily operations of each network a tremendous amount of data is collected for various uses. NCTCOG has developed a regional Data Warehouse that will be utilized by the ICM agencies. The data in the regional Data Warehouse will be used by the Evaluation Model subsystem in order to model the corridor and the potential operational responses to improve the efficiency of the overall corridor network, and used for the baseline model for the DSS.

5.2. Existing Use Case: Plan Trip (External to ICMS)

5.2.1. Brief Description

Prior to making a trip within the region, a traveler will utilize multiple media, personal experience, and current conditions information to plan their route and mode for the trip to and from a location.

5.3. Existing Use Case: Change Trip – En route (External to ICMS)

5.3.1. Brief Description

As travelers make trips, information on the condition of their current route and mode will be available and updated in near real-time; this will potentially have the impact of changing the route or mode of the trip, depending on the traveler's requirements.

5.4. New Use Case: Determine Response

5.4.1. Brief Description

As the ICM Agency monitors their infrastructure and the conditions of their network, incidents will occur. When an incident occurs, the agency system will send data on the incident to the ICM Decision Support Subsystem. Once the DSS receives the data, it will compare the data to its pre-approved response plans, and select the closest matching plan. Once the DSS has selected the response plan, it will notify all ICM Agencies and any 3rd parties of the incident, and recommended response.

5.4.2. Actors

- ICM Agency
- Decision Support Subsystem

5.4.3. Work Scenario

- ICM Agency Inputs information on current incident
- DSS receives agency information
- DSS compares inputted data to pre-approved response plans

- DSS selects closest matching response plan
- DSS sends out response plan and incident data to agencies and regional ATIS

5.4.4. Tool(s)

- Regional Center to Center
- Decision Support Subsystem

5.4.5. Special Requirements

- None

5.4.6. Non-functional Requirements

- Determine Response Plan within 30 seconds
- Send out Response Plan Requests within 10 minutes of receiving data

5.4.7. Interfaces

- ICM Agencies
- Decision Support Subsystem
- Regional ATIS

5.4.8. Post Condition

- Response is selected and sent to be implemented

5.4.9. Priority

- High

5.5. New Use Case: Update Pre-planned Responses

5.5.1. Brief Description

After incidents have occurred, the ICM committee will meet on a routine basis to review how the response plans worked during various incidents. Based upon the Evaluation Model subsystem, and lessons learned from the incident responses, updates to the pre-approved plans may be required.

5.5.2. Actors

- ICM Steering Committee
- Regional Data Warehouse
- Evaluation Model subsystem
- Decision Support Subsystem

5.5.3. Work Scenario

- ICM Steering Committee receives incident information and response plan used from the Regional Data Warehouse
- ICM Steering Committee receives the effectiveness measures from the Evaluation Model subsystem
- ICM Steering Committee reviews the incident information, response plan information, lessons learned, and effectiveness measures for a given incident
- ICM Steering Committee decides if the response plan can be improved, needs alterations, or is okay as written
- ICM Steering Committee updates existing response plan, or creates new response plan
- ICM Steering Committee provides updated and new response plans for the DSS

5.5.4. Tool(s)

- Evaluation Model subsystem
- Decision Support Subsystem

5.5.5. Special Requirements

- None

5.5.6. Non-functional Requirements

Interfaces

- Evaluation Model subsystem
- Regional Data Warehouse

5.5.7. Post Condition

- Pre-approved response plan updated

5.5.8. Priority

- High

5.6. Enhance Use Case: Monitor Network Conditions

5.6.1. Brief Description

Agencies, as part of their normal operations, monitor the conditions of their infrastructure and network. As conditions change, the change in conditions may be due to incidents, congestion, or malfunction of devices.

5.6.2. Actors

- ICM Agency – provides information and data on current incidents

5.6.3. Work Scenario

- ICM Agency monitors network conditions of their infrastructure
- ICM Agency responds to abnormal conditions
- ICM Agency informs others of abnormal conditions

5.6.4. Tool(s)

5.6.5. Special Requirements

- None

5.6.6. Non-functional Requirements

- Receive updates approximately every 5 minutes from field equipment

5.6.7. Interfaces

- ICM Agency ATMS
- ICM Agency Signal Systems
- ICM Agency CAD E911 Systems
- ICM Agency Infrastructure
- ICM Agency Operations
- Regional Center to Center

5.6.8. Post Condition

5.6.9. Priority

- High

5.7. Enhance Use Case: Update Network Conditions

5.7.1. Brief Description

As ICM Agencies operate their infrastructure and network, the ICM System will receive data on the current conditions of each agency's network. During an incident, the ICM system will receive updated conditions and provide this information to the other agencies, travelers, and other systems. This updated condition information could include information on an incident, or information on return to normal conditions, for example.

5.7.2. Actors

- DSS – provide current and predictive status of the network
- ICM Agency – provides information and data on current incidents

5.7.3. Work Scenario

- ICM Agency monitors network conditions of their infrastructure
- ICM Agency informs others of changes in previously reported abnormal conditions
- ICM Agency informs others when return to normal operation

5.7.4. Tool(s)

- ICM Agency Infrastructure (DMS, Websites)
- 3rd Party ISP
- 511 System

5.7.5. Special Requirements

5.7.6. Non-functional Requirements

- ICM Agency systems will be able to receive data from other agencies and systems
- Provide updates approximately every 10 minutes on condition of network

5.7.7. Interfaces

- Regional ATIS
- Regional Center to Center
- ICM Agency Infrastructure

5.7.8. Post Condition

- Network conditions updated

5.7.9. Priority

- High

5.8. New Use Case: Implement Pre-approved response plan

5.8.1. Brief Description

When and incident occurs within the ICM corridor (or impacts the corridor) the DSS system will recommend a pre-approved response plan. This response plan recommendation, along with current incident information, will be provided to the ICM agencies, and 3rd parties. As part of the response plan, the ICM agencies and in some cases the 3rd parties, will implement the response.

5.8.2. Actors

- ICM Agency
- 3rd Party
- Decision Support Subsystem

5.8.3. Work Scenario

- ICM Agency receives pre-approved response plan request from the DSS
- ICM Agency implements response plan; or notifies system and other ICM Agencies if changed
- 3rd Party receives pre-approved response plan request from the DSS (or ICM Agency)

5.8.4. Tool(s)

- ICM Agency Infrastructure (DMS, Websites)
- CAD E911 System
- Regional Center to Center

- Decision Support Subsystem

5.8.5. Special Requirements

5.8.6. Non-functional Requirements

- ICM Agency systems will be able to receive data from the DSS and other ICM agency systems
- Begin to implement response plans within 10 minutes of receiving request (or provide response to requesting agency)

5.8.7. Interfaces

- Decision Support Subsystem
- Regional Center to Center

5.8.8. Post Condition

- Response Plan implemented

5.8.9. Priority

- High

5.9. Enhance Use Case: Collect Historical Information

5.9.1. Brief Description

In order to measure the effectiveness and for planning purposes, the ICM system must collect and store the data and information on the infrastructure and network collected during the operation of the system. This historical information can be used for a variety of planning and operational purposes.

5.9.2. Actors

- ICM Agency
- Decision Support Subsystem
- Regional Data Warehouse
- Evaluation Model subsystem

5.9.3. Work Scenario

- ICM Agency provides data warehouse with network condition data
- ICM Agency provides data warehouse with incident data
- DSS provides data warehouse with response plan list used during incidents
- Evaluation Model subsystem receives data from data warehouse for modeling of the corridor

5.9.4. Tool(s)

- Regional Data Warehouse

5.9.5. Special Requirements

5.9.6. Non-functional Requirements

- Regional Data Warehouse will be able to receive the data from all ICM Agency systems and the DSS in various formats

5.9.7. Interfaces

- ICM Agency network
- ICM Steering Committee
- Regional Data Warehouse
- Decision Support Subsystem
- Regional Center to Center

5.9.8. Post Condition

- Historical information is stored

5.9.9. Priority

- High

6. Requirements Process

6.1. User Needs and Functional Breakdown

The first step in the development of requirements for the ICM was to identify the needs and goals in the Concept of Operations. Once these were developed, User Needs and a definition of those User Needs were developed.

6.2. Use Cases

Use Cases are used in order to define how the system will be used by the users to ensure that all Needs identified are covered.

6.3. Map User Needs to Use Cases

The process that was used by the Dallas ICM Team is an iterative process starting with User Needs and mapping the identified High-Level Use Cases to each User Need. Then Requirements for each User Need/ Use Case were identified. The following table identifies the relationships established between the identified User Needs, and the Use Cases developed for the ICMS.

Table 6.3-1 Use Cases to User Needs Traceability

	Use Cases	User Needs													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
UC-1	Use Case: Plan Trip				x	x	x					x			
UC-2	Use Case: Change Trip – En route				x	x	x					x			
UC-3	Use Case: Determine Response	x		x	x					x	x			x	
UC-4	Use Case: Update Pre-planned Responses	x						x		x	x				x
UC-5	Use Case: Monitor Network Conditions	x	x	x				x	x				x	x	
UC-6	Use Case: Update Network Conditions	x	x	x				x	x				x	x	
UC-7	Use Case: Implement Pre-approved response plan	x						x			x			x	x
UC-8	Use Case: Collect Historical Information			x					x	x			x		

6.4. Develop Requirements for Subsystems

Once user needs, use cases, and scenarios were completed, a conceptual design of the entire ICM system was developed. From this concept, subsystems for the corridor were identified. As discussed previously, four (4) subsystems were identified for development of the ICM system. These subsystems are the Database subsystem, the Evaluation Model subsystem, the Decision Support Subsystem, and the Web subsystem. The figure below shows a high-level concept of the physical architecture of the ICM System.

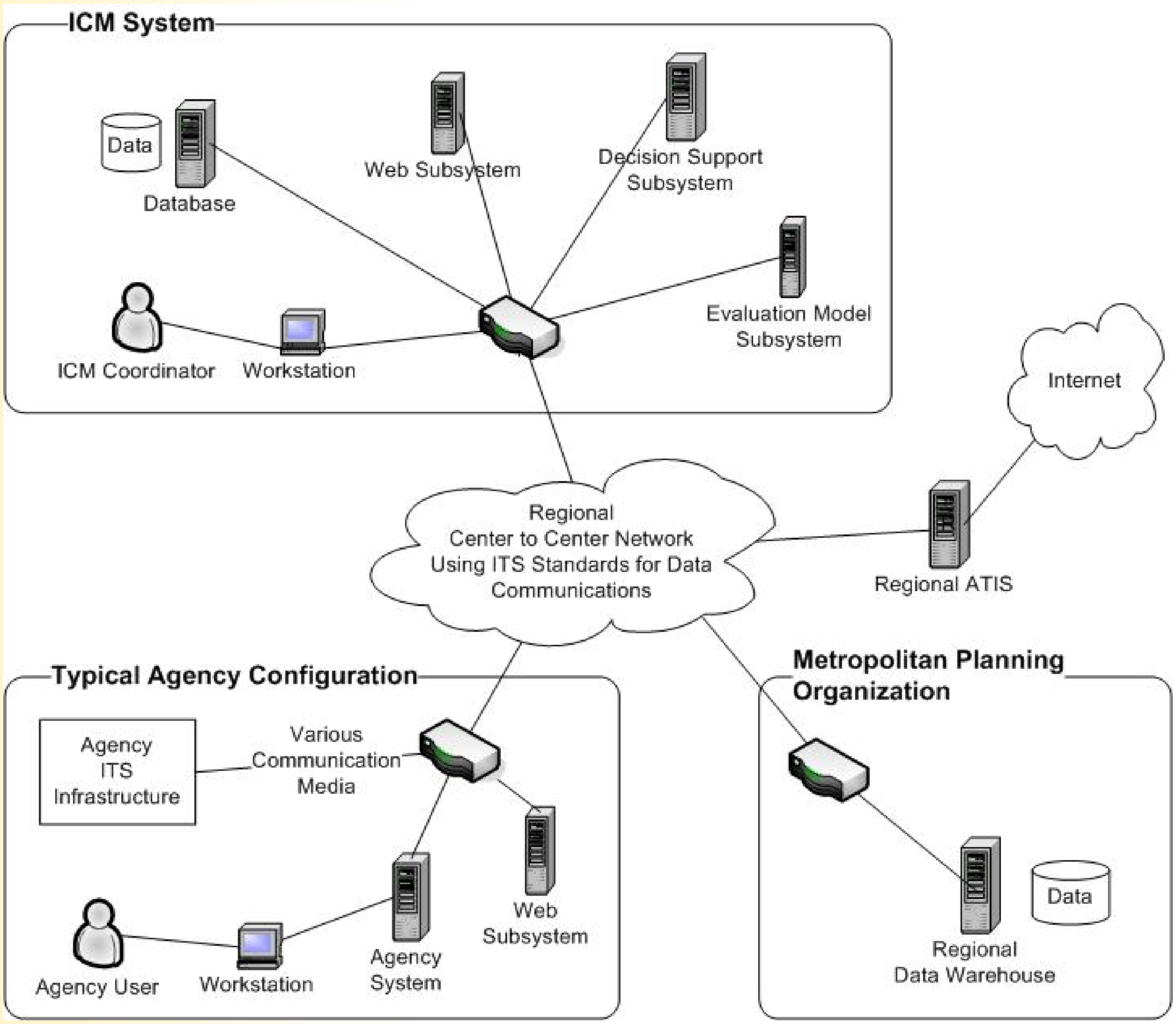

Figure 6.4-1 ICM System Physical Architecture

6.5. Map User Needs to Subsystems

In order to ensure that all functional requirements were identified from the user needs and use cases, a mapping of the user needs to the ICM system and subsystems was completed, as shown in Table 6.5-1. In several cases, the user needs are not directly attributable to the subsystems within the ICM concept, will be impacted by the ICM system and are external to the concept. For instance, User Need 7 - *Need to have physical infrastructure coverage*, and User

Need 11 - *Need to provide multi-modal alternatives for travelers* are out of scope for the initiative, however, they both are required in order for the system to operate well. Each of the stakeholders within the corridor have identified new infrastructure for their individual networks, as discussed in section 3 above. In addition, one of the goals of the ICM is for modal shift, in order for that to occur alternatives must be available and known to the public.

Table 6.5-1 User Needs Traceability

	User Needs													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
ICM System	X						X				X			
• Evaluation Model Subsystem									X			X		
• Decision Support Subsystem	X	X	X	X						X			X	
• Web Subsystem					X	X					X			X
• Database Subsystem							X	X						

6.6. ICMS Data Process

In order to further understand the process flow and data formats of the US-75 ICMS, the following diagram was created. The basic flow of information for the ICMS is:

1. Agencies provide current network information

2. Agencies store and process the information for their own systems,

3. The Agency information is then sent to the ICMS via the Regional Center to Center. The format and content of this data is required to meet the Regional Center to Center ICD, which is based on the TMDD and MS/ETMC standards as defined within the Regional Center to Center documents.

4. The ICMS Database is the first receiving component of the ICMS. The Database stores both historical information received from the Regional Data Warehouse and current network information it received from the ICM agencies and sends this information to the Decision Support subsystem.

5. The Decision Support subsystem processes this data utilizing a macroscopic model to calculate both current conditions and predictive conditions of the network in 30 minutes. Based on these two time horizons, the model compares results against both a set of pre-planned scenarios and develops its own potential response plans. The Decision Support subsystem then sends a response plan request, if it calculates one is needed, to the database and to the agencies via the center to center system.

6. In order to evaluate the performance of the ICMS, the Evaluation Model subsystem will be used on a regular basis to calculate the performance measures selected by the ICM steering committee. The Evaluation Model subsystem processes data utilizing models to calculate the performance measures. The data used in the model is received from the ICM database.

7. The last component of the ICMS is the Web subsystem. The Web subsystem allows both agency users and external users to view the data within the ICMS. The Web subsystem allows authorized users to view, edit, query and update data within the ICM database. The Web subsystem will provide a data feed to regional ATIS systems to provide data on current conditions, planned special events, and construction events within the corridor.

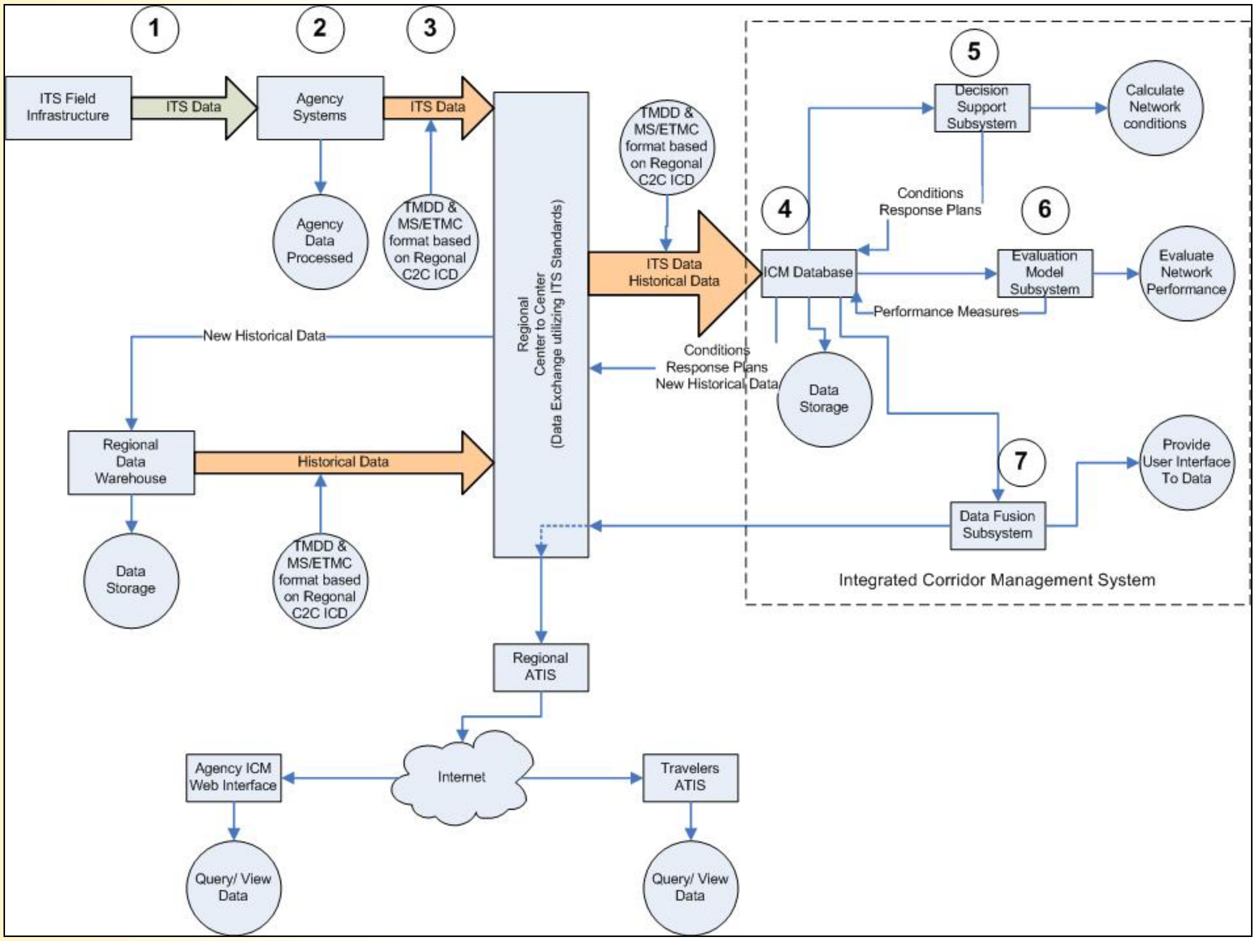

Figure 6.6-1 Data Flow Process

7. Requirements

This section covers the functional, performance, interface, data, and hardware requirements. It also covers non-functional and enabling requirements, and constraints. For the requirements provided below, the requirement ID can be broken down as TYPE-SYSTEM-PARENT ID-SUB1 ID-SUB2 ID.

The TYPE of Requirements provided are:

- F = Functional Requirement
- I = Interface Requirement
- D = Data Requirement
- P = Performance Requirement
- H = Hardware Requirement
- S = Security Requirements
- C = Constraint

The SUBSYSTEM for the Requirements provided are:

- ICMS = Overall Integrated Corridor Management System
- DSS = Decision Support Subsystem
- MOD = Evaluation Model Subsystem
- WEB = Web Subsystem
- DBA = Database

7.1. Assumptions and Dependencies

- The Regional Center to Center will be sufficient for the data exchange needs of the ICM
- The Regional Center to Center will be fully deployed
- The Regional Data Warehouse will be fully deployed
- Communication links between all US 75 stakeholders are completed
- Current deployed infrastructure and systems will be utilized
- This is a research project, so some of the technology and systems deployed may need to be altered once operations has begun
- Current and proposed infrastructure will be sufficient for the data requirements of the ICM, and the real-time Decision Support Subsystem
- Utilize the existing Regional Center to Center system
- Utilize the Regional Video and Data Sharing System
- Existing systems will sufficient for the needs of the system
- DART Network will be deployed
- Regional Data and Video Sharing System will be deployed
- Regional Center to Center plug-in will be deployed for each partner
- Current agency specifications for equipment will be utilized
- Current agency user authorization and authentication practices will be used
- Current agency information technology standards (hardware/ software) will be used
- Decision Support Subsystem will include an API, and web interface for agency's to utilize
- A Regional 511 system will be deployed

- Arterial detection will use both Tolltag readers and point detectors along the recommended arterials
- An Operator at DalTrans will be the corridor coordinator
- Funding will be available for ICM
- Agencies within the corridor will be willing to optimize the entire corridor, even if it impacts their individual network
- Regional Transportation Council and NCTCOG are supportive of the ICM and will provide funding, when needed

7.2. ICMS High-Level "Business" Requirements

The first step in the requirements process is the development of the overall ICMS "business" requirements. The ICM Steering Committee developed the User Needs, Goals, and Vision for the corridor; these were then translated into applicable use cases, and high-level requirements for the ICM System as a whole. These requirements are fulfilled by existing and new systems, and are the requirements for the stakeholders to operate the corridor in an integrated manner.

Table 7.2-1 Overall Integrated Corridor Management System Requirements

Requirement ID	Requirement Description	User Need	Source	Criticality	Verification Method
	Performance Requirements				
P - ICMS - 1 - 0 - 0	The ICMS shall be tested off-line (running with no failures) for 30 days during acceptance testing of the system	7		H	Observation
P - ICMS - 1 - 1 - 0	The ICMS outage time during acceptance testing shall not exceed 5% of the time, not including routine maintenance of the system	7		H	Observation
P - ICMS - 1 - 2 - 0	The time to recover the ICMS from an outage during acceptance testing shall not exceed 15 minutes	7		H	Observation
P - ICMS - 2 - 0 - 0	The ICMS shall be available 98% of the time during normal operations, not including routine maintenance, and outages due to factors beyond the developers control	7		H	Observation
P - ICMS - 3 - 0 - 0	The ICMS shall not be required to run continuously without routine maintenance	7		H	Observation
P - ICMS - 3 - 1 - 0	The ICMS must be brought down and restarted once every thirty (30) days for routine maintenance	7		H	Observation
P - ICMS - 4 - 0 - 0	The ICMS shall send pre-approved response plan requests to agencies within 2 minutes of selection of a pre-approved response plan	1, 3, 9, 13	Section 4, 5 Con Ops	H	Testing
P - ICMS - 5 - 0 - 0	The ICMS shall receive information on the clearance of any roadway incident within 2 minutes of closure within an Agency's systems	1, 2, 3, 4, 5, 6, 8, 9,10, 12, 13	Section 4, 5 Con Ops	H	Testing
P - ICMS - 6 - 0 - 0	The ICMS shall receive information on the clearance of any bus related incident within 2 minutes of closure within DART's systems	1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13	Section 4, 5 Con Ops	H	Testing
P - ICMS - 7 - 0 - 0	The ICMS shall receive information on the clearance of any light rail related incident within 2 minutes of closure within DART's systems	1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13	Section 4, 5 Con Ops	H	Testing

Table 7.2-1 Overall Integrated Corridor Management System Requirements (Continued)

Requirement ID	Requirement Description	User Need	Source	Criticality	Verification Method
P - ICMS - 8 - 0 - 0	The ICMS shall send update on any posted messages on the dynamic message signs within 5 minutes of update within operating agency's systems	1, 2, 3, 4, 5, 6, 8, 9,10, 12, 13	Section 4, 5 Con Ops	M	Testing
P - ICMS - 9 - 0 - 0	The ICMS shall send update on dynamic message signs status within 5 minutes of change in status within Agency's systems	1, 2, 3, 4, 5, 6, 8, 9,10, 12, 13	Section 4, 5 Con Ops	M	Testing
P - ICMS - 10 - 0 - 0	The ICMS shall send information on the implemented signal timing plan within 5 minutes of change of timing plans within Agency's system	1, 2, 3, 4, 5, 6, 8, 9,10, 12, 13	Section 4, 5 Con Ops	M	Testing
P - ICMS - 11 - 0 - 0	The ICMS shall send freeway link speed observations at one minute resolution for the freeway links to the decision support system	1, 2, 3, 4, 5, 6, 8, 9,10, 12, 13	Section 4, 5 Con Ops	M	Testing
P - ICMS - 12 - 0 - 0	The ICMS shall send arterial link speeds at 30 seconds to one minute resolution for at least 10% of the arterial links to the decision support system.	1, 2, 3, 4, 5, 6, 8, 9,10, 12, 13	Section 4, 5 Con Ops	M	Testing
P - ICMS - 13 - 0 - 0	The ICMS shall send information on transit vehicle location at not more than 2 minute interval.	1, 2, 3, 4, 5, 6, 8, 9,10, 12, 13	Section 4, 5 Con Ops	M	Testing
	Security Requirements				
S - ICMS - 1 - 0 - 0	The ICMS shall require a login username and password	7		H	Testing
S - ICMS - 1 - 1 - 0	The ICMS shall have multiple levels of users to include: a. Agency User b. ICM Coordinator c. Administrator d. Developer	1		H	Testing
S - ICMS - 1 - 2 - 0	Login information and privileges will be stored in a centralized access control database	1		M	Testing

Table 7.2-1 Overall Integrated Corridor Management System Requirements (Continued)

Requirement ID	Requirement Description	User Need	Source	Criticality	Verification Method
S - ICMS - 1 - 3 - 0	The ICMS shall restrict a user account to 1 login instance.	1		M	Testing
S - ICMS - 2 - 0 - 0	The ICMS shall include an interface to manage user accounts	1		M	Testing
S - ICMS - 2 - 1 - 0	The ICMS shall include an interface to add user accounts	1		M	Testing
S - ICMS - 2 - 2 - 0	The ICMS shall include an interface to modify user accounts	1		M	Testing
S - ICMS - 2 - 3 - 0	The ICMS shall send an interface to delete user accounts	1		M	Testing
	Hardware Requirements				
H - ICMS - 1 - 0 - 0	The ICMS shall consist of a: a. Database b. Decision Support Subsystem c. Communication connection to the Regional Center to Center system d. Evaluation Model subsystem e. Web subsystem	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11,12,13, 14	Section 4, 5 Con Ops	H	Testing
H - ICMS - 1 - 1 - 0	The ICMS shall include a database server for storage of data	3, 4, 5, 6, 8, 9, 10, 11,12,13, 14	Section 4, 5 Con Ops	H	Inspection
H - ICMS - 1 - 2 - 0	The ICMS shall include an application server(s) for the Decision Support Subsystem	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11,12,13, 14	Section 4, 5 Con Ops	H	Inspection
H - ICMS - 1 - 3 - 0	The ICMS shall include an application server(s) for the Evaluation Model Subsystem	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11,12,13, 14	Section 4, 5 Con Ops	H	Inspection

Table 7.2-1 Overall Integrated Corridor Management System Requirements (Continued)

Requirement ID	Requirement Description	User Need	Source	Criticality	Verification Method
H - ICMS - 1 - 4 - 0	The ICMS shall include an web server(s) for the Web Subsystem	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11,12,13, 14	Section 4, 5 Con Ops	H	Inspection
H - ICMS - 2 - 0 - 0	The ICMS shall include network equipment needed to connect to the regional center to center system	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11,12,13, 14	Section 4, 5 Con Ops	H	Inspection
C - ICMS - 1 - 0 - 0	The ICMS network equipment shall meet the requirements of the regional center to center system network	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11,12,13, 15	Section 4, 5 Con Ops	H	Inspection
	Data - Receiving				
D - ICMS - 1 - 0 - 0	The ICMS shall receive the coordinates of intersections in the corridor from the regional data warehouse via the regional center to center system in a format to meet the requirements of the Regional Center to Center ICD	1, 5, 6, 7, 8, 9, 12, 13	Section 4, 5 Con Ops	H	Testing
D - ICMS - 2 - 0 - 0	The ICMS shall receive a list of links in the corridor from the regional data warehouse via the regional center to center system in a format to meet the requirements of the Regional Center to Center ICD	1, 2, 3, 4, 8	Section 4, 5 Con Ops	H	Testing

Table 7.2-1 Overall Integrated Corridor Management System Requirements (Continued)

Requirement ID	Requirement Description	User Need	Source	Criticality	Verification Method
D - ICMS - 3 - 0 - 0	The ICMS shall receive information from the regional data warehouse on each link via the regional center to center system in a format to meet the requirements of the Regional Center to Center ICD including: a. facility type b. number of lanes c. capacity per lane d. speed limit e. average jam density f. Link owner (s)	1, 5, 6, 7, 8, 9, 12, 13	Section 4, 5 Con Ops	H	Testing
D - ICMS - 4 - 0 - 0	The ICMS shall receive toll data for toll roads in the corridor from the regional data warehouse via the regional center to center system in a format to meet the requirements of the Regional Center to Center ICD	1, 5, 6, 7, 8, 9, 12, 13	Section 4, 5 Con Ops	H	Testing
D - ICMS - 5 - 0 - 0	The ICMS shall receive information from the regional data warehouse for each signalized intersection in the corridor via the regional center to center system in a format to meet the requirements of the Regional Center to Center ICD to include: a. Control type b. Timing Plan	1, 5, 6, 7, 8, 9, 12, 13	Section 4, 5 Con Ops	H	Testing
D - ICMS - 6 - 0 - 0	The ICMS shall receive state information for detectors in the corridor via the regional center to center system in a format to meet the requirements of the Regional Center to Center ICD within 2 minutes of any state change in the agency's systems	1, 5, 6, 7, 8, 9, 12, 13	Section 4, 5 Con Ops	H	Testing
D - ICMS - 7 - 0 - 0	The ICMS shall receive location of dynamic message signs in the corridor from the regional data warehouse via the regional center to center system in a format to meet the requirements of the Regional Center to Center ICD	1, 5, 6, 7, 8, 9, 12, 13	Section 4, 5 Con Ops	H	Testing

Table 7.2-1 Overall Integrated Corridor Management System Requirements (Continued)

Requirement ID	Requirement Description	User Need	Source	Criticality	Verification Method
D - ICMS - 8 - 0 - 0	The ICMS shall receive information on the route structure of bus routes in the corridor from the regional data warehouse via the regional center to center system in a format to meet the requirements of the Regional Center to Center ICD	1, 5, 6, 7, 8, 9, 11, 12, 13	Section 4, 5 Con Ops	H	Testing
D - ICMS - 9 - 0 - 0	The ICMS shall receive information on the route structure of light rail lines in the corridor from the regional data warehouse via the regional center to center system in a format to meet the requirements of the Regional Center to Center ICD	1, 5, 6, 7, 8, 9, 11, 12, 13	Section 4, 5 Con Ops	H	Testing
D - ICMS - 10 - 0 - 0	The ICMS shall receive time table for bus routes in the corridor from the regional data warehouse via the regional center to center system in a format to meet the requirements of the Regional Center to Center ICD	1, 5, 6, 7, 8, 9, 11, 12, 13	Section 4, 5 Con Ops	H	Testing
D - ICMS - 11 - 0 - 0	The ICMS shall receive time table for all light rail lines in the corridor from the regional data warehouse via the regional center to center system in a format to meet the requirements of the Regional Center to Center ICD	1, 5, 6, 7, 8, 9, 11, 12, 13	Section 4, 5 Con Ops	H	Testing
D - ICMS - 12 - 0 - 0	The ICMS shall receive fare structure data for bus routes in the corridor from the regional data warehouse via the regional center to center system in a format to meet the requirements of the Regional Center to Center ICD	1, 5, 6, 7, 8, 9, 11, 12, 13	Section 4, 5 Con Ops	H	Testing
D - ICMS - 13 - 0 - 0	The ICMS shall receive fare structure data for light rail lines in the corridor from the regional data warehouse via the regional center to center system in a format to meet the requirements of the Regional Center to Center ICD	1, 5, 6, 7, 8, 9, 11, 12, 13	Section 4, 5 Con Ops	H	Testing
D - ICMS - 14 - 0 - 0	The ICMS shall receive the location of bus stops in the corridor from the regional data warehouse via the regional center to center system in a format to meet the requirements of the Regional Center to Center ICD	1, 5, 6, 7, 8, 9, 11, 12, 13	Section 4, 5 Con Ops	H	Testing

Table 7.2-1 Overall Integrated Corridor Management System Requirements (Continued)

Requirement ID	Requirement Description	User Need	Source	Criticality	Verification Method
D - ICMS - 15 - 0 - 0	The ICMS shall receive the location of light rail stations in the corridor from the regional data warehouse via the regional center to center system in a format to meet the requirements of the Regional Center to Center ICD	1, 5, 6, 7, 8, 9, 11, 12, 13	Section 4, 5 Con Ops	H	Testing
D - ICMS - 16 - 0 - 0	The ICMS shall receive information on allowed/prohibited turning movements at each intersection from the regional data warehouse via the regional center to center system in a format to meet the requirements of the Regional Center to Center ICD	1, 5, 6, 7, 8, 9, 12, 13	Section 4, 5 Con Ops	H	Testing
D - ICMS - 17 - 0 - 0	The ICMS shall receive the location of park-and-ride facilities in the corridor from the regional data warehouse via the regional center to center system in a format to meet the requirements of the Regional Center to Center ICD	1, 5, 6, 7, 8, 9, 12, 13	Section 4, 5 Con Ops	H	Testing
D - ICMS - 18 - 0 - 0	The ICMS shall receive the capacity of park-and-ride facilities in the corridor from the regional data warehouse via the regional center to center system in a format to meet the requirements of the Regional Center to Center ICD	1, 5, 6, 7, 8, 9, 11, 12, 13	Section 4, 5 Con Ops	H	Testing
D - ICMS - 19 - 0 - 0	The ICMS shall receive the location of agency managed parking lots in the corridor from the regional data warehouse via the regional center to center system in a format to meet the requirements of the Regional Center to Center ICD	1, 5, 6, 7, 8, 9, 11, 12, 13	Section 4, 5 Con Ops	H	Testing
D - ICMS - 20 - 0 - 0	The ICMS shall receive the capacity of agency managed parking lots in the corridor from the regional data warehouse via the regional center to center system in a format to meet the requirements of the Regional Center to Center ICD	1, 5, 6, 7, 8, 9, 11, 12, 13	Section 4, 5 Con Ops	H	Testing
D - ICMS - 21 - 0 - 0	The ICMS shall receive the location of approved 3rd Party parking lots in the corridor via the regional center to center system in a format to meet the requirements of the Regional Center to Center ICD	1, 5, 6, 7, 8, 9, 11, 12, 13, 14	Section 4, 5 Con Ops	H	Testing

Table 7.2-1 Overall Integrated Corridor Management System Requirements (Continued)

Requirement ID	Requirement Description	User Need	Source	Criticality	Verification Method
D - ICMS - 22 - 0 - 0	The ICMS shall receive the capacity of approved 3rd Party parking lots in the corridor via the regional center to center system in a format to meet the requirements of the Regional Center to Center ICD	1, 5, 6, 7, 8, 9, 11, 12, 13, 14	Section 4, 5 Con Ops	H	Testing
D - ICMS - 23 - 0 - 0	The ICMS shall receive information on roadway incidents in the corridor via the regional center to center system in a format to meet the requirements of the Regional Center to Center ICD describing: a. Location b. Time of Day c. Number of Lanes affected d. Estimated Duration	1, 2, 3, 4, 5, 6, 7, 8, 9, 12, 13	Section 4, 5 Con Ops	H	Testing
D - ICMS - 24 - 0 - 0	The ICMS shall receive information on bus related incidents in the corridor via the regional center to center system in a format to meet the requirements of the Regional Center to Center ICD describing: a. Location b. Time of Day c. Bus Route d. Estimated Duration	1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13	Section 4, 5 Con Ops	H	Testing
D - ICMS - 25 - 0 - 0	The ICMS shall receive information on light rail related incidents in the corridor via the regional data warehouse via the regional center to center system in a format to meet the requirements of the Regional Center to Center ICD describing: a. Location b. Time of Day c. Light Rail Line d. Estimated Duration	1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13	Section 4, 5 Con Ops	H	Testing
	Data – Storage				
D - ICMS - 26 - 0 - 0	The ICMS shall store data received from the corridor systems	1, 8	Section 4, 5 Con Ops	H	Testing

Table 7.2-1 Overall Integrated Corridor Management System Requirements (Continued)

Requirement ID	Requirement Description	User Need	Source	Criticality	Verification Method
D - ICMS - 27 - 0 - 0	The ICMS database subsystem shall store: a. Historical information needed for the modeling and decision support subsystems b. Current day activities within the corridor c. Pre-approved response plans d. Contact Lists	5, 8, 9, 10, 12	Section 4, 5 Con Ops	H	Testing
D - ICMS - 28 - 0 - 0	The ICMS shall store state information for detectors in the corridor to include: a. State b. Time of Day c. Location d. Detector ID (if applicable)	5, 8, 9, 10, 12	Section 4, 5 Con Ops	H	Testing
D - ICMS - 29 - 0 - 0	The ICMS shall store information on roadway incidents in the corridor describing: a. Location b. Time of Day c. Number of Lanes affected d. Estimated Duration e. Incident ID f. Lead Agency	5, 8, 9, 10, 12	Section 4, 5 Con Ops	H	Testing
D - ICMS - 30 - 0 - 0	The ICMS shall store information on bus related incidents in the corridor describing: a. Location b. Time of Day c. Bus Route d. Estimated Duration	5, 8, 9, 10, 11, 12	Section 4, 5 Con Ops	H	Testing
D - ICMS - 31 - 0 - 0	The ICMS shall store information on light rail related incidents in the corridor describing: a. Location b. Time of Day c. Light Rail Line d. Estimated Duration	5, 8, 9, 10, 11, 12	Section 4, 5 Con Ops	H	Testing

Table 7.2-1 Overall Integrated Corridor Management System Requirements (Continued)

Requirement ID	Requirement Description	User Need	Source	Criticality	Verification Method
	Data – Sending				
D - ICMS - 32 - 0 - 0	The ICMS shall send new data stored in the database it received during each day to the regional data warehouse utilizing the regional center to center system in a format to meet the requirements of the Regional Center to Center ICD	8	Section 4, 5 Con Ops	H	Testing
D - ICMS - 33 - 0 - 0	The ICMS shall send toll data for toll roads in the corridor to the decision support subsystem	1, 2, 3, 4, 8, 12, 13, 14	Section 4, 5 Con Ops	H	Testing
D - ICMS - 34 - 0 - 0	The ICMS shall send the coordinates of intersections in the corridor to the decision support subsystem to include: a. number of lanes each direction b. Signalized/ unsignalized c. Links connected to intersection d. allowed turning movements	1, 2, 3, 4, 8, 12, 13, 14	Section 4, 5 Con Ops	H	Testing
D - ICMS - 35 - 0 - 0	The ICMS shall send a list of links in the corridor to the decision support subsystem	1, 2, 3, 4, 8, 12, 13, 14	Section 4, 5 Con Ops	H	Testing
D - ICMS - 36 - 0 - 0	The ICMS shall send information to the decision support subsystem on each link including: a. facility type b. number of lanes c. capacity per lane d. speed limit e. average jam density	1, 2, 3, 4, 8, 12, 13, 14	Section 4, 5 Con Ops	H	Testing
D - ICMS - 37 - 0 - 0	The ICMS shall send information to the decision support subsystem for each signalized intersection to include: a. Control type b. Timing Plan	1, 2, 3, 4, 8, 12, 13, 14	Section 4, 5 Con Ops	H	Testing
D - ICMS - 38 - 0 - 0	The ICMS shall send state information for detectors in the corridor to the decision support subsystem within 30 seconds of receipt of a state change	1, 2, 3, 4, 8, 12, 13, 14	Section 4, 5 Con Ops	H	Testing

Table 7.2-1 Overall Integrated Corridor Management System Requirements (Continued)

Requirement ID	Requirement Description	User Need	Source	Criticality	Verification Method
D - ICMS - 39 - 0 - 0	The ICMS shall send location of dynamic message signs in the corridor to the decision support subsystem	1, 2, 3, 4, 8, 12, 13, 14	Section 4, 5 Con Ops	H	Testing
D - ICMS - 40 - 0 - 0	The ICMS shall send information on allowed/prohibited turning movements at each intersection to the decision support subsystem	1, 2, 3, 4, 8, 12, 13, 14	Section 4, 5 Con Ops	H	Testing
D - ICMS - 41 - 0 - 0	The ICMS shall send information on route structure bus routes in the corridor to the decision support subsystem	1, 2, 3, 4, 8, 12, 13, 14	Section 4, 5 Con Ops	H	Testing
D - ICMS - 42 - 0 - 0	The ICMS shall send information on route structure light rail lines in the corridor to the decision support subsystem	1, 2, 3, 4, 8, 12, 13, 14	Section 4, 5 Con Ops	H	Testing
D - ICMS - 43 - 0 - 0	The ICMS shall send time table for bus routes in the corridor to the decision support subsystem	1, 2, 3, 4, 8, 12, 13, 14	Section 4, 5 Con Ops	H	Testing
D - ICMS - 44 - 0 - 0	The ICMS shall send time table for all light rail lines in the corridor to the decision support subsystem	1, 2, 3, 4, 8, 12, 13, 14	Section 4, 5 Con Ops	H	Testing
D - ICMS - 45 - 0 - 0	The ICMS shall send fare structure data for bus routes in the corridor to the decision support subsystem	1, 2, 3, 4, 8, 12, 13, 14	Section 4, 5 Con Ops	H	Testing
D - ICMS - 46 - 0 - 0	The ICMS shall send fare structure data for light rail lines in the corridor to the decision support subsystem	1, 2, 3, 4, 8, 12, 13, 14	Section 4, 5 Con Ops	H	Testing
D - ICMS - 47 - 0 - 0	The ICMS shall send the location of bus stops in the corridor to the decision support subsystem	1, 2, 3, 4, 8, 12, 13, 14	Section 4, 5 Con Ops	H	Testing
D - ICMS - 48 - 0 - 0	The ICMS shall send the location of light rail stations in the corridor to the decision support subsystem	1, 2, 3, 4, 8, 12, 13, 14	Section 4, 5 Con Ops	H	Testing
D - ICMS - 49 - 0 - 0	The ICMS shall send the location of park-and-ride facilities in the corridor to the decision support subsystem	1, 2, 3, 4, 8, 12, 13, 14	Section 4, 5 Con Ops	H	Testing
D - ICMS - 50 - 0 - 0	The ICMS shall send the capacity of park-and-ride facilities in the corridor to the decision support subsystem	1, 2, 3, 4, 8, 12, 13, 14	Section 4, 5 Con Ops	H	Testing

Table 7.2-1 Overall Integrated Corridor Management System Requirements (Continued)

Requirement ID	Requirement Description	User Need	Source	Criticality	Verification Method
D - ICMS - 51 - 0 - 0	The ICMS shall send the location of agency managed parking lots in the corridor to the decision support subsystem	1, 2, 3, 4, 8, 12, 13, 14	Section 4, 5 Con Ops	H	Testing
D - ICMS - 52 - 0 - 0	The ICMS shall send the capacity of agency managed parking lots in the corridor to the decision support subsystem	1, 2, 3, 4, 8, 12, 13, 14	Section 4, 5 Con Ops	H	Testing
D - ICMS - 53 - 0 - 0	The ICMS shall send the location of approved 3rd Party parking lots in the corridor to the decision support subsystem	1, 2, 3, 4, 8, 12, 13, 14	Section 4, 5 Con Ops	H	Testing
D - ICMS - 54 - 0 - 0	The ICMS shall send the capacity of approved 3rd Party parking lots in the corridor to the decision support subsystem	1, 2, 3, 4, 8, 12, 13, 14	Section 4, 5 Con Ops	H	Testing
D - ICMS - 55 - 0 - 0	The ICMS shall send information on roadway incidents in the corridor to the decision support subsystem describing: a. Location b. Time of Day c. Number of Lanes affected d. Estimated Duration e. Incident ID	1, 2, 3, 4, 8, 12, 13, 14	Section 4, 5 Con Ops	H	Testing
D - ICMS - 56 - 0 - 0	The ICMS shall send stored information on roadway incidents in the corridor that occurred that day to the regional data warehouse via the regional center to center system in a format to meet the requirements of the Regional Center to Center ICD describing: a. Location b. Start Time c. End Time d. Date of Incident e. Number of Lanes affected f. Duration g. Incident ID h. Lead Agency	1, 2, 3, 4, 8, 12, 13, 14	Section 4, 5 Con Ops	H	Testing

Table 7.2-1 Overall Integrated Corridor Management System Requirements (Continued)

Requirement ID	Requirement Description	User Need	Source	Criticality	Verification Method
D - ICMS - 57 - 0 - 0	The ICMS shall send information on bus related incidents in the corridor to the decision support subsystem describing: a. Location b. Time of Day c. Bus Route d. Estimated Duration	1, 2, 3, 4, 8, 11, 12, 13, 14	Section 4, 5 Con Ops	H	Testing
D - ICMS - 58 - 0 - 0	The ICMS shall send stored information on bus incidents in the corridor that occurred that day to the regional data warehouse via the regional center to center system in a format to meet the requirements of the Regional Center to Center ICD describing: a. Location b. Start Time c. End Time d. Date of incident e. Bus Route f. Duration	1, 2, 3, 4, 8, 11, 12, 13, 14	Section 4, 5 Con Ops	H	Testing
D - ICMS - 59 - 0 - 0	The ICMS shall send information on light rail related incidents in the corridor to the decision support subsystem describing: a. Location b. Time of Day c. Light Rail Line d. Estimated Duration	1, 2, 3, 4, 8, 11, 12, 13, 14	Section 4, 5 Con Ops	H	Testing
D - ICMS - 60 - 0 - 0	The ICMS shall send stored information on light rail incidents in the corridor that occurred that day to the regional data warehouse via the regional data warehouse via the regional center to center system in a format to meet the requirements of the Regional Center to Center ICD describing: a. Location b. Start Time c. End Time d. Date of incident e. Light Rail Line f. Duration	1, 2, 3, 4, 8, 11, 12, 13, 14	Section 4, 5 Con Ops	H	Testing

Table 7.2-1 Overall Integrated Corridor Management System Requirements (Continued)

Requirement ID	Requirement Description	User Need	Source	Criticality	Verification Method
D - ICMS - 61 - 0 - 0	The ICMS shall send information on light rail related incidents in the corridor to the decision support subsystem describing: a. Location b. Time of Day c. Light Rail Line d. Estimated Duration	1, 2, 3, 4, 8, 11, 12, 13, 14	Section 4, 5 Con Ops	H	Testing
	Data - Processing				
F - ICMS - 1 - 0 - 0	The ICMS shall determine a recommended response plan based on network conditions within the corridor	3, 4, 5, 6, 8, 10, 13, 14	Section 4, 5 Con Ops	H	Testing
F - ICMS - 2 - 0 - 0	The ICMS shall create an Incident ID associated with each unique incident it receives from the corridor agencies	3, 4, 5, 6, 8, 10, 13, 14	Section 4, 5 Con Ops	H	Testing
F - ICMS - 3 - 0 - 0	The ICMS shall send the information necessary to determine a pre-approved response plan to the decision support subsystem as defined by the requirements of the decision support system	3, 4, 5, 6, 8, 10, 13, 14	Section 4, 5 Con Ops	H	Testing
	Interface Requirements/ Constraints				
I - ICMS - 1 - 0 - 0	The ICMS shall interface to the regional center to center system	1	Section 4, 5 Con Ops	H	
I - ICMS - 2 - 0 - 0	The ICMS shall interface to the regional data and video sharing system	1	Section 4, 5 Con Ops	H	
C - ICMS - 1 - 0 - 0	The ICMS shall comply with the Regional Center to Center ICD for data exchange between the systems	1	Section 4, 5 Con Ops	H	
C - ICMS - 2 - 0 - 0	The ICMS shall comply with the Regional Data and Video Sharing (RDVS) system ICD for video exchanged between the systems	1	Section 4, 5 Con Ops	H	

7.3. Subsystem Technical Requirements

For each of the ICM subsystems, requirements were developed to provide high-level functions, data, interfaces, and performance requirements to complete the ICMS. All of these subsystems are a part of the overall ICM System.

Table 7.3-1 Decision Support Subsystem Requirements

Requirement ID	Requirement Description	User Need	Source	Criticality	Verification Method
C - DSS - 1 - 0 - 0	The DSS shall utilize existing data from the regional data warehouse	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
D - DSS - 1 - 0 - 0	The DSS shall receive the coordinates of all intersections in the corridor.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
D - DSS - 2 - 0 - 0	The DSS shall receive a list of all links in the corridor	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
D - DSS - 3 - 0 - 0	The DSS shall receive information on each link including: a. facility type b. number of lanes c. capacity per lane d. speed limit e. average jam density. (jam density is defined as the maximum number of vehicles per unit length of the highway link)	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
D - DSS - 4 - 0 - 0	The DSS shall receive toll data for all toll roads in the corridor	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
D - DSS - 5 - 0 - 0	The DSS shall receive information on the control type and associated timing plan at each signalized intersection.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
D - DSS - 6 - 0 - 0	The DSS shall receive information on each active (not marked as out-of-order or in-maintenance) detectors in the network.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
D - DSS - 7 - 0 - 0	The DSS shall receive location of active (not marked as out-of-order or in-maintenance) dynamic message signs in the network.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
D - DSS - 8 - 0 - 0	The DSS shall receive information on allowed/prohibited turning movements at each intersection.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing

Table 7.3-1 Decision Support Subsystem Requirements (Continued)

Requirement ID	Requirement Description	User Need	Source	Criticality	Verification Method
D - DSS - 9 - 0 - 0	The DSS shall receive information on route structure of all bus and train lines in the network. The route is described in terms of a list of intersections and roadway links.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
D - DSS - 10 - 0 - 0	The DSS shall receive time table for all bus and train lines in the network.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
D - DSS - 11 - 0 - 0	The DSS shall receive fare structure data for all bus and train lines in the network.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
D - DSS - 12 - 0 - 0	The DSS shall receive the location of all bus stops in the network.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
D - DSS - 13 - 0 - 0	The DSS shall receive the location of all train stations.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
D - DSS - 14 - 0 - 0	The DSS shall receive the location of all park-and-ride facilities in the network.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
D - DSS - 15 - 0 - 0	The DSS shall receive the capacity of all park-and-ride facilities in the network.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
D - DSS - 16 - 0 - 0	The DSS shall receive data from the regional center to center network within 2 minutes of a change in data.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
D - DSS - 16 - 1 - 0	The DSS shall receive information on all roadway incidents in the corridor within 2 minutes of verification in controlling agency's systems describing: a. Location b. Time of Day c. Number of Lanes affected d. Estimated Duration	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
D - DSS - 16 - 2 - 0	The DSS shall receive information on all bus related incidents in the corridor within 2 minutes of verification within DART's systems describing: a. Location b. Time of Day c. Bus Route d. Estimated Duration	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing

Table 7.3-1 Decision Support Subsystem Requirements (Continued)

Requirement ID	Requirement Description	User Need	Source	Criticality	Verification Method
D - DSS - 16 - 3 - 0	The DSS shall receive information on all train related incidents in the corridor within 2 minutes of verification within DART's systems describing a. Location b. Time of Day c. Route d. Direction of Travel e. Estimated Duration	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
D - DSS - 16 - 4 - 0	The DSS shall receive information on the clearance of all roadway incident within 2 minutes of closure within agency's systems	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
D - DSS - 16 - 5 - 0	The DSS shall receive information on the clearance of all bus related incident within 2 minutes of closure within DART's systems	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
D - DSS - 16 - 6 - 0	The DSS shall receive information on the clearance of all train related incident within 2 minutes of closure within DART's systems	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
D - DSS - 16 - 7 - 0	The DSS shall receive updates on all posted messages on the dynamic message signs within 2 minutes of update	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
D - DSS - 16 - 8 - 0	The DSS shall receive update on dynamic message signs status within 2 minutes of change in status	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
D - DSS - 16 - 9 - 0	The DSS shall receive information on the implemented signal timing plan within 2 minutes of signal timing plan change	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
D - DSS - 16 - 10 - 0	The DSS shall receive update on traffic signal status within 2 minutes of status change	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
D - DSS - 16 - 11 - 0	The DSS shall receive real-time link speed observations at 30 seconds to one minute resolution for at least 20% of the freeway links.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
D - DSS - 16 - 12 - 0	The DSS shall receive real-time observations at 30 seconds to one minute resolution for at least 10% of the arterial links.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing

Table 7.3-1 Decision Support Subsystem Requirements (Continued)

Requirement ID	Requirement Description	User Need	Source	Criticality	Verification Method
D - DSS - 16 - 13 - 0	The DSS shall receive real-time information on transit vehicle location at not more than 2 minute interval.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 1 - 0 - 0	The DSS shall provide real-time estimation of the intermodal network conditions at 30 seconds interval. Elements of the intermodal network include freeways, HOV lanes, arterials, bus lines, light rail lines, and park-and-ride facilities.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 2 - 0 - 0	The DSS shall provide consistency with the real-world conditions for all travel modes and facilities. a. The system's estimation error of the traffic speed, density and volume on every highway link in the network should not exceed 15% (plus or minus). b. The system's estimation error of the location of every transit vehicle in the network should not exceed 10% (plus or minus). c. The system's estimation error of the occupancy of every park-and-ride facility in the network should not exceed 20% (plus or minus).	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 3 - 0 - 0	The DSS shall provide short term prediction of the intermodal network conditions for one hour horizon. Elements of the intermodal network include freeways, HOV lanes, arterials, bus lines, light rail lines, and park-and-ride facilities.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 4 - 0 - 0	Predicting the network future conditions (travel times and traffic density on every link) requires predicting the travel demand between every origin destination pairs for the prediction horizon which is one hour. The DSS shall provide prediction of the time-dependent origin-destination network demand at 5 to 10 minutes resolution.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing

Table 7.3-1 Decision Support Subsystem Requirements (Continued)

Requirement ID	Requirement Description	User Need	Source	Criticality	Verification Method
F - DSS - 5 - 0 - 0	The DSS shall provide the capability to evaluate all user-specified (predefined) corridor management strategies. These strategies are a. pre-trip and en-route traveler information provision b. congestion pricing c. signal timing modification d. transit service modification e. transit signal priority f. parking management and pricing g. combinations of the above	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 6 - 0 - 0	The DSS shall provide the capability to develop a real-time traffic management scheme. A traffic management scheme consists of the different actions that will be implemented by all agencies to manage the corridor. These actions are: - List of Dynamic Message Signs (DMS) to be activated along with their messages - Transit vehicle service pattern including any route and headway modifications - Timing plan of all signalized intersections	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 7 - 0 - 0	The DSS shall provide measures of performance for all travel modes and facilities.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 8 - 0 - 0	The DSS shall provide estimation of vehicle emissions including CO, CO2, NO2 and SO2	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 9 - 0 - 0	The DSS shall provide visualization capabilities of the traffic distribution and associated measures of performance.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 10 - 0 - 0	The DSS shall provide real-time estimation of the current conditions for the entire intermodal network. Elements of the intermodal network include freeways, HOV lanes, arterials, bus lines, light rail lines, and park-and-ride facilities.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing

Table 7.3-1 Decision Support Subsystem Requirements (Continued)

Requirement ID	Requirement Description	User Need	Source	Criticality	Verification Method
F - DSS - 10 - 1 - 0	The DSS shall provide real-time estimation of average link speed and traffic density for the freeway system at 30 second interval.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 10 - 2 - 0	The DSS shall provide real-time estimation of average link speed and traffic density for the HOV system at 30 second interval.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 10 - 3 - 0	The DSS shall provide real-time estimation of average link speed and traffic density for the arterial system at 30 second interval.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 10 - 4 - 0	The DSS shall provide real-time estimation of queue length on the links of the arterial system at 30 second interval.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 10 - 5 - 0	The DSS shall provide real-time estimation of transit vehicle (train/bus) locations at 30 second interval.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 10 - 6 - 0	The DSS shall provide real-time estimation of number of passengers on board for all transit vehicles at 30 second interval.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 10 - 7 - 0	The DSS shall provide real-time estimation of number of passengers at all bus stops and train stations at 30 second interval.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 10 - 8 - 0	The DSS shall provide real-time estimation of the occupancy of parking lots at 30 second interval.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 10 - 9 - 0	The DSS shall provide real-time estimation of vehicle emissions including CO, CO2, NO2 and SO2.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing

Table 7.3-1 Decision Support Subsystem Requirements (Continued)

Requirement ID	Requirement Description	User Need	Source	Criticality	Verification Method
F - DSS - 10 - 10 - 0	The DSS shall perform internal consistency checking at 2 minutes interval using real-time observations of link speeds and traffic densities. a. The system's estimation error of the traffic speed, density and volume on every highway link in the network should not exceed 15% (plus or minus). b. The system's estimation error of the location of every transit vehicle in the network should not exceed 10% (plus or minus). c. The system's estimation error of the occupancy of every park-and-ride facility in the network should not exceed 20% (plus or minus).	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 10 - 11 - 0	The DSS shall provide animation capabilities of the vehicular traffic along all arterials and freeways.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 10 - 12 - 0	The DSS shall provide animation capabilities of the transit vehicles (buses and trains) along shared and exclusive ROW facilities.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 11 - 0 - 0	The DSS shall provide short-term prediction of the conditions of the entire intermodal network	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 11 - 1 - 0	The DSS shall predict average link speed and traffic density for the freeway system at 30 second interval for one hour horizon.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 11 - 2 - 0	The DSS shall predict average link speed and traffic density for the HOV system at 30 second interval for one hour horizon.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 11 - 3 - 0	The DSS shall predict average link speed and traffic density for the arterial system at 30 second interval for one hour horizon.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 11 - 4 - 0	The DSS shall predict average queue length on the links of the arterial system at 30 second interval for one hour horizon.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 11 - 5 - 0	The DSS shall predict transit vehicle (train/bus) locations at 30 second interval for one hour horizon.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing

Table 7.3-1 Decision Support Subsystem Requirements (Continued)

Requirement ID	Requirement Description	User Need	Source	Criticality	Verification Method
F - DSS - 11 - 6 - 0	The DSS shall predict number of passengers on board for all transit vehicles at 30 second interval for one hour horizon.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 11 - 7 - 0	The DSS shall predict number of passengers at all bus stops and train stations at 30 second interval for one hour horizon.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 11 - 8 - 0	The DSS shall provide real-time estimation of the occupancy of parking lots at 30 second interval for one hour horizon.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 11 - 9 - 0	Predicting the network future conditions (travel times and traffic density on every link) requires predicting the travel demand between every origin destination pairs for the prediction horizon which is one hour. The DSS shall predict the origin-destination demand matrix for the entire prediction horizon.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 11 - 10 - 0	The DSS shall predict how traffic is distributed along the different routes that connect every origin-destination pair. Equilibrium-based traffic assignment models are widely accepted as a technique for modeling route choice in urban networks. The DSS shall predict the traffic route assignment pattern based on equilibrium network conditions	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 11 - 11 - 0	The DSS shall predict traffic route assignment pattern based on multi-criteria (travel time and toll) route-mode choice behavior.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 11 - 12 - 0	The DSS shall provide the prediction results in real-time. For a prediction horizon of X minutes, the prediction results should be available no later than 0.10X minutes from the start of the prediction module.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 11 - 13 - 0	The DSS shall update the prediction results every 10 minutes.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing

Table 7.3-1 Decision Support Subsystem Requirements (Continued)

Requirement ID	Requirement Description	User Need	Source	Criticality	Verification Method
F - DSS - 11 - 14 - 0	The DSS shall predict measures of performance at the arterial level including average travel time and average stop time.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 11 - 15 - 0	The DSS shall predict measures of performance at the network level including average travel time and average stop time.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 11 - 16 - 0	The DSS shall predict measures of performance for the freeway system including travel time and throughput.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 11 - 17 - 0	The DSS shall provide the prediction of measures of performance for the HOV system including travel time and throughput.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 11 - 18 - 0	The DSS shall predict measures of performance for the transit system including average vehicle speed, load factor, and average passenger waiting time.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 11 - 19 - 0	The DSS shall predict measures of performance for park-and-ride facilities including average occupancy.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 11 - 20 - 0	The DSS shall predict of measures of performance for every origin-destination pair including average travel time and average stop time.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 11 - 21 - 0	The DSS shall predict vehicle emissions including CO, CO2, NO2 and SO2	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 12 - 0 - 0	The DSS shall provide evaluation capabilities of pre-developed integrated real-time traffic management schemes	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 12 - 1 - 0	The DSS shall evaluate the impact of roadway incidents with different levels of severity (for different number of closed lanes and for different duration) at the facility and the corridor levels.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 12 - 2 - 0	The DSS shall evaluate pre-timed intersection control timing plans at the network level at the facility and the corridor levels.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing

Table 7.3-1 Decision Support Subsystem Requirements (Continued)

Requirement ID	Requirement Description	User Need	Source	Criticality	Verification Method
F - DSS - 12 - 3 - 0	The DSS shall evaluate adaptive signal control at the network level at the facility and the corridor levels.	1, 9, 10, 13	Section 5.3, Con Ops	L	Testing
F - DSS - 12 - 4 - 0	The DSS shall evaluate the coordination of traffic signals along arterials at the facility and the corridor levels.	1, 9, 10, 13	Section 5.3, Con Ops	L	Testing
F - DSS - 12 - 5 - 0	The DSS shall evaluate transit vehicle priority schemes at the facility and the corridor levels.	1, 9, 10, 13	Section 5.3, Con Ops	L	Testing
F - DSS - 12 - 6 - 0	The DSS shall evaluate congestion pricing strategies, using up to 15-minute toll interval, for the freeway system at the facility and the corridor levels.	1, 9, 10, 13	Section 5.3, Con Ops	L	Testing
F - DSS - 12 - 7 - 0	The DSS shall evaluate congestion pricing strategies, using up to 15-minute toll interval, for the HOV/managed lanes system at the facility and the corridor levels.	1, 9, 10, 13	Section 5.3, Con Ops	L	Testing
F - DSS - 12 - 8 - 0	The DSS shall evaluate congestion pricing strategies, using up to 15-minute toll interval, for the arterial system at the facility and the corridor levels.	1, 9, 10, 13	Section 5.3, Con Ops	L	Testing
F - DSS - 12 - 9 - 0	The DSS shall evaluate the effect of providing route guidance information to travelers through dynamic message signs at freeways and arterials.	1, 9, 10, 13	Section 5.3, Con Ops	L	Testing
F - DSS - 12 - 10 - 0	The DSS shall evaluate the effect of posting speed advisory information to travelers through dynamic message signs at freeways and arterials.	1, 9, 10, 13	Section 5.3, Con Ops	L	Testing
F - DSS - 12 - 11 - 0	The DSS shall evaluate the effect of posting information on incident(s) location and severity on dynamic message signs at freeways and arterials.	1, 9, 10, 13	Section 5.3, Con Ops	L	Testing
F - DSS - 12 - 12 - 0	The DSS shall evaluate the effect of posting park-and-ride information on dynamic message signs at freeways and arterials.	1, 9, 10, 13	Section 5.3, Con Ops	L	Testing
F - DSS - 12 - 13 - 0	The DSS shall evaluate the effect of providing travelers with pre-trip information on efficient intermodal routes.	1, 9, 10, 13	Section 5.3, Con Ops	L	Testing

Table 7.3-1 Decision Support Subsystem Requirements (Continued)

Requirement ID	Requirement Description	User Need	Source	Criticality	Verification Method
F - DSS - 12 - 14 - 0	The DSS shall evaluate the effect of providing travelers with pre-trip information on incident(s) location and severity.	1, 9, 10, 13	Section 5.3, Con Ops	L	Testing
F - DSS - 12 - 15 - 0	The DSS shall evaluate the effect of providing travelers with pre-trip information on travel time.	1, 9, 10, 13	Section 5.3, Con Ops	L	Testing
F - DSS - 12 - 16 - 0	The DSS shall evaluate the effect of providing travelers with pre-trip information on park-and-ride locations.	1, 9, 10, 13	Section 5.3, Con Ops	L	Testing
F - DSS - 12 - 17 - 0	The DSS shall evaluate the effect of providing travelers with en-route information on efficient intermodal routes.	1, 9, 10, 13	Section 5.3, Con Ops	L	Testing
F - DSS - 12 - 18 - 0	The DSS shall evaluate the effect of providing travelers with en-route information on incident(s) location and severity.	1, 9, 10, 13	Section 5.3, Con Ops	L	Testing
F - DSS - 12 - 19 - 0	The DSS shall evaluate the effect of providing travelers with en-route information on travel time.	1, 9, 10, 13	Section 5.3, Con Ops	L	Testing
F - DSS - 12 - 20 - 0	The DSS shall evaluate the effect of providing travelers with en-route information on park-and-ride locations.	1, 9, 10, 13	Section 5.3, Con Ops	L	Testing
F - DSS - 12 - 21 - 0	The DSS shall evaluate bus/train deadheading strategies.	1, 9, 10, 13	Section 5.3, Con Ops	L	Testing
F - DSS - 12 - 22 - 0	The DSS shall evaluate bus/train stop skipping strategies.	1, 9, 10, 13	Section 5.3, Con Ops	L	Testing
F - DSS - 12 - 23 - 0	The DSS shall evaluate real-time bus detour.	1, 9, 10, 13	Section 5.3, Con Ops	L	Testing
F - DSS - 12 - 24 - 0	The DSS shall evaluate bus/train service headways change.	1, 9, 10, 13	Section 5.3, Con Ops	L	Testing
F - DSS - 12 - 25 - 0	The DSS shall evaluate transit charter express services.	1, 9, 10, 13	Section 5.3, Con Ops	L	Testing
F - DSS - 12 - 26 - 0	The DSS shall provide the capability to simultaneously run and compare several (at least three) operation scenarios.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 13 - 0 - 0	The DSS shall provide the capabilities to develop optimal traffic management scheme in real-time	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing

Table 7.3-1 Decision Support Subsystem Requirements (Continued)

Requirement ID	Requirement Description	User Need	Source	Criticality	Verification Method
F - DSS - 13 - 1 - 0	The DSS shall provide the capability to develop efficient incident management scheme.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 13 - 2 - 0	The DSS shall provide the capability to develop optimal arterial-based signal timing scheme.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 13 - 3 - 0	The DSS shall provide the capability to develop optimal area-wide signal timing scheme.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 13 - 4 - 0	The DSS shall provide the capability to develop optimal congestion pricing strategies.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 13 - 5 - 0	The DSS shall provide the capability to develop travelers' pre-trip information provision strategies on all travel modes including route structure, travel time, tolls, parking location, etc.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 13 - 6 - 0	The DSS shall provide the capability to develop travelers' en-route information provision strategies on all travel modes including route structure, travel time, tolls, parking location, etc.	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 14 - 0 - 0	The DSS shall be compliant with the Regional Center to Center ICD	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 15 - 0 - 0	The DSS shall provide a user interface for the agencies	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 15 - 1 - 0	The DSS shall provide an API to integrate with existing agency systems	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 15 - 2 - 0	The DSS shall provide a web based interface for agencies not connected to the regional network	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 16 - 0 - 0	The DSS shall provide a security subsystem	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 16 - 1 - 0	The DSS shall provide a security subsystem to manage user authentication	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 16 - 2 - 0	The DSS shall provide a security subsystem to manage user authorization	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 17 - 0 - 0	The DSS shall provide a report generation function	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing

Table 7.3-1 Decision Support Subsystem Requirements (Continued)

Requirement ID	Requirement Description	User Need	Source	Criticality	Verification Method
F - DSS - 18 - 0 - 0	The DSS shall provide an alarm subsystem	1, 9, 10, 13	Section 5.3, Con Ops	M	Testing
F - DSS - 19 - 0 - 0	The DSS shall provide a response plan database to store pre-approved response plans	1, 9, 10, 13	Section 5.3, Con Ops	H	Testing
F - DSS - 21 - 0 - 0	The DSS shall select a recommended pre-approved response plan based on current network conditions	1, 9, 10, 13	Section 5.3, Con Ops	H	Testing
F - DSS - 21 - 1 - 0	The DSS shall include a search function for selecting pre-approved response plans	1, 9, 10, 13	Section 5.3, Con Ops	H	Testing
F - DSS - 21 - 2 - 0	The DSS shall present recommended pre-approved response plans based on current network conditions	1, 9, 10, 13	Section 5.3, Con Ops	H	Testing
F - DSS - 21 - 2 - 1	The DSS shall provide controls for Operator to receive a response plan request	1, 9, 10, 13	Section 5.3, Con Ops	H	Testing
F - DSS - 21 - 2 - 2	The DSS shall provide controls for an Operator to accept a response plan request	1, 9, 10, 13	Section 5.3, Con Ops	H	Testing
F - DSS - 21 - 2 - 3	The DSS shall provide controls for an Operator to reject a response plan request	1, 9, 10, 13	Section 5.3, Con Ops	H	Testing
F - DSS - 21 - 2 - 4	The DSS shall provide controls for an Operator to modify a response plan request	1, 9, 10, 13	Section 5.3, Con Ops	H	Testing
F - DSS - 21 - 2 - 5	The DSS shall provide controls for an Operator to cancel a response plan	1, 9, 10, 13	Section 5.3, Con Ops	H	Testing
F - DSS - 21 - 2 - 6	The DSS shall provide controls for an Operator to request an alternate response plan	1, 9, 10, 13	Section 5.3, Con Ops	H	Testing
F - DSS - 21 - 2 - 7	The DSS shall provide controls for an Operator to distribute the approved response plan	1, 9, 10, 13	Section 5.3, Con Ops	H	Testing

Table 7.3-2 Evaluation Model Subsystem Requirements

Requirement ID	Requirement Description	User Need	Source	Criticality	Verification
C - MOD - 1 - 0 - 0	The ICM Model shall utilize existing data from the regional data warehouse	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
D - MOD - 1 - 0 - 0	The ICM Model shall receive the coordinates of intersections in the corridor.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
D - MOD - 2 - 0 - 0	The ICM Model shall receive a list of links in the network.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
D - MOD - 3 - 0 - 0	The ICM Model shall receive information on each link including: a. facility type b. number of lanes c. capacity per lane d. speed limit e. average jam density.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
D - MOD - 4 - 0 - 0	The ICM Model shall receive toll data for toll roads in the network.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
D - MOD - 5 - 0 - 0	The ICM Model shall receive information on the control type and associated timing plan at each intersection.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
D - MOD - 6 - 0 - 0	The ICM Model shall receive information on active detectors in the network.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
D - MOD - 7 - 0 - 0	The ICM Model shall receive location of active dynamic message signs in the network.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
D - MOD - 8 - 0 - 0	The ICM Model shall receive information on allowed/prohibited turning movements at each intersection.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
D - MOD - 9 - 0 - 0	The ICM Model shall receive information on route structure of all bus and train lines in the network.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing

Table 7.3-2 Evaluation Model Subsystem Requirements (Continued)

Requirement ID	Requirement Description	User Need	Source	Criticality	Verification
D - MOD - 10 - 0 - 0	The ICM Model shall receive time table for bus and train lines in the network.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
D - MOD - 11 - 0 - 0	The ICM Model shall receive fare structure data for bus and train lines in the network.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
D - MOD - 12 - 0 - 0	The ICM Model shall receive the location of bus stops in the network.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
D - MOD - 13 - 0 - 0	The ICM Model shall receive the location of train stations.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
D - MOD - 14 - 0 - 0	The ICM Model shall receive the location of park-and-ride facilities in the network	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
D - MOD - 15 - 0 - 0	park-and-ride facilities in the network	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
F - MOD - 1 - 0 - 0	The ICM Model shall develop a incident response plan	9, 12	Section 4.10, 4.11, 5.1 Con Ops	H	Testing
F - MOD - 2 - 0 - 0	The ICM Model shall calculate measures of performance for all travel modes and facilities.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	H	Testing
F - MOD - 2 - 1 - 0	The ICM Model shall calculate travel time index	9, 12	Section 4.10, 4.11, 5.1 Con Ops	H	Testing
F - MOD - 2 - 2 - 0	The ICM Model shall calculate average travel time	9, 12	Section 4.10, 4.11, 5.1 Con Ops	H	Testing
F - MOD - 2 - 3 - 0	The ICM Model shall calculate the average corridor throughput	9, 12	Section 4.10, 4.11, 5.1 Con Ops	H	Testing
F - MOD - 2 - 4 - 0	The ICM Model shall calculate the average response time to an incident by jurisdiction	9, 12	Section 4.10, 4.11, 5.1 Con Ops	H	Testing

Table 7.3-2 Evaluation Model Subsystem Requirements (Continued)

Requirement ID	Requirement Description	User Need	Source	Criticality	Verification
F - MOD - 2 - 5 - 0	The ICM Model shall calculate the parking lot volumes at transit locations	9, 12	Section 4.10, 4.11, 5.1 Con Ops	H	Testing
F - MOD - 2 - 6 - 0	The ICM Model shall calculate the ridership per transit vehicle	9, 12	Section 4.10, 4.11, 5.1 Con Ops	H	Testing
F - MOD - 2 - 7 - 0	The ICM Model shall calculate the queue wait time at intersections	9, 12	Section 4.10, 4.11, 5.1 Con Ops	H	Testing
F - MOD - 3 - 0 - 0	The ICM Model shall calculate environment-oriented measures of performance.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	H	Testing
F - MOD - 3 - 1 - 0	The ICM Model shall estimate vehicle emissions including: a. CO b. CO2 c. NO2 d. SO2	9, 12	Section 4.10, 4.11, 5.1 Con Ops	H	Testing
F - MOD - 5 - 0 - 0	The ICM Model shall evaluate pre-approved incident response plans	9, 12	Section 4.10, 4.11, 5.1 Con Ops	H	Testing
F - MOD - 5 - 1 - 0	The ICM Model shall evaluate the impact of roadway incidents	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
F - MOD - 5 - 2 - 0	The ICM Model shall evaluate pre-timed intersection control timing plans	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
F - MOD - 5 - 3 - 0	The ICM Model shall evaluate adaptive signal control at the network level at the facility and the corridor levels.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
F - MOD - 5 - 4 - 0	The ICM Model shall evaluate the coordination of traffic signals along arterials at the facility and the corridor levels.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing

Table 7.3-2 Evaluation Model Subsystem Requirements (Continued)

Requirement ID	Requirement Description	User Need	Source	Criticality	Verification
F - MOD - 5 - 5 - 0	The ICM Model shall evaluate transit vehicle priority schemes at the facility and the corridor levels.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
F - MOD - 5 - 6 - 0	The ICM Model shall evaluate congestion pricing strategies, using up to 15-minute toll interval, for the freeway system at the facility and the corridor levels.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
F - MOD - 5 - 7 - 0	The ICM Model shall evaluate congestion pricing strategies, using up to 15-minute toll interval, for the HOV/managed lanes system at the facility and the corridor levels.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
F - MOD - 5 - 8 - 0	The ICM Model shall evaluate congestion pricing strategies, using up to 15-minute toll interval, for the arterial system at the facility and the corridor levels.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
F - MOD - 5 - 9 - 0	The ICM Model shall evaluate the effect of providing route guidance information to travelers through dynamic message signs at freeways and arterials.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
F - MOD - 5 - 10 - 0	The ICM Model shall evaluate the effect of posting speed advisory information to travelers through dynamic message signs at freeways and arterials.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
F - MOD - 5 - 11 - 0	The ICM Model shall evaluate the effect of posting information on incident(s) location and severity on dynamic message signs at freeways and arterials.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
F - MOD - 5 - 12 - 0	The ICM Model shall evaluate the effect of posting park-and-ride information on dynamic message signs at freeways and arterials.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
F - MOD - 5 - 13 - 0	The ICM Model shall evaluate the effect of providing travelers with pre-trip information on efficient intermodal routes.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
F - MOD - 5 - 14 - 0	The ICM Model shall evaluate the effect of providing travelers with pre-trip information on incident(s) location and severity.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing

Table 7.3-2 Evaluation Model Subsystem Requirements (Continued)

Requirement ID	Requirement Description	User Need	Source	Criticality	Verification
F - MOD - 5 - 15 - 0	The ICM Model shall evaluate the effect of providing travelers with pre-trip information on travel time.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
F - MOD - 5 - 16 - 0	The ICM Model shall evaluate the effect of providing travelers with pre-trip information on park-and-ride locations.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
F - MOD - 5 - 17 - 0	The ICM Model shall evaluate the effect of providing travelers with en-route information on efficient intermodal routes.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
F - MOD - 5 - 18 - 0	The ICM Model shall evaluate the effect of providing travelers with en-route information on incident(s) location and severity.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
F - MOD - 5 - 19 - 0	The ICM Model shall evaluate the effect of providing travelers with en-route information on travel time.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
F - MOD - 5 - 20 - 0	The ICM Model shall evaluate the effect of providing travelers with en-route information on park-and-ride locations.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
F - MOD - 5 - 21 - 0	The ICM Model shall evaluate bus/train deadheading strategies.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
F - MOD - 5 - 22 - 0	The ICM Model shall evaluate bus/train stop skipping strategies.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
F - MOD - 5 - 23 - 0	The ICM Model shall evaluate bus detours	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing
F - MOD - 5 - 24 - 0	The ICM Model shall evaluate bus/train service headways change.	9, 12	Section 4.10, 4.11, 5.1 Con Ops	M	Testing

Table 7.3-3 Web Subsystem Requirements

Requirement ID	Requirement Description	User Needs	Source	Criticality	Verification Method
	SECURITY				
S - WEB - 1 - 0 - 0	The Web subsystem shall allow users, with appropriate authorization the following capabilities for the ICMS data: a. Create b. Update c. Close d. Receive e. Distribute	7	Section 4 Con Ops	M	Testing
S - WEB - 1 - 1 - 0	The Web subsystem shall provide the capability to refresh all views automatically based on an associated time interval.	7	Section 4 Con Ops	M	Testing
S - WEB - 1 - 2 - 0	The Web subsystem shall require a login username and password	7	Section 4 Con Ops	M	Testing
S - WEB - 1 - 3 - 0	The Web subsystem shall have multiple levels of users to include: a. Agency User b. ICM Coordinator c. Administrator e. 3rd Party Partner f. Regional ATIS	7	Section 4 Con Ops	M	Testing
S - WEB - 1 - 4 - 0	Login information and privileges will be stored in a centralized access control database	7	Section 4 Con Ops	M	Testing
S - WEB - 1 - 5 - 0	The Web subsystem shall restrict a user account to 1 login instance.	7	Section 4 Con Ops	M	Testing
S - WEB - 2 - 0 - 0	The ICM Coordinator shall be able to verify any event, and shall be able to override any event	7	Section 4 Con Ops	M	Testing
S - WEB - 3 - 0 - 0	An Agency User shall have the capability to enter an active construction event	7	Section 4 Con Ops	M	Testing
S - WEB - 4 - 0 - 0	An Agency User shall have the capability to enter an active special event	7	Section 4 Con Ops	M	Testing
S - WEB - 5 - 0 - 0	An Agency User shall be able to reopen a previously closed organization owned event.	7	Section 4 Con Ops	M	Testing

Table 7.3-3 Web Subsystem Requirements (Continued)

Requirement ID	Requirement Description	User Needs	Source	Criticality	Verification Method
S - WEB - 6 - 0 - 0	The Web subsystem shall allow all users with read-only privileges to view events	7	Section 4 Con Ops	M	Testing
	FUNCTIONALITY				
F - WEB - 1 - 0 - 0	The Web subsystem shall include a web interface to the ICM System	1, 2, 3, 4, 5, 6, 8, 13, 14	Section 4 Con Ops	M	Testing
F - WEB - 2 - 0 - 0	The Web subsystem shall allow users to view data on a GIS based map to include: a. incident data b. construction data c. special events data d. link data e. DMS data f. HAR data g. highway point data h. transit point data i. CCTV data j. transit stop data k. parking data l. traffic signal data	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing
F - WEB - 3 - 0 - 0	The Web Subsystem shall allow users to view pre-approved response plans	9, 13			Testing
F - WEB - 4 - 0 - 0	The Web Subsystems subsystem shall utilize the Regional GIS based map	1, 2, 3, 4, 5, 6, 7, 8, 13, 14			Testing
F - WEB - 5 - 0 - 0	The Web subsystem shall provide an event tracking interface	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing

Table 7.3-3 Web Subsystem Requirements (Continued)

Requirement ID	Requirement Description	User Needs	Source	Criticality	Verification Method
F - WEB - 6 - 0 - 0	The Web subsystem shall include separate event tracking interface module for: a. Incidents b. Construction c. Special Events d. Alarms/ Help	1, 2, 3, 4, 5, 6, 7, 8, 13, 14			Testing
	Event Tracking				
F - WEB - 7 - 0 - 0	The Event Tracking interface shall have a separate highway and transit view for each of the incident, construction, and special event tracking views	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing
F - WEB - 8 - 0 - 0	The Event Tracking interface shall allow Agency Users to create new events.	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing
F - WEB - 9 - 0 - 0	The Event Tracking interface shall allow Agency Users to update existing events created by that reporting organization	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing
F - WEB - 10 - 0 - 0	The Event Tracking interface shall allow Agency Users to close existing events which were created by that reporting organization	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing
F - WEB - 11 - 0 - 0	The Event Tracking interface shall allow the ICM Coordinator user to update and close events that were created by other organizations.	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing
F - WEB - 12 - 0 - 0	The Event Tracking interface shall allow a user to select values from pick lists to populate fields in the event tracking screen.	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing
F - WEB - 13 - 0 - 0	The Event Tracking interface shall automatically build the event description as values are selected or entered during Create and Update event entry	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing
F - WEB - 14 - 0 - 0	The Event Tracking interface shall allow a user with edit privileges to edit the event description directly.	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing

Table 7.3-3 Web Subsystem Requirements (Continued)

Requirement ID	Requirement Description	User Needs	Source	Criticality	Verification Method
F - WEB - 15 - 0 - 0	The Event Tracking interface shall provide a default organization based on the user's profile.	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing
	Incident Module				
F - WEB - 16 - 0 - 0	The Incident Tracking view shall allow Agency users to: a. update incident information b. view incident information c. close incidents	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing
F - WEB - 17 - 0 - 0	The Incident Tracking view shall have the capability to sort the incidents based on: a. date/time b. Organization c. incident type d. facility	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing
	Construction Module				
F - WEB - 18 - 0 - 0	The Construction Tracking view shall allow entry of construction event schedule information	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing
F - WEB - 19 - 0 - 0	The Construction Tracking view shall allow Agency users to: a. create construction information b. update construction information c. view construction information	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing
F - WEB - 20 - 0 - 0	The Construction Tracking view shall allow Agency users to delete construction information	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing
F - WEB - 21 - 0 - 0	Active Construction events shall appear as an incident in the Incident Tracking view.	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing

Table 7.3-3 Web Subsystem Requirements (Continued)

Requirement ID	Requirement Description	User Needs	Source	Criticality	Verification Method
F - WEB - 22 - 0 - 0	A planned construction schedule shall generate an active alarm, when the scheduled start is about to occur	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing
	Special Events Module				
F - WEB - 23 - 0 - 0	The Special Event Tracking interface shall allow entry of special event information	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing
F - WEB - 24 - 0 - 0	The Special Event Tracking interface shall allow Agency users to: a. Create special event information b. Update special event information c. View special event information	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing
F - WEB - 25 - 0 - 0	The Special Event Tracking interface shall allow Agency users to delete special event information	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing
F - WEB - 26 - 0 - 0	Active Special Events shall appear as an incident in the Incident Tracking view.	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing
F - WEB - 27 - 0 - 0	A planned special event schedule shall be generate an active alarm, when the scheduled start is about to occur	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing
	Network Data				
F - WEB - 28 - 0 - 0	The Web subsystem shall allow ICM Coordinator to view network data	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing
F - WEB - 29 - 0 - 0	The Web subsystem shall allow Agency User to view network data	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing
F - WEB - 30 - 0 - 0	The Web subsystem shall allow ICM Coordinator to update static network data	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing

Table 7.3-3 Web Subsystem Requirements (Continued)

Requirement ID	Requirement Description	User Needs	Source	Criticality	Verification Method
F - WEB - 31 - 0 - 0	The Web subsystem shall allow Agency User to update static network data for their network	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing
F - WEB - 32 - 0 - 0	The Web subsystem shall allow ICM Coordinator to add network data for new infrastructure	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing
	Help/ Alarms				
F - WEB - 33 - 0 - 0	The Web subsystem shall include an alarm subsystem	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing
F - WEB - 34 - 0 - 0	The Web subsystem shall maintain a log storing system errors and a log storing user requests	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing
F - WEB - 35 - 0 - 0	The Web subsystem shall provide a help screen	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing
F - WEB - 36 - 0 - 0	The Alarm view shall display alarms for new, update, and closed events.	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing
F - WEB - 37 - 0 - 0	The Alarm view shall provide a alarm filter for searching	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing
F - WEB - 38 - 0 - 0	The Alarm view shall provide filtering based on type (highway/ Transit), Facility, time of day, direction, and duration	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing
F - WEB - 39 - 0 - 0	The Alarm view filter shall be available to all users.	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing
F - WEB - 40 - 0 - 0	The Alarm view filter criteria shall only be editable by the Administrator	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing

Table 7.3-3 Web Subsystem Requirements (Continued)

Requirement ID	Requirement Description	User Needs	Source	Criticality	Verification Method
F - WEB - 41 - 0 - 0	The Alarm view shall received alarms for pending events, incidents, and planned events.	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing
F - WEB - 42 - 0 - 0	Alarms shall be removed from the Alarm View when a user acknowledges or confirms the notification.	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing
F - WEB - 43 - 0 - 0	Alarms shall be removed for an organization from the Alarm View when an Agency user acknowledges or confirms the notification.	1, 2, 3, 4, 5, 6, 7, 8, 13, 14	Section 4 Con Ops	M	Testing

Table 7.3-4 ICM Database Requirements

Requirement ID	Requirement Description	User Need	Source	Criticality	Allocation
F - DBA - 1 - 0 - 0	The Database shall store data received from the ICMS subsystems	8		H	Testing
F - DBA - 2 - 0 - 0	The Database shall store data received from the corridor systems	8		H	Testing
F - DBA - 4 - 0 - 0	The Database shall store: a. Historical information needed for the modeling and decision support subsystems b. Current day activities within the corridor c. Pre-approved response plans d. Contact Lists	8		H	Testing

8. Glossary

This section defines the terms and definitions used in the requirements document.

Real-time – receipt or calculation of conditions within 2 minutes of occurrence

Near real-time - receipt or calculation of conditions more than 2 minutes of occurrence, but within 30 minutes of occurrence

Status – condition of infrastructure

Active - not marked as out-of-order or in-maintenance

Link - the portion of a model connecting two nodes. The link is defined within the model as:

- facility type
- number of lanes
- capacity per lane
- speed limit
- average jam density

Node – point of branching of physical connections, or terminating a physical connection within a simulation model

Average Jam Density - the maximum number of vehicles per unit length of the highway link

Intermodal network conditions – current status and state of modes of travel within the network

Consistency – the system's estimation error will fall within a pre-determined range

Real-world conditions – model capabilities to match conditions of actual network

- The system's estimation error of the traffic speed, density and volume on every highway link in the network should not exceed 15% (plus or minus).
- The system's estimation error of the location of every transit vehicle in the network should not exceed 10% (plus or minus).
- The system's estimation error of the occupancy of every park-and-ride facility in the network should not exceed 20% (plus or minus).

Corridor management strategy – management plan for an event or incident within the corridor. These strategies include:

- pre-trip and en-route traveler information provision
- congestion pricing
- signal timing modification
- transit service modification
- transit signal priority
- parking management and pricing
- combinations of the above

Traffic Management Scheme – A traffic management scheme consists of the different actions that will be implemented by all agencies to manage the corridor. These actions are:

- List of Dynamic Message Signs (DMS) to be activated along with their messages
- Transit vehicle service pattern including any route and headway modifications
- Timing plan of all signalized intersections

Environment-oriented – factor relating to the environment of the system

Decision Support Subsystem – a server or set of servers within the ICMS utilized for current and predictive modeling of the corridor in order to develop response plans to current and predictive incidents.

Evaluation Model Subsystem – a server or set of servers within the ICMS utilized to calculate the performance measures of the corridor and evaluate the response plans developed for use within the corridor

Web Subsystem – a server or set of servers within the ICMS which provide a web accessible view into the ICMS data. The system will allow authorized users to view, edit, create, query, and develop reports from the ICMS database.

Decision Support Interface – The web view of the ICMS data provided to the Agency users.

Database Subsystem – a server or set of servers within the ICMS which receive, store, and sends data from external systems and internally within the ICMS.