Traffic Incident Management (TIM) Data Collection

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Executive Summary

Background

The California Department of Transportation (Caltrans) is investigating the tools and data needed to report on the three national traffic incident management (TIM) performance measures recommended by the Federal Highway Administration (FHWA) under the fourth round of Every Day Counts (EDC-4) initiative:

- Roadway clearance time.
- Incident clearance time.
- Number of secondary crashes.

Currently Caltrans accesses this data from multiple systems, including the Major Incident Database and the California Highway Patrol (CHP) computer-aided dispatch (CAD). A central, standardized system would allow Caltrans to gather all TIM data and report on performance statewide. As part of its efforts to establish a standardized system, Caltrans is interested in evaluating the data systems and data collection practices used by other state departments of transportation (DOTs).

To assist Caltrans in this evaluation, CTC & Associates conducted an online survey of state DOTs that examined these agencies' available data systems and data collection practices associated with the EDC-4 performance measures. Consultations with a representative from the University of Maryland Center for Advanced Transportation Technology (CATT) Laboratory were also conducted to learn about the sources of the data residing in the CATT Lab's Regional Integrated Transportation Information System (RITIS) and other details about this platform's capabilities and potential applications. A literature search identified recent research and other resources about TIM data systems and practices.

Summary of Findings

Survey of Practice

An online survey was distributed to members of the American Association of State Highway and Transportation Officials (AASHTO) Committee on Transportation System Operations who had experience with TIM data systems and practices. Representatives from 21 state DOTs and one state highway patrol responded to the survey. Sixteen state agencies have a system, process or database that collects TIM data to report on one or more of the three national performance measures.

Roadway Clearance Time

Fourteen state agencies responding to the survey gather data to measure roadway clearance time. Six of these states (Georgia, Maine, Nebraska, North Carolina, Oregon and Wisconsin) gather data for the duration of the incident, typically beginning with the notification of the incident until the roadway is clear and open to traffic. Other states gather data based on the type of incident (Georgia, Kansas and Minnesota); lane closure time (Maryland); or type of roadway (Kansas). Georgia DOT also relies on incident reports from two freeway service patrol (FSP) programs in metropolitan Atlanta: Towing and Recovery Incentive Program (TRIP) and

Highway Emergency Response Operations (HERO). Nevada DOT intends to collect roadway clearance time on all crashes statewide that are reported to law enforcement. In urban areas, the agency strives to collect roadway clearance times for all incidents on state routes within the reach of the traffic management center (TMC). Table ES1 summarizes survey results.

Table ES1. Roadway Clearance Data Gathered

State	Incident Notification to Road Open	Lane Closure Time	Type of Incident/ Event	Type of Roadway	All Lanes Cleared	Other
Arizona					X	
Georgia	X		X			X
Kansas			X	X		
Maine	X					
Maryland		X				
Minnesota			X			
Nebraska	X					
Nevada						X
North Carolina	X					
Oregon	X					
Utah						X
Wisconsin	X					
TOTAL	6	1	3	1	1	3

TMCs and traffic operations centers (TOCs) play a role in providing TIM data to all the states collecting data. Law enforcement is a key source of TIM data in Maryland, Nebraska, Nevada, North Carolina, Oregon, Utah and Wisconsin. Table ES2 summarizes survey results.

Table ES2. Roadway Clearance Time Data Sources

Data Source	State
TMC/TOC	Arizona, Georgia, Kansas, Maine, Maryland, Michigan, Minnesota, Nebraska, Nevada, North Carolina, Oregon, Utah, Wisconsin
Law Enforcement	Maryland, Nebraska, Nevada, North Carolina, Oregon, Utah, Wisconsin
Service Patrol	Maryland, Michigan, Minnesota, Nevada, North Carolina, Oregon
911 Dispatch Centers	Michigan, Nebraska, Oregon
CCTV	Michigan, Minnesota, Wisconsin
First Responders	Maryland, Michigan, Utah
CAD	Michigan[1], Wisconsin
Crowdsourcing	Maryland, Nevada

Data Source	State
DOT/Highway Field Staff	Wisconsin
Maintenance Facilities	Maryland
Other	Arizona, Minnesota, Nevada, Utah, Wisconsin

1 SEMTOC has access to Michigan State Police CAD system for incident notification but not CAD integration.

When receiving data from these sources, five states (Georgia, Kansas, Maine, Maryland and Michigan) primarily rely on an advanced transportation management system (ATMS). Other frequently used formats are CAD (Minnesota, Oregon and Utah) and reports (Kansas, Nebraska and Nevada). Table ES3 summarizes survey results.

Table ES3. Roadway Clearance Time Data Formats

Data Format	State
ATMS	Georgia, Kansas, Maine, Maryland, Michigan,
CAD	Minnesota, Oregon, Utah
Reports	Kansas, Nebraska, Nevada
Audio/Voice Communications	Oregon, Utah
Radio	Minnesota, Nebraska
Excel Spreadsheet	Michigan
Software	Utah
Other	Michigan, Nevada, North Carolina, Wisconsin

These states reported on several challenges with roadway clearance time data collection, including delays in receiving notification of an event (Michigan, Nebraska and Oregon); data collection in rural areas (Maryland and Michigan); data verification (Maine, North Carolina and Utah); and human error (Georgia and Nevada).

Incident Clearance Time

Eleven states gather data to measure incident clearance time. In five states (Arizona, Georgia, Maine, Maryland and Oregon) data collection typically begins with incident notification and ends with roadway clearance. In Michigan, incident clearance time data collection is limited to freeway and major arterials in 13 western counties. In Minnesota, data is collected during specific travel times for all incidents along the Minneapolis/St. Paul metropolitan freeway system that are observed on camera or reported by FSP or the State Patrol through 911 dispatch calls. Utah DOT relies on the observations of its TOC control room operators. Table ES4 summarizes survey results.

Table ES4. Incident Clearance Data Gathered

State	Incident Notification to Road Open	Type of Incident/ Event	Other
Arizona	X		
Georgia	X		
Kansas		X	
Maine	X		
Maryland	X		
Michigan			X
Minnesota			X
Nevada			X
Oregon	X		
Utah			X
TOTAL	**5**	**1**	**4**

TMCs and TOCs are a significant source of TIM data in all states collecting data. Other data sources include law enforcement (Maryland, Minnesota, Nebraska, Nevada, Oregon and Utah) and FSPs (Maryland, Michigan, Minnesota, Nevada and Oregon). Table ES5 summarizes survey results.

Table ES5. Incident Clearance Time Data Sources

Data Source	State
TMC/TOC	Arizona, Kansas[1], Maine, Maryland, Michigan, Minnesota, Nebraska, Nevada, Oregon, Utah
Law Enforcement	Maryland, Minnesota, Nebraska, Nevada, Oregon, Utah
Service Patrol	Maryland, Michigan, Minnesota, Nevada, Oregon
CCTV	Maryland, Michigan[2], Minnesota
First Responders	Maryland, Michigan[2], Utah
ATMS	Georgia, Michigan
CAD	Michigan[3], Minnesota
Crowdsourcing	Maryland, Nevada
911 Dispatch Centers	Nebraska
DOT/Highway Field Staff	Minnesota
Maintenance Facilities	Maryland
Other	Arizona, Georgia, Oregon, Utah

1 TMCs in Wichita and Kansas City only.
2 WMTOC obtains data from CCTV, dispatch centers and first responders.
3 SEMTOC has access to Michigan State Police CAD system for incident notification but not CAD integration.

ATMS is the data format most frequently used in three states (Kansas, Maryland and Michigan); other formats include CAD (Minnesota, Oregon and Utah), audio or voice communications (Oregon and Utah) and reports and Excel spreadsheets (Georgia, Kansas, Michigan and Nevada). Table ES6 summarizes survey results.

Table ES6. Incident Clearance Time Data Formats

Data Format	State
ATMS	Kansas, Maryland, Michigan
CAD	Minnesota, Oregon, Utah
Audio/Voice Communications	Oregon, Utah
Excel Spreadsheet	Georgia, Michigan
Reports	Kansas, Nevada
Crowdsourcing	Nevada
Radio	Minnesota
Software	Utah
Other	Nevada

The challenges in collecting incident clearance time data were similar to those for collecting roadway clearance data: delays in receiving notification of an incident (Michigan and Oregon); data collection in rural areas (Maryland and Michigan); data verification (Utah); and human error (Georgia and Nevada).

Number of Secondary Crashes

The number of secondary crashes is monitored in 10 states collecting data. Four states (Idaho, Maine, Maryland and Wyoming) investigate associated events—those events that were caused by the first incident. All events in Maryland that are determined to be related to the main incident, including secondary crashes, are recorded. Law enforcement agencies in Maryland and Nevada indicate that a collision is a secondary crash by selecting a check box in a crash report. Table ES7 summarizes survey results.

Table ES7. Secondary Crash Data Gathered

State	Associated Incidents	Crash Type	Totals Only	Reporting Practice	Other
Arizona					X
Idaho	X				
Kansas			X		
Maine	X				
Maryland	X				
Michigan					X
Minnesota					X
Nevada				X	

State	Associated Incidents	Crash Type	Totals Only	Reporting Practice	Other
North Carolina		X		X	
Wyoming	X				
TOTAL	**4**	**1**	**1**	**2**	**3**

Law enforcement accident records and police reports are the primary sources of the number of secondary crashes in six states (Arizona, Idaho, Maine, Maryland, Nevada and Wyoming). Other common sources include TMCs and TOCs (Kansas, Maryland and Michigan); closed-circuit television (CCTV) (Michigan and Minnesota); first responders (Michigan); and CAD (Minnesota). Table ES8 summarizes survey results.

Table ES8. Secondary Crash Data Sources

Data Source	State
Law Enforcement	Arizona, Idaho, Maine, Maryland, Nevada, Wyoming
TMC/TOC	Kansas[1], Maryland, Michigan
CCTV	Michigan, Minnesota
CAD	Minnesota
First Responders	Michigan
Other	Maryland, Minnesota, North Carolina

1 TMCs in Wichita and Kansas City only.

The data format most frequently used in five states (Idaho, Kansas, Maryland, Michigan and Wyoming) is electronic reports, often in conjunction with an ATMS. Table ES9 summarizes survey results.

Table ES9. Secondary Crash Data Formats

Data Format	State
Reports	Idaho, Kansas, Maryland, Michigan, Wyoming
Databases	Idaho, Maine, Maryland, Michigan
ATMS	Kansas, Maryland, Michigan
Other	Minnesota, Nevada

The primary challenge in collecting the number of secondary crashes was determining whether the incident was a secondary crash (Idaho, Maryland, Michigan and North Carolina). Other challenges include accurate reporting on police reports and forms (Maryland, Michigan, Nevada and Wyoming); delays in receiving notification of an incident (Michigan); and lack of information about the original crash (Wyoming).

Consultation With the Center for Advanced Transportation Technology Laboratory

We spoke with Michael Pack, director of the CATT Lab at the University of Maryland, to learn about the California data residing in RITIS and to learn about the platform's capabilities and potential applications. Researchers at the CATT Lab gather a range of data, including the incident data from the CHP CAD system; crowdsourced event data; speed and sensor data from Caltrans, INRIX (a private company providing location-based data and analytics) and FHWA's National Performance Management Research Data Set; National Weather Service (NWS) real-time radar and radar predictions; and first responders. The data is displayed in real time within RITIS and archived indefinitely. Data visualizations and analytics tools enable researchers to compute TIM performance measures.

Currently data is obtained electronically from multiple sources and data feeds established when the CATT Lab was under contract with FHWA to evaluate Integrated Corridor Management deployment in San Diego. These sources include CHP and 911 dispatch calls, DOT operations staff, field units and third parties such as INRIX and NWS. Some of the data sources are easily validated (for example, probe, speed sensor and weather data). However, incident and event data are much more difficult to validate. To determine the credibility of these types of data, researchers use several factors, including timeliness indicators, number and location of incidents, and data agreement from multiple sources.

Related Research and Resources

An in-depth literature search of domestic and international resources was conducted to gather information about TIM data systems and practices. Below are highlights of publications and other resources that were identified in this literature search. Complete details and additional citations are available in the **Detailed Findings** section of this report.

National Resources

Several FHWA publications address TIM performance measures, including a 2019 report that summarizes current state activities related to TIM data use; a 2019 online tool that provides TIM reference materials to transportation and public safety professionals; and a 2016 report on the state of the practice in data access, sharing and integration (RITIS and other data environments are summarized in Chapter 3 of this report). A 2018 webinar features representatives from three agencies that actively collect, analyze and use TIM data.

Other citations address data collection and reporting practices, including guidance and agency case studies for implementing TIM performance measurement, and presentations about using data to improve TIM data collection.

State Practices

A Kentucky DOT research study in progress is updating methodologies for TIM performance measures and developing a dashboard to track the performance and evaluate the effectiveness of TIM improvements (expected project completion date: June 2020). A 2019 Utah DOT report analyzes performance measures, and a 2019 Virginia DOT web page provides incident duration data by district and date range, as well as a summary of the information based on percentages or numbers of incidents.

A 2018 Arizona DOT study identifies the benefits of effective TIM practices on secondary crashes in terms of improved safety for motorists and first responders, and a 2018 presentation describes the agency's two traffic data collection and reporting systems: Traffic and Criminal Software (TraCS) and Arizona Crash Information System (ACIS). A 2018 Iowa DOT report establishes specific objectives for TIM management in the state, and a 2018 Texas DOT presentation looks at how TIM data can be used to report on incident management activities.

International Resources

Recent international research includes a 2018 journal article that provides an overview of traffic incident duration analysis and prediction. A framework to coordinate incident management approaches in Australasia is discussed in a 2017 journal article, and 2011 and 2012 publications address TIM best practices in Europe.

Gaps in Findings

Survey respondents from transportation agencies that collect TIM data provided less feedback about secondary crash incidents in their states. Further attempts to engage with these agencies could provide useful details about data collection for this performance measure. Additionally, contacting agencies that did not respond to the survey could produce further guidance and perspectives about TIM data systems and practices.

Next Steps

Moving forward, Caltrans could consider:

- Contacting the respondents from Georgia and Maine DOTs, which both use ATMS, to discuss their agencies' roadway clearance time and incident clearance time data format and collection practices.
- Contacting the respondents from Maryland DOT State Highway Administration (SHA) and Michigan DOT since they use similar data sources and ATMS for roadway clearance time and incident clearance time.
- Investigating Maryland DOT SHA's secondary crash data capture practices, and also discussing the type of training the agency provides to assist responders and operators in identifying an incident as a secondary crash.
- Contacting Utah DOT about its use of Blyncsy to collect data in and around Salt Lake (for example, from universities, ski resorts and signal devices). The data can be shared with anyone who has a Blyncsy account. Caltrans District 11 will be working with the city of Oceanside, which recently opened an account with Blyncsy; data could possibly be extracted from this account.
- Reviewing documentation provided by survey respondents, specifically TIM analytics from Louisiana Department of Transportation and Development and Georgia, Michigan and Nevada DOTs.
- Reviewing incident reports at WICHway.org and kcscout.net.
- Monitoring the Kentucky DOT research study in progress that is updating methodologies for TIM performance measures and developing a dashboard to track TIM performance.
- Evaluating Waycare, a technology used by several agencies to analyze TIM data.
- Engaging with state agencies not responding to the survey to potentially identify other experience with TIM data collection.

Detailed Findings

Background

As part of its commitment to the fourth round of the Federal Highway Administration (FHWA) Every Day Counts (EDC-4) initiative, the California Department of Transportation (Caltrans) is investigating the tools and data needed to adopt the three national traffic incident management (TIM) performance measures recommended under EDC-4:

- Roadway clearance time.
- Incident clearance time.
- Number of secondary crashes.

Although Caltrans has access to multiple data systems that provide partial data, including the Major Incident Database and the California Highway Patrol (CHP) computer-aided dispatch (CAD), the agency does not have a central location that provides all the data needed for these specific performance measures. To establish a standardized system for gathering TIM data and reporting on performance, Caltrans is interested in evaluating the data systems and data collection practices used by other state departments of transportation (DOTs).

To assist Caltrans in this evaluation, CTC & Associates summarized the results of an online survey of state DOTs that examined these agencies' available data systems and data collection practices. In addition, we consulted with a representative from the University of Maryland Center for Advanced Transportation Technology (CATT) Laboratory to learn about the sources of the data residing in the Regional Integrated Transportation Information System (RITIS), and other details about the platform's capabilities and potential applications. A literature search was also conducted to identify publicly available sources of TIM data systems and practices. Findings from these efforts are presented in this Preliminary Investigation in three areas:

- Survey of state practice.
- Consultation with the CATT Laboratory.
- Related research and resources.

Survey of State Practice

An online survey was distributed to members of the American Association of State Highway and Transportation Officials (AASHTO) Committee on Transportation System Operations who had experience with TIM data systems and practices. The survey questions are provided in Appendix A. The full text of survey responses is presented in a supplement to this report.

Summary of Survey Results

Twenty-three respondents from 21 state DOTs and one state highway patrol responded to the survey:

- Alaska.
- Arizona.
- Arkansas.
- Georgia.
- Idaho.
- Kansas.
- Louisiana.
- Maine.
- Maryland.
- Massachusetts (two responses).
- Michigan.
- Minnesota.
- Nebraska.
- Nevada.
- North Carolina.
- North Dakota.
- Oregon.
- South Carolina.
- South Dakota.
- Utah.
- Wisconsin.
- Wyoming.

Of these agencies, respondents from 16 states—Arizona, Georgia, Idaho, Kansas, Maine, Maryland, Massachusetts–Highway Operations Center, Michigan, Minnesota, Nebraska, Nevada, North Carolina, Oregon, Utah, Wisconsin and Wyoming—reported that their agencies use a system, process or database to collect TIM data to report on one or more of the three national performance measures that are recommended under FHWA's EDC-4 initiative.

Respondents from seven states—Alaska, Arkansas, Louisiana, Massachusetts–Emergency Preparedness, North Dakota, South Carolina and South Dakota—reported that their agencies do not use a system, process or database to collect and report TIM data for these performance measures. Additional information provided by these respondents is summarized below:

- Louisiana Department of Transportation and Development (DOTD) and South Dakota DOT plan to report on these performance measures.
    - Louisiana DOTD stores TIM data in the Intelligent NETworks (iNET) advanced transportation management system (ATMS) provided by Parsons Corporation (the iNET system was originally developed by Delcan Technologies, which Parsons acquired in 2014). The system can provide records or information related to TIM performance measures; however, the agency is currently not participating in this national initiative. See **Related Resources**, page 30, for more information about iNET.
    - South Dakota is developing methods to collect data from a CAD system and crash reports.

- Alaska Department of Transportation and Public Facilities, Massachusetts–Emergency Preparedness, and Arkansas and South Carolina DOTs have an interest in reporting on these performance measures but lack the resources to do so.
- North Dakota DOT has no interest in reporting on these performance measures. The respondent added that the agency currently doesn't gather data to measure the number of secondary crashes but is adding this information to its crash reporting.

Below are survey results from the 16 agencies that use a system, process or database to collect TIM data to report on the following performance measures:

- Roadway clearance time.
- Incident clearance time.
- Number of secondary crashes.

Results for each of these performance measures are further categorized according to:

- Type of data gathered.
- Data sources.
- Data formats.
- Data collection challenges.

Following these survey results is supplemental information about TIM data systems and practices in Nevada and Utah along with resources provided by these and other survey respondents. Contact information for additional agency staff who can provide more information about an agency's TIM data system and practices is available on page 51.

Roadway Clearance Time

Of the 16 agencies collecting TIM data related to the three performance measures, all but two—Idaho and Wyoming—gather data to measure roadway clearance time. Below is information about the type of roadway clearance time data gathered, the sources used to gather this data, the data format provided by these sources and the challenges that agencies experience in gathering the data.

Type of Data Gathered

Six states—Georgia, Maine, Nebraska, North Carolina, Oregon and Wisconsin—gather data for the duration of the incident, typically beginning with the notification of the incident until the roadway is clear and open to traffic. Other data gathered includes the type of incident (Georgia, Kansas and Minnesota), lane closure time (Maryland) and type of roadway (Kansas).

Additional agency practices are described below:

- Among the data gathered by Georgia DOT are times to clear Towing and Recovery Incentive Program (TRIP) incidents and information from the Highway Emergency Response Operations (HERO) log report. TRIP was implemented in metropolitan Atlanta to "facilitate improved management of large-scale commercial vehicle incidents." HERO is a freeway service patrol (FSP) that provides roadside assistance in metropolitan Atlanta. See **Related Resources**, page 29, for more information about these programs.

- In Maryland, lane closures are tracked within the agency's ATMS. Its reporting tool, developed by the University of Maryland CATT Laboratory, calculates the total time a lane was closed (the duration of the incident).
- Michigan DOT operates four Transportation Operations Centers (TOCs): the Southeast Michigan Transportation Operations Center (SEMTOC), Statewide Transportation Operations Center (STOC), West Michigan Transportation Operations Center (WMTOC) and Blue Water Bridge Transportation Operations Center (BWBTOC). SEMTOC only collects data for freeways in three counties in southeast Michigan. The remaining TOCs collect data for freeway and major arterials statewide.
- Minnesota DOT gathers data on all blocking incidents on the Minneapolis/St. Paul metropolitan area freeway system that are observed on camera or reported by the FSP or State Patrol (Monday through Friday, from 4:30 a.m. to 10 p.m., and Saturday and Sunday, 10 a.m. to 8 p.m.).
- Nevada DOT intends to collect roadway clearance time on all crashes statewide that are reported to law enforcement. In urban areas, the agency strives to collect roadway clearance times for all incidents on state routes within the reach of the Traffic Management Center (TMC).

Survey results are summarized in Table 1 below.

Table 1. Roadway Clearance Data Gathered

<table>
<tr><th>Type of Data or Practice</th><th>State</th><th>Description</th></tr>
<tr><td>Incident Notification to Road Open</td><td>Georgia, Maine, Nebraska, North Carolina, Oregon, Wisconsin</td><td>Georgia: Time to clear TRIP incidents.
Maine: Time of notice of crash. Time lanes are cleared. Time roadway is clear.
Nebraska, North Carolina: Time incident is called into dispatch to the time roadway is open.
Oregon, Wisconsin: Event start, all lanes clear, all responders clear.</td></tr>
<tr><td>Lane Closure Time</td><td>Maryland</td><td>Maryland: Number of days/hours/minutes a lane is closed.</td></tr>
<tr><td>Type of Incident/Event</td><td>Georgia, Kansas, Minnesota</td><td>Georgia: Emergency/nonemergency events.
Kansas: Average clearance time by type of incident.
Minnesota: All blocking incidents on freeway system.</td></tr>
<tr><td>Type of Roadway</td><td>Kansas</td><td>Kansas: Average clearance time by roadway and type of incident.</td></tr>
<tr><td>All Lanes Cleared</td><td>Arizona</td><td>N/A.</td></tr>
<tr><td>Other</td><td>Georgia, Nevada, Utah</td><td>Georgia: HERO log reports.
Nevada:
• <u>Statewide</u>: All crashes.
• <u>Urban areas</u>: All incidents on state routes within the TMC area.
Utah: Observations of the TOC control room operators.</td></tr>
</table>

Data Sources

Survey respondents reported on a range of data sources and practices to gather roadway clearance time data. Of the 13 states providing information, all indicated a TMC or TOC, and seven states (Maryland, Nebraska, Nevada, North Carolina, Oregon, Utah and Wisconsin) indicated law enforcement. Key findings of survey responses are highlighted below; all results are summarized in Tables 2 and 3 following these highlights:

- In Arizona, data is sourced from accident records and TOC logs.
- Kansas gathers data from TMCs in Wichita and Kansas City only.
- In Maryland, TMCs enter data observed on CCTV or reported by law enforcement and fire department partners, FSPs, agency maintenance facilities and citizens (information is later verified by response units).
- Michigan TOCs obtain data from CCTV, dispatch centers, FSP and first responders using ATMS software and the operator database. SEMTOC also has access to the Michigan State Police CAD system for notification of incidents and information regarding incidents that may be used to determine lane closures, roadway clearance time and incident clearance time, but it does not have CAD integration.
- Minnesota DOT's TMC is integrated with the State Patrol's CAD system. Incident start time is the event creation time (determined either by the DOT or State Patrol). Lane clearance time is either observed on camera or reported by FSP or State Patrol on radio.
- In Nevada, roadway clearance times are reported by law enforcement agencies statewide on a standard crash form. It takes several months for the data to get back to the agency. The TMC also evaluates road clearance using crowdsourced data through Waycare software. (Waycare uses predictive analytics to optimize transportation systems. See **Related Resources**, page 32, for more information.) FSP reports on the clearance times of its incidents but that data is already captured in other reports that Nevada DOT uses to provide data to FHWA. Currently, Nevada DOT does not compare FSP data with other clearance data.
- Utah DOT sources data from its TOC, law enforcement, incident management teams and third parties.
- Wisconsin DOT's TMC retrieves data from law enforcement, DOT and highway field personnel and media, cameras, the CAD system in Milwaukee, and dispatch centers in Waukesha and Dane counties.

Table 2. Data Sources: Roadway Clearance Time

State	TMC/ TOC	Law Enforce ment	Service Patrol	First Responders	DOT/ Highway Field Staff
Arizona	X				
Georgia	X				
Kansas	X				
Maine	X				
Maryland	X	X	X	X	
Michigan	X		X	X	

State	TMC/ TOC	Law Enforcement	Service Patrol	First Responders	DOT/ Highway Field Staff
Minnesota	X		X		
Nebraska	X	X			
Nevada	X	X	X		
North Carolina	X	X	X		
Oregon	X	X	X		
Utah	X	X		X	
Wisconsin	X	X			X
TOTAL	**13**	**7**	**6**	**3**	**1**

Table 3. Data Sources: Roadway Clearance Time

State	Maintenance Facilities	Crowd sourcing	CCTV	911 Dispatch Centers	CAD	Other
Arizona						X
Maryland	X	X				
Michigan			X	X	X[1]	
Minnesota			X			X
Nebraska				X		
Nevada		X				X
Oregon				X		
Utah						X
Wisconsin			X		X	X
TOTAL	**1**	**2**	**3**	**3**	**2**	**5**

1 SEMTOC has access to Michigan State Police CAD system for incident notification but not CAD integration.

Data Formats

Twelve agency respondents reported on the format used when receiving data from its sources. Five agencies—Georgia, Kansas, Maine, Maryland and Michigan—primarily rely on ATMS. Other frequently used formats are CAD (Minnesota, Oregon and Utah) and reports (Kansas, Nebraska and Nevada). Highlights of survey results are provided below; all results are summarized in Table 4 following these highlights:

- Maryland captures data electronically within its ATMS and keeps the data perpetually within a Structured Query Language (SQL) database that is replicated and shared with the University of Maryland CATT Lab.
- Michigan DOT TOCs export data from ATMS and the operator database into Excel files that the agency's TIM unit combines with the statewide TIM database and uses for analysis.

- Minnesota captures data from its Intergraph CAD (a commercial product provided by Hexagon Safety and Infrastructure) and a statewide radio system.
- In Nevada, law enforcement data is processed by a third party, summarized by the month and provided to the department with some metadata. Waycare data is analyzed by the software provider, which can produce custom summary reports. The agency currently requests monthly and quarterly reports.
- North Carolina DOT's data formatting process is not fully automated.
- The data format received by Oregon DOT depends on the source (CAD-to-CAD or audio).
- In Wisconsin, the data format that is used for roadway clearance time looks at the percent of time incident types are cleared within a specific time frame (less than two hours for intermediate incidents and less than four hours for major incidents). The agency defines an intermediate incident as an incident that partially blocks highway lanes and/or a service ramp; a major incident is an incident blocking all lanes in one or both directions and/or a system ramp.

Table 4. Data Formats: Roadway Clearance Time

State	ATMS	Reports	Excel Spreadsheet	CAD	Radio	Audio/ Voice	Software	Other
Georgia	X							
Kansas	X	X						
Maine	X							
Maryland	X							
Michigan	X		X					X
Minnesota				X	X			
Nebraska		X			X			
Nevada		X						X
North Carolina								X
Oregon				X		X		
Utah				X		X	X	
Wisconsin								X
TOTAL	**5**	**3**	**1**	**3**	**2**	**2**	**1**	**4**

<u>Data Collection Challenges</u>

Respondents reported on several challenges with collecting roadway clearance time data, including data collection on arterials and in rural areas, data verification, human error and delays in event notification. Survey responses are summarized below by topic.

Data Collection on Arterials and in Rural Areas

- *Maryland*: In metropolitan areas, the data for interstates and primary U.S. routes is very accurate and comprehensive because FSPs are active on these roadways and because of the agency's long-standing relationship with law enforcement. However, gathering data on arterials and in rural areas can be difficult. If the area does not have a Coordinated Highways Action Response Team (CHART) emergency patrol or CCTV coverage, TOCs can go unnotified unless or until agency assistance is required or requested.

- *Michigan*: The agency is not always notified immediately when an incident occurs or when an incident clears the roadway, especially in rural areas.

Data Verification

- *Maine*: The agency is recording the data but needs to manually verify the times.
- *North Carolina*: Some divisions want to visually verify an incident, especially events that are more severe and complex. The number of reported events compared to the number of crashes recorded is a small fraction.
- *Utah*: Verification of data accuracy and timeliness is challenging.

Human Error

- *Georgia*:
    - Operators sometimes forget to update the appropriate event status.
    - Sometimes communication is lost in the field, and incidents must be manually input on the HERO log. Once communication is restored, the log may not be uploaded into the system.
- *Nevada*:
    - Data reported by law enforcement is often incomplete, estimated or improperly defined.
    - The terms "roadway clearance" and "incident clearance" are regularly confused or left blank. The time recorded is clearly rounded to the nearest 15 minutes and not the actual time of clearance.

Notification Delays/Lapses

- *Michigan*:
    - The agency is not always notified immediately when an incident occurs or when an incident clears the roadway.
    - TOCs may be aware of an incident, but details are unknown, such as if lanes are blocked or how many lanes are affected.
    - TOCs may never be notified of the incident. Enhancements made to ATMS in 2019 allow all TOCs to collect roadway clearance time data. The agency's TIM unit is currently determining how to best leverage these enhancements to measure and report on the performance measure statewide.
- *Nebraska*: Responders are not always able to call in times or record times on crash reports "in the heat of the moment."
- *Oregon*: TOCs are often not notified about incidents occurring on the highway network.

Other

- *Minnesota*: The TMC has been gathering this data for about 30 years. Logging lane clearance times accurately, promptly and simultaneously with FSP clearing the event can be challenging.

- *Nevada*:
  - Waycare data is limited by cost, available communications and population density.
  - Outside of the population centers of the state, communication limitations and the limited sample size of the crowd lead to a breakdown in the algorithm learning of the system.
- *Wisconsin*: The challenges are the unknown factors that play into gathering data, such as the responders' performance, the specific location, time of day, weather condition, incident complexity and the number of simultaneous incidents. These factors all affect the amount of time required to clear the highway.

Incident Clearance Time

Of the 16 agencies collecting TIM data related to the three performance measures, all but five—Idaho, Massachusetts–Highway Operations Center, Nebraska, Wisconsin and Wyoming—gather data to measure incident clearance time. While North Carolina DOT does collect incident clearance time data, the respondent did not provide information about agency practices. Below is information about the type of incident clearance time data gathered, the sources used to gather this data, the data format provided by these sources and the challenges agencies experience in gathering the data.

Type of Data Gathered

Five states—Arizona, Georgia, Maine, Maryland, Oregon—reported on specific types of data collected, typically beginning with incident notification through roadway clearance. In Maryland, the incident duration is tracked within the agency's ATMS, where an opened and closed time is recorded for each event. The University of Maryland CATT Lab reporting tool then automatically calculates the event duration, in addition to the lane closure time.

Other respondents provided more general information about their agencies' data collection practices:

- Incident clearance time data collection is limited in Michigan. WMTOC only collects this data from freeway and major arterials in 13 counties in the western part of the state.
- Minnesota DOT gathers data for all incidents in the Minneapolis/St. Paul metropolitan freeway system that are observed on camera or reported by FSP or State Patrol (911 dispatch calls) at specific travel times (4:30 a.m. to 10 p.m. Monday through Friday, and 10 a.m. to 8 p.m. Saturday and Sunday).
- Statewide, Nevada DOT intends to collect incident clearance time on all crashes reported to law enforcement. In urban areas, the agency strives to collect data for all incidents on state routes within the reach of the TMC.
- Utah DOT relies on the observations of its TOC control room operators.

Survey results are summarized in Table 5 below.

Table 5. Incident Clearance Data Gathered

Type of Data or Practice	State	Description
Incident Notification to Road Open	Arizona, Georgia, Maine, Maryland, Oregon	*Arizona:* • Response times to incident. • All lanes cleared. *Georgia*: • Dispatch notification. • Event response. • Lane clearance. • Incident clearance times. *Maine*: • Event notification. • Lane clearance. • Roadway clearance. *Maryland*. Event duration is tracked within the agency's ATMS. *Oregon*. From event start to all responders clear.
Type of Incident/Event	Kansas	*Kansas.* Average incident clearance time by roadway.
Other	Michigan, Minnesota, Nevada, Utah	*Michigan*. Incident clearance time data collected from freeway and major arterials in 13 west Michigan counties only. *Minnesota*. All freeway system incidents observed on camera or reported by service patrols (911 dispatch calls). *Nevada*: • Statewide: All crashes reported to law enforcement. • Urban areas: All incidents on state routes within the reach of the TMC. *Utah*. Observations of TOC control room operators.

Data Sources

Survey respondents reported on a range of data sources and practices to gather incident clearance time data. Key findings of survey responses are highlighted below; all results are summarized in Tables 6 and 7 following these highlights:

- Arizona DOT collects data from accident records and TOC logs, while Georgia DOT retrieves data from HERO logs and from its ATMS.
- Maryland TMCs enter data observed on CCTV or reported by law enforcement and fire department partners, State Highway Administration (SHA) emergency response patrols, SHA maintenance facilities and citizens (information is later verified by response units).
- In Michigan, WMTOC gets data from CCTV, dispatch centers and first responders. Data has also been collected using ATMS software and an operator database. In 2019, the agency began managing the data using only ATMS software. SEMTOC also has access to Michigan State Police CAD for notification of incidents and information regarding

incidents that may be used to determine lane closures, roadway clearance time and incident clearance time; SEMTOC does not have CAD integration.

- The Minnesota TMC is integrated with the State Patrol's CAD system. Incident start time is the event creation time (reported either by Minnesota DOT or the State Patrol). Incident clearance time is either observed on camera or reported by FSP or the State Patrol on radio.
- In Nevada, incident clearance times are reported by law enforcement agencies statewide on a standard crash form. Data is sent to Nevada DOT several months later. The agency's TMC also evaluates incident clearance using crowdsourced data through Waycare. Service patrols report on incident clearance times but that data is already captured in other reports that are used to provide data to FHWA. Currently the agency does not compare FSP data with DOT clearance data.
- Utah DOT gathers data from its TOC, law enforcement, incident management teams and third parties.

Table 6. Data Sources: Incident Clearance Time

State	TMC/ TOC	Law Enforce ment	Service Patrol	First Responders	DOT/ Highway Field Staff	Maintenance Facilities
Arizona	X					
Kansas	X[1]					
Maine	X					
Maryland	X	X	X	X		X
Michigan[2]	X		X	X		
Minnesota	X	X	X		X	
Nebraska	X	X				
Nevada	X	X	X			
Oregon	X	X	X			
Utah	X	X		X		
TOTAL	**10**	**6**	**5**	**3**	**1**	**1**

1 TMCs in Wichita and Kansas City only.

2 WMTOC obtains data from CCTV, dispatch centers and first responders.

Table 7. Data Sources: Incident Clearance Time

State	Crowd sourcing	CCTV	911 Dispatch Centers	ATMS	CAD	Other
Arizona						X
Georgia				X		X
Maryland	X	X				
Michigan[2]		X		X	X[3]	

State	Crowd sourcing	CCTV	911 Dispatch Centers	ATMS	CAD	Other
Minnesota		X			X	
Nebraska			X			
Nevada	X					
Oregon						X
Utah						X
TOTAL	**2**	**3**	**1**	**2**	**2**	**4**

1 TMCs in Wichita and Kansas City only.

2 WMTOC obtains data from CCTV, dispatch centers and first responders.

3 SEMTOC has access to Michigan State Police CAD system for incident notification but not CAD integration.

Data Formats

Eight agency respondents reported on the format used when receiving data. Three agencies—Kansas, Maryland and Michigan—primarily rely on ATMS. Other frequently used formats are CAD (Minnesota, Oregon and Utah), Excel spreadsheets (Georgia and Michigan) and voice communications (Oregon and Utah). Highlights of survey results are provided below; all results are summarized in Table 8 following these highlights:

- Maryland captures data electronically within its ATMS and keeps the data perpetually within an SQL database that is replicated and shared with the University of Maryland CATT Lab.
- In Michigan, WMTOC had exported data from ATMS and operator databases into Excel files that are analyzed by the agency's TIM unit. Beginning in 2019, WMTOC data is exported using only ATMS software.
- In Nevada, law enforcement data is processed by a third party, summarized each month and provided to the department with some metadata. Waycare data is analyzed by the software provider, which then produces monthly and quarterly custom summary reports.

Table 8. Data Formats: Incident Clearance Time

State	ATMS	Reports	Excel Spreadsheet	CAD	Radio	Audio/ Voice	Crowd sourcing	Software	Other
Georgia			X						
Kansas	X	X							
Maryland	X								
Michigan	X		X						
Minnesota[1]				X	X				
Nevada		X					X		X
Oregon				X		X			
Utah				X		X		X	
TOTAL	**3**	**2**	**2**	**3**	**1**	**2**	**1**	**1**	**1**

1 CAD vendor: Intergraph. Radio: statewide radio system.

Data Collection Challenges

The challenges in collecting incident clearance time data were similar to those for collecting roadway clearance data. Delays in data collection on arterials and in rural areas, data verification, human error and incident notification delays were all cited by respondents. Survey results are summarized below by topic.

Data Collection on Arterials and in Rural Areas

- *Maryland*: In metropolitan areas, the data for interstates and primary U.S. routes is very accurate and comprehensive because the sources of the data are emergency response patrols and law enforcement. However, gathering data on arterials and in rural areas can be difficult if the area does not have a CHART emergency patrol or CCTV coverage (TOCs often are not notified until agency assistance is required or requested).
- *Michigan*: The agency is not always notified immediately when an incident clears the roadway, especially in rural areas.

Data Verification

- *Utah*: Verification of data accuracy and timeliness is challenging.

Human Error

- *Georgia*: Excel spreadsheet lacks manually recorded data.
- *Nevada*:
    - Data reported by law enforcement is often incomplete, estimated or improperly defined.
    - The terms “roadway clearance” and “incident clearance” are regularly confused or left blank. The time recorded is clearly rounded to the nearest 15 minutes and not the actual time of clearance.

Notification Delays/Lapses

- *Michigan*:
    - The agency may not be notified immediately when an incident clears the roadway.
    - TOCs may never be notified of the incident. Enhancements made to ATMS in 2019 allow all TOCs to collect incident clearance time. The agency’s TIM unit is currently determining how to best leverage these enhancements to measure and report on the performance measure statewide.
- *Oregon*: TOCs are often not notified about incidents occurring on the highway network.

Other

- *Minnesota*: The TMC has been gathering this data for about 30 years, and the volume of incidents increased as the system grew. CAD integration was “a great help” in managing data.

- *Nevada*:
    - Waycare data is limited by cost, available communications and population density.
    - Outside of the population centers of the state, communication limitations and the limited sample size of the crowd lead to a breakdown in the algorithm learning of the system.

Number of Secondary Crashes

Of the 16 agencies collecting TIM data related to the three performance measures, 10 agencies—Arizona, Idaho, Kansas, Maine, Maryland, Michigan, Minnesota, Nevada, North Carolina and Wyoming—gather data to measure the number of secondary crashes. In Utah, data gathering is observational only; currently there is no direct reporting form.

Below is information about the type of secondary crash data gathered, the sources used to gather this data, the data format provided by these sources and the challenges agencies experience in gathering the data.

Type of Data Gathered

Four states (Idaho, Maine, Maryland and Wyoming) reported that their agencies investigate associated events—those events that were caused by the first incident—when gathering data on the number of secondary crashes. Maryland DOT SHA records all associated events that are determined to be related, including secondary crashes. In addition, police agencies in the state indicate that a collision is a secondary crash by selecting a check box in the Automated Crash Reporting System (ACRS).

Other respondents provided more general information about their agencies' data collection practices:

- In Michigan, WMTOC collects secondary crash data for freeway and major arterials for 13 counties in western Michigan. STOC collects data for some known secondary crashes on freeway and major arterials statewide. SEMTOC and BWBTOC have not been collecting secondary crash data.
- Minnesota DOT's TMC investigated the recorded traffic camera video of all crashes logged in CAD for two two-week periods in 2016 and 2017. Researchers examined the video to determine the cause of the incident and whether the crash was secondary.
- Nevada DOT collects secondary crash data statewide by selecting a check box on the law enforcement crash report form.
- North Carolina DOT has used several different algorithms with varying levels of success. Currently, the agency uses the number of rear-end crashes on freeways.

Survey results are summarized in Table 9 below.

Table 9. Secondary Crash Data Gathered

<table>
<tr><th>Type of Data or Practice</th><th>State</th><th>Description</th></tr>
<tr><td>Associated Incidents</td><td>Idaho, Maine, Maryland, Wyoming</td><td>Idaho and Wyoming. If the first incident caused a secondary incident.
Maine. Time and distance away from the first crash.
Maryland:
The agency records associated events, which are related to the first incident (including secondary crashes).
Police agencies report collision as a secondary crash in ACRS.</td></tr>
<tr><td>Crash Type</td><td>North Carolina</td><td>North Carolina. Number of rear-end crashes on freeways.</td></tr>
<tr><td>Totals Only</td><td>Kansas</td><td>Kansas. Number of secondary crashes.</td></tr>
<tr><td>Reporting Practice</td><td>Nevada, North Carolina</td><td>Nevada. Data collected statewide on the law enforcement crash report.
North Carolina. Different algorithms used with varying levels of success.</td></tr>
<tr><td>Other</td><td>Arizona, Michigan, Minnesota</td><td>Arizona. All secondary crash data.
Michigan:
<u>WMTOC</u>: Data from freeway and major arterials in 13 western Michigan counties.
<u>STOC</u>: Data from some known secondary crashes on freeway and major arterials statewide.
<u>SEMTOC and BWBTOC</u>: No data.
Minnesota: Traffic camera video of all crashes logged in CAD for two periods in 2016 and 2017.</td></tr>
</table>

<u>Data Sources</u>

Law enforcement accident records and police reports are the primary sources of the number of secondary crashes in six states: Arizona, Idaho, Maine, Maryland, Nevada and Wyoming. Data is retrieved from State Highway Patrol accident records in Arizona and from state crash reports in Michigan, Nevada and Wyoming. Since 2016, Michigan's state crash report (UD-10) has included a field to record secondary crashes. Nevada's statewide crash form includes a check box to indicate if a crash is secondary. (The respondent added that it can take several months to receive this data. The agency is currently exploring the use of Waycare to identify secondary crashes at its TMC.) A similar check box option is available in Maryland's electronic ACRS.

Below are other key findings from survey participants; all survey responses are summarized in Table 10 following these highlights:

- In Kansas, secondary crash data is obtained from TMCs in Kansas City and Wichita only.
- In Maryland, TMCs rely on a dependable source at the scene to verify that the event is secondary and that it can then be associated to the primary event.

- WMTOC and STOC operators in Michigan are alerted to secondary crashes through CCTV and notification from first responders. TOC operators have recorded secondary crashes in ATMS and operator databases.
- Minnesota DOT gathers secondary crash data from the State Patrol's CAD and recordings from TMC cameras.
- North Carolina DOT primarily uses its crash database for this information. The respondent noted that the agency will track specific events on some projects and corridors, but statewide tracking is too labor-intensive.

Table 10. Data Sources: Number of Secondary Crashes

State	TMC/ TOC	Law Enforcement	First Responders	CCTV	CAD	Other
Arizona		X				
Idaho		X				
Kansas	X[1]					
Maine		X				
Maryland	X	X				X
Michigan	X		X	X		
Minnesota				X	X	X
Nebraska						
Nevada		X				
North Carolina						X
Wyoming		X				
TOTAL	**3**	**6**	**1**	**2**	**1**	**3**

1 TMCs in Wichita and Kansas City only.

<u>Data Formats</u>

Eight agency respondents reported on the format used when receiving data from these sources. Five of these states—Idaho, Kansas, Maryland, Michigan and Wyoming—produce reports that can be entered into a database:

- Kansas DOT uses ATMS software to create reports in PDF format.
- In Maryland, both ATMS and ACRS produce real-time electronic reports that can be printed, and information can be recorded in SQL databases.
- WMTOC and STOC operators in Michigan also record secondary crashes in ATMS and operator databases. (UD-10 reports are available in PDF format.)

The Maine DOT respondent reported that the agency uses an Oracle database. Minnesota DOT conducts a visual analysis and results are logged in an Excel spreadsheet. In Nevada, the number of crashes is reported as a statewide total each month.

Survey results are summarized in Table 11 below.

Table 11. Data Format: Number of Secondary Crashes

State	ATMS	Databases	Reports	Other
Idaho		X	X	
Kansas	X		X	
Maine		X		
Maryland	X	X	X	
Michigan	X	X	X	
Minnesota				X
Nevada				X
Wyoming			X	
TOTAL	**3**	**4**	**5**	**2**

Data Collection Challenges

Respondents from seven agencies discussed the challenges in collecting secondary crash data. The primary challenge reported by respondents was determining whether the incident was a secondary crash (Idaho, Maryland, Michigan and North Carolina). Other challenges include accurate reporting on police reports and forms (Maryland, Michigan, Nevada and Wyoming), delays in receiving notification of an incident (Michigan) and lack of information about the original crash (Wyoming). Below are key findings of the survey results by topic:

Accurate Reporting

- *Maryland*: Responders/operators may not report the incident as a secondary crash.
- *Nevada*: The number of secondary crashes reported statewide indicates that law enforcement officers are not checking the box on the report form as often as they should.
- *Wyoming*: Officers need to be reminded to complete the form with accuracy and narrate the initial crash.

Determining a Secondary Crash

- *Maryland*: Training responders/operators to identify an incident as a secondary crash has been more difficult than anticipated.
- *Nevada*: There is a lack of understanding of what qualifies as a secondary crash.

Notification Delays/Lapses

- *Michigan*: TOCs may never be notified of the incident. Enhancements made to ATMS in 2019 allow all TOCs to collect secondary crash data. The agency's TIM unit is currently determining how to best leverage these enhancements to measure and report on the performance measure statewide.

Other

- *Minnesota*: The respondent noted that reporting secondary crash data is labor-intensive and the subjective decision is limited to only one or two staff members.
- *Wyoming*: There is a lack of information about the original crash that caused the queue resulting in the secondary crash.

Supplemental Information

Nevada

In a follow-up email, the respondent from Nevada DOT noted that TIM performance measures were added to the statewide crash form in April 2018. Statewide, roadway clearance, incident clearance and secondary crash data is collected by law enforcement on the standard crash form. This form is supplemented in urban areas with TMCs that collect data on clearances through Waycare. This product does not collect secondary crash data, but the agency is exploring the possibilities.

Additionally, the respondent provided two screenshots from the TIM dashboard along with an explanation of the data:

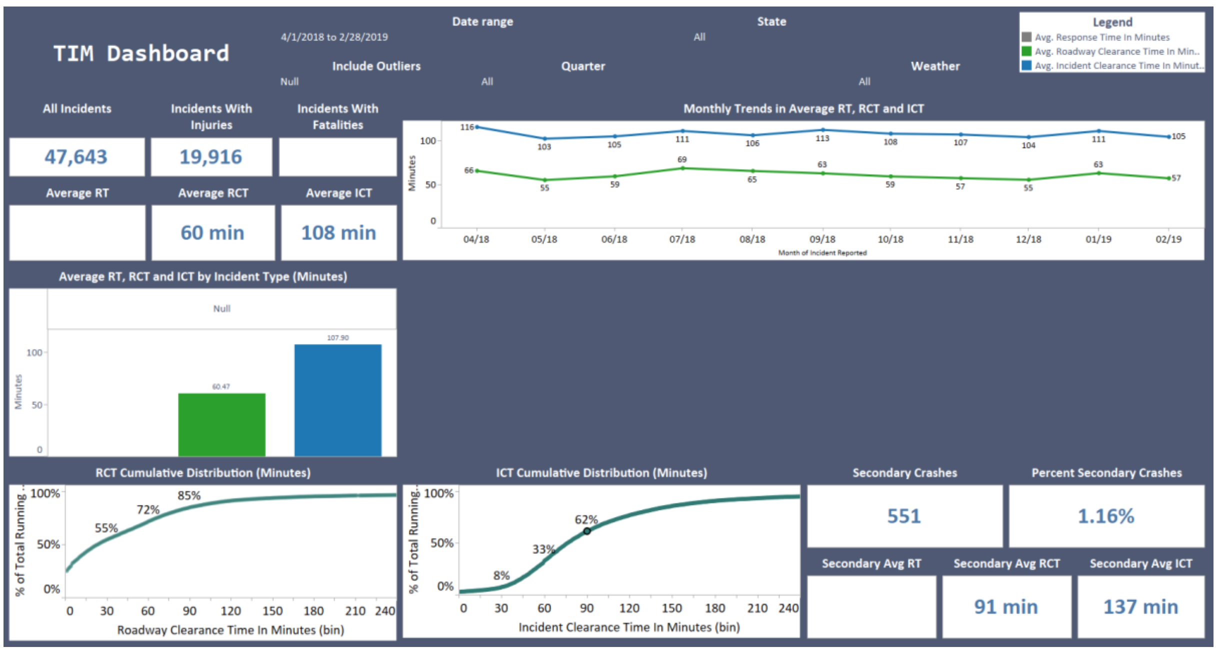

Figure 1. Nevada DOT TIM Dashboard Output: Road Clearance Time and Incident Clearance Time, April 2018 Through February 2019

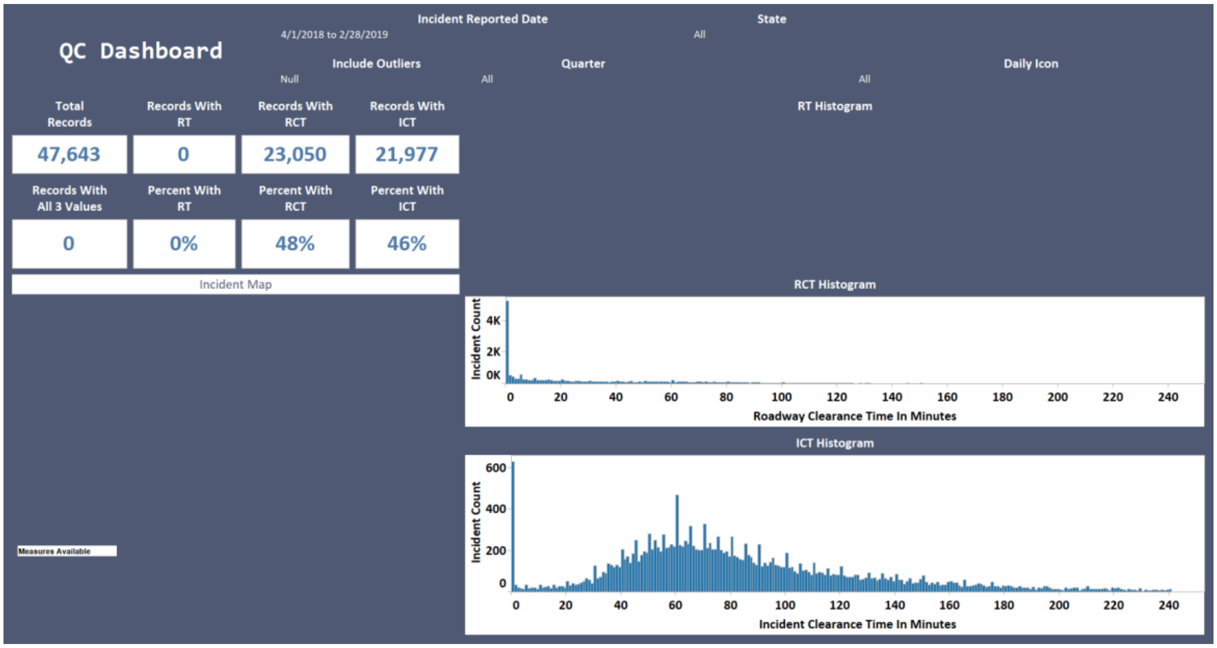

Figure 2. Quality Control Analysis of the Nevada DOT TIM Dashboard Output

- Out of the 53,959 records provided, 47,643 records (88.3 percent) had high enough data quality to use for analysis (the remaining 11.7 percent had too many missing or erroneous values).

Roadway Clearance Time and Incident Clearance Time

- 46 percent of the usable records allowed for the calculation of incident clearance time.
- 48 percent of usable records allowed for the calculation of roadway clearance time.
- Roadway clearance time distribution shape is flat because 47.3 percent of calculated roadway clearance times are 0. This may happen when officers put 0 as roadway clearance time when the crash is a non-lane blocking crash, which skews the roadway clearance time distribution and average measure.
- Incident clearance time T distribution shape is as expected except for the spikes, which are evidence that the incident clearance time is being rounded (usually to the nearest five minutes—30, 40, 45, 55, etc.) arbitrarily by some officers. There is an unusually high spike at 60 minutes, showing the excessive recording of 60-minute incident clearance time (and probably roadway clearance time) by many officers.
- If the 0 roadway clearance times for the non-lane blocking crashes are removed (there should be no roadway clearance time for a non-lane blocking crash), the average roadway clearance time will go up.
- Both roadway clearance time and incident clearance time are showing a decreasing trend over the last 12 months.

Secondary Crashes

- Total secondary crashes were 551 (1.16 percent), which correlates with what is seen in other states.
- Average roadway clearance time and incident clearance time for secondary crashes are 91 minutes and 137 minutes, respectively.

Utah

Utah DOT is currently collecting some of the performance data. The respondent noted that the agency is forming a statewide TIM coalition and developing a dashboard to facilitate data gathering and analysis, and report in real time. The agency expects to accomplish these tasks by the end of this year and at that time, will have "a greatly improved program."

Related Resources

Below are sample reports, documents and other resources provided by survey respondents that are related to their agencies' TIM data system and data collection practices. Supplementing these materials are citations describing agency systems and tools. The Nebraska DOT respondent reported that while no documentation is currently available, software for crash reports and other incident data is estimated to be completed by 2021.

Georgia

Highway Emergency Response Operations (HERO), Georgia Department of Transportation, undated.
http://www.dot.ga.gov/DS/Travel/HEROs
From the web site:

> Highway Emergency Response Operators (HEROs) are dispatched to traffic-related incidents in metropolitan Atlanta with the primary duty to clear roads so that normal traffic flow is restored. HEROs also assist stranded motorists with flat tires, dead batteries or in need of fuel or coolant.

Sample weekly and monthly HERO reports are provided as supplements to this report.

Towing and Recovery Incentive Program (TRIP), Traffic Incident Management Enhancement (TIME) Task Force of Georgia, undated.
http://timetaskforce.com/time-initiatives/trip/
From the web site: Georgia's Towing and Recovery Incentive Program (TRIP) was implemented in metro Atlanta to facilitate improved management of large-scale commercial vehicle incidents. These large-scale incidents can significantly affect traffic in the region, causing long motorist delays, polluting the air, and creating safety hazards. TRIP encourages the quick, safe clearance of these incidents by paying performance incentives to highly-skilled, TRIP-certified towing and recovery companies for clearing wrecks within established clearance goals.

Kansas

WICHway, Kansas Department of Transportation, undated.
http://wichway.org/wichway
Monthly incident reports: http://wichway.org/wichway/Reports
From the web site:

> WICHway provides the latest traffic information on Wichita's highways. It is part of the statewide Intelligent Transportation System (ITS) designed to help travelers, commuters, commercial transport and other drivers make informed decisions as they travel Kansas highways. … It is owned and operated by the Kansas Department of Transportation in cooperation with many partners including Sedgwick County, City of Wichita, Kansas Highway Patrol, Kansas Turnpike Authority, Wichita Area Metropolitan Planning Organization, and Federal Highway Administration.

> The WICHway network has 68 closed circuit cameras, 75 traffic sensors and 25 dynamic message signs. A Traffic Management Center at the Sedgwick County Public Safety Building is operated Monday – Friday, 6 a.m. – 7 p.m. with 911 operators at the control console.

Links at this web site direct users to a map of Wichita that indicates travel speeds, road conditions, construction, and cameras and signs. An additional feature shows incidents on the map.

Links to annual and monthly incident reports dating back to June 2013 are also available at the web site. Current monthly reports include crash clearance time by highway, average incident clearance time by month and year, total incidents, incident breakdown by type and severity levels.

KC Scout, Kansas Department of Transportation, Missouri Department of Transportation, undated.
http://kcscout.net/About.aspx
Monthly incident reports: http://kcscout.net/ReportsMonthly.aspx
From the web site:

> KC Scout is Kansas City's bi-state traffic management system, designed to lessen traffic jams by improving rush-hour speeds, increasing safety by decreasing the number of rush-hour accidents and improving emergency response to traffic situations by clearing incidents quickly and safely. Scout manages traffic on more than 300 miles of continuous freeways in the greater Kansas City metropolitan area.

Links to fiscal year 2014 and 2015 annual reports and to monthly incident reports from September 2018 through February 2019 are also available at the web site. Current monthly reports provide an incident summary that includes total incidents, incidents with lane blockages, total minutes of blocked lanes and average time to clear lanes. Links to the complete report are also available.

Louisiana

Intelligent NETworks, Parsons Corporation, 2016.
https://www.parsons.com/wp-content/uploads/2017/08/iNET-Brochure.pdf
From the brochure:

> The Intelligent NETworks (iNET) Advanced Transportation Management System (ATMS) is Parsons' industry-leading software used to improve the management, efficiency, effectiveness, and safety of your transportation network. Whether it's a freeway, highway, toll road, transit route, tunnel, arterial road, or other transportation system, iNET applies state-of-the-art operational solutions to improve these facilities.

System capabilities and benefits are featured in the brochure along with base, device, intelligent management and external modules that are available.

Maryland

ATMS System Architecture, CHART Program, Version 27.0, General Dynamics, August 2018.
See Attachment A
This document presents the architecture of Maryland DOT SHA's CHART ATMS and details every feature currently included for recording data. Traffic event data is discussed in

Section 3.38.4 (page 78 of the report); performance monitoring is discussed in Section 7.6.3 (page 126 of the report).

CHART Data Export Guide, CHART Program, Version 7.0, General Dynamics, August 2018.
See Attachment B
This guide shows the available fields that are exported to the external systems of authorized agencies through a secure token. (Maryland DOT SHA's public Really Simple Syndication (RSS) feed does not contain all the information contained in the Interface Control Document.) Traffic event data is discussed in Section 2.3.1 (beginning on page 11 of the report).

Maryland State Highway Mobility Report, Maryland Department of Transportation State Highway Administration, 2018.
https://chart.maryland.gov/downloads/readingroom/tsmo/2018MobilityReportLowRes05072019.pdf
A summary of CHART practices begins on page 102 of the PDF.

CHART Traffic Management Center Operations: Standard Operating Procedures, Maryland Department of Transportation State Highway Administration, September 2016.
https://transportationops.org/publications/chart-traffic-management-center-operations-standard-operating-procedures (click on "Skip to content")
From Chapter 1:

> This document is the Standard Operating Procedures (SOP) manual that provides guidance to CHART TMC HOTs [highway operations technicians] (i.e., HOTs, Operators) in performing traffic management center operational duties at the SOC and TOCs. It outlines policies and procedures for conducting daily technical and administrative activities.

Section 1.5 (page 23 of the PDF) provides an overview of incident management. Policies and procedures related to traffic events are provided in Section 3.2 (page 115 of the PDF).

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CHART Traffic Incident Management, Coordinated Highways Action Response Team (CHART) Statewide Operations Center, undated.
https://chart.maryland.gov/about/incident_management.asp
This web page summarizes the CHART TIM program and provides access to other CHART program information.

Minnesota

Computer-Aided Dispatch, Intergraph Corporation, undated.
http://www.intergraph.com/global/it/publicsafety/cad.aspx
From the web site: Intergraph's Computer-Aided Dispatch (CAD) system provides call-center and communications center operators with the tools they need to field calls, create and update incidents, and manage an organization's critical resources by providing real-time interaction of crucial data. Combined with historical and local searches, operators are ensured they have the right information available to them when making urgent decisions.

Our Web-based solutions provide occasional or remote access to the CAD system, providing first responders and security personnel with secure Web access to live operational information and the ability to search for historical data on incidents and resources. For optimal communications, our solution smoothly integrates voice and data and includes built-in interfaces to radio and telecommunications systems, allowing fast, efficient radio messaging and data distribution.

….

This “intelligent” mapping and data entry system seamlessly integrates an interactive, real-time map display with call handling, dispatching, records and information management, remote access, and mobile data. The application enables precise and exceptionally fast response, while conveniently generating a full incident record for downstream use.

Nevada

Waycare Solutions, Waycare, undated.
http://waycaretech.com/
Waycare uses predictive analytics to optimize transportation systems. *From the web site*:

> By integrating disparate systems and multiple sources of data into a GIS [geographic information system]-based interface, the operator platform offers AI [artificial intelligence] driven incident identification, dynamic congestion, travel analysis and predictive analytics to identify near-term dangerous roads. … The platform includes a back office function with data visualization tools and automated reporting capabilities. An integrated interface provides accessibility to the data layers and allows PDF exports for building external reports.

North Carolina

Incident Clearance Goal, North Carolina Department of Transportation, undated.
See Attachment C
This document briefly describes North Carolina DOT’s proposed incident clearance goals and measures to achieve these goals.

Wisconsin

Incident Response, MAPSS Performance Improvement Program, Wisconsin Department of Transportation, undated.
https://wisconsindot.gov/Pages/about-wisdot/performance/mapss/measures/mobility/incident.aspx
Mobility: https://wisconsindot.gov/Pages/about-wisdot/performance/mapss/goalmobility.aspx
The MAPSS [Mobility, Accountability, Preservation, Safety and Service] Performance Improvement Program includes the agency’s five core goals for developing and operating a safe, efficient transportation system. Performance for each goal is assessed in a MAPSS Performance Scorecard, which includes performance measures, how the agency measures performance, performance for the current report period, the performance goal and comments about the performance.

Mobility is one of the agency’s five core goals. The Mobility web page summarizes performance data for July 2019, including incident response for calendar year 2018, which provides statistics about the percent of incidents cleared within a specific time frame.

Consultation With the Center for Advanced Transportation Technology Laboratory

The Regional Integrated Transportation Information System (RITIS) is a data aggregation, dissemination and analytics platform that uses transportation data from public and private sector agencies and systems for incident response and planning.

We contacted Michael Pack, director of the Center for Advanced Transportation Technology (CATT) Laboratory at the University of Maryland, to learn about the California data residing in RITIS and other details about the platform's capabilities and potential applications. Below is a summary of phone and email conversations with Pack. He also provided a document that includes additional resources and tools illustrating the RITIS platform using real-time data from California and other agencies; the document is available as a supplement to this report. Following this discussion are publications and other relevant research about RITIS.

Type of Data Gathered

Currently, RITIS has access to the following data from California:

- Caltrans incident data (primarily from the CHP CAD system).
- Crowdsourced event data from Waze, the GPS navigation app.
- Caltrans sensor data (inductive loop and other spot sensor data) that collects volume and speed data at specific locations.
- Probe-based speed data from INRIX, a private company providing location-based data and analytics.
- Probe-based speed data from FHWA's National Performance Management Research Data Set.
- National Weather Service (NWS) radar predictions.
- NWS real-time radar (precipitation rates on roads).
- Road weather information system (RWIS) data, such as surface temperatures, visibility, wind speed and direction.
- First responder radio communications.
- CCTV (streams and snapshots, depending on the location).
- Dynamic message signs (DMS).

The data is gathered and displayed in real time within RITIS and archived indefinitely. The CATT Lab has created a series of data visualizations and analytics tools that make it easier to compute TIM performance measures as defined by FHWA in its EDC program. (*Note*: FHWA contracted with the CATT Lab to build EDC TIM performance measures for event and roadway clearance times into these tools.) Caltrans events are standardized to the performance measures and then computed. (See *Related Resource* below for a link to a short video demonstrating the analytics.)

Related Resource:

EDC-Caltrans, Center for Advanced Transportation Technology Laboratory, July 2019.
https://vimeo.com/350489604
This two-minute video demonstrates TIM performance measures analytics in RITIS.

Data Sources

While the CATT Lab is not under contract with Caltrans to collect, manage and archive data, it is still archiving Caltrans data feeds from an expired contract with FHWA (2010-2014) when the lab was evaluating Integrated Corridor Management deployment in San Diego. Currently data is obtained electronically from multiple sources, including CHP and 911 dispatch calls, DOT operations staff, field units and third parties such as INRIX and NWS.

Data Credibility

Some of the data sources are easily validated (for example, probe, speed sensor and weather data). Incident or event data is much more difficult to validate. To determine the credibility of these types of data, researchers use the following:

- *Timeliness indicators*: Has the data (or data feed) been updated when expected?
- *Quantity and location*: Is the number of incidents what is typically expected? How far out of the norm is the pattern—both spatially and temporally?
- *Agreement*: If incident data is coming from multiple sources, do the sources agree? Is one source timelier than another source?
- *Impactful*: Is the incident or event impacting traffic? Researchers can use probe data and/or sensor data to understand the impacts, determine if incidents are really happening on the roadway, and if so, estimate when they began and/or ended.
- *Complete*: Law enforcement doesn't complete a collision report for every incident on the roadway (for example, a debris event or disabled vehicle). DOTs are more likely to log these smaller events in their ATMS platforms. To have complete data, researchers merge these two data sets, remove the duplicates and use a combination of them to validate each other and fill in the gaps. Comparing police, DOT and Waze data is a useful way to understand how complete the data may or may not be.

Other RITIS analytics help to analyze and validate the data. For example, looking at trends in events over time (such as time of day or day of the week) can indicate any temporal gaps in the data. Mapping the data will show where spatial gaps may exist.

Data Collection Challenges

The CATT Lab isn't computing roadway clearance data for California because the data is not machine-readable. CAD messages are input by operators in a nonstandard format with many variations. Caltrans data needs to be standardized and machine-readable for analysis.

Contact: Michael Pack, Director, Center for Advanced Transportation Technology Laboratory, University of Maryland, 240-676-4060, packml@umd.edu.

Related Resources

Usage of the Regional Integrated Transportation Information System (RITIS), Andrew Meese, Metropolitan Washington Council of Governments, March 2018.
https://www.mwcog.org/assets/1/28/03082018_-_Item_9_-_Usage_of_the_Regional_Integrated_Transportation_Information_System.pdf
This presentation describes RITIS, including system features and case studies, in the National Capital Region.

"USA's Political Mosaic Makes Transport Agency Data Sharing Critically Important," Keith Nuthall, *Traffic Engineering and Control*, Vol. 54, No. 4, September 2013.
Citation at https://trid.trb.org/view/1264654
From the abstract: This article discusses the Regional Integrated Transportation Information System (RITIS), an automated transport data sharing, dissemination, and archiving system designed to improve communication between government and the traveling public. The system, which originally was developed to unit[e] the transport data systems of Maryland, Virginia and [Washington, D.C.], has now been adopted by about 100 transport management agencies across the country, including the U.S. Secret Service and Department of Homeland Security. The author also highlights a research project on improvements to information sharing systems being conducted by the National Cooperative Highway Research System. The project will identify successful multi-agency data sharing practices, including [t]he types of data being shared, how it is transmitted, how it impacts decision making and how to form data sharing agreements.

Regional Integrated Transportation Information System, Center for Advanced Transportation Technology Laboratory (CATT Lab), University of Maryland, undated.
https://ritis.org/intro
From the web site:

> RITIS is the leading big data aggregation and dissemination platform for solving challenging and complex transportation problems. Its broad spectrum of advanced analytics—from comprehensive situational awareness to in-depth archived data evaluation—provides enhanced, multi-faceted insight of the transportation system across geographic and agency boundaries. RITIS is used nationwide by thousands of decision-makers in planning, operations, research, the military and Homeland Security for developing smart, cost-effective mobility, safety and security solutions.
>
> ….
>
> RITIS is a situational awareness, data archiving, and analytics platform used by transportation officials, first responders, planners, researchers, and more. RITIS fuses data from many agencies, many systems, and even the private sector—enabling effective decision making for incident response and planning. Within RITIS are a broad portfolio of analytical tools and features. Ultimately, RITIS enables a wide range of capabilities and insights, reduces the cost of planning activities and conducting research, and breaks down the barriers within and between agencies for information sharing, collaboration, and coordination.

An extensive catalog of available tools and case studies are also included on the web site.

Related Resource:

> **CATT Lab (Center for Advanced Transportation Technology Laboratory)**, University of Maryland, undated.
> https://www.cattlab.umd.edu/
> *From the web site*: The CATT Lab develops real-time systems that fuse and integrate hundreds of [g]igabytes of data per day in real-time from emergency operations centers, transportation management centers, thousands of sensors, CCTV cameras and subsystems throughout the country.

Regional Integrated Transportation Information System (RITIS), I-95 Corridor Coalition, undated.
https://i95coalition.org/projects/regional-integrated-transportation-information-system-ritis/
The I-95 Corridor Coalition is a partnership of transportation agencies, toll authorities, public safety and related organizations from the eastern United States and Canada. This web page describes the coalition's use of RITIS and provides access to its RITIS user group.

Related Research and Resources

A literature search of recent publicly available resources identified publications and other resources that are organized into four topic areas:

- National resources.
- State practices.
- International resources.
- Related resources.

National Resources

Every Day Counts: An Innovation Partnership With States, EDC-4 Final Report, Federal Highway Administration, April 2019.
https://www.njdottechtransfer.net/wp-content/uploads/2019/05/edc4_finalreport.pdf
Pages 41 through 44 of the report (pages 43 through 46 of the PDF) provide a summary of state activities related to using data to improve traffic incident management.

Traffic Incident Management Knowledgebase, Federal Highway Administration, 2019.
https://ops.fhwa.dot.gov/eto_tim_pse/preparedness/tim/knowledgebase/
From the web site: This Knowledgebase began as a tool to house online reference materials that furnished transportation and public safety professionals with knowledge and tools they need to conduct TIM incident-specific performance measurements. However, FHWA captured so much great information while meeting with jurisdictions' transportation and public safety mid-level managers, decision makers and practitioners during its TIM Workshops and SHRP2 [Strategic Highway Research Program Second Round] TIM Responder Train-the-Trainer initiatives, that the Knowledgebase necessarily expanded to accommodate great tools and information. As a result, the TI&EM [Traffic Incident and Events Management] team expanded this KMS [Knowledge Management System], building upon the performance measurement foundation to include other documents and models graciously provided by other [s]tates, local and regional jurisdictions and functional disciplines. The visitor will find documents and tools that range from policy, safe/quick clearance legislation, training, traffic management center operations and TIM, TIM Committee formation and operations, TIM resources, Public Outreach and other TIM functions.

Collection, Analysis and Use of Data to Improve Traffic Incident Management (TIM): Innovative Examples from Successful States, National Operations Center of Excellence, September 2018.
https://transportationops.org/ondemand-learning/collection-analysis-and-use-data-improve-traffic-incident-management-tim
From the web site: During this webinar, you will hear firsthand from three agencies that actively collect, analyze and use TIM data. These speakers will share the ways in which they use this information and the value they have derived from it to improve TIM and responder safety. This interactive webinar will allow participants an opportunity to ask questions of the presenters and participate in relevant polling questions.

State of the Practice on Data Access, Sharing and Integration, Anita Vandervalk, Krista Jeanotte, Dena Snyder and Jocelyn Bauer, Federal Highway Administration, December 2016.
Full report: https://www.hsdl.org/?view&did=798282
Chapter 3: https://www.fhwa.dot.gov/publications/research/operations/15072/003.cfm
From the abstract:

> The purpose of this state-of-the-practice review was to lay both technical and institutional foundation for all aspects of the development of the Virtual Data Access Framework. The review focused on current data sharing and integration practices among [s]tate and local agencies, example data environments, technical integration formats, and business rules for integration and sharing. State, local and regional transportation operators, planners and data professionals can use this report to enhance their data sharing and integration efforts by building on the experiences and effective practices of other agencies documented in this report.

RITIS and other data environments are summarized in Chapter 3 of this report.

Best Practices Supporting Traffic Incident Management (TIM) Through Integrated Communication Between Traffic Management Center and Law Enforcement and Effective Performance-Measurement Data Collection, NCHRP Project 20 68A, Scan 10-04, September 2013.
http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-68A_10-04.pdf
From the executive summary: This scan focused on examining the TIM practices in regions that have enhanced TIM performance through integrated communication between traffic management centers (TMCs) and law enforcement (LE) and effective performance-measurement data collection. The scan team selected and subsequently interviewed scan participants to learn about their best practices and the important features of those practices in each region. The team placed additional focus on collecting the lessons learned and insights gained through the participants' adoption of their particular practices, with particular regard for adoption of CAD and related technologies. The scan explicitly considered the perspectives of transportation, LE, and other incident-response agencies. The scan team was particularly interested in having discussions with state departments of transportation (DOTs) and other agencies that perform traditional traffic operations, specifically related to TIM, in collaboration with LE or emergency management and their respective CAD technologies. Furthermore, of those entities that have developed processes and procedures for collaboration, the team wanted to learn what performance measures they regularly monitor and track to ensure that their program is delivering the desired results. Additionally, the team searched for those entities that perform the above-mentioned collaboration in a collocated facility or TMC.

Analysis, Modeling, and Simulation for Traffic Incident Management Applications, Richard Margiotta, Rick Dowling and Jawad Paracha, Federal Highway Administration, July 2012.
https://ops.fhwa.dot.gov/publications/fhwahop12045/fhwahop12045.pdf
From the abstract: To support modeling and evaluation of TIM strategies, this document provides a synthesis of analysis, modeling, and simulation (AMS) methods for incident impacts. The focus is on incidents effects on congestion and reliability as well as secondary incidents, for the purpose of estimating benefits and evaluating programs and proposed strategies. This document covers several specific topics including a synthesis of AMS methods for incidents, TIM AMS application areas, data required to undertake modeling and evaluations of TIM strategies, and identification of future improvements to TIM AMS applications.

Improved DOT Collaboration and Communication Could Enhance the Use of Technology to Manage Congestion, Report to the Committee on Science, Space and Technology, U.S. House of Representatives, March 2012.
https://www.gao.gov/assets/590/589430.pdf
From the abstract:

> Since 1994, [the U.S.] DOT has overseen the allocation and expenditure of more than $3 billion for deploying and researching ITS [intelligent transportation systems]. GAO [Government Accountability Office] was asked to address (1) the current and emerging uses of ITS technologies by state and local governments, (2) the challenges these governments face in using ITS, and (3) the extent to which DOT's efforts to promote and support ITS address these challenges and follow leading practices. To conduct this work GAO visited four sites, and interviewed and analyzed documents and data from DOT and state and local transportation officials, ITS experts, and other stakeholders.

A discussion of RITIS begins on page 17 of the report (page 21 of the PDF).

Recommendations for Improving the Use of Traffic Incident Management Performance Measures When Comparing Operations Performance Between State DOTs, Thomas H. Jacobs, Nikola Ivanov and Michael L. Pack, NCHRP Project 20-24(37)D, January 2011.
http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-24(37)D_FR.pdf
From the abstract: The initial premise behind the project was to use available state [d]epartments of [t]ransportation (DOTs) data on traffic incident response performance to provide a time series/cross section-sectional analysis of incident response performance, which could be measured based on average, median, or maximum incident response time, total incident duration or incident clearance time. The idea was that a cross-state comparison and examination of changes in performance over time might identify best practices that could be instrumental in reducing incident duration with associated benefits to travelers. For reasons explained in this research report, the primary emphasis of this project shifted to one of developing specific recommendations that could improve TIM performance measurement. While this research did result in a cross-state comparison for some of the participating agencies, the lack of standardization in collection and use of nationally adopted TIM performance measures made it difficult to draw definitive conclusions as to how the agencies are performing with respect to one another. What the research did yield is a set of recommendations that will be useful in enhancing existing agency TIM data collection and reporting efforts and the possible development of a standard approach to TIM performance data collection that will allow future efforts at cross-comparison to yield results that are consistent and more readily comparable.

Best Practices in Traffic Incident Management, Federal Highway Administration, September 2010.
https://ops.fhwa.dot.gov/publications/fhwahop10050/fhwahop10050.pdf
From the abstract: This report describes task-specific and cross-cutting issues or challenges commonly encountered by TIM responders in the performance of their duties, and novel and/or effective strategies for overcoming these issues and challenges (i.e., best practices). Task-specific challenges may include obtaining accurate information from motorists, accessing the scene, and condemning a spilled load. Cross-cutting challenges may include interagency coordination and communication, technology procurement and deployment, and performance measurement. The reported tools and strategies for improving TIM range from sophisticated, high-technology strategies to simple, procedural strategies. Information to support this investigation was obtained through (1) a review of published and electronic information sources and (2) input from TIM personnel in Arizona, California, Florida, Maryland, Michigan, Nevada, New Jersey, New York, Ohio, Pennsylvania, Tennessee, Texas, Utah, and Washington representing law enforcement, fire and rescue, emergency medical services, transportation, and towing and recovery agencies. For many of the individual tools and strategies, a wide range of effectiveness was reported by locale, challenging the explicit identification of best practices and suggesting that local conditions related to the nature and extent of operation, maintenance, marketing, etc., have a significant impact on the perceived or measured success of specific TIM efforts.

Federal Highway Administration Focus States Initiative: Traffic Incident Management Performance Measures Final Report, Nicholas D. Owens, April H. Armstrong, Carol Mitchell and Rebecca Brewster, Federal Highway Administration, December 2009.
https://ops.fhwa.dot.gov/publications/fhwahop10010/fhwahop10010.pdf
From the abstract: The Traffic Incident Management Performance Measures Focus States Initiative (TIM PM FSI) involves 11 [s]tates that have defined three traffic incident performance measures (PM) and conducted field tests of two of these measures. The following measures were defined in December 2005 and field tested for 18 months: 1. Reduce “roadway clearance” time (defined as the time between awareness of an incident and restoration of lanes to full operational status); and 2. Reduce “incident clearance” time (defined as the time between awareness of an incident and removal of all evidence of the incident, including debris or remaining assets, from shoulders). A third measure was defined at the final project workshop in October 2007 but has not yet been field tested; 3. Reduce the number of secondary incidents—specifically unplanned incidents for which a response or intervention is taken, where a collision occurs either a) within the incident scene or b) within the queue (which could include opposite direction) resulting from the original incident. The FSI represents the first effort by multiple [s]tates to measure TIM performance using common performance metrics. The results of the FSI demonstrated that TIM performance measurement is institutionally and technically viable. The participating [s]tates also demonstrated that integrating and coordinating TIM operations between multiple agencies can be done seamlessly. The final products of the FSI are an outreach plan and outreach products that can be used by [s]tates to promote TIM PM and integrated TIM programs.

Data Collection and Reporting Practices

The citations below provide information about data collection and reporting practices.

Guidance for Implementation of Traffic Incident Management Performance Measurement, National Cooperative Highway Research Program, undated.
http://nchrptimpm.timnetwork.org/
This web site provides "concise guidance on the consistent use and application of TIM performance measures in support of the overall efforts of TIM program assessment." The web site also includes information on performance measurement for TIM programs, including agency case studies, as well as information on creating a model database.

Related Resource:

> **Agency Case Studies**, Performance Measurement for Traffic Incident Management Programs, Applied Engineering Management Corp. and Texas A&M Transportation Institute, undated.
> http://nchrptimpm.timnetwork.org/?page_id=69
> An evaluation of TIM performance measurement practices in several states was conducted as part of the NCHRP 07-20 project and presented as case studies. *From the web site*:
>
> > The case studies encompassed a range of TIM capabilities and program maturity, with some at the start of performance measurement and others that have institutionalized TIM program assessment. The case studies focus on four core areas:
> >
> > - TIM program description,
> > - Data collection and management practices,
> > - Performance analysis and reporting practices, and
> > - Notable benefits from TIM performance measurement.

Using Data to Improve Traffic Incident Management, Federal Highway Administration, April 2018.
https://www.fhwa.dot.gov/innovation/everydaycounts/edc_4/timdata.cfm
This web site includes resources, webinars/videos and tools associated with TIM data collection and performance measures.

Related Resource:

> **Using Data to Improve Traffic Incident Management (TIM)**, Federal Highway Administration, 2016.
> https://www.fhwa.dot.gov/innovation/everydaycounts/edc_4/factsheet/traffic_incident_management.pdf
> This two-page fact sheet summarizes the state of the practice of data collection and performance measurement reporting.

Using Data to Improve Traffic Incident Management, Paul Jodoin, Federal Highway Administration, April 2018.
https://i95coalition.org/wp-content/uploads/2018/06/2-I95CC-CAD-Workshop-EDC4-TIM-FHWA-Presentation-Apr2018.pdf?x70560
This presentation to the I-95 Corridor Coalition includes data analysis examples from multiple states.

Using Data to Improve Traffic Incident Management: Next Generation TIM, Paul Jodoin, Federal Highway Administration, October 2016.
http://txstic.org/1.TXSTIC.Traffic%20Incident%20Management.pdf
This presentation to the Texas State Transportation Innovation Council addresses the Every Day Counts initiative and the "process of coordinating resources of many agencies and companies to detect, respond to, and clear traffic incidents as quickly as possible." The presentation includes data collection examples from Arizona and Michigan DOTs.

State Practices

Arizona

Traffic Incident Management and Reducing Secondary Crashes in Arizona, Eric Rensel, Peter Rafferty and Charles Yorks, Arizona Department of Transportation, November 2018.
https://apps.azdot.gov/files/ADOTLibrary/publications/project_reports/pdf/spr740.pdf
From the abstract: This study concentrated on identification of the benefits of effective Traffic Incident Management (TIM) practices on secondary crashes in terms of improved safety for motorists and first responders. The study begins the process of developing an assessment model that examines a well-defined situation and a known threat and estimates the relative risk. Based on the findings, recommendations were made to establish several action items for statewide TIM implementation and relationship building. The study resulted in identification of opportunities to collect additional data that will help better understand the time and spatial relationships of secondary crashes, linked to the time and spatial relationships of TIM tactics engaged in primary crashes. This has the potential for enhancing the recommended risk model that considers a number of factors and necessary data that would become available.

"TraCS and ACIS," Transportation Systems Management and Operations, Arizona Department of Transportation, *20th Annual Arizona Rural Transportation Summit*, October 2018.
https://www.azrts.org/2018-docs/04-Presentation-PPT-ADOT.pdf
This presentation describes the agency's traffic data collection and reporting systems: Traffic and Criminal Software (TraCS) and Arizona Crash Information System (ACIS).

Florida

Traffic Incident Management, Florida Department of Transportation, undated.
http://www.floridatim.com/
This web site summarizes Florida DOT's TIM program, including links to documents and publications, meetings, events, programs and services.

Illinois

"Development of Incident Management Performance Measures for the Illinois State Toll Highway Authority," Jeff Hochmuth, John Benda, Jim Powell and Bill Hereth, *18th ITS World Congress*, ITS America, 2011.
https://ertico.assetbank-server.com/assetbank-ertico/action/viewAsset?id=8612&index=177&total=569&collection=2011+Orlando&categoryId=32&categoryTypeId=1&filterId=0&modal=true&sortAttributeId=0&sortDescending=false
From the abstract: The Illinois Tollway has operated ITS devices for several decades. In 2002 the Tollway opened their state of the art Traffic and Incident Management System (TIMS), which now manages all ITS devices including CCTV, DMS, and real time traffic information from two sources. By 2003, TIMS was integrated with the existing Tollway computer aided dispatch (CAD) system. This allowed incident information from the Illinois State Police and Tollway

Maintenance Forces to be directly input into the TIMS system. Vast amounts of data are produced by both the TIMS and CAD systems daily. This in turn has created an ever increasing number of inquiries from managers and executives. The industry was reviewed to understand how other agencies were successfully using similar data. Collectively, over 100 different performance measures were identified. Wilbur Smith identified 26 existing reports and 23 new reports that best matched the Tollway data and operational needs. Many of these reports required a baseline—a defined “normal” condition—for which to compare incident conditions, with a focus on actual conditions as opposed to modeled or daily speed profiles across the system. By comparing daily and average speed profiles near crashes, the Tollway can now directly and accurately determine the measured impact of incidents. With these new tools, the Illinois Tollway is able to make more informed operational and planning decisions on a variety of issues.

Iowa

Traffic Incident Management (TIM) Service Layer Plan, Version 1.4, Iowa Transportation Systems Management and Operations (TSMO), Iowa Department of Transportation, January 2018.
https://iowadot.gov/TSMO/ServiceLayerPlan2.pdf
From the goals and objectives: The TIM Service Layer supports both the strategic and programmatic goals and objectives of the Iowa DOT. It establishes specific objectives to guide the day-to-day activities, prioritize projects and services, and establish performance-based management of TIM activities in Iowa. Table 1 shows the TSMO strategic goals and objectives for Iowa DOT. Table 2 shows the programmatic objectives identified for performance monitoring within the TIM Service Layer. Further consideration for the TIM Service Layer identifies more specific objectives to support the program objectives and the TSMO strategic objectives. Iowa DOT staff and key TIM partners identified service layer objectives, also shown in Table 2. These objectives reflect key components of successful TIM plans identified in Federal Highway Administration’s (FHWA) Traffic Incident Management Gap Analysis Primer.

Kentucky

Improving the Quality of Traffic Records for Traffic Incident Management, Reginald Souleyrette, Mei Chen, Xu Zang, Eric R. Green and Shraddha Sagar, Kentucky Transportation Cabinet, December 2018.
https://uknowledge.uky.edu/cgi/viewcontent.cgi?article=2630&context=ktc_researchreports
From the abstract: This project analyzes the three TIM performance measures: roadway clearance time, incident clearance time and secondary crashes of Kentucky to identify a baseline for performance which may indicate potential for improvement. The study pinpoints different data sources, tools and technologies that can be used to collect and analyze TIM performance measures. Kentucky State Police (KSP) Crash Database and TRIMARC Incident Records are the two principal data sources used. In addition, Waze and HERE speed data are also examined for potential use. Lastly, the three national performance measures are summarized and analyzed. They comprise a baseline for future performance assessment.

Research in Progress:

> **Traffic Incident Management (TIM) Dashboard**, Kentucky Transportation Cabinet; start date: July 1, 2019, expected completion date: June 30, 2020.
> Project description at https://trid.trb.org/view/1638639
> *From the project description*: The study will update methodologies for TIM performance measures and develop a dashboard to track the performance and evaluate the effectiveness

of TIM improvements. Researchers will conduct a literature review on practices used in other states, with a particular focus on the institutionalization of TIM. They will produce an expanded list of TIM performance measures for Kentucky: roadway clearance time (RCT), incident clearance time (ICT), secondary crashes (SC), and responders struck by (RSB) and develop a Kentucky TIM dashboard for periodically updating and tracking performance measures.

Nevada

Development of a Statewide Pilot Project for Standardized TIM Performance Measurement and Reporting, Kelley Klaver Pecheux, Benjamin Pecheux and Cara O'Donnell, Nevada Department of Transportation, July 2016.
https://www.nevadadot.com/home/showdocument?id=9371
From the abstract: This report describes the approach and findings associated with the development of a statewide pilot project for standardized traffic incident management (TIM) performance measurement and reporting. The project included four primary objectives: (1) benchmark Nevada's practices against those of leading peer agencies, (2) assess the quantity and quality of incident data available in Nevada, (3) develop a prototype integrated TIM performance database using available data, and (4) develop a prototype interactive dashboard that displays TIM performance measures using the database. Five sources of incident data were assessed: the Nevada Department of Transportation's (NDOT) freeway service patrol program; NDOT's statewide crash database; the Nevada Highway Patrol's computer-aided dispatch system; the Northern Nevada Road Operation Center; and the Freeway and Arterial System of Traffic. A step-by-step process for integrating data from the various sources was developed and implemented. A number of challenges and limitations associated with the data were identified. Finally, a prototype dashboard was developed that displays a variety of aggregate and disaggregate TIM performance measures. Recommendations for filling some of the data gaps are provided.

Texas

"Every Day Counts–Round 4 (EDC4): Accelerated Traffic Incident Management (TIM) Data Collection to Improve Overall Traffic Incident Management," Jeff Kaufman, *TxSTIC Meeting*, November 2018.
http://www.txstic.org/docs/download/Nov%202018%20TxSTIC%20Presentation.pdf
This presentation summarizes the FHWA EDC4 Program including project background, project scope, Waze and CAD integration and performance measures. The presentation also addresses how the information collected can be used to report on incident management activities throughout Texas.

Review of Literature and Practices for Incident Management Programs, Tim Lomax and Lauren Simcic, Texas A&M Transportation Institute, June 2016.
https://static.tti.tamu.edu/tti.tamu.edu/documents/PRC-15-56-T.pdf
This report focuses on the review of literature and practices for incident management programs, the FHWA's analysis of the important elements of TIM programs and characteristics that are associated with a high-performing program, incident management key strategies, performance measures and targets, key rapid clearance strategy elements, and attributes and experiences from incident management programs.

Evaluating and Improving Incident Management Using Historical Incident Data: Case Studies at Texas Transportation Management Centers, Praprut Songchitruksa, Kevin Balke, Xiaosi Zeng, Chi-Leung Chu, Yunlong Zhang and Geza Pesti, Texas Department of Transportation, August 2009.
https://pdfs.semanticscholar.org/d68b/c06ffeb4596bab8194c7401550707e7413a5.pdf
From the abstract: The companion guidebook (0-5485-P2) developed as part of this study provides the procedures and methodologies for effective use of historical incident data at Texas Transportation Management Centers (TMCs). This research report documents the results from the case studies conducted using the procedures outlined in the guidebook. Researchers examined the data collected from three Texas TMCs, which are Houston's TranStar, Austin's Combined Transportation and Emergency Communications Center (CTECC), and Fort Worth's TransVISION. Researchers conducted six categories of analyses in this study – (a) analysis of incident characteristics, (b) hot spot analysis, (c) incident impact estimation, (d) analysis of incident management performance measures, (e) incident duration prediction, and (f) incident-induced congestion clearance time prediction.

Researchers found that historical incident data can be effectively used to support incident management and performance evaluation processes both reactively and proactively. Some procedures need to be automated to be used efficiently in day-to-day operations. As such, various prototype tools, such as the incident duration and incident-induced congestion clearance prediction tools, were developed during this study to facilitate and automate the proposed methodologies. These prototype tools provided a platform for TxDOT to deploy the research results in the future.

Related Resource:

> **A Guidebook for Effective Use of Incident Data at Texas Transportation Management Centers**, Praprut Songchitruksa, Kevin Balke, Xiaosi Zeng, Chi-Leung Chu, Yunlong Zhang and Geza Pesti, Texas Department of Transportation, February 2009.
> Publication available at https://rosap.ntl.bts.gov/view/dot/37051
> *From the abstract*: This guidebook provides methodologies and procedures for using incident data collected at Texas transportation management centers (TMCs) to perform two types of analysis – evaluation/planning analysis and predictive analysis. For the evaluation/planning analysis, this guidebook provides (1) guidelines for reporting incident characteristics, (2) methods for analyzing hot spots, (3) methodologies for estimating incident impacts, and (4) guidelines and procedures for calculating performance measures. For predictive analysis, this guidebook describes (1) methodologies for predicting incident duration using incident characteristics and (2) methodologies for predicting incident-induced congestion clearance time using combined historical and real-time traffic data. Examples of applications and results from the methodologies and procedures described are provided throughout this guidebook.

Utah

Analysis of Performance Measures of Traffic Incident Management in Utah, Grant G. Schultz, Mitsuru Saito, Mitchell G. Hadfield, Logan S. Bennett and Dennis L. Eggett, Utah Department of Transportation, April 2019.
https://www.udot.utah.gov/main/uconowner.gf?n=7287761759464127
From the abstract: In 2009 the Federal Highway Administration published a report regarding a Focus States Initiative that had been conducted with 11 states to discuss the development of national Traffic Incident Management (TIM) standards. Performance measures were defined, and a national TIM dashboard created, but very little data have been added to the dashboard

since. In this research study, performance measures of the Utah Department of Transportation (UDOT) TIM program were analyzed. Data availability was first assessed to determine whether these performance measures could be calculated. It was determined that crash response data available from the Utah Highway Patrol (UHP) could be used to calculate the performance measures of Incident Management Teams (IMT) and UHP units; however, roadway clearance data were missing. UHP personnel agreed to collect additional data regarding crash roadway clearance for six months of the study. Performance measures were calculated for responding units at 168 crashes. Using the crash response data from UHP and traffic speed, travel time, and volume data from UDOT databases, 83 crashes were evaluated to determine the volume of traffic affected by each incident and the associated user cost. Statistical analyses were conducted to assist UDOT in optimizing the allocation of their IMT resources.

Virginia

Highway Performance—Incident Duration, Virginia Department of Transportation, September 2019.
http://dashboard.virginiadot.org/Pages/Performance/IncidentDuration.aspx
This web page provides incident duration data by district and date range, as well as a summary of the information based on percentages or numbers of incidents. The "Details" tab provides incident clearance data by date; the "Trends" tab charts the percent of incidents cleared by length of time (less than 30 minutes, 30 to 60 minutes, 60 to 90 minutes and greater than 90 minutes) and date.

Primary and Secondary Incident Management: Predicting Durations in Real Time, Asad J. Khattak, Xin Wang, Hongbing Zhang and Mecit Cetin, Virginia Center for Transportation Innovation and Research, April 2011.
http://www.virginiadot.org/vtrc/main/online_reports/pdf/11-r11.pdf
From the abstract: The main objectives of this study were to define secondary incidents, understand and analyze the occurrence and nature of such incidents, and develop tools that can comprehensively and continuously analyze primary and secondary incidents at the planning and operational levels, ultimately contributing to congestion management. The scope of the study is limited to freeway incidents in the Hampton Roads (HR) area.
….
This study developed and applied a dynamic queue-based tool (SiT) [Secondary Incident Identification Tool] to identify primary and secondary incidents from historical incident data and incorporated the models developed for incident duration, secondary incident occurrence and associated delays in an online prediction tool (iMiT) [Incident Management Integration Tool]. Although the tools developed in this study (SiT and iMiT) are currently calibrated using HR data, the methodology is transferable to other regions of Virginia.

International Resources

"Overview of Traffic Incident Duration Analysis and Prediction," Ruimin Li, Francisco C. Pereira and Moshe E. Ben-Akiva, *European Transport Research Review,* Vol. 10, Article 22, May 2018.
https://etrr.springeropen.com/articles/10.1186/s12544-018-0300-1
From the introduction: The objective of this study is to conduct a thorough review and discuss the research evolution, mainly including the different phases of incident duration, data resources, and the various methods that are applied in the traffic incident duration influence factor analysis and duration time prediction.

"Traffic Incident Management: Framework and Contemporary Practices," Auttapone Karndacharuk and Asif Hassan, *Australasian Transport Research Forum*, November 2017.
https://www.atrf.info/papers/2017/files/ATRF2017_108.pdf
From the abstract: A framework has been developed to present many aspects of traffic incident management (TIM) with an aim to harmonize incident management approaches in Australasia. By providing road network managers and incident management service providers with a guidance and common understanding of the ongoing process for integrating TIM practices and techniques, traffic disruption and road safety risk can be managed in a more coordinated and effective manner. Based on the Austroads research report (AP-R547-17), this paper presents the TIM framework and underlying principles for the various incident management phases from multi-agency collaboration and planning to performance evaluation and capability development. The outcome of identifying contemporary TIM practices from a review of jurisdictional policy and procedure documentation is discussed to support the overarching goal of the framework in maintaining mobility and improving safety during an incident.

Related Resource:

> **Techniques for Incident Management to Support Network Operations Planning**, Auttapone Karndacharuk and Asif Hassan, Austroads, July 2017.
> https://austroads.com.au/publications/traffic-management/ap-r547-17
> *From the abstract*: This report investigates current local and international incident management techniques and proposes an Australasian incident management framework that supports network operations planning. A literature review highlights the fact that traffic incident management (TIM) is not only a process of managing multi-agency, multi-jurisdictional response to road traffic incidents, but also a broader management program that involves an objective setup, stakeholder collaboration, option development and selection, implementation and performance evaluation. Baseline and emerging TIM techniques and practices for the collection of road and traffic data and the response to incident management needs were also reviewed and new and emerging techniques for traffic incident management identified. To assist in the establishment of a harmonised TIM methodology across Australasia, an incident management framework was developed based on the leading practices and techniques. The adoption of this integrated framework, which is underpinned by seven management principles, would improve the operation and safety of the road network by reducing the impact of planned and unplanned incidents. While the potential implications and benefits of the new technologies within the TIM framework have been briefly discussed in this report, quantifying the safety and efficiency impacts of different TIM techniques requires further investigation.

"Best Practice in European Traffic Incident Management," John Steenbruggen, Michel Kusters and Gerrit Broekhuizen, *Procedia-Social and Behavioral Sciences*, Vol. 48, pages 297-310, 2012.
https://core.ac.uk/download/pdf/82224351.pdf
From the abstract: The Conference of European Directors of Roads (CEDR) investigates how countries can develop their IM [incident management] capabilities to support policy goals and the needs of road users. The purpose of this study is to facilitate the cooperation, on a European level, by exchanging experience and information. This will support countries across Europe to minimise the economic cost of incidents, improve road safety and, decrease mobility problems through the implementation of relatively low cost IM measures.

"A Synthesis of Emerging Data Collection Technologies and Their Impact on Traffic Management Applications," Constantinos Antoniou, Ramachandran Balakrishna and Haris N. Koutsopoulos, *European Transport Research Review*, Vol. 3, Issue 3, pages 139-148, November 2011.
https://link.springer.com/article/10.1007/s12544-011-0058-1
From the abstract: The objective of this research is to provide an overview of emerging data collection technologies and their impact on traffic management applications. Several existing and emerging surveillance technologies are being used for traffic data collection. Each of these technologies has different technical characteristics and operating principles, which determine the types of data collected, accuracy of the measurements, levels of maturity, feasibility and cost, and network coverage. This paper reviews the different sources of traffic surveillance data currently employed, and the types of traffic management applications they may support. Automated Vehicle Identification data have several applications in traffic management and many more are certain to emerge as these data become more widely available, reliable, and accessible. Representative examples in this field are presented. Furthermore, the fusion of condition information with traffic data can result in better and more responsive dynamic traffic management applications with a richer data background**.**

"Best Practice in European Traffic Incident Management," David Stones, *Conference of European Directors of Roads*, March 2011.
https://www.cedr.eu/download/Publications/2012/e_Incident_Management.pdf
From the executive summary: The first part of the report … outlines the motivation, composition, strategy, methodology and results of the task, as well as issues "for decision." This is followed by appendices devoted to best practice at operational, tactical and strategic levels. Appendix A is a framework guide that summarizes the essential components and factors in TIM including the cycle of phases which make up the critical timeline. Appendix B addresses wider concepts for effective TIM including international best practice. Appendix C highlights both the role of TIM in relation to the EC's ITS Action Plan and the EasyWay project and paths for development of TIM capability. Appendix D contains definitions and references.

Related Resources

The citations below provide information about TIM modeling and metrics. Also included is a presentation about EventFlow, a potential system of interest.

"Temporal Event Analytics With EventFlow: A Case Study of the Response to Fatal Incidents, Baltimore Region, 2014–2016," Jason Dicembre, Michael VanDaniker, Catherine Plaisant, Fan Du and Eileen Singleton, *8th International Visualization in Transportation Symposium*, Baltimore Metropolitan Council, July 2017.
http://onlinepubs.trb.org/onlinepubs/Conferences/2017/visualization/Presentations_Viz/48.VanDaniker.pdf
This presentation describes the use of EventFlow for evaluating traffic incidents.

"A Comprehensive Framework of Performance Measurement for Traffic Incident Management Programs," Md Sakoat Hossan, Xia Jin, Zhaohan Zhang, Albert Gan and Dong Chen, *Transportation Research Board 94th Annual Meeting*, Paper #15-0286, 2015.
Citation at https://trid.trb.org/view/1336582
From the abstract: This paper presents a comprehensive performance measurement framework that covers all aspects of TIM activities. This framework applies to all stages of TIM programming, from initiating a new program, to evaluating or improving an existing one. Specific, feasible and quantifiable indicators are developed that address all elements in a TIM

program, from strategic program planning and development, to tactical operations and tools, and supporting data and communication component. This performance measurement framework provides a guidance and serves a basic outline to facilitate any further customization for a TIM program. In addition, a brief overview of performance of TIM programs is provided based on a nationwide TMC survey. This benchmark analysis could provide some useful information for agencies who are interested to compare their performances.

"Modeling Analysis of Incident and Roadway Clearance Time," Huaguo Zhou and Zhaofeng Tian, *Procedia-Social and Behavioral Sciences*, Vol. 43, pages 349-355, 2012.
https://cyberleninka.org/article/n/1168243.pdf
From the abstract: This research explored the relationship between incident clearance time and roadway clearance time using microsimulation VISSIM modelling to run different traffic incident scenarios. Approximately 50 traffic incident scenarios were developed to generate the data for different types of incidents under traffic conditions. Number of through lanes, number of blocked lanes, and traffic volumes were some of the variables being considered. Then, a mathematic model was developed to demonstrate the relationship between roadway clearance time and incident clearance time.

Identifying Methods and Metrics for Evaluating Interagency Coordination in Traffic Incident Management, Robert G. Feyen and Chinweike I. Eseonu, Intelligent Transportation Systems Institute, Center for Transportation Studies, University of Minnesota, May 2009.
Report available at
http://www.cts.umn.edu/Publications/ResearchReports/reportdetail.html?id=1764
From the abstract: This study found DOTs collect basic TIM performance measures (e.g., lane clearance times), but many do not record additional measures, consistently review the collected data or analyze it unless needed to answer specific questions. Since performance evaluation of interagency coordination is one area of TIM in which little success has been attained (FHWA, 2003), process improvement methods from operations management may prove useful. To illustrate, interagency incident response for a disabled vehicle (no injuries or property damage) is modeled as a process in which appropriate resources (e.g., state police, tow) must coordinate to safely remove the vehicle and restore normal traffic flow. Completing these events requires the resources to perform specific functions, each taking more or less time depending on various factors (e.g., weather, time of day). Response time data can highlight geographic areas or process segments with highly variable event times, leading to investigation and recommendations to reduce variability and, ultimately, traffic delays. Based on this approach, recommendations are made for data collection and analysis of appropriate TIM performance measures.

Contacts

State Agencies

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Appendix A: Survey Questions

The following survey was distributed to members of the American Association of State Highway and Transportation Officials (AASHTO) Committee on Transportation System Operations who had experience with traffic incident management (TIM) data systems and practices.

Traffic Incident Management Data Collection

Note: Response to the question below determined how a respondent completed the survey:

- *Respondents who answered "no" were directed to the **Agencies Not Gathering Data for Performance Measures** section in the survey.*
- *Respondents who answered "yes" were directed to the **Roadway Clearance Time** section in the survey.*

Is your agency using a system, process or database to collect traffic incident management (TIM) data to report on one or more of the three national performance measures listed below that are recommended under Federal Highway Administration's Every Day Counts (EDC-4) initiative?

- Roadway clearance time (time it takes to open the roadway due to an incident).
- Incident clearance time (time it takes to clear the incident; when the responders have left).
- Number of secondary crashes.
    - No.
    - Yes.

Agencies Not Gathering Data for Performance Measures

*Note: After responding to the question below, this group of respondents is directed to the **Wrap-Up** section.*

Does your agency have an interest in or plans to use a system, process or database to collect data to report on TIM-related performance measures?

- Our agency has no interest in reporting on these performance measures.
- Our agency has an interest in reporting on these performance measures but lacks the resources to do so.
- Our agency plans to report on these performance measures. (Please describe your agency's plans below.)

Roadway Clearance Time

Does your agency gather data to measure **roadway clearance time**?

- No (directs the respondent to **Incident Clearance Time**)
- Yes (directs the respondent to the questions below)

1. What roadway clearance time data does your agency gather?
2. What data sources does your agency use to gather this data (for example, traffic management centers, law enforcement, highway service patrols and freeway service patrols)?
3. When receiving data from these sources, what data format is used?
4. Please describe the challenges your agency has experienced when gathering data to measure and report on roadway clearance time.

Incident Clearance Time

Does your agency gather data to measure **incident clearance time**?

- No (directs the respondent to **Number of Secondary Crashes**)
- Yes (directs the respondent to the questions below)

1. What incident clearance time data does your agency gather?
2. What data sources does your agency use to gather this data (for example, traffic management centers, law enforcement, highway service patrols and freeway service patrols)?
3. When receiving data from these sources, what data format is used?
4. Please describe the challenges your agency has experienced when gathering data to measure and report on incident clearance time.

Number of Secondary Crashes

Does your agency gather data to measure the **number of secondary crashes**?

- No (directs the respondent to **Wrap-Up**)
- Yes (directs the respondent to the questions below)

1. What secondary crash data does your agency gather?
2. What data sources does your agency use to gather this data (for example, traffic management centers, law enforcement, highway service patrols and freeway service patrols)?
3. When receiving data from these sources, what data format is used?
4. Please describe the challenges your agency has experienced when gathering data to measure and report on secondary crashes.

Wrap-Up

1. If available, please provide links to documentation related to your agency's TIM data system and data collection practices. Send any files not available online to carol.rolland@ctcandassociates.com.
2. Please provide contact information for the staff member(s) we can contact to obtain more information about your agency's practices.
3. Please use this space to provide any comments or additional information about your previous responses.

CHART PROGRAM

ATMS

SYSTEM ARCHITECTURE

Version 27.0
Doc# ATMS-OPS-003

Date: August 28, 2018

Prepared by: GENERAL DYNAMICS Information Technology

Approved via separate Deliverable Acceptance Form per RFP section 3.9.2

Revision History

Date	Version	Description	Page Affected	Author
09/05/2000	0	Initial Release	All	
06/30/2005	1	Update for R1B4 and incorporation of Video into CHART II		
12/11/2009	2	Updates for R2B3, R3B1, R3B3, R3B3 CHART ATMS Releases		
04/29/2010	3	Updates for R4 CHART ATMS Release		
04/30/2010		Updates to reflect client comments		
09/28/2010	4	Updates for CHART R5 Release		
01/11/2011	5	Updates for CHART R6 Release		
01/13/2011	6	Updates to address comments from D. Lineweaver		
06/29/2011	7	Updates for CHART R7 Release		
09/05/2011	8	Updates for CHART R8 Release		
12/15/2011	9	Updates for CHART R9 Release		
04/24/2012	10	Updates for CHART R9S Release	Most	
10/10/2012	11	Updates for CHART R10 Release	Various	
10/31/2012	12	Updates for CHART R10C Release	Various	
03/01/2013	13	Updates for CHART R11 Release	Complete Rewrite	
11/25/2013	14	Updates for Mapping R11, LCP Phase 1 and CHART R12 Release	Various	
03/03/2014	15	Final updates for CHART R12 Release	Various	
05/02/2014	16	Updates for CHART ATMS R13 Release	Various	
11/07/2014	17	Updates for CHART ATMS R14 Release	Various	
05/22/2015	18	Requested updates to the CHART ATMS R14 version: add Figure 3-3, modify Figure 5-1. Also updated prototype.js version to 1.7.2	55, 104, 144	
02/05/2016	19	Updates for CHART ATMS R15 Release	Various	
05/19/2016	20	Updates for CHART ATMS R16 Releases / External Connection Updates	Various	
06/17/2016	21	Updates for WO55	Various	
10/25/2016	22	Update for WO 09	Various	Chris Brennan
12/22/2016	22.1	Corrected cover page title, added doc#, and the file name; Added Revision History.	Cover, Revision History Pages	Delena McFadden-Mello

03/08/2017	22.2	Corrected cover page title, added doc#, and the file name; Added Rev History.	Cover, History	Michael Fleming
06/15/2017	23.0	Updated for WO 10	Various Pages	CSRA Team
08/08/2017	24.0	Updates for WO14 Del 23 Streaming Video Player Upgrade Phase2 ATMS R18.1	Various	CSRA Team
12/05/2017	25.0	Updates for WO15 Del 13 MD511 Merge into ATMS - Phase 1 and Phase 2 - ATMS R18.2 and R18.3	Various	CSRA Team
02/02/2018	26.0	Updates for WO15 MD511 – Phase 3 – ATMS R18.4	Various	CSRA Team
4/13/2018 8/28/2018	27.0	Updates for WO22 upgrades to COTS, Decision Support, HAR Templates, and RITIS import ATMS R19	Various	GD Team

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1 INTRODUCTION

1.1 Purpose

This document presents the architecture of the Coordinated Highways Action Response Team (CHART) Advanced Traffic Management System (ATMS). The architecture of the CHART ATMS is presented as a number of different "views", with each view representing a different perspective of the system.

1.2 Views Descriptions

Each view is described in Table 1-1. In addition, there are various appendices, described in Table 1-2.

Table 1-1. CHART ATMS Architecture Document Views

View Name	Description	Typical Stakeholders	Section
Feature List View	Provides a brief high-level overview of the CHART ATMS and describes the features available in the system	Representatives from other agencies interested in CHART ATMS's capabilities, as well as operators, support personnel, developers, and managers	2
Functional View	Describes basic CHART ATMS functionality and some key operational concepts that drove how the functionality has been implemented	Developers, managers and officials from other organizations, looking to interface with or build a system like the CHART ATMS	3
System View	Shows system components and how they connect to each other	System administrators, software developers and architects and others interested in the system-level architecture	4
Interface View	Describes the CHART ATMS external interfaces	Representatives from other agencies interested in CHART ATMS's capabilities, specifically software and system architects who may be looking to interface with CHART ATMS	5
Data View	Describes how data moves into, out of, and around the CHART ATMS	CHART ATMS database administrators (DBAs), management, developers, and stakeholders of connected systems	6

View Name	Description	Typical Stakeholders	Section
Deployment View	Describes the various CHART ATMS deployment configurations	Operations & Maintenance personnel, network engineers	7
Subsystem View	Describes CHART ATMS software/ hardware subsystems and Commercial Off-The-Shelf (COTS) products	Developers, configuration managers, and management	8
Standards View	Describes the standards used by the CHART ATMS	Management, CHART ATMS developers, and those looking to interface with the CHART ATMS	9
Business Architecture View	Describes the CHART ATMS from a business process perspective	Business Area Architecture (BAA) process participants, those interested in CHART's business plan and its mapping to CHART capabilities	10
System Maintenance View	Describes Operations and Maintenance aspects of the CHART ATMS	System administrators, software and system architects, others interested in CHART ATMS maintenance tasks	11

Table 1-2. CHART ATMS Architecture Document Appendices

Appendix	Description
A	Design studies performed during the development of the CHART ATMS
B	Major prototypes created during the development of the CHART ATMS
C	Database entity-relationship (ER) diagrams describing the design of the CHART ATMS database
D	Release history of the CHART ATMS

1.3 Applicable Documents

Relevant documents associated with the system architecture are listed in the Table 1-3 below.

Table 1-3. Document References

Requirements and Vision
CHART II System Requirements, May 5, 2000, M361-RS-002R2.
CHART II Business Area Architecture Report, August 23, 2000, M361-BA-005.
CHART Video Software Requirements, June 2005

CHART R2B3 Requirements, October 2006
CHART Business Area Architecture, January 2007, W01-BA-001
CHART R3B1 Updated Software Requirements Revision 2, January 2008, W009-WS-001R2
CHART Business Area Architecture Revision 1, January 2008, W01-BA-001R1
CHART R3B2 Updated Software Requirements Revision 3, September 2008, W011-RS-002R3
CHART Business Area Architecture Revision 2, October 2008, W01-BA-001R2
CHART R3B3 Updated Software Requirements Revision 2, November 2009, WO15-RS-001R2
CHART Business Area Architecture Revision 3, December 2009, WO001-RS-001R3
CHART R4 Updated Software Requirements Revision 1, March 2010, WO17-RS-001R1
CHART Business Area Architecture Revision 4, April 2010, WO001-RS-001R4
CHART R5 Updated Software Requirements Revision 1, March 2010, WO18-RS-001R1
CHART Business Area Architecture Revision 5, September 2010, WO001-RS-001R5
CHART R6 Updated Software Requirements, August 2010, WO19-RS-001
CHART R7 Updated Software Requirements, February 8 2011, WO21-RS-001
CHART R8 Updated Software Requirements Revision 4, August 1 2011, WO23-RS-001R4
CHART R9 Updated Software Requirements, July 25 2011, WO24-RS-001
CHART Business Area Architecture Revision 10, April 2, 2012, WO1-BA-001R10
CHART R10 Updated Software Requirements, August 14, 2012, W028-RS-001
CHART Release 11/Mapping R10 Software Requirements, October 24, 2012, WO31-RS-001
CHART Business Area Architecture Revision 11, November 30, 2012, W01-BA-001R11
CHART R12 Software Requirements Revision 1, October 8, 2013, WO35-RS-001R1
CHART Business Area Architecture Revision 12, July 10, 2013, W01-BA-001R12
CHART ATMS/Mapping R13 Software Requirements, December 11, 2013, WO38-RS-001
CHART Business Area Architecture Revision 13, January 28, 2014, W01-BA-001R13
CHART ATMS R14 Software Requirements, September 9, 2014, WO41-RS-001
CHART Business Area Architecture Revision 14, September 5, 2015, W01-BA-001R14
WO49 CHART ATMS R15/LCP R5 Software Requirements Rev 3, March 1, 2016, WO49-RS-001R3
WO53 CHART ATMS R16/Mapping R17/CHARTWeb 3.1/EORS 6.2 WO54 External Connections Updates Software Requirements Rev 1, May 17, 2016, WO53-RS-001R1

WO 09 ATMS R17 Updated Software Requirements, September 13, 2016
WO 10 Del 1 ATMS R18 Software Requirements Rev2, May 15, 2017
2016 Business Area Architecture Revision 17, March 15, 2017, CHART-OPS-014-v17
WO14 Del 9 ATMS R18.1 Software Requirements, July 10, 2017
WO15 Del 1 ATMS R18.2 Software Requirements, September 7, 2017
WO15 Del 3 ATMS R18.3 Software Requirements, January 16, 2018
WO22 Del 1 ATMS R19 Software Requirements, April 13, 2018, WO22-ATMS-RD-001-v1.0
Design
CHART II R1B1 High Level Design, July 16, 1999, M361-DS-001R0
CHART II R1B1 Detailed Design, January 21, 2000, M361-DS-002R0
CHART II R1B1 Graphical User Interface (GUI) High Level Design, January 21, 2000, M361-DS-003R0
CHART II R1B1 GUI Detailed Design, January 21, 2000, M361-DS-004R0
CHART II R1B2 High Level Design, May 17, 2000, M361-DS-005R0
CHART II R1B2 Servers Detailed Design, May 2000, M361-DS-006R0
CHART II R1B2 GUI Detailed Design, May 2000, M361-DS-007R0
CHART II R1B3 High Level Design, January 2001, M362-DS-009R0
CHART II R1B3 Servers Detailed Design, March 2001, M362-DS-011R0
CHART II R1B3 GUI Detailed Design, March 2001, M362-DS-010
CHART II R1B4 National Transportation Communication for Intelligent Transportation Society (ITS) Protocol (NTCIP) Driver High Level Design, December 2001
CHART II R1B4 NTCIP Driver Detailed Design, May 2002
CHART Lite 2.0 System Design Document, April 2005
CHART II R2B1 Design, February 2006, M362-DS-019
CHART R2B2 Design, March 2006, M362-DS-020
CHART R2B3 Design, November 2006
CHART R3B1 Detailed Design, July 2007, W009-DS-001
CHART R3B2 Detailed Design, July 2008, W011-DS-001R2
CHART R3B3 Detailed Design, December 2008, W015-DS-001
CHART R4 Detailed Design Revision 1, March 2010, WO17-DS-001R1
CHART R5 Detailed Design Revision 1, March 2010, WO18-DS-001R1
CHART R6 Detailed Design, September 2010, WO19-DS-001

CHART R7 Detailed Design, March 2 2011, WO21-DS-001
CHART R8 Detailed Design, May 23 2011, WO23-DS-001
CHART R9 Detailed Design, August 26 2011, WO24-DS-001
CHART R10 Detailed Design Revision 3, August 14, 2012, WO28-DS-001
CHART R11 Detailed Design, November 26, 2012, WO31-DS-001
CHART R12 Detailed Design, September 20, 2013, WO35-DS-001
CHART R13 Detailed Design Rev 1, February 27, 2014, WO38-DS-001
CHART R14 Detailed Design, October 28, 2014, WO41-DS-001
CHART ATMS Release 15 Detailed Design, September 25, 2015, WO49-DS-001
CHART ATMS Release 16 Detailed Design, April 21, 2016, WO53-DS-001
WO 09 ATMS Release 17 System Design Document, September 22, 2016
WO 10 Del 3 ATMS R18 Detailed Design, June 21, 2017
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WO 22 Del 1 ATMS R19 Detailed Design, August 24, 2018, WO22-ATMS-RD-002-V1.0
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2 FEATURE LIST VIEW

2.1 View Description and Typical Stakeholders

This view provides a brief high-level overview of the CHART ATMS and describes the features available in the system. This section is suitable for those who would like to have an easy-to-digest list of features CHART ATMS provides, such as representatives from other agencies interested in CHART ATMS's capabilities, as well as operators, support personnel, developers, and managers just coming in who are new to CHART, or who would like a quick refresher.

2.2 CHART ATMS Overview

The CHART ATMS is a set of software programs used to identify and track traffic flow disruptions, send responders to correct the disruption and notify the public using Dynamic Message Signs (DMSs) and Highway Advisory Radios (HARs), and send notifications to the media and feeding data to a live traffic web site (http://www.traffic.maryland.gov) and Maryland 511. The system runs on a combination of Windows 2016 Servers, connected to a statewide network of Closed Circuit Television (CCTV) cameras, overhead and portable DMSs, HARs, Traffic Sensor Systems (TSSs) (microwave traffic flow detectors), remote weather stations, and On/Off devices (electronic relay devices such as for horns and fog beacons). The software is built using Java and C++ and connects to a Microsoft SQL Server database. Interprocess communications is achieved using an industry standard CORBA (Common Object Request Broker Architecture) package and web services (typically Extensible Markup Language (XML) over Hyper Text Transfer Protocol (HTTP)). A web-based Graphical User Interface (GUI) is connected to the CHART ATMS services using CORBA listeners and provides full CHART ATMS functionality to authorized users over a browser. The system provides data to interested parties via multiple systems both inside and outside the CHART Program umbrella, including CHART's own CHARTWeb public web site and the CHART Mapping Intranet Map (both part of CHART), and the Regional Integrated Transportation Information System (RITIS) at the University of Maryland (largely independent of SHA). This data is provided by means of two data exporter services (one internal, one external). The CHART Program provides data which is originally created via the CHART ATMS through a secure connection to the MDOT network, by providing a secure Geographic Information System export and by providing Really Simple Syndication (RSS) XML feeds on the internet. CHART ATMS and the CHART Program as a whole provide video by transcoding the statewide video and feeding it in multiple video formats through the MDOT internal network, the Statewide Government Intranet (SWGI) and the internet.

2.3 Feature List

The complete list of all features supported by the CHART ATMS is shown below:

- Operations Center
    - Select Operations Center at Login
    - Add an Operations Center
    - Remove an Operations Center
    - Modify an Operations Center

- User management
  - Add and modify user accounts, assign user roles to them, reset passwords
  - Delete user accounts
  - Configure password strength and password expiration rules
  - Administratively disable and re-enable user accounts
  - Configure automatic disabling of no-longer used user accounts
  - Define user roles by assigning granular functional rights to them
  - Define external client roles by assigning (usually very few) functional rights to them
  - Log in, authenticate, grant rights to logged in users
  - Authenticate, grant rights to web service clients
  - Administratively force logout
  - Alert for unhandled resources controlled by operations center with no one logged in
- Areas of Responsibility (AOR) management
  - Create/modify/delete AORs
  - View AORs on map
  - Filter device lists based on AOR (and folder)
  - Filter location aliases based on AOR
  - Run traffic event based auto mode tours on monitors based on AOR
- Patrol Areas
  - Create/modify/delete patrol areas
  - View patrol areas on a map
  - Assign patrol area to field unit
- Device management and control
  - Add or delete devices
  - Import and manage import of external DMSs and TSSs
  - Export and manage export of internal devices (except video monitors)
  - View and modify device configuration information
  - Protect sensitive configuration data per organization
  - Set DMS online, offline, maintenance mode, reset DMS
  - Upload font to DMS, copy font from one DMS to another
  - Set TSS online, offline, maintenance mode
  - View TSS volume, speed, occupancy data (summary / per lane)
  - Protect volume, speed, occupancy data per organization
  - Set HAR online, offline, maintenance mode
  - Blank, monitor, reset HAR
  - View HAR Status
  - Set SHAZAM online, offline, maintenance mode
  - Reset SHAZAM to last known state
  - Set On/Off device online, offline, maintenance mode

- Associate DMS or SHAZAM to HAR as HAR Notifier
- Associate HAR to Synchronized HAR as constituent HAR
- Copy DMS/HAR/SHAZAM/TSS /On/Off device
- Add, delete, modify port configuration information
- View or modify device location
- Sort/filter device lists by location, model, message, status, connectivity, etc.
- Specify/retain columns to display in device lists
- Manage 2 models of DMS devices including NTCIP
- Manage 3 models of HAR devices
  - One model is "MD511", not actually a HAR but a phone system
- Manage 2 types of SHAZAM devices
- Manage 2 varieties of Remote Traffic Microwave Sensor (RTMS) TSS devices
- Manage any number of types of On/Off device (e.g., Fog Beacon, Fog Horn) controlled by one communications protocol
- Specify default font, line spacing character spacing on NTCIP DMSs
- Run pixel test on supported DMSs
- Get/view extended device status on supported DMSs
- Configure alerts/notification for device communications or hardware failures

- DMS Message Libraries
  - Create/delete message libraries
  - Create/delete library messages
- HAR Message Libraries
  - Create/delete message libraries
  - Create/delete library messages
    - Manage audio or text HAR messages
- DMS/HAR Messages
  - Put message on DMS, blank DMS
  - Play message on HAR, remove message from HAR
  - Manage audio HAR messages
  - Provide text-to-speech conversion of textual HAR messages
  - Automatic HAR word substitution for pronouncing word phonetically
  - Arbitrate between multiple desired messages on DMS/HAR
  - Combine up to two pages of suitably combinable DMS messages
  - Combine up to two minutes of HAR messages
  - Automatic/manual DMS Message Formatting
- Arbitration Queue
  - Add message to Device Queue
  - Evaluate Device Queue
  - Adjust priority of message in Device Queue

- Remove message from Device Queue
- Revoke item in response tabs

- Travel Routes
  - Create/modify/delete travel routes
  - Associate INRIX roadway links to travel routes for travel time calculation/display
  - Configure alerts/notifications for high travel times
  - Associate Vector toll routes to travel routes for toll rate display
  - Configure alerts/notifications for missing toll rates
  - Configure messages templates for standardized display of travel route data on DMSs
  - Configure traveler information messages with template/routes for display on DMSs
  - Enable/disable travel route information messages for display on DMSs
  - Set default priority of travel time and toll rate messages relative to event messages
  - Restrict travel time message display by time-of-day, globally or per-DMS
- Automatic Weather Messages
  - Create/modify/delete triggers
  - Add/edit/remove weather sensors as trigger conditions
  - Create/modify/delete DMS triggered messages
  - Create/modify/delete HAR triggered messages
  - Create/modify/delete On/Off Device triggered activations
  - Enable/disable DMS triggered messages
  - Enable/disable HAR triggered messages
  - Enable/disable On/Off device triggered activations
  - View triggered actions
  - Enable/disable DMS, HAR, and On/Off triggered messages/activations system wide
- Manage video distribution
  - View Camera, Monitor configuration information
  - Specify a current Monitor Group
  - Set Camera, Monitor online, offline
  - View Camera, Monitor Status
  - Display a camera on a CHART monitor
  - Display cameras on the desktop
  - Request Pan, Tilt, Zoom (PTZ) control of a CHART camera
  - Override PTZ control of a CHART camera
  - Command a COHU 3955 or 3960 camera
    - Pan/Tilt/Zoom/Focus
    - Iris control
    - Red/Blue color balance
    - Lens speed

    - Set camera title (first line)
    - Set camera title (second line)
    - Reset
    - Power on/off
  - Command a Vicon Surveyor 2000 camera
    - Pan/Tilt/Zoom/Focus
    - Iris control
    - Red/Blue color balance
    - Lens speed
    - Set camera title (first line)
    - Reset
    - Power on/off
  - Command an NTCIP camera
    - Pan/Tilt/Zoom/Focus
    - Iris control
    - Set camera title (first line)
    - Power on/off
  - Configure tour list
  - Start a tour list on a specified monitor or user's own desktop
  - Stop a tour list running on a specified monitor or user's own desktop
  - View / Administratively stop desktop video to free resources
  - Block/unblock display of video to public/media
  - Block/unblock display of video to selected organizations
  - Revoke/Allow control of video camera to selected organizations
  - Manage monitor groups
  - Manage video fabrics
  - Manage Streaming Flash Server (SFS) configurations of cameras
- DMS Plan Libraries
  - View/Filter plan libraries
  - Create/delete plan libraries
  - Create/delete plan items
- HAR Plan Libraries
  - View/Filter plan libraries
  - Create/delete plan libraries
  - Create/delete plan items
- On/Off Device Plan Libraries
  - View/Filter plan libraries
  - Create/delete plan libraries

- Create/delete plan items

- Operations Log
  - Log user activity
  - Log system and device status information
- System Management/Monitoring
  - View CORBA trader offers (with delete if truly necessary)
  - Force discovery of CORBA objects
  - View GUI Usage Statistics (database only)
- Monitor services
  - Monitor/view service availability, up time, memory usage
  - Automatic restart of failed services
  - Manual stop/start of services via GUI
  - Provide Alerts, Notifications for failed or restarted services
  - View GUI heap usage, and object and request counts
- Configure System
  - Manage DMS/HAR decision support templates, substitutions
  - Manage which devices to import from RITIS
  - Manage criteria for importing events from RITIS
  - Manage many System Profile settings not otherwise mentioned herein
- Communications Log
  - Create/manage communications log entries
  - Search communication log entries
- Traffic Events
  - Create/manage events of the following types:
    - Incident Event
    - Planned Roadway Closure Event
    - Disabled Vehicle Event
    - Congestion Event
    - Special Event
    - Action Event
    - Weather Event
    - Safety Message Event
  - Import external traffic events based on configurable selection criteria
  - Create/manage/utilize/schedule pending events
  - Create/manage/search event history log entries
  - Create/manage events associated with lane closure permits
  - View lists of devices near event
  - View map of devices near event

- Suggest cameras for auto-mode (temporary tour) on AOR auto-mode monitors
- Include all (one) MD511 “HARs”in response plan automatically
- Suggest DMSs/HARs for use in a response plan
- Recommend removal of DMSs/HARs rules indicate are no longer needed
- Suggest DMS/HAR messages
- Put message on DMS, blank DMS, turn DMS beacons on/off
- Put message on HAR/blank HAR
- Activate/deactivate SHAZAMs and DMSs used as SHAZAMs
- Activate/deactivate On/Off devices
- Manage web alert text displayed on public web site for high priority events
- Alert users if event open past reminder time
- Warn users of potential duplicate events during event creation
- Alert users to duplicate events after event creation
- View FITM plans near a traffic event (or outside the context of any traffic event)
- Merge traffic events
- Assist operators with Standard Operating Procedures (SOPs)
- Calculate queue length caused by traffic event
- Manage priority event list of highest priority statewide events
    - Support automatic or manual manipulation of priority event list
- Post rule-based auto-generated or manually overridden messages to Social Media

- Participant management
    - Select participants for traffic event
        - Select specific contact for a participant in traffic event
    - Select participant type for traffic event
    - Substitute specific participant when participant of desired type arrives on scene
    - Detect/mark participant as arrived on scene, with timestamp
    - Detect/mark participant as departed scene, with timestamp
    - Manage in-service/out-of-service status of participants
    - Track location of Automatic Vehicle Location (AVL) enabled participants
    - View AVL-enabled participants on map
- Traffic Signal management
    - Associate traffic signal(s) with action event
    - View traffic signals associated with action event on map
    - View traffic signals not associated with action event on map (only zoomed-in)
- Manage Contacts
    - Manage contacts
    - Manage call down lists
    - Associate contact with traffic event
- Manage Field Units and Facilities

  - Set field unit or facility in or out of service
  - Add comm log entry to track in/out of service status
  - Assign patrol area(s) to in service field unit
  - Assign contact to in service field unit
- Notification
  - Send/manage notifications
  - Search notification history
  - Manage notifications for DMS, travel routes, external events and connections
  - Manage notification contacts and notification contact groups
- Alerts
  - Create/display/manage alerts
  - Help users respond to alerts
  - Escalate alerts
- Schedules
  - Create/manage schedules
  - Execute schedules, when activated or immediately on demand
  - Copy and execute response of pending safety message event or special event when schedule activated
- Dictionaries
  - Banned words dictionary
  - Spell-check dictionary
  - Text To Speech Pronunciation dictionary
- External System Interfaces
  - Import selected DMSs/TSSs from RITIS, maintain/view their status
  - Import events from RITIS matching selected criteria
  - Mark matching imported RITIS event as "interesting"
  - Provide Alert/Notification for matching imported RITIS event
  - Export traffic events and related traffic signal data to CHART Map/Web and RITIS
  - Export DMS, HAR, SHAZAM, TSS, CCTV data to CHART Map/Web and RITIS
  - Import Travel Time data from INRIX
  - Accept Toll Rate data from Vector
  - Provide Alert/Notification for external connection in failed or warning state
  - Send Notifications via SMTP mail
  - Import lane closure permits that exist in the LCP system and allow users to perform actions on those permits from within CHART ATMS and to search for permits
- Operations support
  - CHART ATMS installer packages
  - Support for failover site at SHA Headquarters
  - Support for emergency ATMS operations at AOC, data refreshed every 5 minutes

- Support for training (current release), data refreshed nightly
- Support for training (for future release), data manually initialized as needed

3 FUNCTIONAL VIEW

3.1 View Description and Typical Stakeholders

This view into the CHART ATMS describes basic CHART ATMS functionality and some key operational concepts that drove how the system was constructed. This is not a User's Guide or tutorial. Although there are some design concepts presented, it does not get to the level of a formal design document. See the CHART ATMS User's Guide for additional information. This view is useful for anyone interested in how the CHART ATMS works at a high level, including developers, SHA management, MDOT management, and officials from other organizations, looking to interface with or build a system like the CHART ATMS.

3.2 CHART ATMS Web-based Graphical User Interface

The CHART ATMS GUI is a web-based application. Users connect to the CHART ATMS GUI via any web browser (currently Microsoft Internet Explorer 11 is the officially supported browser, although other browsers generally work as well, including mobile browsers). Anyone connecting to a CHART ATMS web page is required to log in. User accounts can be created by a CHART ATMS administrator (who is simply a CHART ATMS user who has been granted many or all user rights). A CHART ATMS administrator can also grant rights to other users (thereby creating other CHART ATMS administrators as desired). User rights are grouped by CHART ATMS administrators into "roles" for ease in assigning rights to users. (To be more precise, all users are actually granted "roles", which are collections of rights, rather than being granted rights directly.) Password rules are highly configurable, to meet current DoIT and MDOT requirements, and can be adjusted as necessary.

The CHART ATMS GUI is designed as a two-window web-based application. It is intended for use with a dual-monitor workstation, with one window on each monitor, although it is generally equally functional on a single-monitor workstation. The two windows consist of a "home page" window and a "working" window. The "home page" is what the user sees immediately after logging into the CHART ATMS. The "home page" is the "home base" for CHART ATMS operations, providing access to traffic events, alerts, resources, and the primary ("home page") CHART ATMS map. It also provides the form for creating a new traffic event, and it provides a "navigation bar" (collapsible menu) down the left side for accessing all CHART ATMS functionality. Upon selecting a menu item from the home page, the appropriate page is opened in the user's "working" window, thus keeping the home page always accessible. The working window also provides a limited menu of popular functions as well, including access to recently viewed traffic events and an option to redisplay the home window in case it has gotten lost. Upon logging in, the user's working window is initially populated with an Operations Center Report, which provides an overview of activity occurring in the users own operations center. This report can be recalled and refreshed at any time. The CHART ATMS "working" window is used to perform tasks like editing traffic events, video display, camera control, working directly with signs, etc.

Users have an ability to select their own personal (or shared) "Home Monitor" when they log in. An icon representing this monitor is always visible on the home page, which provides direct access to managing video on that monitor. The home monitor is tracked as a user cookie and is not known to the server.

3.3 CHART ATMS Map

The CHART ATMS map, which is the map used in the CHART ATMS GUI, has sometimes been referred to as the "Integrated Map," to distinguish it from the "Intranet Map" and "Internet Map" provided by CHART Mapping (a completely separate system from the CHART ATMS, but part of the overall CHART Program). The CHART ATMS map uses an open source JavaScript mapping Applications Programming Interface (API) called OpenLayers to render CHART traffic events and devices geographically within the CHART ATMS GUI process. There are multiple maps which can be seen within the CHART ATMS. The primary map is the Home Page Map, which provides users with a map view that is always available to them. A second type of map is the Nearby Devices Map which is available within to the details page of each traffic event. The Nearby Devices Map focuses on the display of devices near the traffic event, which could be used for verification or response. A third type of map is the Object Location Map. This map allows users to see a geographic view of where they are locating a traffic event or device. The Create Events Map, has similar functionality to the Object Location Map, but is used specifically for locating a brand new traffic event. From here users can set or change the precise point location for the event or device as well. Another map is the Response Preview Map, which shows what devices near a traffic event would display/broadcast if the current response plan were to be executed.

For each type of map the GUI starts with a base map that is exported from the existing Environmental Systems Research Institute (ESRI) map server. This design leverages the work that has already been done by CHART Mapping and provides a consistent user experience. The map also provides exits and mileposts layers that are also each exported from the ESRI map server as a Web Map Service (WMS). The exits and milepost layers are displayed only when zoomed in to a high level of detail and can be independently toggled on or off in that case. Above these the map adds dynamic marker layers. Dynamic marker layers are layers that are populated using the JavaScript API. A marker icon is added to the map for each device or traffic event on the layer. The user can then click on these markers in order to obtain information about the object it represents via a callout graphic. The dynamic marker layers are ordered such that devices are below traffic events and traffic events are displayed on separate layers based on type. Incident type events are on the top layer. The data used to populate the dynamic markers is retrieved from the CHART ATMS GUI Servlet via Representational State Transfer (REST) Web Service requests. The CHART ATMS GUI responds with data in JavaScript Object Notation (JSON) format (a lightweight alternative to XML that is easier to parse using JavaScript) that describes each marker. The map JavaScript code parses this JSON data and passes it to the OpenLayers JavaScript API in order to add or update the marker and its associated callout.

The Home Page Map allows users to navigate their map to view any devices and traffic events that have been populated with a point location geographically. The Nearby Devices Map, on the other hand, allows users only to see devices within a specified distance from a target traffic event. This map is always centered on the reference traffic event, and cannot be panned. It can be zoomed in and out, however. This map is designed in the same way as the Home Page Map with the exception that it does not display any traffic events except for the target traffic event. Additionally, the nearby devices map allows users to efficiently select nearby devices directly from the map that should be added to the response plan of the target traffic event. The map changes the display of the selected devices to indicate that they are the candidates for addition or removal.

The Object Location Map works in conjunction with a pulldown-based object location form that is currently used to set the location for traffic events and devices. When users make selections on the form they see visual feedback on the Object Location Map. For instance, if a user selects Maryland from the list of states on the form, the associated map pans and zooms to the extents of the state of Maryland. When the user selects a county within Maryland the map further zooms to show only the county of interest. If the user clicks on a point on the Object Location Map, the object location form updates the selected state and county to show the state and county containing the point that was clicked. The GIS data required for this operation is queried from a REST web service provided by CHART Mapping. This service can return geographic extents for a state, the geographic extents and boundary polygons for a county within a state, as well as the state and county that a point resides in. Additionally this service can provide data about the mileposts and exits along a particular roadway within a particular county and state. This GIS knowledge was kept outside of the CHART ATMS map process in order to make it accessible to other CHART systems that might benefit from it.

In addition to the aforementioned map types, the CHART ATMS map also employs a REST web service that provides the non-spatial data that is consumed by the object location form such as the list of states, list of counties within a state, list of road types in a specified county and state, and list of roads of a particular type that exist within a specified county and state. Additionally this service provides a REST web service API that allows for the management and querying of location aliases. Location aliases are used by the Object Location Map and form to allow the user to quickly locate an object at a known landmark (example: "Bay Bridge") rather than having to select a number of drop downs or pan/zoom the map to get to this location. The addition, modification, or removal of a location alias via the web services API requires the calling client to digitally sign their request using a key issued by a CHART ATMS administrator. The API that returns the list of known location aliases is publicly available and may be used by any CHART system that needs this functionality.

3.4 Configurability – System Profile and Properties

One of the key aspects of the CHART ATMS is its configurability. Hundreds and hundreds of settings are configurable. Many are configurable via the "System Profile", a facility accessible within the CHART ATMS GUI by CHART ATMS administrators. Many more are configurable in various properties files. Every conventional service, every web service, and the GUI have a properties file ("*.props") with scores of well documented settings. Changes to a properties file requires a restart of the application which reads that properties file. Most System Profile settings take place immediately, or on the next cycle of whatever is being configured.

3.5 CHART ATMS Traffic Event Management

The CHART ATMS is a traffic event centric system. Operators use CHART ATMS to enter a variety of information for specific traffic events and track the status of events for real-time and historical purposes.

This information includes the traffic event type, times, location, and a number of other elements to describe the traffic event. These elements include event type, reporting source, roadway description and status, various descriptive elements, and queue length caused by the traffic event. The detailed queue length information will use existing INRIX link data in CHART to provide system calculated queue length values on an automatic (ongoing) or user-initiated basis. Operators will also be able to specify queue length information manually. The first two sets of queue information represent the current directional queues for the event (primary/opposite for directional events, North/South, East/West, and Inner/Outer Loop for bidirectional events). The third set of queue information stores the maximum queue length over the lifetime of the event. The system allows queue calculation for open traffic events with a primary route, a lat/lon and a direction other than NONE.

Messages are normally put on DMSs and HARs within the context of an open traffic event. Most traffic events include a "response plan" into which DMSs and HARs are inserted. Messages to go on these devices can be selected from a preconfigured "Plan", selected from a list of messages the "Decision Support" subsystem generates (based on traffic event parameters, the locations of the event and device(s), and pre-defined "message templates"), or can be input manually, singly or en masse. Once devices and messages are configured into the response plan, the response plan (or individual items within it) can be "executed" which puts the messages into an "arbitration queue" managed by the software object representing each physical device. The arbitration queue arbitrates between various messages being requested for its device, and puts the highest priority message (or messages) on the device. Users can change or "revoke" messages on devices at any time. Also, as lane closure status is changed within the traffic event, the Decision Support subsystem recommends changes to the list of devices being used, and to the messages on those devices. When the traffic event is closed, any messages still on these devices are automatically removed from the queue and from the device. This was a major advantage over the predecessor system, which was a collection of manufacturer software to control the devices independently. With no overarching management system, there was potential for messages to be left on devices after they were no longer relevant.

One type of "HAR" that is treated specially is the MD511 "HAR". This represents the statewide Maryland 511 phone system. This device is not a HAR in reality, but it behaves like a HAR, in that it accepts audio messages for relay to the public. All HARs of the MD511 model type (of which there is expected to be only one) is added to every traffic event automatically, as it is created. This puts it to the operator whether the Maryland 511 system should be used in or deleted from the response plan. If a message is executed on this MD511 HAR, it plays on the Maryland 511 phone system (provided it fits within the configured maximum message runtime). (If MD511 is ever expanded to multiple MD511 phone systems, all MD511 HARs will be automatically added to the response plan, as there is currently no geographical intelligence in the ATMS MD511 system – it is expected that the MD511 HAR(s) will not have a location.)

CCTV Cameras can also be inserted into the response plan of a traffic event. When this response plan item is executed, the cameras are added to the "auto mode" tour list of any monitor configured for auto mode within the centers responsible for handling the event.

On/Off devices can be inserted into the response plan of a traffic event as well. On/Off devices follow the same basic model as DMSs and HARs in that they can be configured into plans and utilize an arbitration queue to turn these devices on and off. However, On/Off devices are not tied to the "Decision Support" subsystem.

Decision support is discussed in more detail later in this section.

There are several types of traffic events supported by the system. In order of highest to lowest priority (with regard to arbitration of messages queued for DMSs and HARs), the traffic event types are:

- Incident (for accidents)
- Planned Roadway Closure
- Congestion (recurring or not)
- Weather

- Special Event (e.g., ballgames, Baltimore Grand Prix, Bay Bridge Walk, etc.)
- Action Event (utility problems, debris, signal problems, animal carcass, etc.)
- Safety (frequently used for public service announcements, Amber Alerts, etc.)

There is one other type of event, a Disabled Vehicle Event, but this type of event does not allow a response plan. (Note: if a disabled vehicle is blocking a travel lane, that is an Incident.)

In addition to the priority "buckets" for those event types, there several others:

- Urgent (the highest priority – no messages are initially put here, but can be moved here)
- Toll Rate Message (used for Traveler Information Messages containing a toll rate)
- Very High (event messages can be moved here, automated messages such as travel times, toll rates, and triggered messages/activations can be configured to be placed here)
- Travel Time Message (for Traveler Information Messages with a travel time, no toll rate)
- High (event messages can be moved here, automated messages such as travel times, toll rates, and triggered messages/activations can be configured to be placed here)
- SHAZAM (Notification of a significant HAR message being broadcast in the vicinity)
- Medium (event messages can be moved here, automated messages such as travel times, toll rates, and triggered messages/activations can be configured to be placed here)
- Low (event messages can be moved here, automated messages such as travel times, toll rates, and triggered messages/activations can be configured to be placed here)

Users with sufficient rights can reorder the queued messages on an arbitration queue of any device, including moving queued messages to a different bucket (such as the Urgent bucket).

CHART ATMS users can view lane closure permits from the Lane Closure Permits (LCP) System and create an associated Planned Roadway Closure. This displays all the lane closure permit information with the Planned Roadway Closure event within the CHART ATMS. Users can also perform actions on the permits directly from CHART ATMS, and the associated Planned Roadway Closure can be opened and closed based on the status of the permit.

Users can view FITM plans located near a traffic event (or any FITM plan, without any connection to any specific traffic event).

For weather events and incidents, the CHART ATMS interfaces with Lufft to help indicate weather conditions and specify pavement condition at the location of the event.

To assist operators with managing traffic events, Standard Procedures (SOPs) are built into CHART ATMS, providing guidance to operators based upon certain triggers. For instance, an SOP could be displayed to an operator when they indicate that an incident involves HAZMAT. The content of the SOPs displayed to operators is configurable. Although display of SOPs may be triggered by a variety of conditions in the system (e.g., system logon), most SOPs relate to Traffic Event Management.

3.6 LCP Lane Closure Permit Integration

The CHART ATMS interfaces with the LCP system to facilitate the sharing of lane closure permit information. LCP is the currently the system used to enter and approve permits for contractors to close lanes in Maryland for roadwork or utility work requiring lane closures. This interface allows CHART ATMS users to associate a CHART Planned Roadway Closure Event with a lane closure permit. The Operations Center Report lists permits relevant to the user's Operations Center, grouped by status, such as Queueable, Permitted, or Active. Users can easily create an associated Planned Roadway Closure Event for the permit and the system will use location information from the permit in the event. If a Planned Roadway Closure Event is already associated with a permit, the user can easily view it. The user can also perform actions on a permit to activate, deactivate, queue, dequeue, or extend. The system will automatically open the event associated with a queued permit when that permit becomes active, and close (make pending) the event when the associated permit is deactivated. The event is kept in the system in a pending state to keep the user from having to recreate event data for permits that are active on a recurring basis.

Users can also find a specific permit via a search function. A text entry field is always available on the Home Page, where search criteria can be entered. If the user types part of a lane closure permit tracking number, the system suggests permits from which the user can select. If the user does not see the permit sought, a search button can be clicked, which searches all active and queued permits from the permit tracking system. The searching feature is not limited to tracking numbers. It searches all the following fields of each permit: permit tracking number, start county name, end county name, permit type, route location, route type, route number, work order description, permittee name, contract number and days of week. Thus a user may search for permits using search text such as "Bridge Montgomery Monday". Returned permits are ranked according to their relevance to the search text specified. In addition to searching for permits, users can view permits that apply to their operations center on their operations center report. All permits that are permitted to be active within two hours from the current time or at the current time appear. Once a permit is found via search, the same functions are available as when the permit is found listed on the user's Operations Center Report.

This interface between CHART ATMS and LCP is accomplished using RESTful web services. The LCP data exporter provides an interface that CHART ATMS uses to query the list of permits and to subscribe to real-time updates. CHART ATMS via its Permit Service provides a web service that the LCP system can call to provide the real-time updates.

3.7 Weather Integration

A CHART Web Service called the CHART Weather Service provides internal CHART systems with weather related data. This web service retrieves Weather Station data from external systems (currently Lufft) and provides it to the CHART systems in a generic XML form that is not tied to any specific system.

The CHART ATMS GUI and Traffic Event Service use this Web Service to allow pre-population of Traffic Event Road Conditions where applicable and provide display of other weather details for a Traffic Event. The CHART ATMS GUI and the Trigger module in the Schedule Service also use data from the Weather Service as trigger conditions. Triggers can include weather conditions and criteria based on those conditions that can cause a trigger to activate. Automatic weather messages for DMS and HAR can then be associated to the trigger and they will activate/deactivate in lock step with the trigger. The same is true for on/off device triggered activations, although a message is not applicable to those devices, they simply activate or deactivate based on the active/inactive state of the associated trigger.

The design of the Weather Service includes an extensible message set and isolates all weather system-specific fields and parameters into one area of the Weather web service.

- The design includes a modular approach to weather data sources. The addition of a new data source requires only the addition of an interface to the new source in the web service. This could be a new database (DB) connection, a flat file, access to another web service or similar format. The rest of the architecture remains unchanged.

- The design includes a modular approach to weather data clients. If the new client requires access to summary weather information (air temperature, wind speed and direction, surface temperature, surface conditions, or precipitation) then no changes to the weather web service is required. More detailed weather information such as relative humidity, dew point, trends, and historical reports would require changes to the messaging, though no changes to the architecture.

3.8 Participant Management and AVL

Every type of traffic event, except Safety Message and Planned Closure Events, contain a Participation section for tracking organizations and individuals which have some involvement in resolving the situation. This includes the time each was notified of the event, times of arrival and departure on the scene, and contact information. The CHART ATMS allows administrators to define event resource types and event resources that can be added as participants in events. In addition, standalone contacts can be added as participants in events. A contact can also be selected for an event resource or event resource type that has a call out list. These event resources and types can be added to operations centers to make them available as participants for traffic events controlled by the center and traffic events managed by the center's users. Event resources can be associated with Automatic Vehicle Location (AVL) devices and the location information is used by the system (optionally) to automatically detect when an event resource has arrived on the scene (or has departed the scene) of a traffic event. The system can also automatically detect when a specific resource arrives on the scene when a generic resource of that type was requested (for example if the user requested a generic non-specific dump truck and then a specific dump truck arrives on the scene). The system optionally replaces the generic resource type with the specific resource when this occurs. The location information for an event resource is also used to help the user select participants to add to a traffic event by allowing the user to sort by distance from the event. Users can make annotations to each participant assigned to a traffic event. This allows the user to identify the participant's radio call sign, driver name, and add miscellaneous notes about the participant. The CHART ATMS also allows users to track the in-service and out-of-service status of field units and facilities, and allows AVL equipped event resources to be viewed on the Home Page Map. Other usability enhancements exist as part of this feature:

- An event resource can be associated with a camera, and links exist to allow the user to view the associated camera on the desktop (if supported) or to launch the form used to display the camera on a monitor.
- Event lists show the number of participants assigned to events and allow the user to set a participant as notified, arrived/responded, and departed directly from the event list. The user can also launch the form used to add participants to the event directly from the event list. These enhancements save time for the user as the user is no longer required to view the event details page for these tasks.
- When creating a traffic event, the user can select a specific field unit and that unit will automatically be added as a notified participant in the newly created event.

The Participants / AVL feature exists directly in the TrafficEventModule. A CORBA-accessible object that provides for the management of event resources and types and an object that interfaces with the AVL system are in the module. By including these objects in the same module, processing efficiency is gained, by allowing them to share data via "in process" objects, rather than requiring CORBA or Web Service calls. This processing efficiency is required due to the large number of AVL vehicles and event resources that may exist in the system.

When AVL data is retrieved from the AVL service, the AVLDataManager object updates location data in memory and then calls the EventResourceManager object to associate the AVL data with event resources based on the AVL vehicle ID. The EventResourceManager then calls the TrafficEventFactory to notify it that event resource locations have changed and allow it to do its automatic AVL detection processing. All of this location-based processing accesses the same exact Java objects in memory, eliminating the need to pass large volumes of location data among various modules in the server.

When the TrafficEventFactory is notified that event resource locations have been updated, it performs its automatic AVL detection processing. There are three distinct types of detection that are attempted for each applicable traffic event participant, provided automatic AVL detection is enabled for the traffic event:

- Generic resource type on scene detection. This automated detection applies to participants that are an event resource type that has auto-configuration enabled. The system keeps track of all event resources of that type that fall within a configured arrival radius from the traffic event location and automatically changes the participant from a resource type to the closest specific resource of that type that has been on the scene for the required amount of time. The time requirement is configurable and is meant to keep the system from performing this action if a vehicle is merely driving by the scene. Once a participant that was a resource type is changed to be a specific resource, the remaining two detections apply.
- Arrival detection. This automated detection applies only to participants that are event resources with AVL support, and does not apply if the user has manually set the arrived/responded or departed flags for the participant. The system detects when the location of the event resource is within a configurable radius of the traffic event, and when this occurs, the system automatically marks the participant's arrived flag to true and sets the associated timestamp.
- Departure detection. This automated detection applies only to participants that are event resources with AVL support,and does not apply if the user has manually set the arrived/responded or departed flags for the participant. Additionally, this detection only applies if the participant's arrived/responded flag is set to true. The system detects when the location of the event resource falls outside a configurable radius of the traffic event, and when this occurs, the system automatically marks the participant's departed flag to true and sets the associated timestamp.

Note that with the arrival and departure detection, there is no requirement that the event resource be on the scene for a specific amount of time, or away from the scene a specific amount of time. It is assumed that since the resource is specifically assigned to the traffic event, if it is detected to be on the scene of the event it is not just passing by the incident, and once it is detected to have left the scene it is not coming back. In case these assumptions are ever wrong, the user always has the ability to override the Arrived and Departed flags.

In addition to obtaining location data from the AVL Service, the AVLDataManager also periodically polls the AVL service for inventory data. The AVLDataManager keeps track of a list of known vehicles in the AVL system so that it may detect additions, deletions, and changes to

AVL vehicles and notify the EventResourceManager of these changes. The EventResourceManager uses these notifications to support the auto-configure feature that can automatically add event resources to the CHART ATMS based on the AVL vehicle type and configuration information in event resource types. Additionally, when an automatically configured event resource is found to no longer exist as part of the AVL inventory, CHART ATMS can automatically remove the event resource. The automatic removal of event resources can encounter the case where an event resource is in use in a traffic event at the time its removal from the AVL system is detected. CHART ATMS handles this by allowing event resources (and types) to be marked for deletion without actually deleting them. A periodic timer later detects when event resources and types are no longer in use and take them offline at that time. When taken offline, event resources and types are removed from memory and marked as offline in the database. An archival process removes any event resources that are marked offline after it has removed all traffic events that have been marked as offline.

3.9 Traffic Signals in Action Events

Users can associate Traffic Signal devices from the Signal Book database with an Action Event and describe one or more failures common to all signals in the event. Any number of signals can be associated with a traffic event but typically there is only one. The term 'Traffic Signal' is a bit misleading as the Signal Book contains traffic signals, cameras, beacons (school, bridge, warning), pre-emption signals (fire, bus, rail), reversible lane signals, and weigh station devices. Currently there are over 5000 objects in the Signal Book

The following key design decisions relate to the traffic signal integration feature in CHART ATMS:

- Traffic Signals devices that are currently associated with an Action Event are displayed on a separate map layer. This layer is visible on any zoom level of the home page and event creation maps.
- For performance reasons, Traffic Signals NOT currently associated with an Action Event are displayed on a separate map layer visible only on the two most zoomed-in zoom levels of the home page and event creation maps. Currently there are over 5000 Traffic Signals in the Signal Book.
- Traffic signals displayed on the event creation map can be used to populate the location fields on the event creation page.
- A user can associate a User Defined Signal to an Action Event. This feature is used when the traffic signal data available to CHART ATMS does not include a signal that a user wants to add to an Action Event. The user specifies a description for the signal when associating. User Defined Signals are only listed for the Action Event they were specified for. They are not displayed on the CHART ATMS map nor the Intranet Map and are not available to be associated with any other event.
- Traffic Signals associated with active traffic events are exported – primarily so the Intranet Map can display them.
- The CHART ATMS GUI periodically discovers updates to the traffic signals through a Traffic Signals web service called the Signal Service (similar to the CHART Weather web service).

- Because of the large number of traffic signals, only enough information to support map requirements are cached in the GUI. Detailed location information for a traffic signal is requested from the web service only when needed.
- Also because of the number of traffic signals, objects representing signals are cached by the GUI in a separate traffic signal manager object instead of the generic data model. This is similar to how caching is managed for roadway links, another high-volume type of object (approximately 12,000).

3.10 Object Location Using Known Roads

CHART ATMS provides the capability to populate event locations and device locations using the CHART ATMS map, pull down menus for known roads, or a combination of both. The location choices are populated by calling the CHART GIS service, which serves up location data. The user first selects a county (the state of Maryland is always pre-populated by default). The user can also select a "region" (such as "Eastern Shore", "Western Maryland") if the county is not known. The user then specifies the primary route, by first selecting a roadway type from pick list. Route types include Interstate (I), United States (US), Maryland (MD), etc. The user then selects a route number. The user can also select a primary route by road name. The "intersecting feature" is specified next. First the "proximity" is selected. Choices include "at", "prior to", "past", and also directional proximities, such as "north of", "east of", etc. The feature type is then selected. Choices are exit, road, or mile marker. (Exit is preferred). Finally the intersecting feature of the appropriate type is selected. As for the primary route, an intersecting road can be specified by route type and route number, or by road name. If an exit is selected, the intersecting route or road is included as part of the exit description. Once a Maryland county is selected, the map zooms in to the extents of that county. Once an intersecting feature is selected, the map zooms in to that precise location. The user can then double-click the map to more precisely specify the location, if desired. The choices for each step in the process would be filtered based on the information already entered. For example, if the user had already chosen Howard County, I-95, only roads intersecting I-95 in Howard County would be available.

Data entry rules are enforced to produce more consistent location data in the database. If the user selects Maryland as the state, the user cannot use free-form text for county or region, or the route type and route number (or road name). Instead, if the user wishes to specify one of these fields, they must make a choice from the values presented in the pick list. If the state is not specified or is other than Maryland, free-form text is allowed in these fields. Choices are not provided and freeform text is required for primary road and intersecting feature if the state is not Maryland or if a region is selected rather than a county. Freeform text is always allowed when specifying an intersecting roadway, although this is highly discouraged unless absolutely necessary. Even if location information is free-formed, a point location should still be specified by double-clicking the map.

Other choices for "proximity," specifically for traffic events, are "between" and "from-to." A user can specify that the location of the event is between two features (meaning at an unknown point location somewhere between the two features), or from an intersecting feature and to a second intersecting feature (meaning the event is known to stretch between the two features, as a planned roadway closure). When the user selects either of these proximity values, they are provided with additional input fields that allow them to specify the second intersecting feature for the location. If a location can be determined for the two intersecting features the system displays markers at each of the locations to visually indicate to the user where the first and second intersecting feature being used in the event location are located. The system generally sets the location of the event initially to the location of the first intersecting feature (provided it has a defined latitude and longitude coordinate). If no coordinates can be determined for the first intersecting feature, the system attempts to use the latitude/longitude coordinates of the second intersecting feature as the initial event location. If the second intersecting feature has no defined coordinates either, the system cannot set an initial location for the event. Regardless of the initial location set, the user may double click any location on the map to specify that actual desired coordinate that should be used as the point location of the event. (Although the system does not prohibit using "between" or "from-to" for locating a device, in practice these are not used for devices, as a device location is always at a single point and the precise location of each device is always known. Furthermore it is important that the precise location of devices are input into the system to allow selection (by users directly and by the Decision Support system) of appropriate devices to use in traffic event response plans.)

CHART ATMS also supports location aliases. The alias list contains "short cuts" for filling in the other location data. For example, selecting an alias of "Bay Bridge" would automatically fill in county of Anne Arundel, Route Type of "US" (United States), and Route Number of 50. The user could then fill in the remaining fields. An alias has an internal name and a public name. For instance, for the Francis Scott Key (FSK) Bridge, the public name may be "Key Bridge" and the internal name may be "FSK". The list of aliases and the alias details are configurable for a suitably privileged user.

Traffic event location descriptions and traffic event names are closely controlled. The GUI generates a traffic event location description using the values in the location fields. The traffic event name consists of the type of traffic event, an "at" sign ("@"), and the location description. Occasionally, depending on the traffic event type and specific information included in the event, related information is included in brackets at the end of the traffic event name. Users can override the GUI generated location description, although this is discouraged through the use of multiple warning messages. If the user overrides the location description, the traffic event name is updated to include the overridden description. The traffic event location and name are not fixed; these are regenerated throughout the life of the event as (and if) the underlying data changes.

3.11 Event Duplication Prevention and Merging

CHART ATMS helps prevent duplicate events and merge existing duplicate events. Duplicate events are identified based on the location data associated with each traffic event.

3.11.1 Event Duplication Prevention

The specific individually populated location fields (route type, route number, intersection) make it possible to help prevent duplicate traffic events from being entered. While the user selects these location fields, the system finds events with similar locations and displays them to the user in a list of potential duplicates. Initially, there are many potential duplicates, but as more and more location fields are specified, the list should shrink, ideally (typically) to zero. If any potential duplicates remain after all location information is specified, the user should review the list of possible duplicate events and may opt to abandon the creation of an additional event. Note that the type of traffic event is not considered in the list of potential duplicates, as the event type of the event being created has not been input by the user into the system at this time.

3.11.2 Event Duplication Identification

In the background, CHART ATMS detects existing open duplicate events based on their location and type. When a duplicate event is identified an alert is issued (if the system is configured to do so), upon which the operator can take action. That action may include deleting one of the events or merging the two events.

3.11.3 Event Merging

The process of merging events can be initiated from an alert of a duplicate event that is detected by the system,or can be initiated by the user directly. This feature can be used when different events exist in the system that may be using different resources. For example, Traffic Operations Center (TOC) 4, Authority Operations Center (AOC) South, and the Statewide Operations Center (SOC) may all open events using different devices related to the Bay Bridge walk.

During a merge, the system shows the user data from each of the events involved in the merge, and allows the user make some high-level choices about the data that is to be merged, based on the groups of data such as basic event data, roadway configuration, lane status, event history, participants (resources), response plan (devices), etc. The system then merges the events, combining the devices/messages, communications log entries, and other basic information based on the user input collected during the merge process. The target event is kept, with fields from the source event merged in as requested, and the other ("source") event is automatically closed as a false alarm.

3.12 Lane Configuration

3.12.1 Background

Lane configuration is an important aspect of most traffic events. (Some traffic events, namely Congestion, Action, and Safety events, do not represent a physical roadway location and do not have lane configuration data.) A lane configuration is selected by the system if the event is geo-located and occurs on a significant enough highway to have lane configurations defined. Users can also build their own lane configuration, starting from either the lane configuration preselected by the system, or from a one of a set of "standard" lane configurations, or from an empty slate. The following types of lanes are configurable within CHART ATMS: "traffic" lanes (normal everyday lanes upon which traffic normally flows), shoulders, Collector-Distributor (CD) lanes, tunnel lanes, toll plaza lanes, medians, double yellow lines, center turn lanes, plus all the following which can be designated as "left" or "right": on ramps, off ramps, merge lanes, turn lanes, acceleration lanes, and deceleration lanes./separators, left exits, and multi-lane exits. Once a lane configuration is specified within the traffic event, lane closures of individual lanes can be specified. In addition, the current traffic flow direction of the lane can be specified (regardless of the side of the median where a lane exists). This accommodates situations such as when there is two- way traffic for example due to an accident or roadwork, in a single tunnel bore, bridge, or other roadway. In addition to setting a lane to a single direction, a lane can also be set to be bidirectional (alternating traffic) for use when a single lane of roadway is being controlled by a flagging or signaling operation.

3.12.2 CHART ATMS

The lane configuration features of the CHART ATMS GUI are provided by a standalone Lane Configuration Editor web service, which makes these features reusable in other systems. (It has always been expected that the lane closure permitting system would use this feature.) The CHART ATMS GUI accesses the lane configuration features via the web service's HTTP/XML interface. In addition to providing an HTTP/XML interface, the web service also serves the lane editor web page (HTML) and supports requests used by the web page as the user interacts with the form. The requests performed during user interaction with the form use AJAX techniques to perform these requests asynchronously to prevent form refreshes and provide a better user experience. All AJAX requests elicit a response that uses JSON (JavaScript Object Notation) to allow the responses to be more easily handled via JavaScript on the lane editor web page.

The general processing flow for editing the lane configuration and status for a traffic event in CHART ATMS is as follows:

The CHART ATMS GUI calls the Lane Configuration Editor web service via HTTP/XML to initialize an editing session. The initialization provides information to the service to allow it to call the Mapping Lane Configuration web service to find lane configurations nearby the traffic event location. The initialization process also allows an existing lane configuration and status to be passed in to initialize the editor when the user is editing an existing lane configuration. The web service returns a unique identifier for the lane editing session.

The CHART ATMS GUI creates a popup window and sets its URL to the address of the Lane Configuration Editor web service's request to view a lane editor, passing the lane editing session ID as a parameter. The response is HTML for the lane editor web page.

The user interacts with the lane editor web page. The lane editor allows the user to choose a configuration from a list of configurations that includes lane configurations for the roadway that are near the traffic event location, as well as a list of standard lane configurations. The user can set the state (open, closed, unknown) for each lane and can also set the travel direction for each lane. Lanes of any type can be added to any selected lane configuration, and lanes of any type can be removed. As the user interacts with the form, the web page sends requests to the Lane Configuration Editor web service which keeps track of the lane configuration and status and generates the corresponding lane image. The Lane Configuration Editor web service responds with JSON that allows the web page to update its image as well as the image map that is used to allow the user to select lanes and perform actions on them.

The user submits the lane editor form. When the user clicks the submit button, a standard HTTP submit is not used, and instead a request is sent to the Lane Configuration Editor web service via AJAX. The Lane Configuration Editor web service calls back to the CHART ATMS GUI using HTTP/XML to indicate the lane editing session has been submitted, and the CHART ATMS GUI updates the lane configuration and status for the traffic event. The CHART ATMS GUI responds back to the Lane Configuration Editor web service to indicate if its processing was successful, and in turn, the Lane Configuration Editor web service returns a JSON response to the lane editor web page to indicate success or failure. Additionally, if the lane editing session was initialized with a location that includes latitude/longitude coordinates and a primary route, the Lane Configuration Editor web service sends the lane configuration to the Mapping Lane Configuration web service via HTTP/XML to allow the user specified lane configuration to be stored at the specified location so it is available for use the next time a traffic event occurs near that location. In this way, the system "learns" of lane configurations at various points along Maryland's highways, which is uses to supplement the initial set of configurations populated into the system.

The lane editor web page processes the response from the submit request. If an error is indicated, it is displayed to the user and the lane editing form remains open. If the submittal was successful, the lane editing form calls a JavaScript function in its parent window (if present) to let the parent window know the lane editing session has ended. The parent window can then update if needed to show the current lane configuration and status as specified by the user. Finally, the popup window containing the lane editor is closed.

In addition to lane editor related functionality, the Lane Configuration Editor web service also supports a request to allow a lane configuration to be rendered into a GIF image. This feature allows the client application to retrieve an image for a specified lane configuration and status for use within the client application. The returned data includes metadata for the image such as lane boundaries to allow clients to create an image map for the image, making features such as lane selection possible to implement.

3.12.3 Intranet Mapping

The Mapping Lane Configuration web service is part of CHART Mapping. The purpose of this web service is to provide access to lane configuration data available from the State's mapping database, and to allow this data to be augmented by lane configurations specified by users. The lane configuration data in the mapping database is stored per road segment, and the user specified lane configurations utilize this same scheme.

The Mapping Lane Configuration web service supports two requests, a query and a post. The query is used by client applications (e.g., the CHART Lane Configuration Editor web service) to locate lane configurations nearby a given point (latitude/longitude). A radius is provided, and a route can be provided to further narrow the results. The request is processed by finding all roadway segments that fall within the given search circle, narrowing it to include only those on the specified route (if one is provided), and returning lane configurations for those roadway segments (both those defined in the mapping database and those that are user specified).

The post request provides the ability for user specified lane configurations to augment the data that exists in the mapping database. The client application (e.g., the CHART Lane Configuration Editor web service) can post the lane configuration specified by the user for a specific latitude and longitude and route, and the Mapping Lane Configuration web service locates the roadway segment on the specified route that is closest to the specified latitude and longitude, and stores the specified lane configuration as the user specified configuration for that roadway segment. The next time a query is done that includes that same roadway segment, even by a different user, and/or different operations center, this configuration as specified by this user is returned as part of the query results. In this way, the system "learns" the appropriate configurations to use at all places on the highways. Each user specified lane configuration includes a timestamp indicating the time it was stored or last used, allowing for cleanup of the user specified lane configuration data in the future if needed (by a DBA).

Because the post request alters data in the database, the Mapping Lane Configuration web service allows this request to be performed by only authorized clients. The post request requires two parameters, a clientID and signature, which are used by the web service to determine if the request is from an authorized client. The web service keeps a list of all the authorized clients and the associated public key for each. When a post request is received, it uses the specified clientID to look up the public key and use the public key to verify the signature that was generated by the client using its private key. Only requests with a verified signature are processed – others result in an error being returned to the client.

3.13 Communications Log/Event Log

CHART ATMS provides a Communications Log, which is generally managed as a manually created log of communications CHART ATMS operators have with other entities, such as Safety Service Patrol (SSP) CHART Units or police. The Communications Log is also used to track the in-service and out-of-service status of CHART units. The communications log also contains system-generated entries in the Communications log, such as when traffic events are opened, closed, or renamed (relocated).

Each CHART traffic event includes a history of all activity regarding that traffic event, including device messages (system generated messages pertaining specifically to messages going on (or queued for) devices), other system generated messages, and user generated messages. CHART ATMS provides views into event history logs that filter in or filter out device messages, (other) system messages, and user generated messages.

The log viewing capabilities include:

- Searching/Filtering: Users can search based on text in the log entries, operations center, and/or author fields, can specify start and/or end date and hour of day, limit to a specific source type (e.g., CHART Unit, State or Local Police, Citizen, etc.), as well as the message filter attributes.
- Filtering attributes: operator generated messages, user generated messages, and device generated messages can be filtered separately, or in combination. These attributes are automatically applied by the system when the messages are generated in the CHART ATMS. The messages are stored with their attributes in the CHART ATMS database.
- Paging: Users can control the number of entries per page and jump to a specific page of the log.

All the same searching, filtering, and paging capabilities apply to the Communications Log as well as the event history logs. Communications Log entries are removed from of the system after 12 hours. Event history log entries are removed from the system the traffic event they pertain to is taken offline, 12 hours after the event is closed. All Communications Log and Event Log entries are archived indefinitely.

3.14 Message Libraries

The CHART ATMS allows administrators to create libraries of DMS and HAR messages which can be used for event frequently used (or occasionally used) events over the life of the CHART ATMS. These include Amber Alerts; special events such as sporting events, Grand Prix, Bay Bridge walk, etc.; weather conditions (ice, fog, heavy winds, etc.); recurring congestion, bridge and tunnel closures and delays, BWI parking messages, safety messages (regarding drunk driving, use of safety belts, reporting suspicious activity, watching for motorcycles, deer, school buses, trick-or-treaters, etc.) and others. Messages are grouped into "libraries" for ease in managing the many messages. Library messages are not used directly by users, but instead used as source data for creating "Plans", which tie generic library messages to specific DMSs and HARs. These plans are then used by users when managing the specific traffic events which are occurring at any given time. CHART ATMS currently has thousands of library messages stored in dozens of libraries.

3.15 Device Plans, Advanced Sort and Searching

CHART ATMS provides a concept of device plans (commonly referred to simply as "plans"), to support expedient handling of frequently occurring traffic events. A plan is a combination of devices and messages to go on those devices in response to an event which is suspected to occur more than once. CHART ATMS currently has hundreds of plans.

To help users manage and select from plans, CHART ATMS provides "filter attributes," by which plans can be classified. These filter attributes include: event type, operating center, county or region, location aliases, plus any other user-defined keywords.

Any or all of these attributes can be used to help classify a plan. The event type attribute means if the user is selecting a plan for, say, a congestion event, only plans tagged as congestion event plans appear by default in the resultant selection list. Users can always choose to ignore any or all filter attributes, to widen the list of plans they have to select from, but this is what happens by default.

Multiple values of a given filter attribute may be specified. If multiple operating centers may occasionally use a plan, all those operating centers can be specified as filter attributes for that plan, so that users at any of those operating centers see those plans in their selection lists (provided all other relevant filter attributes also match). By the same token, users at all the other operating centers do NOT see those plans (unless they choose to ignore the operating center filter attribute).

The keyword attribute allows for specification of user-defined attributes, for instance, the keyword "summer" could be attached to special event plans which take place in the summer, or "winter" could be attached to weather events specifically relating to winter weather, even though the words "summer" or "winter" might not appear elsewhere in the plan name or message text. Textual searches beyond keywords are also supported. Users can search for text in the plan name, in the message text going to the devices, or in the device names themselves.

Filter attributes can be left unspecified. For instance, if a particular plan, such as a weather related plan, may be used for traffic events for any county or region in the state, no county/region filter needs to be specified for that plan (specifying no county/region attributes means the same as specifying ALL counties and regions).

3.16 Pending Traffic Events

CHART ATMS includes a concept of "pending" traffic events, which can be created in advance, before opening them (before it is time to open them). This is one step beyond device plans – as not only the response plan is created in advance, but the entire traffic event (which can include a response plan, which could be populated from a device plan) can be created in advance. These pending events can be scheduled and can be opened directly, without being scheduled. Pending Traffic Events are not "real" in the sense that they are not "open" or "closed", they are never flagged as duplicates of "real" open events, they are never archived, and they never show up on either of the CHART Mapping maps nor on the public web site. Pending Traffic Events can be opened, in which case they become "real", or they can be copied and opened, thus allowing the pending event to be retained in the system as a template for future instantiations of the same sort of event. Pending events can have any attributes that a "real" traffic event can have, including a location, specified in the same way as a regular traffic event, response plans, lane configuration and even lane closure information, lane closure permit information, etc. – although some attributes make more sense to leave till an event is actually created from the pending event before populating. The CHART ATMS currently contains scores of pending traffic events.

3.17 Event Scheduler

The CHART ATMS provides administrators with the capability to create and manage schedules. A schedule is a group of zero or more "actions" which can be scheduled to be activated at some time(s) in the future. The following are key terms which describe the concept.

Action – A schedulable task which can be put on a schedule. Currently the only types of actions which can be scheduled are "Open Event" and "Open and Activate Event"

Activation – A schedule is activated when its next scheduled activation time arrives. Activation of a schedule causes the actions within the schedule to be activated. For Open Event actions, an Execute Scheduled Actions Alert is sent to the operations center configured in the schedule. See Execute Scheduled Actions Alert just below to see resolution details for that alert. For Open and Activate Event actions, the associated pending event is copied as an open event and the event's response plan is executed. Optionally, depending on system profile settings, an alert is also sent to the operations center specified in the schedule. Open and Activate Event actions also allow the user to specify a duration for the event. When this optional feature is used, the system will automatically close the event (and deactivate its response plan) when the specified duration has elapsed.

Activation time – A time that a schedule will activate. A schedule can be configured with multiple activation times. Activation times can be specified by listing specific dates and times (such as for an Orioles schedule) or by recurring days of the week at a specific time period (such as for planned roadwork), possibly of undefined length (such as for recurring congestion).

Execution (of scheduled actions) – This refers to execution of actions defined in a schedule. Users can perform execution of schedule actions via two paths: 1) by responding to an Execute Scheduled Actions Alert (or alerts) generated by a schedule as the schedule activates one or more Open Event actions (i.e., when the scheduled time for the schedule arrives); or 2) by selecting a schedule and choosing to manually run it immediately (instead of or in addition to its next scheduled activation time). In this latter case, the schedule actions can be executed without the schedule activating. See Execute Scheduled Actions Alert just below. At the time of a manual execution (path 2 above) the user has the option of suppressing the next scheduled activation of the schedule – if an activation is scheduled to occur within a few minutes of the current manual execution.

Execute Scheduled Actions Alert – An alert which contains all Open Event actions associated with a particular schedule. This may be zero, one, or more scheduled Open Event actions. If the schedule contains more than one action, the Resolve function for this type of alert takes the user to an Execute Schedule Actions page where the user can select/deselect actions to be performed and then execute them en masse. If the schedule contains one action, the Resolve function takes the user directly to a page more closely associated with the action. (Currently, since the only scheduled action is an open pending event action, this is always a pending event details page.) If the schedule contains zero actions, the Resolve function takes the user to the alert details page, from which the explanatory schedule description text can be read and the alert can be closed. This could be a reminder (such as from a supervisor, or from one's own self) to do something unrelated to opening a pending event.

Scheduled Event Action Opened and Activated Alert - An alert created when the system has automatically opened an event and activated its response when an Open and Activate Event schedule action has been executed.

Scheduled Event Action Deactivated and Closed Alert - An alert created when the system has automatically deactivated the response plan and closed an event that was previously opened when an Open and Activate Event schedule action was executed.

At startup the Scheduler takes into account scheduled activations that were missed while the system was down. A configurable system wide parameter controls how far back the system looks for missed activations. Any missed activations for a schedule within this window cause the schedule(s) to be activated at startup.

The system automatically removes schedules that have not been used for a configurable period of time (some number of days). In this context, the term "used" means that the schedule has been activated, executed or modified.

3.18 Decision Support

The CHART ATMS includes a complex Decision Support system which helps the operator manage traffic event response plans. This includes determining the best DMS, HAR and CCTV camera devices to use in response to a traffic event and suggesting messages that the operator should consider putting on the selected DMS and HAR devices. The ATMS uses network routing ("driving directions") from each device to a particular traffic event to determine which devices may be useful for the event. ATMS calls the Mapping GIS Service to obtain those driving directions. All devices that are "upstream" from the event are considered, even those not on the same primary route as the event. If the driving directions from the device to the event are within a certain configurable (small) number of turns and within a certain configurable (very small) number of U-turns (such as zero U-turns), the device will be considered. The driving directions from each device to the event can also be displayed on a map, aiding the operator in making the final determination as to whether the device is appropriate to use within that event.

3.18.1 Decision Support for DMS and HAR

Decision support with respect to DMSs and HARs are discussed in this section. First of all, the system can be pre-configured by administrators with message templates that pertain to one or more traffic event types, devices within certain proximities, and signs with specified geometries. Upon request, the system finds the devices near a traffic event (using devices further away as more lanes are closed) and then searches through the pre-configured templates looking for those that pertain to each device identified as being recommended for use in that traffic event's response plan. The variables in the template are then replaced with current data from the traffic event to create the suggested message. Each device can have multiple suggested messages, so the system presents the suggestions to the user with the highest scoring suggestion at the top. The system scores each message it creates from a template based on how specific the message content is. This is measured by counting the number of parameters in the template which could be populated from the available data relating to the traffic event. Templates which have parameters which cannot be filled are not suggested. In this way, the most detailed and complete message for each device is presented most visibly. Additional suggestions can be viewed by opening up a list of other suggestions for any device.

In addition to active message suggestions, CHART ATMS also indicates to the user when the current response plan does not contain a device that decision support rules indicate should be used, or when the response plan is using a DMS that the rules indicate should not be used. The response plan section of the page also allows the operator to request a Response Preview Map that shows all suggested response devices and what messages they would have on them if the response plan was executed.

3.18.2 Decision Support for CCTV

Within the Traffic Event Service, each traffic event allows a single video tour response plan item. The Traffic Event Service maintains a local cache of areas of responsibility that is updated periodically (at a configurable rate) by pulling from the server. The Traffic Event service makes use of the AORManager utility classes for this. The Traffic Event Service also maintains a cache of monitors and the areas of responsibility that are associated with each monitor.

The Traffic Event Factory has a periodic task that does the following for each traffic event: a) find the areas of responsibility that contain the traffic event, b) find the Monitors configured for those areas of responsibility, and c) update the response plan video tour to target those monitors. The Traffic Event Factory also has a periodic task that renews the set of tour entries for each monitor. The last executed set of cameras is sent to each of the last executed monitors. If a monitor does not get a renewal for a configured number of hours, it removes the tour entry that is outdated.

When a video tour response plan item is executed, the cameras in the response plan are added to the auto mode tour list of each monitor associated with an area of responsibility within which the traffic event is located. Any of these monitors which are in auto mode run a tour that contains these cameras, cycled through along with any other cameras that any other traffic event response plan executions have added to the auto mode tour list. A monitor running an auto mode tour list can be used as a normal monitor while it has no cameras on its auto mode tour list.

Each camera within a video tour response plan item can be associated with a preset. When an auto mode tour is running, when that camera is displayed within the tour, the camera is requested to move to that preset. All cameras have a throttle, though, which prevent them from changing presets too often (to reduce wear on camera PTZ units), so whether it moves or not is dependent on how long it has been since it last moved to a preset. (This is PTZ-saving feature is actually always in force (outside the realm of decision support, too).) The move to preset request is not "saved for later" – either it moves right away or the request is discarded. Therefore, the more places the camera tour is displayed the less likely it is that a given move to preset request will be honored.

Any tour, whether a response plan item auto mode tour or a standalone persistent tour, can have the same camera in it multiple times. This is useful without presets, to give more "air time" to a camera more significant within the tour, or with presets, to view a different camera angle from the same camera at different points in the tour. Note that having multiple presets within a tour exacerbates the limitation that a camera cannot move to preset too often, if the tour is displayed in more than one location. If the same tour runs in more than one place, the tours are not "coordinated" – each monitor or desktop video session runs its own tour independently, so each tour may be at different points in the tour, and the tours may actually drift with respect to each other.

3.18.3 Key Design Decisions

The following are key design decisions with respect to decision support:

- To improve performance of Decision Support requests ("Suggest Response Messages") to operators, ATMS may (optionally) "pre-fetch" driving directions from devices to the traffic event location upon creation of the traffic event. This means that the calls to the Mapping GIS service to generate these driving directions are made in the background for all possible relevant devices and are hopefully completed by the time the operator hits the "Suggest Response Messages" link, resulting in results returned in seconds rather than up to 2 minutes.

- The second, complementary, approach to improve performance of Decision Support requests is to (optionally) cache results (driving directions) in the ATMS database at traffic event locations. This means that when driving directions are generated when pre-fetching or manually Suggesting Response Messages, they are written to the ATMS database. Thus, retrieval of driving directions is done from the database directly when a traffic event is created at a location near a previous traffic event location rather than by making calls to the Mapping GIS Service, resulting in much faster suggestions.
- All Decision Support work is Traffic Event specific and relies heavily on the availability of current Traffic Event data in order to work. To optimize performance and reduce complexity, the Decision Support algorithms are implemented in the CHART ATMS Traffic Event Service.
- Although the Decision Support suggestions revolve around traffic events, it is not difficult to imagine the use of decision support type suggestions for other portions of the CHART ATMS. To ensure this type of flexibility, the DecisionSupportEnabled interface has been defined outside of the traffic event domain. This CORBA interface can be implemented by any component that needs to be able to make suggestions.
- The types of data suggested have also been designed for easy extensibility so that the system can suggest actions other than "put this message on this DMS" or "use this plan".
- The DecisionSupportUtility package contains decision support algorithms and utilities that are not traffic event specific. This allows for the potential re-use of code for other decision support related activities in the future.
- Assembling a list of suggested actions for an operator based on current system conditions can be a relatively long-running operation. The design takes advantage of the existing CommandStatus interface used for device communications and camera control requests to allow the UI to continue on without waiting for the suggestions. The server then updates the status text to inform the user of the progress on their request. The interface is designed to allow the server to stream back suggestions as they are found if desired.
- The CHART Mapping GIS Web Service allows the CHART ATMS to request information about the nearest exit to the traffic event, and also to determine if each device that is located on the same route as the traffic event is upstream or downstream from the traffic event.
- Each Traffic Event caches the list of devices that are nearby and whether that device is on the same route as the traffic event. If the device is on the same route the event also caches flags that indicate if the device is in the same direction as the traffic event and if the device is upstream or downstream from the traffic event. This cache is updated periodically on a configurable basis to account for the rare occasions when devices are added, deleted or moved. The cache is also be updated any time the traffic event location is changed. This cached information allows the system to quickly provide a list of devices that are recommended for use in the response plan for the traffic event (upstream devices in same direction) and a list of devices that are specifically NOT recommended for use (downstream devices in same direction).

- The Decision Support message templates are designed as an extension of the DMS message template framework that was created for travel time and toll rate messages.
- Monitor Auto Mode Tour Entries and Camera Temporary Presets can be created only within the context of Traffic Event Response plan. However, they are designed as generic features so that they could be expanded for other uses in the future.
- Auto Mode Tour display processing is done in a similar manner to standard video tour display processing.
- Clean up of Auto Mode Tour Entries and Temporary Presets
  - Done by owning Traffic event when needed.
  - System periodically removes un-needed Auto Mode Tour Entries and Temporary Presets that were not successfully removed by owner.
  - User with Configure Monitor or Configure Camera functional right can remove them if needed using the GUI.

3.19 DMSs

3.19.1 Models

CHART ATMS provides control of DMS devices via proprietary custom manufacturer protocols and via industry-standard NTCIP versions 1 and 2. There are relatively few proprietary DMSs left in the CHART ATMS. Once there are no more DMSs that use a specific protocol left, it is doubtful that any new ones would be added. (For instance, there are no more FP2001 DMSs. There are only about a handful at most of most of the others.) However, support for the existing proprietary protocols is still built into the CHART ATMS. The only remaining proprietary DMS protocol supported is FP9500.

The various protocols vary somewhat in their facilities. For instance, some support a pixel test (all pixels on), and some support, and "extended status" query, which gathers additional information beyond that which can be acquired via a standard DMS poll. The standard DMS poll operates at a minimal level to provide basic health and message querying capability, but does not collect any additional data.

CHART ATMS currently supports NTCIP DMSs, version 1 and version 2. It turns out that all basic features needed by CHART ATMS are supported identically in NTCIP version 1 and NTCIP version 2. This means that there is no flag or indicator to specify whether a particular NTCIP DMS is NTCIP version 1 or NTCIP version 2. NTCIP supports a pixel test and an extended status query. An NTCIP Compliance Tester for DMSs is kept up to date with CHART ATMS changes to the NTCIP protocol, so that the compliance tester always uses the latest CHART ATMS software.

3.19.2 Protocol Handlers

DMS communications are provided at the lowest level by DMS Protocol Handlers. The Protocol Handler encapsulates the specific manufacturer protocol (or industry-standard NTCIP protocol), translating the generic commands from the DMS objects, such as set message or blank sign, to protocol-specific commands. All DMS communications are accomplished via Transmission Control Protocol (TCP) over Internet Protocol (IP), so communications are conducted directly between the Protocol Handler and the device controller. The Protocol Handler also processes responses and pass responses success or failure indications back to the DMS objects.

3.19.3 Communications

All DMSs are communicated to via TCP/IP communications. Within the MDOT network, Raven-X wireless modems provide the TCP/IP communications paths, but as far as the CHART ATMS software knows, they are always-on, directly-connected TCP/IP devices.

3.19.4 DMS Fonts

CHART ATMS supports character matrix, line matrix, and full matrix DMSs, and supports the designation of one font to be used for all messages on the DMS. CHART ATMS accurately models the properties of DMSs, including the sign type, actual size relevant to the sign type, and the actual font being used, which allow DMS message images that appear throughout the system to accurately depict how the message appears on the actual DMS in WYSIWYG ("What You See Is What You Get) format. Using this information, CHART ATMS can precisely determine if a message will fit on a DMS, even if a variable width font is employed.

To support this functionality, display-related data including the sign type, sign size, font, and other display related data is stored in a structure referred to as a DMS Display Configuration. One DMS Display Configuration can be shared by multiple DMSs. Therefore, when adding DMSs of a standard type and size from a single manufacturer, an administrator can define the size, font, and other settings one time in CHART ATMS, and then reference that collection of settings, by name, for each DMS rather than having to define them separately for each DMS. DMSs that share a display configuration, they utilize the same font. This makes it easy to standardize fonts, which helps to provide consistency for the traveling public.

In CHART ATMS DMS message editors that allow editing messages for multiple DMSs at once, such as for a message library or to set the message on multiple DMSs used in a traffic event response plan, there are many variables that affect the DMS message image and the fit checking algorithm. A message that fits on one 3x20 sign may not necessarily fit on a different 3x20 full matrix sign that uses a larger font. These message editors show the user how the message will appear for each display configuration, rather than showing how it will look on every single DMS.

CHART ATMS actively manages the fonts stored within NTCIP DMSs. CHART ATMS uploads the font specified in the display configuration used by a DMS into the controller of NTCIP DMSs to ensure that the font definition used by CHART ATMS in its message images and its fit checking algorithm exactly matches the font used by the actual DMS. Whenever a DMS is put into maintenance mode or online, CHART ATMS checks that the font CHART ATMS expects is loaded in the DMS is in fact actually loaded, and if it is not, CHART ATMS reloads the font into the DMS automatically. With this active font management CHART ATMS can maintain accuracy with regard to message images and message fit on NTCIP DMSs.

CHART ATMS does not provide active font management for non-NTCIP DMSs. For non-NTCIP signs, CHART ATMS can be only as accurate as the font specified in the display configuration used by those DMSs. This means if the actual font used by a non-NTCIP sign is available and specified in the display configuration used by the non-NTCIP DMS, CHART ATMS can be very accurate with regard to its message images and fit check algorithm. Otherwise, the accuracy for the non-NTCIP signs may suffer.

The design for this aspect of CHART ATMS assumes that at some point in the future the system will be required to support the use of more than one font for a single DMS. This design supports this future expansion through the use of a font table in the display configuration and by defining "logical fonts". Currently there is only one font in the font table, and it is logically known as the default font. A specific slot (e.g., slot 1) is assigned for the default font, and that slot number is used on all NTCIP DMSs to store the one font that the display configuration allows in CHART ATMS. In a future release, more fonts could be stored in the DMS display configuration, with logical meanings such as “fixed width template font”, “small font”, “large font”, etc.. Likewise specific slot numbers would be assigned to these logical fonts. By using logical fonts and standardized font slots for those logical fonts, DMS messages that target multiple DMSs (such as library messages) can utilize the logical fonts and the system can more easily ensure the proper font is used. For example, if the CHART ATMS IDL someday specifies that slot 5 is always used for a font known as the “large font”, the MULTI that defines a message can include a tag such as <fn5> and the proper font would be used for message as defined in each DMS display configuration. If desired, certain DMS display configurations could use the same font for all defined logical fonts, in which case a single actual font would be used for all messages (the “large font” would not look different from the “default font”), even though some messages might include multiple “logical” fonts.

3.19.5 Alerts and Notifications

CHART ATMS allows alert and notification settings to be set for each DMS, regardless of its model. Separate values are supported to specify the op center to receive communication failure alerts, the op center to receive hardware failure alerts, the notification group to receive notifications of communication failures, and the notification group to receive notifications of hardware failures. Any or all of these values can be set to “None” to disable that particular alert or notification. When enabled, if CHART ATMS detects a status change related to the given type of failure (hardware or communication), CHART ATMS creates an alert and assigns it to the specified operations center and/or sends a notification to the specified notification group.

3.20 HARs

3.20.1 Background

A HAR is Highway Advisory Radio. These are also referred to in the industry as a “TAR” (Traffic Advisory Radio), but within the Maryland domain, they are referred to exclusively as HARs. A HAR is a limited power radio used to communicate traffic information to the travelling public. The range is typically in the neighborhood of two miles. (For this reason, the length of a HAR message is typically limited to 2 minutes (about 2 miles at 60 mph, assuming travel through the diameter of the HAR broadcast range). When a significant message is playing, “HAR Notifiers” (highway signs) inform the public that they should tune their radio to the specific frequency to hear the message. A HAR Notifier is typically a “SHAZAM” (see separate section within this Functional View), a painted highway sign with beacons that flash when a message is active. A HAR Notifier can also be a DMS which happens to be near the HAR. Within CHART ATMS, a HAR Notifier (SHAZAM or DMS) can be associated with exactly one HAR (or no HAR at all). When a DMS is used as a HAR Notifier, part of the DMS configuration indicates the message to display when the DMS is being used as a notifier.

3.20.2 Models

CHART ATMS supports three models of HARs. Two are “real” HARs, and one is a “pseudo” HAR. The real HARs are the model AP55 from Information Station Specialists (ISS) and the model DR1500 by Highway Information Systems (HIS). The AP55 was included very early in CHART ATMS; the DR1500 was included somewhat more recently.

The "pseudo" HAR model is the MD511 "HAR", supporting the statewide Maryland 511 telephone system. This device is not truly a HAR, but has HAR-like behavior: it accepts audio messages (recorded audio or text to speech) and makes the messages available to the public. Because of this similarly, Maryland 511 integration into the ATMS was modeled like a HAR. All HARs of type MD511 (of which there is expected to be only one, at least initially) are automatically added to the response plan of every traffic event, as it is created. The operator can then decide whether to put a message on Maryland 511 or remove the MD511 HAR(s) from the response plan. (An operator can also leave the MD511 HAR unused in the response plan, if it is initially uncertain whether the event warrants broadcast of Maryland 511.) Unlike other types of HARs, MD511 HARs do not support SHAZAMs or DMS-based notifiers, as the MD511 HAR does not exist at a specific point on a specific roadway where a notifier would make sense.

3.20.3 Protocols

The HIS DR1500 protocol is essentially a superset of the AP55 protocol, therefore much of the ISS AP55 code was reused for the DR1500. Both the HIS DR1500 and the ISS AP55 support:

- Store message
- Play message
- Blank HAR
- Turn HAR transmitter On/Off
- Monitor broadcast
- Set up HAR
- Reset HAR (automatically followed by a Set up HAR command)

Because the HIS DR1500 has the additional capability to play messages in a synchronized manner across multiple HARs, the HIS DR1500 also supports:

- Play synchronized message
- Clear HAR memory (defragments and reclaims memory)

The HIS DR1500 also has the capability to respond to commands. Although the HIS DR1500 has more extended status/response capabilities, CHART ATMS processes only DR1500 responses to the commands that CHART ATMS sends to the HIS DR1500 in order to assess whether the commands succeeded or failed. This allows users to get feedback from the HAR. CHART ATMS also needs to get the HAR memory usage in order to defragment and reclaim HAR memory.

- Receive response to command
- Get HAR memory usage

3.20.4 Protocol Handlers

HAR communications for the AP55 and DR1500 HARs are provided at the lowest level by HAR Protocol Handlers. The Protocol Handler encapsulates the specific manufacturer protocols, translating the generic commands from the HAR objects, such as download audio or set play list, to protocol-specific commands (such as play messages in the case of DR1500 HARs)

The MD511 HAR does not use a Protocol Handler, but uses an analogous approach to communicating with the Maryland 511 phone system provider (currently CR Dynamics). The

ATMS communicates with the MD511 HAR, which is via HTTP through a VPN tunnel. If multiple MD511 HARs are ever deployed, the telephone number will distinguish which MD511 system is the target of a particular communication. The ATMS attempts to prevent two MD511 HARs being configured with the same telephone number.

3.20.5 Synchronized HAR

The HIS DR1500 provides the capability for multiple DR1500 HARs in close physical proximity to play messages in a synchronized manner. This is intended primarily for HARs so close along a highway that their broadcast ranges overlap. All broadcast on the same frequency, providing a continuous broadcast stream along the length of highway. (Of course synchronized mode can also be used for HAR which are not that close in proximity.)

Within CHART, a "Synchronized HAR" is a HAR-like entity that is comprised of one or more individual constituent HARs that play messages in a synchronized manner. The Synchronized HAR itself does not exist in the real world – it represents the collection of individual constituent HARs (although within CHART a Synchronized HAR is given a real location in the world that represents, for instance, the rough center of the collection of individual HARs being represented). The Synchronized HAR provides a single interface to command and control such a group of HARs. Currently a Synchronized HAR may be comprised of only HIS DR1500 HARs, since this is the only HAR model within CHART that supports synchronization. However, the converse is not true. A DR1500 does not have to be configured as a constituent HAR within a Synchronized HAR; it can alternatively be configured as an individual independent HAR not associated with any Synchronized HAR. In fact, a DR1500 must be added to the system as an individual HAR first, and then added to a Synchronized HAR if desired.

In general, a Synchronized HAR appears to be a single HAR to the user and can be added to a traffic event's response plan and executed just like any other HAR within CHART ATMS. By default, online and maintenance mode messages put on a Synchronized HAR go out to all its constituent HARs. However, the user has additional options when putting a message on a Synchronized HAR. The user has the option to individually select which constituents on which to broadcast, and which notifiers those constituents should use.

A Synchronized HAR always ensures that every one of its constituent HARs either play the same message as all the others, or be completely silent (not transmitting). If the user chooses to broadcast on a subset of the available constituent HARs within a Synchronized HAR, the constituent HAR(s) not selected simply become silent. Had the typical default message be broadcast, it would interfere with the message being broadcast on the actively selected constituent HARs. This "silent" status is depicted in the GUI with the text "silent" and a slight graying of the background. This logic applies to playing a message in maintenance mode or as part of a traffic event.

The following administrative functions work with Synchronized HARs just like any other HAR within CHART ATMS:

- Put Synchronized HAR online
- Take Synchronized HAR offline
- Put Synchronized HAR in maintenance mode
- Perform synchronized HAR maintenance mode commands:
    - Store message

- Play message
- Blank HAR
- Turn HAR Transmitter On/Off
- Monitor broadcast
- Set up HAR
- Reset HAR

- Add Synchronized HAR to system (includes adding default header, message, trailer)
- Delete Synchronized HAR from system
- Edit Synchronized HAR (includes adding and deleting constituent HARs)

These administrative commands for a Synchronized HAR trickle down to its individual constituents. This means that if a user chooses to put a Synchronized HAR online, the individual synchronized HARs go online as well. This same logic applies for the other administrative functions listed above.

While the Synchronized HAR functions very much like any other HAR in the CHART ATMS, including having a description/location, message, device status, etc., users can drill down to the individual constituent HARs to see their status, etc. Users can see a table of constituent HARs on a Synchronized HAR details page, can see the status of those constituent HARs, and can turn individual constituents off when broadcasting a message. Users also can view the constituent HAR details. Also, suitably privileged administrators can perform administrative functions on individual constituent HARs. This means that an individual constituent may be placed offline, online, or in maintenance mode. When in maintenance mode, a user can command the individual constituent HAR without generally affecting the other constituents or the Synchronized HAR itself. There are some cases where there are some restrictions on individual constituents. For instance, a constituent HAR in maintenance mode may not have its transmitter turned on if any of the other constituent HARs comprising the Synchronized HAR are online. This is to prevent conflicting messages from playing when the Synchronized HAR is online.

3.20.6 Multiple HAR Operations

CHART ATMS allows a user to command multiple HARs of any type using the Multiple HAR Response Plan Item (RPI) Editor. This means that a user can configure a broadcast of the same message on multiple HARs, including Synchronized HARs and MD511 HARs, including indicating – for real HARs – which notifiers to activate based on direction. However, a user may not select individual constituent HARs of a synchronized HAR using the Multiple HAR RPI Editor.

3.20.7 Communications

In addition to providing telephony communications to AP55 HARs and DR1500 HARs, CHART ATMS also supports communications to DR1500 HARs via TCP/IP. An optional module known as the Digital Communications Controller (DCC) must be added to a DR1500 HAR to enable TCP/IP communications. Several existing DR1500 HARs are outfitted with this module.

When adding a DR1500 HAR to the system, an administrator must specify TCP/IP communication. When TCP/IP is selected for a DR1500 HAR, the user may also enable polling of the device to have the system periodically check the status of the HAR. The communications type can be edited after a HAR is initially added to the system using the Control Line Communications Settings form.

3.20.8 Polling

When a DR1500 HAR is set to use TCP/IP communications and polling is enabled, the system queries its status on the interval as specified in the configuration. During each status poll, the system checks the HAR state as reported by the device against the HAR state as specified in CHART ATMS to determine if the HAR indicates it is doing what CHART ATMS last commanded it to do. CHART ATMS checks the play list, the transmitter on/off status, and the HAR Timestamp to determine if there is a status match. If the status does not match, CHART ATMS automatically queues a Setup command for the HAR to restore the appropriate clips, playlist, and transmitter status to the HAR

Another function performed during a poll of a DR1500 is to check status values against configured thresholds for those values. Configuration values are included to allow thresholds for various status values to be specified, and these values are used by the system during polling to determine if a hardware failure condition exists. If during a status poll CHART ATMS determines a status value lies outside the configured threshold it sets the HAR status to hardware failed. The values CHART ATMS checks against thresholds are the DC Voltage, Broadcast Monitor Percent, Modulation Percent, and Voltage Standing Wave Ratio (VSWR).

The status values obtained from the most recent poll of the HAR are displayed on the HAR's details page within the GUI and indicates which values (if any) are found to be outside the configured thresholds and therefore cause a hardware failure condition.

The MD511 HAR is polled on a regular basis (while online), and the Maryland 511 phone system vendor will play a System Unavailable message if a it does not hear from the ATMS within its configured comm loss timeout. An MD511 HAR can also be forced into this System Unavailable state by placing the MD511 HAR offline in the ATMS. (Both the comm loss timeout and the System Unavailable message are configured outside of the ATMS via a separate standalone web site.) Polling of the MD511 HAR(s) is required.

3.20.9 Monitoring HAR Audio

When a DR1500 HAR is operated using TCP/IP communications, monitoring the HAR's audio is not possible. Monitoring of audio for MD511 HARs is not supported. The Maryland 511 system message can be verified by dialing 511 on any telephone in the state of Maryland.

3.20.10 Alerts and Notifications

CHART ATMS allows alert and notification settings to be set for each HAR, regardless of its model and the type of communications used to control it. Separate values are supported to specify the op center to receive communication failure alerts, the op center to receive hardware failure alerts, the notification group to receive notifications of communication failures, and the notification group to receive notifications of hardware failures. Any or all of these values can be set to "None" to disable that particular alert or notification. When enabled, if CHART ATMS detects a status change related to the given type of failure (hardware or communication), CHART ATMS creates an alert and assign it to the specified operations center and/or sends a notification to the specified notification group. An MD511 HAR goes into communications failure if the vendor's website cannot be reached, and goes into hardware failure if the website returns and error status or any other unexpected status.

Some HAR models (such as the AP55 and DR1500 configured to use a Telephony port) do not support polling or retrieving status, so these HARs cannot ever raise a hardware failed condition. Therefore, setting an op center and/or notification group for such HARs serves no purpose (nor does no harm). However, for simplicity, the feature exists for all HARs. The alert and notification feature was developed generically to apply to all HARs to avoid rework in the future if support for other HAR models is added to the system.

3.21 HAR Audio Management

3.21.1 HAR Messages and Audio Clips

CHART ATMS allows operators to enter text or upload pre-recorded audio at their workstation for broadcast on a HAR device. Each message consists of one or more "clips". A message can specify its own header clip or it can use the default header for the HAR(s) it is destined for. A message can also specify its own trailer clip, or can use the default trailer, or it can use no trailer. Typically (or virtually always), the default header and default trailer are specified for all messages. A user must specify exactly one "body" clip for a HAR message. This is where the actual unique part of the HAR message goes. (A message created within the HAR service can consist of multiple body clips when HAR messages are combined. The header plays once, all the body clips play, then the trailer plays once, and this cycle is repeated.) Each clip specified by a user can be uploaded audio or text.

Because voice data can be very large, the passing of voice data with HAR messages is minimized through the use of wrapper objects and streamers.

Uploaded audio is supported in the CHART ATMS for:

- immediate broadcast on a HAR
- storage in a slot on a HAR for future broadcast, and
- storage in a message library.

When audio is uploaded the data is packaged in a HARMessageAudioDataClip object, which in turn is included in a HARMessage object. Upon receiving a HARMessageAudioDataClip, the object receiving it (a HAR, a TrafficEvent's ResponsePlanItem, or MessageLibraryDB) uses a utility class called an AudioClipManager to persist the "heavyweight" HARMessageAudioDataClip audio data and obtain a HARMessageAudioClip in its place. The HARMessageAudioClip contains a unique ID and a reference to an object known as a streamer that can provide access to the actual voice data given the ID. The AudioClipManager is a streamer and places a reference to itself in every HARMessageAudioClip it creates.

Because HARMessageAudioClip objects are small, they can be passed throughout the system as the part of the device status for a HAR without having a significant impact on network bandwidth usage. The only times the audio data is passed across the network after its initial storage are when the user wishes to listen to the voice data from the HAR or the voice data needs to be recorded onto the HAR device. When this occurs, the HARMessageAudioClip is told to stream the data and the HARMessageAudioClip delegates the request to the streamer reference it contains, which is always the AudioClipManager where the data was originally stored.

As various software objects within CHART ATMS gain access to a HARAudioClip and find a need to have the data persisted, they register their interest in the clip with the AudioClipManager stored within the clip. The AudioClipManager never deletes the voice data associated with a clip as long as at least one clip "owner" is registered for it. A clip stored in a message library, specified in a ResponsePlanItem, and being broadcast on a HAR would have those three separate entities maintaining interest in the clip with the AudioClipManager.

3.21.2 Audio Clip Manager

Uploaded audio data is cleaned up within the AudioClipManager as owners deregister interest in clips when they are no longer needed. As HARs, ResponsePlanItem objects, and MessageLibraryDB objects lose interest in a clip, they deregister interest in the clip, which passes the request on to the AudioClipManager. The AudioClipManager removes the association between the clip owners and the clip as deregister requests come in, and it deletes the voice data itself when there are no registered owners left for a clip. Because this system is not foolproof, and because audio data is large and expensive to store, the AudioClipManager periodically requests services to revalidate their interest in the clips they are registered for. This is a low-bandwidth operation during a period of low bandwidth usage (in the middle of the night), and is more efficient than coding the software entities to be fail-safe in deregistering interest. In other words, if the AudioClipManager happens to be down or unreachable, an audio clip owner need not take extraordinary effort to retain information about the failed deregistration attempt and undertake a complicated retry scheme.

3.21.3 Text-To-Speech Capabilities

CHART ATMS also provides the capability for Text To Speech. This is the preferred method for broadcasting HAR messages, as the text is easy to read and easy to type, provides a consistent sound for the traveling public, and can be maintained in the CHART ATMS archive database indefinitely, at low cost. Audio messages are not maintained once the need for the voice clip has passed. Some operators also are uncomfortable with having their voice broadcast publicly, and may find it difficult to record a voice message that they are satisfied with.

To facilitate the use of Text To Speech, CHART ATMS includes a pronunciation glossary. This enables operators to type text without having to alter spelling in order to improve the pronunciation in the text-to-speech engine. Any suitably privileged operator can maintain the pronunciation entries in the dictionary.

Operators should type all HAR messages using the correct spelling of all words. Any words not in the pronunciation dictionary should be added during the preview process, or as soon as possible. Any a word that requires substitution is substituted before the text-to-speech conversion is done. The operator need not be aware of this process. Some operators seem to prefer the way of typing HAR messages learned long ago, making extensive use of phonetic spellings, such as EYE for “I,” “EGGS IT” for “EXIT”, etc. This is not necessary, but works fine.

3.22 Arbitration Queues

A key feature of CHART ATMS DMSs and HARs is the “arbitration queue”. An arbitration queue arbitrates the usage of a device by maintaining a prioritized message queue for the associated device. As messages are requested to be displayed or broadcast on a specific device, they are assigned priorities based on a predefined message priority scheme (discussed later) and are added to the queue. The Arbitration Queue has the responsibility of determining which message should be shown/broadcast by a messaging device. It allows any number of traffic events to add entries to a device’s arbitration queue. The queue can hold multiple entries and decides which entry is to be placed on the device based on priority.

Each message in the queue is queued by a traffic event (or by a DMS, in the case of a Traveler Information Message such as a travel time or toll rate message or a Triggered Message such as a weather condition message, or by a HAR, in the case of in the case of a Triggered Message, or a SHAZAM message being placed on a DMS). Generally, a traffic event (or DMS or HAR) can have only one message at a time in a device's queue (although a device can post multiple Triggered Weather Messages on itself, such usage is rare). A message is removed from the queue when the related traffic event is closed (or when the response plan item deactivates them), when the DMS Traveler Information Message is deactivated (either by a user or due to inadequate data), when the conditions that warrant a Triggered Message are no longer true, or when a HAR message using a DMS as a SHAZAM is no longer broadcasting the relevant message. Messages can be added to and removed from a device's arbitration queue regardless of the current communication mode of the device. In this way, a device that has been offline is automatically brought immediately up to date with the latest highest priority messages requested for it as soon as the device is brought online again. The queue is automatically be evaluated whenever a device is placed online, in order to ensure that the correct message is sent to the device.

Whenever a message is added to or removed from the arbitration queue, the queue evaluates all entries and decides which message (or messages) should be shown/broadcast by the queue's associated device as follows:

- If a message is added to the queue and the queue is empty, the message is put on the device.
- If a message is added to the queue and the queue is not empty, the queue evaluates the messages on the queue (including the new message), determines which message(s) has or have the highest priority, and places the highest priority message(s) on the device.
- If a message is removed from the queue and this leaves the queue empty, the device is blanked or a default message is broadcast depending upon the type of the device.
- If a message is removed from the queue and other messages remain on the queue, the queue evaluates the messages on the queue (excluding the removed message), determines which message(s) has or have the highest priority, and places the highest priority message(s) on the device.

As alluded to in the processing described above, Arbitration Queues can allow multiple messages to share a device. In the case of a DMS two single page messages can be concatenated into a single two-page message. In the case of a HAR, multiple messages can be concatenated if the total amount of playtime of the messages is less than the configurable limit set by the administrator.

Settings in the system profile allow an administrator to specify which DMS messages can be combined based on the arbitration queue "bucket" where they currently reside. The administrator can allow any combination of messages they wish, without restriction. The DMS will restrict combination of messages, even if allowed, if the combined message would exceed the page limit specified for the DMS. The matrix in Table 3-1 provides a recent example of the pairings used to combine messages on DMSs. (Note that the shaded lower left part of the diagram is a mirror image of the upper right part of the diagram and in the GUI does not allow selections as it is redundant.

Table 3-1. CHART ATMS DMS Message Combinability

Arbitration Queue Bucket	**U**	**I**	**P**	**R**	**VH**	**T**	**H**	**C**	**SH**	**W**	**M**	**SP**	**A**	**L**	**SA**
Urgent (U)	X	X							X						
Incident (I)	X	X							X						
Planned Roadway Closure (P)			X					X	X						
Toll Rate (R)															
Very High (VH)															
Travel Time (T)															
High (H)															
Congestion (C)			X					X	X						
SHAZAM (SH)	X	X	X					X							
Weather (W)															
Medium (M)															
Special Event (SP)															
Action Event (A)															
Low (L)															
Safety Message (SA)															

A maximum of two messages are allowed for combining for a DMS. Combination is only allowed in the pairs indicated by Xs in the above matrix. For instance, an "Urgent" message can be combined only with another "Urgent" message, an "Incident" message, or a "SHAZAM" message. For HARs, messages can be combined up to a 2-minute limit (system-wide configurable parameter). All types of messages are eligible for combining on a HAR (the above matrix for DMS message combining does not apply for HARs). HAR Messages are searched in priority order until the 2-minute limit is hit. The search is terminated once a message is found which does not fit – rather than continuing the search to see if any lower priority messages that happen to be shorter would fit instead.

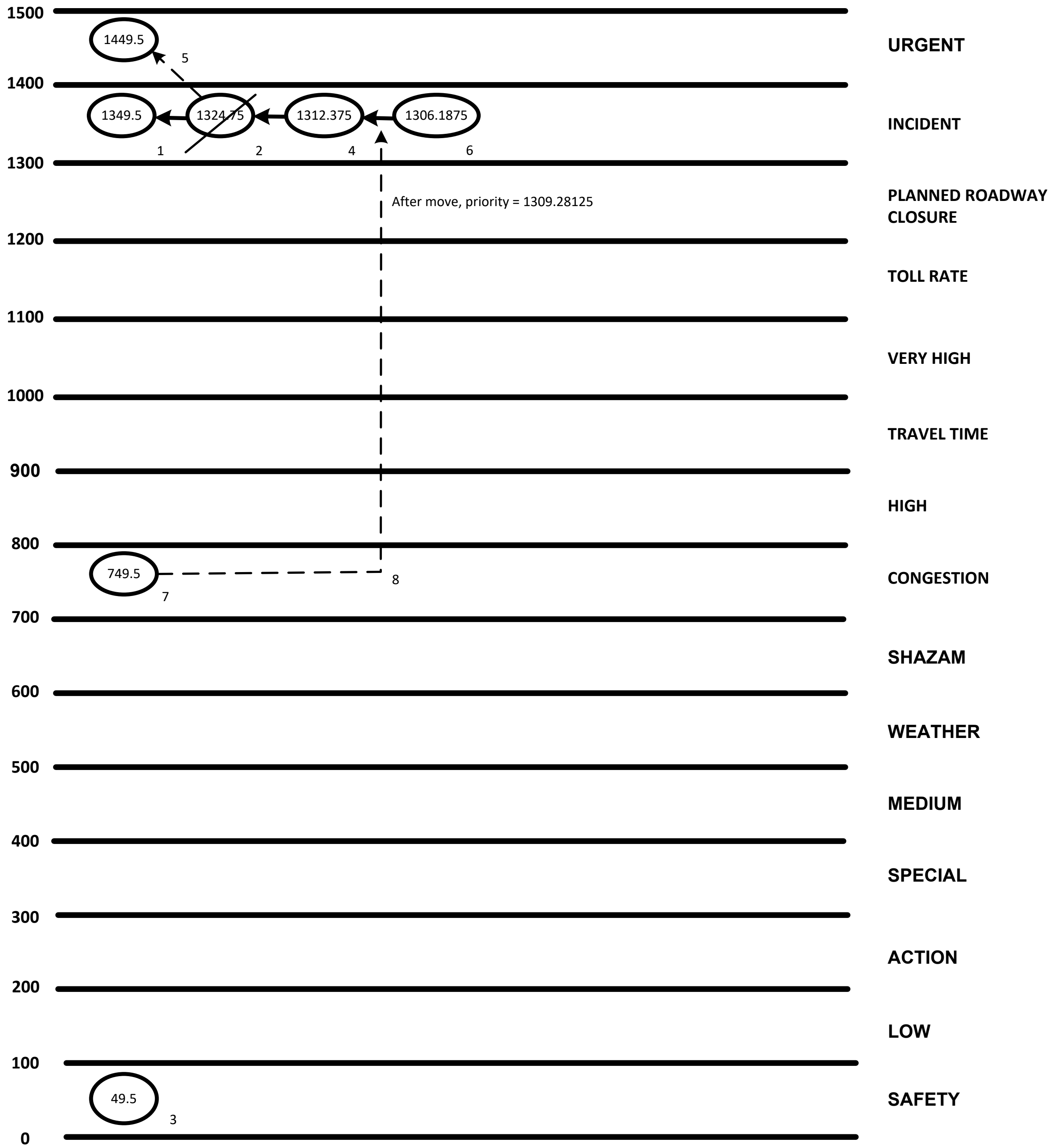
Note that by design On/Off devices also use an arbitration queue. The main difference between On/Off devices and HAR/DMS devices is that On/Off devices don't have a message; they can simply be on or off. When an On/Off device is included in the response plan of a traffic event, or when an On/Off device executes a Triggered Activation on itself, the intent is for the On/Off device to be on/activated while the response plan item or triggered activation is in an "executed" state, and for the device to be off/deactivated while the response plan item or triggered activation is not in an "executed" state. When multiple traffic events and/or triggered activations call for an on/off device to be activated, the system will activate the device. It doesn't matter if other events include the On/Off device in their response plan in a "not executed" state or if other triggered activations are not associated with an activated trigger; it only takes one such activation request for the device to be activated. For this reason, the priority levels in the arbitration queue for an On/Off device don't have any bearing on whether or not the device will be activated. Despite this fact, the system will include priority levels in an On/Off device arbitration queue and even allow the user to change priority levels of an event on the queue, however doing so will have no effect on whether or not the device is active. This is done to allow existing GUI and Server design and code to be reused for on/off devices.

3.22.1 Priority Scheme

Each entry in the queue is assigned a priority. A number is used to indicate the priority of each message on the queue, with a higher number indicating a higher priority (and thus more likely to be placed on the device). When a message is added to a queue, it is given a default priority number that is based on the type of event from which the message originated and the number of messages already in that arbitration queue category (often referred to as a "bucket"). The agreed-upon priority order of message types are, from highest to lowest,

- Urgent (nothing is enqueued here directly, but certain users can move messages here)
- Incident Event (enqueued by a Traffic Event on a DMS or HAR)
- Planned Roadway Closure Event (enqueued by a Traffic Event on a DMS or HAR)
- Toll Rate Message (enqueued by a DMS on itself (using Travel Route data))
- Very High (may be enqueued by a device for a triggered message/activation)
- Travel Time Message (enqueued by a DMS on itself (using Travel Route data))
- High (may be enqueued by a device for a triggered message/activation)
- Congestion Event (enqueued by a Traffic Event on a DMS or HAR)
- SHAZAM Message (enqueued by a HAR on a DMS configured as a notifier for it)
- Weather Event (enqueued by a Traffic Event on a DMS or HAR)
- Medium (may be enqueued by a device for a triggered message/activation)
- Special Event (enqueued by a Traffic Event on a DMS or HAR)
- Action Event (enqueued by a Traffic Event on a DMS or HAR)
- Low (may be enqueued by a device for a triggered message/activation)
- Safety Event (enqueued by a Traffic Event on a DMS or HAR)

The concept of the "Urgent" category is to place messages in this category that should surpass all events added in the system. Sufficiently privileged users are able to move a message to (and out of) this level. Within a level, the FIFO (first in – first out) queue concept is used. Messages can be moved into other arbitration queue buckets or can be rearranged within a single arbitration queue bucket. Repositioning a message into a new bucket changes the priority of the message on the queue, but does not change the type of the event. For example, a congestion response plan moved to the incident level will not change the type of the event to incident. It just changes the priority of the activation of the plan on the device.



1. Add Incident
2. Add Incident
3. Add Safety event
4. Add Incident
5. Move Incident to Urgent
6. Add Incident
7. Add Congestion
8. Move Congestion to Incident

Figure 3-1. CHART ATMS Arbitration Queue Priorities

Figure 3-1 shows an example of a sequence of system actions that occur when response plans are added, removed or placed on different priority levels on a device's arbitration queue. Initially, the queue for a device is empty. When an incident response plan$_1$ is activated the message gets placed on the device's queue. The priority number assigned is based on the pre-defined range level for the event type. In this example, the range level for incidents is between 1300 and 1399 (as the number 1400 is actually part of the Urgent bucket's range). The priority assigned to the event is the mean of the two limits, e.g., 1349.5. An automatic evaluation of the queue places the message on the device, since it is the only message on the Arbitration queue. When another incident message$_2$ gets added to the queue, the system automatically assigns it a lower priority than the previous one. This is computed as the mean of the lowest priority message in the queue (1349.5) and the bottom end of the bucket's numerical range (1300), resulting in a value of 1324.75. Assuming DMS message concatenation does not come into play, automatic evaluation of the queue at this time does not place the newly added message on the device. The message currently on the device has a higher priority and the associated response plan is still active in the system. A Safety message$_3$ and an Incident$_4$ response plan added are placed in their levels, each with an assigned priority. If at this point, the user gives the incident$_5$ the highest priority (a new priority is assigned), the currently active incident response plan$_1$ is suspended and the higher priority message$_2$ is activated. Moving a congestion response plan$_7$ between the two incident messages$_{4,6}$ reassigns the congestion event a new priority$_8$ but does not change its event type.

The Chart2DMSImpl, HARImpl, and OnOffDeviceImpl implement the ArbitrationQueue interface defined for the Arbitration Queue. The responsibility to manage entries, i.e. add, remove, change priority, is delegated to the MessageQueue, a utility class. The entries in the list are ordered according to their assigned priority. The Chart2DMSImpl, HARImpl, and OnOffDeviceImpl are responsible for evaluating the queue, concatenating messages (DMS/HAR), determining the message that should be sent to the device (DMS/HAR) and sending queue updates to the CHART ATMS GUI. Unlike DMS and HAR devices, for which each Arbitration Queue entry contains a different message, the entries on an On/Off Device Arbitration Queue all are requesting the same action; to activate the device. For this reason, the priorities in the Arbitration Queue of an On/Off Device do not have a bearing on the state of the device. As long as there is one entry on the Arbitration Queue of an On/Off Device the device will be activated.

3.22.2 Detailed Device Status and Arbitration Queue Manipulation

The CHART ATMS GUI allows users to view the entries in a device's arbitration queue. A user with the proper functional rights can manually change the priority of items on a device's queue to override the queue's automated prioritization scheme. When the priorities of entries on an arbitration queue are manually changed, the arbitration queue evaluates the priorities of the entries on the queue to determine if the message on the queue's associated device (DMS/HAR) should be changed. New entries added after a reordering are placed in the proper relative position. When a user re-orders the queue, they do so by manually moving one entry at a time to a new position in the queue. When an entry is moved, the priority number of the entry that was moved is changed to be slightly higher than the priority of the entry immediately following it. In the case where an entry is moved to be the last in the queue, it is given a priority number slightly less than the message above it. This is accomplished by using floating point numbers to indicate priority. If a user moves an incident entry behind a roadwork entry, new roadwork entries are placed behind this entry while new incident entries are placed in the incident level below the lowest incident on that level. Each manual entry repositioning is accomplished by issuing one request to the queue, to avoid the delays that locking the entire arbitration queue would entail.

The GUI also allows the user to view the queue and device status, i.e., current entry prioritization, active entries, and recent communication actions with the device. The CORBA event service is used to notify GUIs regarding any changes to the device's queue.

Figure 3-2 shows a representation of how the view is organized. The top section shows all the entries on the Arbitration Queue. A suitably privileged user is able to change priorities of the entries. The middle section shows the Queue status regarding changes to the queue as they are being executed. The bottom section shows the device status while commanding the device.

Message	Op Center	Type	State
Accident Ahead on I-495 near Exit 22	TOC3	Incident	Active
Drive Safely	SOC	Safety	Queued
Accident on 1-270 near Exit 3 (Montrose Road)	TOC3	Incident	Queued

Queue Status

Message " Congestion Ahead" removed from the Queue

Device Status

Dialing Device

Figure 3-2. CHART ATMS Arbitration Queue Status

3.23 SHAZAMs

3.23.1 Background

A "SHAZAM" is a sign on a roadway near a HAR which provides an indication that a message of some significance is being broadcast by the HAR nearby. The sign is mostly painted, like a standard highway sign, and also includes beacons (lights), typically two, which light up or, typically, flash on and off, generally in alternating fashion, to indicate a message is on the HAR. The painted part of the sign informs the traveling public of the radio frequency to tune to. The "SHAZAM" is a term which appears to be unique within the State of Maryland. Most of the ITS industry refers to these simply as "beacons". A SHAZAM is a standalone device operated independently of the HAR it is associated with (although the CHART ATMS helps to tie these devices more closely together). Even if there is a message on a HAR, operators can choose whether to activate any SHAZAMs or not. (Note: DMSs can also be used to inform the public of a message on a HAR. When a DMS is used in this fashion, the message is referred to (within Maryland) as a "SHAZAM message".)

3.23.2 Models

The ATMS supports two models of SHAZAMs: HWG ER02a and ER02b. Note that the ER02b uses the same protocol as the ER02a so ATMS treats both as a single protocol. The ER02a by itself is not a SHAZAM at all; it is a simple device that provides network access to two electronic relays. One of the two relays is connected to the beacon circuitry of the SHAZAM being controlled. The beacons themselves are configured within the SHAZAM to be always on, but they need the relay to be closed in order to complete the circuit and cause the beacons to flash. In all respects, the ER02a is the on-off switch. The other relay is unused. When the SHAZAM is activated in CHART ATMS, CHART ATMS closes the relay that is used to turn the beacons on. Likewise, when the SHAZAM is deactivated in CHART ATMS, CHART ATMS opens the relay which causes the beacons to turn off.

3.23.3 Protocol Handlers

SHAZAM communications are provided at the lowest level by Relay Protocol Handlers. The Protocol Handler encapsulates the specific manufacturer protocols, translating the generic commands from the SHAZAM objects, such as enable beacons or disable beacons, to protocol-specific commands (play messages for HWG-relay-based SHAZAMs), and, in the case of the HWG devices, can also process responses and pass success or failure indications back to the HAR objects.

3.23.4 Communications

As for all other types of devices, when adding a SHAZAM to the system, an administrator can select the model of the SHAZAM being added. Currently only the HWG ER02a can be selected. When the ER02a model is selected, TCP/IP communications is automatically selected as the only choice for this model, and the administrator enters the IP address and port.

3.23.5 Refresh / Polling

The CHART ATMS provides a refresh feature for SHAZAM devices. This feature allows refresh to be enabled for any SHAZAM and for a refresh interval to be specified. When refresh is enabled, CHART ATMS periodically connects to the SHAZAM and issues commands to set the SHAZAM's beacons to the state currently specified in CHART ATMS (beacons on or off). For the HWG ER02a, CHART ATMS can query the device for the status of its relay (and thus the status of the beacons) to be queried. When doing a refresh for a HWG ER02a SHAZAM, CHART ATMS checks the status of the relay after the refresh command to determine if the relay is set as CHART ATMS commanded it. If not, CHART ATMS sets the SHAZAM's status to indicate a hardware failure.Alerts and Notifications

CHART ATMS allows alert and notification settings to be set for each SHAZAM, regardless of its model and the type of communications used to control it. Separate values are supported to specify the op center to receive communication failure alerts, the op center to receive hardware failure alerts, the notification group to receive notifications of communication failures, and the notification group to receive notifications of hardware failures. Any or all of these values can be set to "None" to disable that particular alert or notification. When enabled, if CHART ATMS detects a status change related to the given type of failure (hardware or communication), CHART ATMS creates an alert and assigns it to the specified operations center and/or sends a notification to the specified notification group.

As noted above, only the HWG ER02a SHAZAM model supports detecting a hardware failure. The Viking RC2A never raises a hardware failed condition and therefore setting an op center and/or notification group for those SHAZAMs serves no purpose (although it causes no harm). The alert and notification feature is implemented generically to apply to all SHAZAMs to avoid rework in the future in case support for new SHAZAM models is added to the system in the future.

3.24 On/Off devices

3.24.1 Background

On/off devices are controlled by an underlying electronic relay. CHART ATMS supports the use of electronic relays from HW-Group, models ER02a and ER02b. The ER02b model is only supported if it has been loaded with the ER02a firmware. CHART ATMS operates either model relay exactly the same, using the ER02a protocol. When adding an On/Off device to CHART ATMS or changing the model of an existing On/Off device in CHART ATMS, the system allows the administrator to specify which model relay is used to control the device. When the On/Off device is activated in CHART ATMS, CHART ATMS closes the relay that is used to activate the device. Likewise, when the On/Off device is deactivated in CHART ATMS, CHART ATMS opens the relay which causes the device to turn off.

In addition to model types, CHART ATMS supports the concept of a device type, used to further classify on/off devices. The system is initially populated with two On/Off device types, Fog Beacon and Fog Horn. In addition to providing a name for a type of On/Off device, the definition of an On/Off device type also serves to specify the set of icons used to represent that type of On/Off device within CHART ATMS.

3.24.2 Models

On/Off devices do not have model types per se. The system is initially populated with two On/Off device types, Fog Beacon and Fog Horn. In addition to providing a name for a type of On/Off device, the definition of an On/Off device type also serves to specify the set of icons used to represent that type of On/Off device within CHART ATMS. CHART ATMS supports the use of electronic relays from HW-Group, models ER02a and ER02b as the underlying controller for an On/Off device. The ER02b model is only supported if it has been loaded with the ER02a firmware. CHART ATMS operates either model relay exactly the same, using the ER02a protocol. When adding an On/Off device to CHART ATMS or changing the model of an existing On/Off device in CHART ATMS, the system allows the administrator to specify which model relay is used to control the device. When the On/Off device is activated in CHART ATMS, CHART ATMS closes the relay that is used to activate the device. Likewise, when the On/Off device is deactivated in CHART ATMS, CHART ATMS opens the relay which causes the device to turn off.

3.24.3 Protocol Handlers

On/Off device communications are provided at the lowest level by Relay Protocol Handlers. The Protocol Handler encapsulates the specific manufacturer protocols, translating the generic commands from the On/Off device objects, such as activate or de-activate, to protocol-specific commands (i.e., TCP messages for HWG-relay-based On/Off devices), and, in the case of the HWG devices, can also process responses (TCP/IP) and pass success or failure indications back to the On/Off device objects. The protocol handler is generic and is used to control both On/Off devices and SHAZAMs.

3.24.4 Communications

Similar to other types of devices, when adding an On/Off device to the system, an administrator can select the type of On/Off device (e.g., Fog beacon or Fog Horn) and the model of relay device (e.g., HWG ER02a or HWG ER02. When the ER02a/b relay device is selected, TCP/IP communications is automatically selected as the only choice for this model, and the administrator enters the IP address and port.

3.24.5 Polling

The CHART ATMS provides a polling feature for On/Off devices. This feature allows a user to poll the underlying relay device when an On/Off device is online or in maintenance mode, and allows an administrator to enable automated polling of the on/off device on a specified interval. Automated polling only takes place when the on/off device is online. When an On/Off device is polled, CHART ATMS contacts the underlying electronic relay to obtain its current status. If the state of the electronic relay is found to not match the state as last commanded by CHART ATMS, the system will command the relay to the desired state. If after commanding the relay to the desired state the queried electronic relay status still does not match the desired state, CHART ATMS will consider the device hardware failed. Note that the polling feature is made possible due to the ability of the HWG ER02a/b models to return their current status. If other electronic relay models are added in the future, support for polling those devices will be dependent upon their ability to return their current status.

3.24.6 Alerts and Notifications

CHART ATMS allows alert and notification settings to be set for each On/Off device, regardless of its type and the type of communications used to control it. Separate values are supported to specify the op center to receive communication failure alerts, the op center to receive hardware failure alerts, the notification group to receive notifications of communication failures, and the notification group to receive notifications of hardware failures. Any or all of these values can be set to "None" to disable that particular alert or notification. When enabled, if CHART ATMS detects a status change related to the given type of failure (hardware or communication), CHART ATMS creates an alert and assigns it to the specified operations center and/or sends a notification to the specified notification group.

3.25 TSSs

3.25.1 Background

A TSS is "Traffic Sensor System". This is generally a radar based device when monitors the speed of vehicular traffic passing by. Within the CHART ATMS domain, TSSs are also known as RTMSs (after the model of TSS supported) or more simply as "detectors", or, less frequently, simply as "sensors".

In addition to measuring speed, detectors typically count the vehicles passing by; perform some level of classification (by length) of the various vehicles passing by; and compute a measure of "occupancy" of the highway (percent of time some part of a vehicle is being detected vs. the time no vehicle is being detected). A TSS can perform all these measurements and report results for multiple lanes, on a per-lane basis. In this context, the term "zone" comes into play. Typically (if not universally) each zone represents a single lane of traffic. Zones can be grouped into "zone groups", for instance, local lanes vs. express lanes, or northbound vs. southbound lanes. As this implies, a TSS can be positioned and configured to monitor both directions of traffic simultaneously, or just one direction. In the latter case, typically within Maryland two detectors are positioned at virtually the same point on the map, just across the median from each other and monitoring opposite direction of travel, to provide a complete picture and minimize necessary communications infrastructure (at least historically from the days of wired communications). Each time a TSS is polled, its counts are reset and it starts counting from zero again for the next poll cycle. A TSS is typically polled every five minutes within CHART ATMS.

Note that CHART ATMS can be configured to display a different granularity of data for different users, depending on the user's role and the rules established for the detector by the detector's owner. Some detectors require that only "summary" data be displayed for certain users. Speeds are grouped into "buckets', such as 0-30 mph, 30-50 mph, and 50+ mph. Some users can be granted privilege to see exact speed, and the capability exists to prohibit some users from seeing any data at all (only the existence and operational status of the detector). These rights can be set on a per-detector basis, based on the owning organization of the detectors. Such limitations currently apply only to "external" detectors (not polled directly by CHART ATMS at all, but imported from RITIS).

3.25.2 Models

CHART ATMS supports two models of TSS, both variants of RTMS (Remote Traffic Microwave System) developed by Electronic Integrated Systems (EIS), now owned by Image Sensing Systems (ISS). The two models are the older X3 and the newer G4. The G4 provides information for 12 detection zones; the X3 provides information for 8 zones. The G4 protocol is substantially different than the X3; it is built to support additional traffic parameters (such as gap (a.k.a. headway)), up to 6 vehicle classes, additional zones, and future expansion. The X3 protocol provides 2 vehicle classes. However, classification data is not collected by CHART ATMS. The only vehicle counts saved and displayed by CHART ATMS are total vehicle counts. The CHART ATMS software allows an administrator to specify whether a TSS is a X3 RTMS or a G4 RTMS. When a detector is polled, volume, speed, and occupancy data is retrieved for each of the zones in use. The CHART ATMS GUI displays 12 zones for G4 RTMS sensors in each place where 8 zones can currently be displayed. All existing rules regarding display of summary data vs. actual data apply to the new additional zones, naturally.

The G4 protocol provides information for 12 detection zones instead of 8 zones like the X3. The G4 protocol is substantially different than the X3; it is built to support additional traffic parameters (such as gap (a.k.a. headway)), up to 6 vehicle classes, additional zones, and future expansion. The CHART ATMS allows the administrator to specify whether a TSS is a X3 RTMS (the "original" RTMS model) or a new G4 RTMS model. When a G4 model is indicated, zone groups defined for the TSS can use zones 1 through 12. When a G4 model is polled, volume, speed, and occupancy data is retrieved for each of the zones in use. The CHART ATMS GUI allows display of whatever zones are collected (12 or 8). All rules regarding display of summary data vs. actual data apply to the full complement of zones.

The data exporter support detectors with up to 12 zones as well. TSS simulation software built into the TSS service also supports simulating data with up to 12 zones from a G4 RTMS.

Raw traffic data is logged directly to the live CHART ATMS database. This is done for both the X3 and G4 models and for up to 8 or 12 zones of data as appropriate. Archive jobs move the TSS raw data from the live CHART ATMS database to the archive database.

3.25.3 Protocol Handlers

TSS communications are provided at the lowest level by TSS Protocol Handlers. The Protocol Handler encapsulates the specific manufacturer protocol, translating the generic commands from the TSS objects, such as polling for latest traffic statistics, to protocol-specific commands. All

TSS communications are accomplished via TCP/IP, so communications are conducted directly between the Protocol Handler and the device controller. The Protocol Handler also processes responses and pass responses success or failure indications back to the TSS objects.

3.25.4 Communications

All CHART ATMS detectors use TCP/IP communications. This is accomplished via RavenX wireless modems that make all detectors appear to be hardwired TCP/IP nodes..

3.25.5 Polling

The TSS Service used to run a Built-in Test (BIT) based on the receipt of a bad health bit during data polling. However, the G4 RTMS does not populate this health bit, and the manufacturer has recommended against this practice even for the X3 RTMS. For one thing, for both models, running BIT halts data collection for about 20 seconds (vehicles are not detected). As a compromise, the system can be configured to poll TSSs automatically once a night. A system-wide TSS BIT execution time (expected to be during early morning hours, e.g., 3:00 in the morning) can be configured into the System Profile. Each TSS can be individually configured to run or not run BIT at the scheduled time. This facility is rarely used. Typically only flaky detectors are configured to run BIT, and most normally operating detectors are not.

To support multi-drop capability, the CHART ATMS software groups the polling of TSSs that use TCP/IP communications and have the same IP address and TCP port, or the same phone number. During the polling cycle, each detector that shares the same connection or phone number is polled sequentially to avoid having these detectors polled simultaneously, which is known to cause contention issues. During this polling process, detectors are checked to see if they are configured to run scheduled BIT, and if the test has not been run since the BIT time arrived. Any detectors needing to run BIT execute their BIT following data collection.

3.25.6 Configuration

An administrator can configure the map display options for a TSS. These changes can be made regardless of the TSS mode (online, offline, maintenance mode) and can be made to external detectors that have been imported into CHART ATMS as well as native CHART ATMS detectors. The map display options pages allow a user to specify the direction that the arrows for a TSS should be oriented when displaying on the map. The administrator can also indicate if each zone group should be displayed using an arrow that points toward the TSS bearing, using an arrow that points 180 degrees opposite the TSS bearing, or should not be displayed at all. If a TSS has multiple zone groups that are configured to display in the same direction the CHART ATMS administrator may configure their relative display order so that zone groups that represent outer lanes can be displayed further away from the root TSS latitude/longitude position and zone groups that represent inner lanes can be displayed closer to the center.

3.25.7 Map Display

When displaying a TSS on any of the CHART ATMS maps, the system always displays an icon on the map for any TSS that has a defined location. If a bearing has been defined and at least one zone group is configured for map display and the TSS is online the system renders the TSS on the map using an arrow for each configured zone group. The color of each arrow represents current speed for the zone group it represents. If any of those conditions are not met, the TSS is displayed using the same icon that is used in the GUI list pages for the TSS. When a TSS is added to the system, either via import from an external system or via an administrator action, it is added with no defined bearing. This implies that the system displays the TSS on maps using the list icon until an administrator manually sets the bearing. The system inspects the TSS route direction from its location settings and also inspects the direction of each configured zone group, and sets the display type to primary if the direction matches, to opposite if the direction is opposite, or sets the "do not display on maps" if the direction of the zone group is neither the same nor opposite the direction of the TSS route. The system does not attempt to default the display order if there are multiple zone groups in a single direction. Using this algorithm an administrator normally should need only set the TSS location, zone group directions, and then bearing in order to get the TSS to properly display on the map.

If external systems do not provide the route direction location information for an external TSS that has been imported from RITIS, in order for the external TSS to display properly on the map with traffic flow arrows, the CHART ATMS administrator must set the TSS bearing, then set the display type (primary, opposite, none) for each zone group in order to get the TSS to display properly using arrows. This needs to be done only once per imported TSS. Once the TSS has been imported, it is stored permanently in the CHART ATMS database, and the CHART-specific TSS display settings are also stored there in the CHART ATMS database.

3.25.8 Key Design Decisions

Because there are many TSS objects that need to be rendered on maps, performance related decisions were key in the design of this feature.

- In order to avoid overloading the mapping server, the TSS objects are rendered client side.
- Because there would be over 400 TSS objects to render when viewing the entire state and surrounding areas, and because browser recommendations are that no more than 50-100 markers should be rendered client side (both to avoid clutter and to avoid CPU overload on the browser machine), the system allows the TSS layers to be visible only at configured map scales (zoom levels).
- Because the client browser has to request the data used to render the TSS objects using AJAX requests that return data in JSON format (ASCII Text), which the browser must parse into JavaScript objects, it is important to limit the size of the JSON documents being returned to the browser each time the user needs their map display updated. To that end, the system request JSON only for objects within the visible display area of the user's current map. This means that when a user pans the map to include a previously unviewed area, or zooms the map out (so that more area becomes visible around the previously viewed area) there is a delay of the appearance of the newly exposed TSS objects while the JSON data for the objects in the newly visible area are retrieved from the web server, parsed, and rendered.

3.26 Field Communications

Figure 3-3 illustrates the field communications device architecture for CHART ATMS.

CHART Field Device Architecture

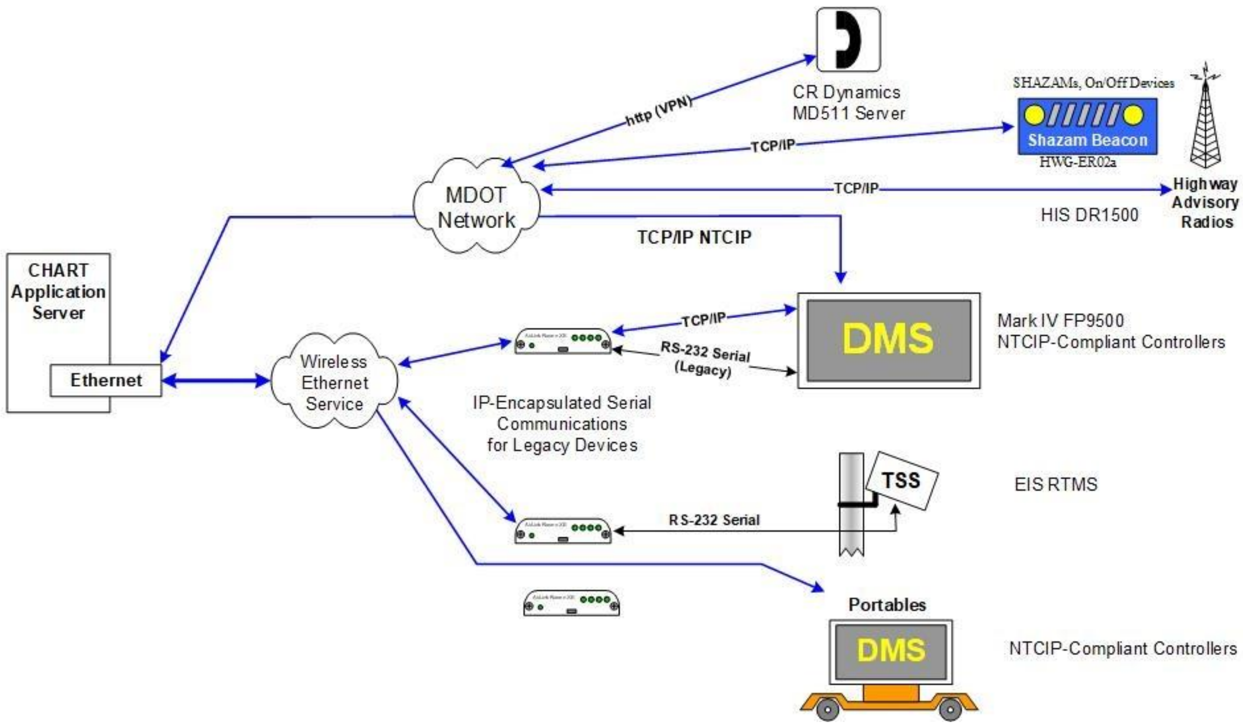


Figure 3-3. CHART Field Device Architecture

3.27 CCTV Camera Display

3.27.1 Background

CHART provides management and control of video. CHART cameras can be displayed on CHART monitors, and also directly on users' desktops. Cameras which are controllable are controllable directly within CHART ATMS, rather than having to use this manufacturer's software for some cameras, other manufacturer's software for other cameras, etc. CHART ATMS provides a common look at feel for all camera control, regardless of the specific model of camera being controlled. Features that are not available for a specific camera due to camera limitations are grayed out or not displayed at all.

SHA CHART cameras are attached to the CHART network using IP based video encoders. Likewise, the SHA monitors are attached to the CHART network using IP-based MPEG-4 video decoders or Impath H.264 decoders. MDTA cameras and monitors as also attached via MPEG-2 video codecs. Each of these technologies, MPEG-4, MPEG-2, H.264 provide separate video "networks" referred to within CHART ATMS as video "fabrics". In addition to video decoders, the CHART ATMS supports the Turnkey Remote Video Display Solution (RVDS). The RVDS is comprised of a Video Streaming Device (VSD) connected to each monitor and a Video Streamer Service (VSS) which commands the VSDs. The VSD is a small single board computer (currently a Raspberry Pi) which is connected to a monitor. The VSD operates without manual intervention. Upon booting up, the VSD calls out to connect to its configured VSS, and that connection, which is held open indefinitely via “keep-alive” packets, is used by the VSS to command the VSD to play or stop playing a video stream which is accessible to the VSD. The video stream need not be accessible to the VSS.

Note that video signals are “transcoded” into multiple formats at (near) the source (camera) so that cameras encoded in one format (e.g., MPEG-2) may be displayed on monitors fed by decoders of a different format (e.g., MPEG-4).

3.27.2 Codec Video Display

CHART ATMS provides the capability to command Core Tec MPEG-4 decoders, Impath MPEG-2 decoders, or Impath H.264 decoders for the purpose of displaying video. The Core Tec decoders are controlled directly via Distributed Component Object Model (DCOM). The Impath MPEG-2 decoders are controlled using an SNMP based interface over TCP/IP. The Impath H.264 decoders are controlled using HTTP over TCP/IP. CHART ATMS switches the multicast address and port on the decoders to point to the multicast address and port of the corresponding encoder of the same variety.

3.27.3 RVDS Video Display

In CHART ATMS, the RVDS is modeled as a “decoder”, even though the VSD is distinctly different from other supported CODECs. In particular, the RVDS and the VSD has no concept of video “fabrics”, and can display a video stream from any fabric, provided the stream is reachable. Therefore, an RVDS Monitor has no fabric. To support identification of which video streams are reachable, an RVDS monitor can be configured to accept streams from any number of Streaming Flash Servers (SFSs).

3.27.4 Video Display Enhancements

Later updates have enhanced CHART ATMS video services. Administrators can now configure multiple video sending devices for each camera. This ability allows correct, clean use of transcoding video signals which currently eliminates need for the video router. Use of multiple sending devices eliminates the old practice of creating multiple camera devices to display images from a single camera in different formats. This practice led to confusion and conflicts over video control. At the same time the ability to enable and disable public flash video streams came into existence. Disabling public flash video streams was colloquially known within CHART as using “the kill switch” or “the red button”. Further enhancements have allowed any video stream to be disabled (or re-enabled), not just public video streams.

When a camera is added or edited, CHART ATMS provides links to add, configure, or remove encoders, switches and flash streams. As a link is clicked a table appears for the item being added. There is a separate table for each item type encoder, switch and flash video stream. As additional items are added they are added to an existing table. Each item has boxes that allow an administrator to modify attributes of the encoder, switch or flash video stream. Each item has a remove link that allows the administrator to remove the item from the table. Once the edited video source page is submitted, the video sending devices and flash video steams will appear on the video source page under the configuration section.

To display an image on a monitor, the system makes connections between video sources and video sinks by selecting receiving devices and sending devices on the same fabric if possible. If the monitor is not on the same fabric any of the camera's sending devices, the system uses the video router to look for a bridge circuit that will attempt to provide the needed route.

Flash video streams designated as "public" that are associated with a camera are automatically disabled as Block to Public is executed. The user simply clicks the Block to Public Monitors link and all public flash video stream configured are blocked along with the public monitors. Public flash video streams are automatically enabled as Unblock to Public Monitors is executed. The public flash stream, as well as others, can also be enabled and disabled directly.

3.27.5 Desktop Video

To display desktop video, the CHART ATMS GUI makes use of a camera's Flash video stream that has already been configured in one of the several Streaming Flash Servers (SFSs) used in the CHART ATMS using the SFS software. (Also note that a camera stream must be configured in the Transcoding Server to encode the image for use by a Streaming Flash Server). SFS can be identified as Internal, Public, SWGI, or MView. A given camera may have streams set up in some or all of the SFSs. A camera must be configured in CHART ATMS to specify which of the SFSs have streams representing it in order for CHART ATMS to support desktop video for that camera. At present time, each instance of the GUI uses only one specific SFS, so a camera is viewable only if it is configured for that SFS. External clients require a separate functional right to receive exported Streaming Server info for each zone.

CHART also supports "Flash Only" cameras – cameras which are not transcoded at all within CHART, and may not even be CHART entities. For instance, cameras from Maryland counties could be added to CHART, with video streaming servers owned and maintained by the counties in place of CHART SFSs. The CHART ATMS supports any number of video streaming servers per camera. RVDS monitors use SFS output as well.

3.27.6 Video Sessions: Limiting and Tracking Desktop Video Usage

The concept of a "video session" is used to track and limit usage of desktop video. A video session represents the potential use of the network resources to stream a single live camera image, and can be thought of as a single video window that is open on a user's desktop. In an attempt to limit the network bandwidth usage by desktop video, the number of video sessions is limited per operations center. Each operations center can support only up to that maximum total number of video sessions, counting all sessions that all users logged into that center can have open. Before opening each video window, the system checks to make sure that the resource limit has not been exceeded. Once the initial resource limit check is made, the user can stream video without checking the resource limit again as long as that video window is open (regardless of whether video is actually streaming or not). An administrator can end a user's video session to free up system resources, which causes the video to stop streaming. Video sessions also provide status tracking information, and users are able to see who is viewing which cameras and tours via desktop video. In case for some reason a user's browser or the GUI servlet should fail to release the video session when a video window is closed, there is resource cleanup logic at both the GUI servlet level and at the CHART ATMS service level to make sure resources are released after a configurable timeout. If operations center's desktop video limit is reduced during operations to a point below the current usage, all current sessions are allowed to continue; however, no new sessions can be opened until the total for that operations center is below the new limit.

Video sessions are managed by the Resources Module (User Management Service) rather than by the Video Service, to simplify logic and reduce potential failure conditions that could occur. It might seem that video sessions should be managed by the Video Service, but what they really represent is network usage and they are completely independent of all of the types of objects hosted by the Video Service. Video sessions are really a negotiation between the GUI and Resource Management, as it is the GUI that is using the network resources and the Video Service does not need to be involved.

3.27.7 Camera Image Revocation

A suitably privileged operator shall have the ability to revoke a camera image from any monitors owned by a particular organization. Furthermore the camera image may be revoked from any number of owning organizations.

When a camera image is revoked from an organization, any monitors owned by that organization that are currently displaying the camera image will have a "No Video Available" image placed on the monitor. A camera that is revoked will not be available for display on monitors owned by revoked organizations until such time that they are un-revoked by a suitably privileged operator. Multiple organizations may be revoked for camera image display at one time.

Monitors in CHART ATMS can be designated as "public" monitors. These are typically monitors associated with media outlets, such as television stations and traffic reporting services. A camera image may be blocked from the public at any time. Any monitors designated as public monitors may have their camera image revoked by a suitable privileged operator who chooses to block the camera image from the public. The image on the monitor is replaced with a "No Video Available" image if possible (otherwise the screen goes black). A camera that is blocked from the public will not be available for display on public monitors until such time that it is unblocked by a suitably privileged operator.

3.27.8 Blocking / Unblocking and Video Stream Status

Likewise the flash video associated with cameras can be blocked, either by blocking to public, or by blocking to specific organizations.

The Block / Unblock Camera To Public functionality affects only video streams designated as "public". Non-public SFSs are not affected by these "public" commands, although any flash stream associated with a camera can be blocked or unblocked via a separate command on an individual SFS basis (regardless of whether the SFS is public or not).

Currently the SFS software API does not support querying the existence or the blocking status of the camera streams within the SFS. As a result, CHART ATMS maintains its own status information for each camera stream within an SFS. To maintain the accuracy of this status, it is has to be assumed that blocking of a camera's stream is done only via CHART ATMS. The SFS software provides this capability as well, but it should never be used for this purpose. Should the status get out of synch, the workaround (using CHART ATMS) would involve issuing a block (or unblock) command to the individual SFS to get it back to a known state.

Blocking a camera to a given organization affects desktop video usage for the organization associated to the operations center at which the user logged in. If the matching organization is blocked, the users logged into that operations center are not able to view desktop video.

3.27.9 Video Tours

A video tour is a list of cameras (optionally with presets specified), which can be run on a physical monitor or via Flash. Note that cameras are prevented from moving to presets too rapidly while running a tour, in order to reduce wear on the camera's Pan/Tilt/Zoom PTZ motors. If a tour is running only on one monitor (or desktop), this generally does not come into play, but if a tour is running in multiple locations, each tour runs on its own clock, and the tours may be entirely out of phase with each other. This could have the effect of limiting or even preventing cameras from moving to presets within the tour, for any cameras which appear in the tour with more than one preset.

A user can view preconfigured (persistent) video tours via desktop video, with a couple of limitations. First, only cameras that have video streams configured for the GUI's assigned SFS are included in the tour. Second, any camera presets configured for the tour are ignored. (The use of presets would require camera communications, and multiple users viewing tours with presets would have the potential to cause serious communication problems with the cameras. Also, using presets with desktop video would have required precise timing between the application of the preset and the desktop video buffering in the GUI, which may not even be feasible.)

The video from multiple cameras in the tour is buffered one at a time, so that there is a slight delay when switching between camera streams. Because buffering is done one camera at a time, viewing a tour counts as a single video session with respect to the operations center resource limit. (More sophisticated buffering that could eliminate the delay, but would require use of two video sessions: one being actively viewed, and one buffering up the next video stream in the background.)

Normally only one instance of a camera is allowed on a desktop; however, desktop tours are permitted to contain the same camera as an existing desktop session – even if it is the only camera displaying in the desktop tour.

3.28 CCTV Camera Control

3.28.1 Models

CHART ATMS provides PTZ control of three types of cameras: Cohu 3955 (and other compatible models, such as the Cohu 3960 and Cohu 3965), the Vicon SurveyorVFT (also known as the SurveyorVFT, S2000, or S2K), and any suitably compliant NTCIP camera. The term "PTZ" in this context refers to not just panning, tilting, and zoom, but also other similar functionality.

As for other devices, a "protocol handler" has been written to support each camera model. A protocol handler handles the translation from application level actions such as Pan and Zoom to camera commands that the camera understands, to be delivered to the camera controller. Re-use has been incorporated where possible. For instance, the NTCIP camera protocol handler re-uses utility code that shared by protocol handler code that manages NTCIP communications to DMS devices.

3.28.2 Encoder Camera Control

CHART ATMS provides the capability to use Core Tec MPEG-4 encoders, Impath MPEG-2 encoders, or Impath H.264 encoders to route the communications necessary to control the cameras from the CHART ATMS to the camera, and route responses back to CHART ATMS. A TCP/IP connection is established between the CHART ATMS server and the encoder and all camera commands and responses are exchanged over that socket.

3.28.3 COM Port Camera Control

CHART ATMS also includes an ability to control a camera directly connected via a COM Port. This is used only for internal testing (and also for the NTCIP Camera Compliance Tester).

3.28.4 Viewing a Controlled Camera Image

For many years within CHART, prior to the introduction of desktop video, the CHART ATMS required a camera to be displayed on a local monitor (a monitor in the operator's monitor group, generally based on the operator's operations center) before the operator was allowed to gain PTZ control of the camera. Now with desktop video, if the camera is not already displayed on a local monitor when the user requests control and provided the camera is eligible for streaming, a desktop video session is automatically opened for the user so that they can see the effects of the control operations on the camera. Note that flash video generally lags on the order of one to two seconds behind live, so controlling a camera while monitoring it via flash is challenging, especially for the uninitiated.

Similarly, if a camera control session contains the camera's video and that same camera is later put on a local monitor, the user is then allowed to remove the desktop video session from the camera control session.

As it is with local monitors, for the purposes of camera control, a camera in a desktop tour does not satisfy the requirement that a user be able to view a camera before obtaining control. This is true even if the camera is the only one displaying in the desktop tour.

3.28.5 Pan, Tilt, Zoom, Focus

All models support these basic functions. However, for the SurveyorVFT there is no capability to programmatically toggle between auto and manual focus. The SurveyorVFT goes to manual focus mode if it receives a Focus Far or Focus Near command. It goes to auto focus mode if it receives a Zoom command

One area where control of NTCIP cameras differs from the Cohu and Vicon camera models is that the NTCIP protocol requires a speed parameter on every movement command. Rather than supporting variable speed movement via GUI controls, the approach is to allow default speed values to be set for each camera for each of 4 movements: pan, tilt, zoom, and focus. Each camera has one speed setting for Zoom and one speed setting for Focus. A single speed value for Pan and Tilt is not sufficient; however, because when zoomed in one needs the camera to move much slower than when zoomed out. A pan or tilt speed which is slow enough to be usable while zoomed all the way in is agonizingly slow when zoomed all the way out. To address this, there are two speed settings for each camera for Pan (minimum and maximum), and two settings for Tilt (minimum and maximum). When a pan or tilt operation is performed, CHART ATMS determines the speed to use on a percent-zoomed basis, based on the minimum and maximum speed settings and the current zoom level of the camera. Two additional settings, minimum zoom value and maximum zoom value also need to be configured for each camera to allow for this zoom based variable speed behavior.

3.28.6 Message Setup

The SurveyorVFT does not provide a software interface for setting camera and preset titles. This is done through the programming menus as described in the SurveyorVFT Camera Dome Programming Manual. CHART ATMS is programmed to execute pre-compiled macro commands that navigate through the menu, picking letters one at a time, in order to provide titling capabilities. This was very tedious, and it could take up to two minutes for a titling operation to complete. As noted earlier, execution of those macros use code that is reused from AVCM and called from CHART ATMS. In practice, this capability has been proven unreliable, so has been disabled. The SurveyorVFT does not provide a software interface for setting the titles to either the top or the bottom of the display or for enabling or disabling the titles. These capabilities are provided through the programming menus of the SurveyorVFT as described in the SurveyorVFT Camera Dome Programming Manual. CHART ATMS provides a capability to access the SurveyorVFT programming menu.

3.28.7 Saving and Moving to Presets

The CHART ATMS provides the capability to store and move to preset positions (i.e., pan, tilt, zoom, and focus) for all camera types. This includes not only the preset but an associated title to be displayed on line 2 of the camera display. Also, when a camera is no longer displayed on any monitor, the camera is moved to a default preset, if a default preset is programmed.

CHART ATMS gathers the raw pan, tilt and zoom values when saving and setting preset positions for all camera types (Cohu 3955, Vicon SurveyorVFT and NTCIP cameras. CHART ATMS saves the values in the database when a preset is saved. However, these raw values are not used to command the camera to move. For all camera types, the preset location (PTZ) is stored on the camera itself, and the camera is commanded to move to a specific preset number. The camera then looks up the PTZ values within the camera controller, and moves to the indicated position.

For the Cohu and NTCIP cameras, the CHART ATMS then commands the camera to set the appropriate preset title on line 2 of the camera. The SurveyorVFT stores this title text with the preset, and displays the title directly. Although the SurveyorVFT may be commanded to move to a raw preset, there is no way to access line 2 of the camera title directly. The only way to access line 2 of the title is by associating it with a preset through the camera menu system. The SurveyorVFT menu system can be used for storing presets and titles. The method by which SurveyorVFT titles are stored on the camera, however, is not computer-friendly. Although it works reasonably well in a lab environment, in the field environment it has proven to be unreliable, so has been disabled. Titles can be stored manually using the SurveyorVFT menu system directly, if desired.

3.28.8 Color Gain

The SurveyorVFT does not provide a software interface to adjust the color gain of a camera. The color gain is accessed through the programming menus of the SurveyorVFT as described in the SurveyorVFT Camera Dome Programming Manual. A suitably privileged operator can activate a programming menu for color gain and then back out. The SurveyorVFT programming menu is accessed by executing pre-compiled macros re-used directly from AVCM. Execution of those macros uses code that is re-used from AVCM and called from CHART ATMS.

Note that the macros are used to set the proper camera color gain mode (automatic or manual) and to adjust the color balance itself.

3.28.9 Camera Power

The SurveyorVFT does not provide a software interface to power the camera on and off. For the SurveyorVFT, the power indicator indicates if the receiver is online or offline. The camera is considered to be online when it responds to a status query. Otherwise, it is offline.

3.28.10 Lens Speed

The SurveyorVFT does not provide a software interface to retrieve the current lens speed of the camera. The SurveyorVFT has 3 lens speeds – slow, medium, and fast. CHART ATMS provides an interface to toggle the lens speed but does not provide feedback as to the current setting of the lens. The SurveyorVFT camera can be programmed to enable the lens title with fade control enabled for the lens title. If enabled, this provides feedback to the operator on a monitor where the image is displayed when the lens speed is toggled; then that indication fades from the image. See the SurveyorVFT Camera Dome Programming Manual for details on how to enable the lens title and how to enable fade control for the lens title. The lens title may also be positioned anywhere on the display.

3.28.11 Reset Camera

This issues a factory reset command to the camera. The camera does not respond to control commands while it is resetting itself. Depending on the camera, this can take up to 2 minutes.

3.28.12 SurveyorVFT Programming Menu

Many configuration capabilities of the SurveyorVFT camera are provided through the programming menus of the SurveyorVFT as described in the SurveyorVFT Camera Dome Programming Manual. CHART ATMS provides an interface that a suitably privileged operator can use to activate the programming menu. The operator navigates through the SurveyorVFT programming menus by looking at the monitor(s) displaying the camera image. Although automatic titling using pre-compiled macros has been disabled, a suitably privileged operator can use the programming menu manually to accomplish this.

3.28.13 Camera Control Revocation

A suitably privileged operator shall have the ability to revoke a camera control from any operators whose chosen (or default) monitor group is owned by a particular organization. Camera control may be revoked from any number of owning organizations.

When camera control is revoked from an organization, any active camera control sessions initiated by operators whose monitor group is owned by the revoked organization are terminated. A camera that is revoked is not available for control by operators with monitor groups that are owned by revoked organizations until such time that they are un-revoked by a suitably privileged operator. Multiple organizations may be revoked for camera control at one time. If an operator is controlling a camera by virtue of desktop video display, control is revoked based on the operator’s operations center’s owning organization.

3.29 Contact Management

The Contact Management function is used to manage CHART contacts and is used for all contacts, whether or not they are candidates to receive notifications from CHART ATMS. A contact may be configured to be eligible for receiving notifications from CHART ATMS, although many contacts will not. Contacts can also be marked as being eligible to be assigned to a field unit, and most contacts will not. A contact can be marked as "do not contact" during scheduled times, as an indicator to operators to avoid calling a contact during sick days or vacations. A contact can be associated with one or more operations centers and additional areas of responsibility (AOR). Contact Management also includes the management of "call out lists".

A "call out list" is a list of contacts for an operator to call (in priority order) to quickly find a responsible contact for a specific event resource or event resource type. A call list can be created for (i.e., associated with) an event resource or resource type, allowing an operator to select the person contacted for that resource / type when it is used in a traffic event. Not all event resources and types have call lists (most probably will not), so the list of all call lists is viewable independently from the list of event resources and types, and it can be viewed by non-administrative users. Once a contact is selected from a call list, information for that contact is displayed in the traffic event participation record in case the contact needs to be reached again subsequently. A contact can also be added as a standalone participant in a traffic event (i.e., without specifying an event resource or event resource type and bringing up a call list).

Contacts are loosely associated with CHART ATMS user accounts. Contacts are not required to have a CHART ATMS user account (the majority do not), and user accounts are not required to have an associated Contact.

3.29.1 Manage Contacts and Notification Groups

A contact is either an individual or an agency. Contacts information includes information such as name, email address(es), agency, call sign, office, business address, phone number(s) (plus optional extension), AOR, Operations Center, and "do not call" schedule. The key design difference between an agency and individual is that an individual has a first and last name, while an agency has a single name. Contacts can be a member of 0 or more contact groups.

Notification groups provide a means for grouping contacts for ease in sending notifications. Groups can contain 0 or more contacts. Contacts and notification groups are stored directly in the CHART ATMS database.

3.30 Notification Services

The CHART ATMS notification service provides two major functions: the ability to send notifications to contacts configured to receive notifications (manually via operator request, or automatically when certain conditions occur), and to view notification history. Note that the ability to manage notification contacts is discussed under the Contact Management function.

3.30.1 Send Notification

The CHART ATMS provides users with the capability to issue (send) notifications. A notification is important information sent to an individual person or a group of people. Users with the appropriate rights can send notifications using the GUI. These notifications can be created in standalone mode or as part of a traffic event. When creating the notification, the user selects recipients and provides a text message, possibly using provided available shortcuts. If the notification is being created from within the context of a traffic event, many shortcuts are available to help create the text of the message. For instance, the user can ask the system to suggest a message, or the user can, with one click, add text to describe specific characteristics of the event, such as its location, or lane closure information, or the user can select a and paste in a facility name (such as BHT or FMT). The sender's initials are automatically appended to the message. The user must input the appropriate initials once per login-session, and the initials are remembered from that point forward. The recipients consist of individuals and/or groups that are configured as notification contacts within the Contact Management function.

The CHART ATMS also provides the ability for subsystems of the CHART ATMS itself to send notifications, automatically, when trouble or other noteworthy information is acquired. For instance, notifications can be sent when device failures are detected, when external connections problems are detected, when toll rates expire or are not received on the expected schedule, when CHART ATMS services are failed or are automatically restarted by the CHART ATMS watchdog, when travel times exceed expected levels. All of these are configurable. For some notifications, such as external connection failures and device hardware failures, the CHART ATMS can also be configured so that notifications are also sent when the condition that caused the notification to be sent clears up. One other type of automatic notification that can be sent is administrators can specify that a notification should be sent if an incoming external event comes in that meets certain criteria (such as on I-95 or I-495 above a certain latitude and all lanes closed). (Although such can be a sign of traffic trouble as in this case, this is not a trouble condition within the system, in the same sense as induces other automatic notifications.)

The CHART ATMS notification service sends the notifications via an SMTP mail server. All notifications are sent from CHART ATMS via email. Some users may have the ability to receive a text via a specially configured email address from the cell phone provider, but CHART ATMS sends them out via email. Pages could be sent out the same way.

The notification service uses the JavaMail API for sending e-mail via SMTP. The notification service supports primary and backup email server configurations. The server configurations consist of an IP address, port, name, password, and SMTP_AUTH configuration.

The email notifications sent out can include an informative subject in the notification, based on the notification type, as provided by the calling services. In addition, the subject line contains a configurable prefix. Currently subject lines for notifications are administratively disabled within the CHART ATMS, because different text services count email subjects differently in measuring a text against the service-specific text size limitation (e.g., 140 characters). However, the CHART ATMS is able to configure these subject prefixes as follows:

- Device notifications include the device type, name, and device status in the subject line
  - <Device Type> <DeviceName> <Status Type>
- External event import notifications include "External Event Imported" in the subject line.
- External connection notifications include the connection name and the status type
  - <External System> - <Status Type>
- Watchdog notifications include the service name and an indicator the service was restarted.
  - <Service Name> @ <Site> <Info>

A separate log file is written by the notification service regarding the sending of notifications. This log file contains communications information between the mail server and the notification service and the text of all messages sent. Additionally, the traffic event history log includes the contents of the notification and the configured recipients.

3.30.2 View Notification History

CHART ATMS users have the ability to view notification histories for all online notifications. The users are able to browse notification statuses either page by page or with direct page access.

Notifications that have existed in the system longer than a system-prescribed time are taken offline. Those notifications that are too old are marked as offline and are no longer be visible in the

CHART ATMS. Notifications associated with traffic events are not taken offline until their corresponding traffic event is taken offline.

3.31 Alerts

CHART ATMS also provides the capability to create and manage alerts. The following alerts can be generated:

- Unhandled controlled resources
- Device in hardware failure or communication failure
- Duplicate traffic events
- Traffic event not closed by a specified time
- Time to execute Open Event actions specified in a schedule
- A schedule has executed an Open and Activate Event action and opened a new traffic event (or automatically closed the event)
- External connection failure (or warning, if configured)
- Incoming external event detected to meet alert criteria (roadway, % lanes closed, etc.)
- Service detected failed or restarted by watchdog
- Toll rates expired or missing
- Travel time exceeds alert threshold
- Manual, operator-initiated alerts

Each alert has a state, and alerts can transition from state to state during their lifetime. The alert states are: new, accepted, closed, and delayed. The accepted and delayed states are time-limited. Accepted and delayed alerts which have been in that state too long (beyond a certain "reminder time") are returned to the new state automatically. Alerts in the new, accepted, or delayed state will not be duplicated. That is, if condition which caused the alert clears, then occurs again, another alert with the exact same details is suppressed as long as there is already an alert in the new, accepted, or delayed state. If conditions are oscillating, causing alerts to occur repeatedly, an alert can be delayed, to suppress the duplicate alerts until the underlying problem is resolved.

The possible actions which an operator can take on an alert are:

- Accept the alert, with an optional reminder time. This moves it from 'new' or 'delayed' to 'accepted' and indicates the accepting operator intends to soon take some action necessary before the alert can be closed. The system moves the alert back to 'new' at the reminder time. If a reminder time is not specified, a default reminder time is used.
- Unaccept the alert. This moves it from 'accepted' to 'new' and indicates the operator has changed his mind and will not soon be working on the alert.
- Close the alert. This moves it from 'new', 'accepted', or 'delayed' to 'closed', and requests if the same thing happens again, issue a new alert for it.
- Delay the alert, with an optional reminder time. This moves it from 'new' or 'accepted' to 'delayed'. This indicates the alert is bogus, not of interest, repetitive, or already handled. The system moves the alert back to 'new' at the reminder time. If a reminder time is not specified, a default reminder time is used.
- Undelay the alert. This moves it from 'delayed' to 'new'.

- Escalate the alert. This requests the alert immediately be escalated rather than waiting until the escalation timeout occurs.
- Provide a comment on the alert. The comment entered by the user appears in the timestamped history log of the alert. All other operator-initiated alert state changes can also be accompanied by an optional user-provided comment (presumably about why the alert is being transitioned to the new state).

Alerts are filtered by alert state. By default, the new alerts are shown; however, the user can easily view alerts in other states (accepted, delayed, or closed). The CHART ATMS home page shows a summary of alerts by state (new, accepted, delayed, or closed). The user can also filter alerts to show those for which they are personally responsible (those which they individually have accepted or delayed), those for which their center is responsible, or all alerts (if they have a special functional right).

Each alert has a history, which can be viewed on the alert's details page. The history shows the state transitions of each alert, indicating who modified the alert and when. A record of all operations centers with visibility to the alert is shown, indicating when each operations center was added to the alert's visibility.

Each operations center is configured to have one or more backup operations centers, to be used for alert escalation. Every alert is initially issued to one or more operations centers (in a future release this may be changed to be one or more AORs). If an alert remains in the new state for more than a configurable escalation time period, the alert is automatically escalated to the backup operations center(s) configured for each of the operations centers the alert is currently issued to. Escalation is forced immediately by the system if no users are logged in with the functional right to manage the alert's type at the currently specified operations centers. Escalation is additive: When an alert is escalated, the list of backup operations centers is ADDED to the list, rather than replacing the current list. In this way the universe of operators available to handle the alert never shrinks because the alert was escalated.

Functional rights include:

- View user's own operations center's alerts (by alert type)
- View all alerts
- Manage user's own operations center's alerts (by alert type)
- Manage all alerts
- Create Manual Alerts

Closed alerts have an expiration time. Closed alerts automatically expire and are removed from the system (like traffic events are) after a configurable period of time, such as 8 hours, for example. Closed alerts do not influence system behavior – i.e., their existence in the system does not suppress generation of new alerts for the same item. If suppression is desired, the delay feature can be used.

The subsystems which use alerts are designed, to reasonable extent, to avoid creation of duplicate alerts. (For instance, for a duplicate traffic event, the newer event is flagged as a duplicate of the older, not vice versa.) Furthermore, the alert manager also automatically detects and deletes duplicate alerts. For instance, a device hardware failure triggers an alert only when the device first transitions into hardware failure, but the alert manager de-duplication process prevents duplicate alerts for a device which is oscillating between OK and hardware failure, or between comm failure and hardware failure (as long as the first alert is not closed). The delay feature can further be used to explicitly suppress certain bothersome repetitive alerts.

All alert data is persisted and depersisted such that restarting an alert manager has no visible effect on the system, once the alert manager returns to full operational status. All alert data, including all history, is archived.

3.32 Travel Routes

A "travel route," as defined in CHART, represents a segment of roadway, usually starting at a DMS and ending at some well known point (an exit number, route number, etc.). CHART ATMS travel routes are used to supply travel time and/or toll rate data to a DMS for inclusion in a traveler information message. Each travel route may have one or more roadway links included. Each roadway link is identified by an ID, which corresponds to a link that exists in the INRIX system, which provides travel time data to CHART. (The system is designed with potential support for multiple travel time providers in mind, however.) A travel route with no roadway links included cannot be used for travel times. Travel routes may also have a toll rate source assigned. Toll rate sources are identified by a beginning and ending ID, which correspond to a toll route in the Vector system, which provides toll rate data to CHART. (The system is designed with potential support for multiple toll rate providers in mind, however.) Travel routes without a toll rate source assigned cannot be used for toll rates.

Travel Routes are the building blocks for "Traveler Information Messages", which are defined within CHART ATMS as messages which provide travel time and toll rate data to the public. In addition to being building blocks for traveler information messages; however, Travel Routes are also useful in their own right, in that they allow CHART ATMS users to view current travel times and toll rates. For display on DMSs, travel times can be constrained to a minimum value (e.g., conforming to the minimum travel time for the distance if the speed limit is obeyed). Internally for CHART ATMS users; however, actual travel times are displayed. Alerts and/or notifications can be configured if travel times exceed a certain value. These alerts are not intended for incident detection, but can provide hints as to where to look. Sorting and filtering capabilities as well as recent data trends providing users with another means to assess current roadway conditions.

3.32.1 Traveler Information Messages

Traveler information messages combine a pre-defined message template with data from one or more travel routes to show motorists current travel times and/or toll rates on DMSs. Traveler information messages are automatically updated as data from their associated travel routes changes. Traveler information messages are created for any DMS where travel times or toll rates are to be displayed. These messages can be created in advance,and activated by users when desired. Traveler information messages can be designated as being applicable to only certain days of the week, and/or only on holidays or non-holidays. Multiple traveler information messages for a DMS can be created in advance and multiple traveler information messages can be enabled; however only one may be active on a DMS at any given time. The system determines based on day-of-week, holiday/non-holiday settings and message priority to select the highest priority message applicable for a given day.

Traveler information messages, when activated, utilize the DMS arbitration queue. Two arbitration queue "buckets" are used to set the initial queue priority for toll rate and travel time messages. Any traveler information message that contains toll rate data is considered a toll rate message (even if it also contains travel time data) and is initially be placed in the "toll rate" queue bucket. Any traveler information message that contains travel time data (but not toll rate data) is considered a travel time message and is initially placed in the "travel time" queue bucket. The system allows the administrator to override this behavior per DMS and specify different buckets to be used for toll rate and travel time messages. Once a traveler information message is on a DMS arbitration queue, all existing arbitration queue features apply, including the ability to reprioritize the message within the queue, and the ability to combine the message with other messages on the queue (if so configured).

CHART ATMS includes a travel time display schedule which specifies the periods during the day when travel time messages may be displayed. Travel time messages may be enabled or remain enabled during times when travel times are not scheduled to be displayed; however the message is displayed on the DMS only during times when travel time display is scheduled. The system-wide travel time display schedule can be overridden per DMS. Typically within CHART ATMS travel time messages are displayed between 5:00 a.m. and 9:00 p.m. The schedule allows messages to remain enabled overnight without being displayed. Display automatically resumes at the designated time the next morning. A travel time summary page helps users determine which messages are active or inactive for all DMSs with at least one travel time message configured.

3.32.2 Traveler Information Message Templates

Traveler Information Message Templates are another building block for traveler information messages. An administrator creates templates that specify the layout and content of traveler information messages. These templates are for a specific DMS display configuration, and at least one template must exist for each display configuration used by all the DMSs where a traveler information message is displayed. In addition to static text (such as "TRAVEL TIME TO", or "TOLLS"), the content may include data fields, which are place holders within the message where data from travel routes is to be inserted. The following data fields are available:

- Destination
- Travel Time (actual)
- Travel Time (range)
- Toll Rate
- Distance
- Toll Rate Effective Time (the "as of" time)

Templates allow the administrator to specify which fields are supplied by the same travel route. This allows templates to contain data from one or more travel routes, with the data from each route correlated properly. Templates also allow the administrator to specify the format to be used for each type of data field included in the template. All fields of the same type share a common format, eliminating the possibility for a mismatch within the same messages. Because it's possible that data fields specified in a template may become unavailable during its actual use, the administrator also specifies a missing data rule for each template. Using the missing data rule, the administrator can specify that the entire message should be considered invalid (and therefore not posted) if any data is missing; or that the page containing the missing data is to be considered invalid, or that just the row containing the missing data is invalid. The appropriate rule to choose depends on the content and layout of the template.

3.33 Triggers

CHART ATMS allows triggers to be defined that activate and deactivate based on one or more conditions which they contain. An example of a condition would be “pavement sensor from weather station XYZ is reading a temperature of less than 32 degrees Fahrenheit”. When all conditions within a trigger evaluate to true, the trigger is considered to be active. Otherwise the trigger is considered to be inactive. While triggers don’t perform any other action besides becoming active or inactive, they can be used in other areas of the system which perform actions based on the trigger’s current state (see Automatic Weather Messages below).

Users can view the list of triggers defined in the system including all conditions contained within the trigger and can view the current state of each condition and the overall state of the trigger. Users with the appropriate rights can add, edit, and remove triggers, or enable and disable triggers

3.34 Automatic Weather Messages

CHART ATMS allows messages related to weather conditions to be automatically displayed on DMS devices, played on HAR devices, or in the case of an on/off device, activate a weather related device (such as a Fog Horn). This is accomplished through triggered messages (DMS/HAR) and triggered activations (On/Off Devices). Triggered messages and activations are added to and removed from the device arbitration queue based on the current status of an associated Trigger. When the associated trigger becomes active, the device adds the triggered message/activation to its Arbitration Queue and when the trigger becomes inactive the device removes the triggered message/activation from its arbitration queue. A setting in each triggered message specifies the Arbitration Queue bucket where the message is to be added. For On/Off Devices where Arbitration Queue priority is not relevant, a system profile setting specifies the Arbitration Queue bucket where all triggered activations will be placed for all On/Off Devices. The system profile also contains settings to allow triggered messages and activations to be enabled/disabled system wide.

When a triggered message or activation is on a device’s Arbitration Queue, the normal Arbitration Queue prioritization and message combination rules will determine which message is placed on the device (DMS/HAR) . As mentioned previously, the presence of any entry on the queue of an On/Off Device will cause the On/Off Device to be activated.

3.35 External Travel Time Interfaces from INRIX and MDTA

External interfaces to the INRIX and MDTA travel time systems are used to obtain travel times for travel routes. INRIX is a web service available to paying customers on the Internet, and CHART ATMS connects to it periodically (currently every 2 minutes) via HTTP to obtain travel time data for roadway links within Maryland. The MDTA travel time system conforms to the INRIX interface, and was developed for providing travel times on MDTA managed roads where INRIX cannot distinguish between managed and unmanaged roadways, such as along the HOT lanes north of Baltimore. Once travel time data is obtained from the provider, CHART ATMS updates the travel time data for roadway links used by CHART ATMS travel routes, and the travel routes update their overall travel time by adding together the travel times of each link contained in the travel route. Changes to travel time data for a travel route propagate within CHART ATMS to any active traveler information message using data from that travel route, and travel times for all travel routes are updated in the GUI.

Settings in CHART ATMS allow a percentage of a link to be used when computing the overall travel route travel time to accommodate situations such as when locations of DMSs intended to display travel times do not match cleanly to pre-defined link starting points. Other settings in CHART ATMS specify a minimum data quality (as supplied by travel time provider) for each roadway link, and CHART ATMS travel routes consider the travel time unavailable if too many links fall below their configured minimum quality level.

3.36 External Toll Rate Interface from Vector

An external interface to the MDTA Vector system is used by CHART ATMS to obtain current toll rates for CHART ATMS travel routes. Toll rate data is pushed to the CHART ATMS by the Vector system via a web service interface which runs within CHART ATMS. The CHART ATMS interface supports either HTTP or Hyper Text Transfer Protocol Secure (HTTPS) connections and expects data in an XML packet conforming to an Interface Control Document (ICD) written by the CHART ATMS developers. The Vector system connects to this service via HTTP. When the CHART web service receives data from the Vector system, it updates the current toll rate data for any CHART ATMS travel route that has a Vector specified as the toll rate source (currently Vector is the only toll rate source transmitting data to CHART). Changes to the toll rate for a CHART travel route are propagated to any traveler information message that includes toll rate data from that travel route. Notifications can be configured to be sent when toll rates are missing (warning state) or expired (failure state).

3.37 External Interface from RITIS

CHART collects data from RITIS (Regional Integrated Traffic Information System), a regional clearinghouse for traffic information within and well beyond the state of Maryland. RITIS is run by the Center for Advanced Transportation Technology (CATT) Lab at the University of Maryland (UMD). The transport layer is RITIS-specific using Apache's ActiveMQ implementation of the Java Messaging Service (JMS). The traffic event data layer implements the J2354 standard with a few RITIS extensions to the standard. The DMS and TSS data layers implement the Transportation Management Data Dictionary (TMDD) standard for each of these devices. The sections below describe further concepts related to RITIS data importing.

CHART collects information on traffic events, DMSs, and TSSs from around the region from RITIS. Filtering mechanisms are provided to manage the data and gain access to a desired subset of the larger set of information available.

3.37.1 Connection Status

The status of the RITIS connection is displayed on the View External Events Page. By default, the status is shown only when the connection is known to be failed, and the list of external events is cleared if the connection is failed for a specified period of time. An administrator can control this behavior, and has the option of making the status display at all times (instead of just when failed) and can control when the event list is cleared (if at all) in the case of a failed connection.

The connection status is also shown on the event details page for an external event if the connection which supplied the event is failed. This display can also be made to display at all times, even when a failure does not exist.

3.37.2 Operation Centers

A special "RITIS" operations center is defined be the default controlling operations center for all external events. External events never generate Unhandled Resource Alerts so there is no problem if no one is logged into this new operations center. Future releases could provide for operations centers to automatically be created as new agencies are found in the external data stream; however, so far this has not been a coveted feature.

3.37.3 Owning Organizations

When importing traffic events, DMS devices, and TSS devices, CHART ATMS utilizes a mapping from external system / agency to a CHART organization. If a mapping is not found for a traffic event or device that is imported, the system uses a default organization.

3.37.4 External Event Views

Users have three views of external events:

1. View External Events Page: All open external events are displayed on a page similar to the page for viewing internal open events, except it also has an "interesting" column displaying the flag that indicates whether it should appear in the External Event tab on the Home Page. It also has a column that shows the originating agency for the event. Users have the option of setting or clearing the 'interesting' marker, and choosing to view closed external events.
2. Home Page: A tab is available on the Home Page to hold external events identified as "interesting." The fields for this tab are event type, name, location, county/state, and a lane closure graphic (if applicable).
3. External Event Details: From either of the previous views, a user can bring up an external event details page which is similar to that of a normal CHART ATMS event. The primary differences are an indication that the event is external and therefore cannot be modified, and the indication as to whether the event has been marked as "interesting." Sections that do not apply to an external event, such as the response plan and participants, are not shown.

Any external event within the users operations center's AOR that is not currently associated with a linked event, but has been marked as interesting appears highlighted in the following summary reports:

- Operations Center Report
- Open & Open/Closed Event List
- Home Page Event List
- Open Events and Devices with Messages List

3.37.5 Linked Events

Users cannot modify external events or devices imported from RITIS. For events that are relevant enough, CHART ATMS users can "link" a CHART event to an external event. When this is done, the user can select which of four sections (basic event data, location data, lane configuration data, and incident info) should be loaded and continually updated from the external event, and which of these sections should be merely monitored. In the latter case, if the monitored information changes, the data is flagged as changed until a CHART operator acknowledges the change. CHART operators can change at any time which of the four sections are automatically updated or merely monitored, for each linked traffic event. In a linked event, CHART-specific sections which cannot be linked to the external event (as well as sections not being automatically updated) can be freely updated by CHART operators. The CHART-specific sections are the response plan, participants, notifications, roadway conditions, and associated events.

The only control CHART ATMS administrators have over an actual external event is the ability to close it (for example if it is stale because the RITIS connection was lost). See External Event Closure below.

3.37.6 Persistence

To ensure continuity between CHART ATMS restarts, the lists of external events and devices are persisted in the CHART ATMS database. After restart, the external events list is refreshed once the RITIS connection is regained, possibly closing some of the persisted external events.

3.37.7 External Event Filtering

Because there are many events available in RITIS that are not relevant within Maryland, several filtering options are available with regard to external events. For starters, filtering of external events always includes rejecting badly formed external traffic events, rejecting external traffic events that have no meaning in CHART ATMS (e.g., parking events), and ensuring CHART ATMS does not receive its own events back. Beyond this, CHART ATMS includes the ability to define traffic event import rules that are applied automatically by the RITIS traffic event importer. Each rule can contain one or more filter criteria, including geographical areas, route types, etc., as defined below. A RITIS event must match all criteria specified in a rule to match the rule.

Administrator-settable filtering includes:

- Filtering by geographic area. Administrators can set up geographic areas within which events must be located in order to be selected. A geographic area can be a wide area, such as following county boundaries, or can be small polygons which follow the contours of a road. Although users can see and draw Areas of Responsibility directly in CHART, this ability has not been retrofitted into geographic areas. Users cannot see or draw these polygons on a map to view or define these areas. An administrator can define a geographical area as a polygon containing 3 or more points specified by latitude/longitude, or, more likely, can draw polygons in a third party system (such as Google Maps / Google Earth), export them to KML, and import the resulting KML data into the CHART ATMS.
- Filtering by route type. Interstate Route, US Route, State Route, etc.
- Filtering by “Regional” flag. External Events can contain a “Regional” flag by which the external agencies can mark the event as possibly of interest to other agencies. (Other filtering criteria such as geographic filtering can be used in concert to determine if it is regional near the Maryland border or regional near another of the border states.)
- Filtering by number of lanes closed.
- Filtering by Event/Incident type. Incident, Planned Closure, Congestion, Weather, etc. These are CHART event types (into which the external event would be categorized), not all the external agencies’ event types.
- Filtering by included text. External fields searched are the Name, Description, Route Number, and County. For instance, “I-95” could be a search string (matching name or description) or “95” could be a search string (matching route number).

If a potential (candidate) incoming external traffic event matches a rule, it is imported into the CHART ATMS. In addition, each import rule can also contain rule actions. These actions are performed when a RITIS event matches the rule (and is therefore being imported into the CHART ATMS). The available actions are Issue Alert, Send Notification, and Mark as Interesting. The Issue Alert action, when enabled, causes the CHART ATMS to send an alert to a specified operations center when an event is imported that matches the rule. The Send Notification action, when enabled, causes the CHART ATMS to send a notification to a specified notification group when an event is imported that matches the rule. The Mark as Interesting action, when enabled, causes the CHART ATMS to set the "interesting" flag for the event when an event is imported that matches the rule. The "interesting" flag causes the event to appear on the home page of the CHART ATMS GUI in the external events tab.

3.37.8 External Event Closure

There are two ways external events are closed in the CHART ATMS. The normal way is for the external owning agency to close the event; however this assumes the external event listener, RITIS, and the external agency are all functioning normally. When this is not the case and an external event is orphaned, CHART ATMS administrators are able to close them manually.

CHART ATMS does not have control over how external agencies manage their traffic events so, unlike a CHART event; it is possible for a closed external event to be re-opened. In this case, if the closed external event has not yet been archived, it is re-opened within CHART ATMS. If the closed external event has already been archived out of CHART ATMS, a new external event is created with no relationship to the previous external event.

Closed external events are aged out of the system and archived just like normal internal events. In this context, 'closed' refers only to the CHART perspective – the external event may or may not still be existing and open from the perspective of other agencies.

3.37.9 Archiving of External Events

External events are archived for offline analysis along with internal CHART events, and are permanently flagged as external events in the archive.

3.37.10 DMS and TSS Import

Whereas events are transient objects, being opened and closed continuously and constantly changing, "rules" determine which events are imports. Devices, on the other hand, are relatively static, rarely created and remaining in service for years. Therefore, devices can be carefully hand-selected and included with deliberation. This is referred to as a "candidate review" process.

The CHART ATMS allows the administrator to specify which devices from RITIS are to be included in CHART ATMS, as well as those the administrator explicitly wants excluded from CHART ATMS. A query capability that includes several search criteria allows the administrator to search the potentially large list of DMS and TSS devices that may exist in RITIS so that they may choose devices to include in CHART ATMS or mark as excluded. The search feature also allows the administrator to view and evaluated the devices they have already marked as included, already marked as excluded, and/or not yet marked as either included or excluded. The advantage of explicitly excluding devices from CHART ATMS, is that the next time the candidate review process is undertaken, perhaps months later, the explicitly excluded devices do not have be considered for import again. By marking devices (e.g., very distant devices) as excluded, they do not have to be considered and re-evaluated for inclusion again. As noted, however, the list of explicitly excluded devices can be requested for candidate review and consideration again if desired, but this should not normally be necessary.

The CHART ATMS DMS and TSS lists allow users with rights to view external DMS or TSS to show or hide these external devices within the lists. When external devices are shown, the system allows the user to filter the list to hide CHART ATMS devices and to filter the list to show only external devices from specific agencies. CHART ATMS uses a different background color to differentiate external devices from CHART devices within device lists. The device details pages for external devices are read-only for all users, except that privileged users are permitted to mark the external device as "excluded", removing it from the CHART ATMS. (This is a shortcut to going back through the candidate review process again, if, for instance, a device has been marked as "included" by accident.)

Once added to the CHART ATMS, the CHART RITIS import service keeps the status of these devices updated within the CHART ATMS.

3.37.11 Archiving of External DMS and TSS Data

External DMSs and TSSs that have been imported into the CHART ATMS are archived for offline analysis along with internal CHART DMSs and TSSs, and are permanently flagged as external devices in the archive.

3.38 CHART Data Exporter

3.38.1 Background

CHART includes a web service that allows pre-approved external systems to obtain data from the CHART ATMS. External systems can issue data requests (via HTTPS) and receive the requested data in the form of an XML document. CHART allows traffic events, DMS, TSS, HAR, SHAZAM, and CCTV data to be retrieved in this manner. Authentication and data protection schemes ensure that only authorized clients can retrieve data, and that clients can only retrieve data for which they are permitted to receive.

The CHART ATMS Data Exporter replaced the former CORBA-based export in order to protect CHART ATMS operational system from direct calls by external systems. It prevents access to CHART ATMS data by not providing IDL level access. External systems retrieve data using defined requests (via HTTPS). Data exported is guarded by the access rights granted to the client by the administrator. An administrator in CHART ATMS grants rights to an external client – like a CHART ATMS user, most data may be viewed by virtue of being an authenticated user. Also like a CHART ATMS user, additional rights are needed before being able to view sensitive data such as fatalities. The Data Exporter can be considered a second user interface or presentation layer. In this light, it is natural that user rights and roles are applied just as they are applied to the GUI and its users.

The Data Exporter service allows the consumer to request inventory and status in its entirety or based on a lookback time period. The full inventory and status contains data for all requested data type entities in the CHART ATMS for which the client has rights. Any device of a particular type that is marked as "managed export" is supplied only to clients which have the right to receive data for the device's owning organization. (Devices not marked as "managed export" are supplied to all clients without further filtering.) The lookback inventory and status restricts the data exported based on how far back to look in time for changes to the requested data type entities in the CHART ATMS.

In addition to this pull-based mechanism, a more responsive push-based option is available, whereby client provides a URL where the Data Exporter can post real-time updates. Updates are pushed to this URL as they happen. Updates are queued during times when the consumer is unavailable, unreachable, or temporarily unable to keep up with the throughput. Once the queue is full, the queue is flushed and a flag is set in the next message informing the client that they have missed data and should pull a fresh inventory.

There are four systems which receive CHART data via the Data Exporter. Two are internal to the overall CHART Program: CHART Mapping (which serves the Intranet Map) and the public web site (a.k.a. CHARTWeb, a.k.a. CHART on the Web), which also services the CHARTWeb Map. Two are external to CHART: RITIS and MD511. However, there are only three clients of the Data Exporter, as explained below. There are also two Data Exporter Services – one internal, serving the internal CHART systems, and one external, serving external systems. Each Data Exporter is capable of serving any number of clients. The external Data Exporter resides in the demilitarized zone (generally referred to exclusively by its acronym, DMZ), with a firewall to provide protection to internal systems such as the CHART ATMS. The internal Data Exporter that serves CHART Mapping and CHARTWeb runs entirely inside the firewalls.

3.38.2 Data Exporter Clients

The Intranet Map and CHARTWeb (including the CHARTWeb map) are special clients of the Exporter in that they do not communicate directly with the Data Exporter. Instead a separate Export Client application acts as an intermediary. There is just one Export Client for both these two applications. The Export Client's prime responsibility is to gather data from the Data Exporter and update the database shared by the Internet/Intranet Map and the public web site. When configuration changes are detected by this application, it notifies CHART Mapping via a HTTP message. This triggers the maps to re-cache their data. The CHART Exporter Client does this by sending an HTTP GET request to the CHART Mapping Synchronization Application, a standalone application which then notifies the map software via .NET interfaces.

The RITIS system and MD511 are the clients of the external Data Exporter. Because RITIS and MD511 are an external systems, they connect to a separate Data Exporter than the Export Client used by the CHART Mapping and CHARTWeb. RITIS and MD511 use two different models for receiving data from the CHART ATMS. RITIS "subscribes" to updates from the CHART ATMS, and receives unsolicited data from the Data Exporter in near real-time. RITIS also periodically polls the Data Exporter for current state, to make sure it's view of the CHART ATMS data is fresh. MD511 does not subscribe to updates. It gets its data exclusively through polling the Data Exporter.

The Data Exporter was designed with the idea that any number of clients could obtain CHART data by connecting to the Data Exporter. The emergence of RITIS has made this less likely, but nonetheless MD511 does connect directly to the Data Exporter to get its data. All that would be required is for a CHART ATMS administrator to set up a another external client account with appropriate rights and pass the resultant generated private key to the client organization. (That and firewalls would need to be opened to allow the necessary connection/data to flow.) Additional clients from the inside could also connect to the Internal Data Exporter, but that is even less likely (but equally easy to set up).

3.38.3 Export Client Data Management

The Data Exporter does not guarantee delivery; therefore it is possible for event and device data to be lost or dropped (although in practice, this is rare). To account for this possibility, the CHART Data Export Client is configured to retrieve a full inventory and status update of devices and traffic events from the CHART Data Exporter at a configurable interval. Also, each time the CHART Data Exporter Client is started, it also retrieves a full inventory and status update. Thus, the update model becomes a push model with an occasional pull for failsafe.

This process is used to recover from the following situations:

1. The CHART Data Exporter Client receives no data because the CHART Data Exporter is down or other network related issues.
2. The CHART Data Exporter Client is up but did not receive new data from the CHART Data Exporter.
3. The CHART Data Exporter Client is up but is failing to send requests to the synchronization application to update the spatial information.

Another likely scenario is that the CHART ATMS server or service(s) restart. As the CHART ATMS services would not be processing events during this time, no events are likely to be missed. Therefore, the CHART Data Exporter Client does not need to do anything special to handle a CHART ATMS server or service(s) restart.

(Note that management of these considerations within the RITIS application is strictly within the domain of RITIS, and beyond the scope of this document.)

3.38.4 Traffic Event Data Export

Figure 3-4 shows the common ground between the CHART traffic event data in the left circle, and Advanced Traveler Information System (ATIS) standards in the right circle, along with the exported data available to the external entities shown in the lower circle. Often CHART data could not be fully expressed by the ATIS standard message set so additional elements were added as necessary (listed on the left of the figure).

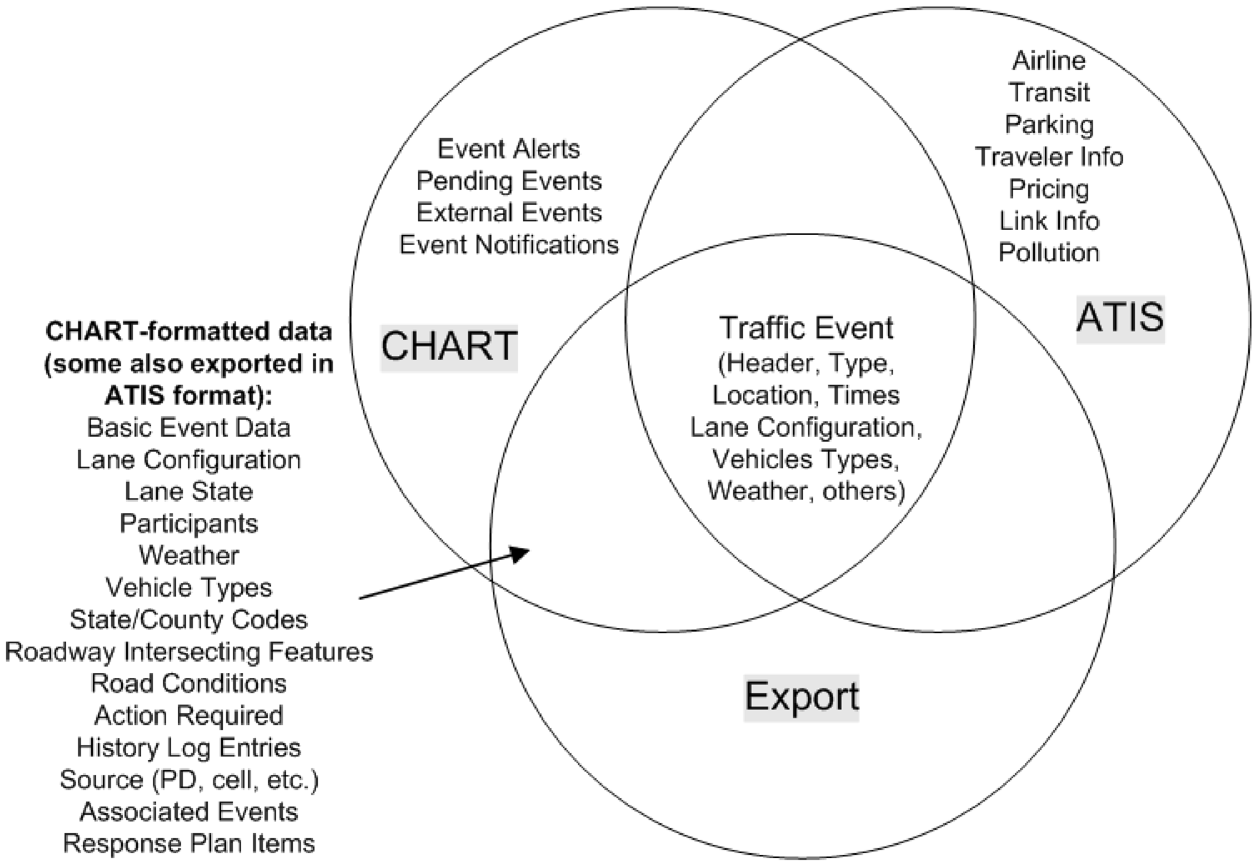


Figure 3-4. Export ATIS Events

The following extensions were added to the ATIS standards to support CHART specific data:

- <statusBlock> contains elements that indicate whether the response is a full inventory. If this message is sent in response to a subscription request, the missedData flag indicates to the client that there was a problem with the previous publication back to the client's URL so the client may wish to request a full inventory to ensure they are up-to-date.
- <AdminAreaGroup> to include information for region name, state code and county code.
- routeLocation was extended to include CHART specific route information, location alias public, location alias intersection, intersecting feature and direction.
- IncidentInformation was extended to include CHART basic event data, incident data, lane configuration, weather conditions data, action data, lane closure permit tracking number, participant, response plan information, event history log and related events.

The Traffic Event Export ICD contains additional details on how each field is exported.

3.38.5 Device Data Export

Figure 3-5 shows the common ground between the CHART device data in the left circle and TMDD standards in the right circle, along with the exported data that is available to the external entities in the lower circle.

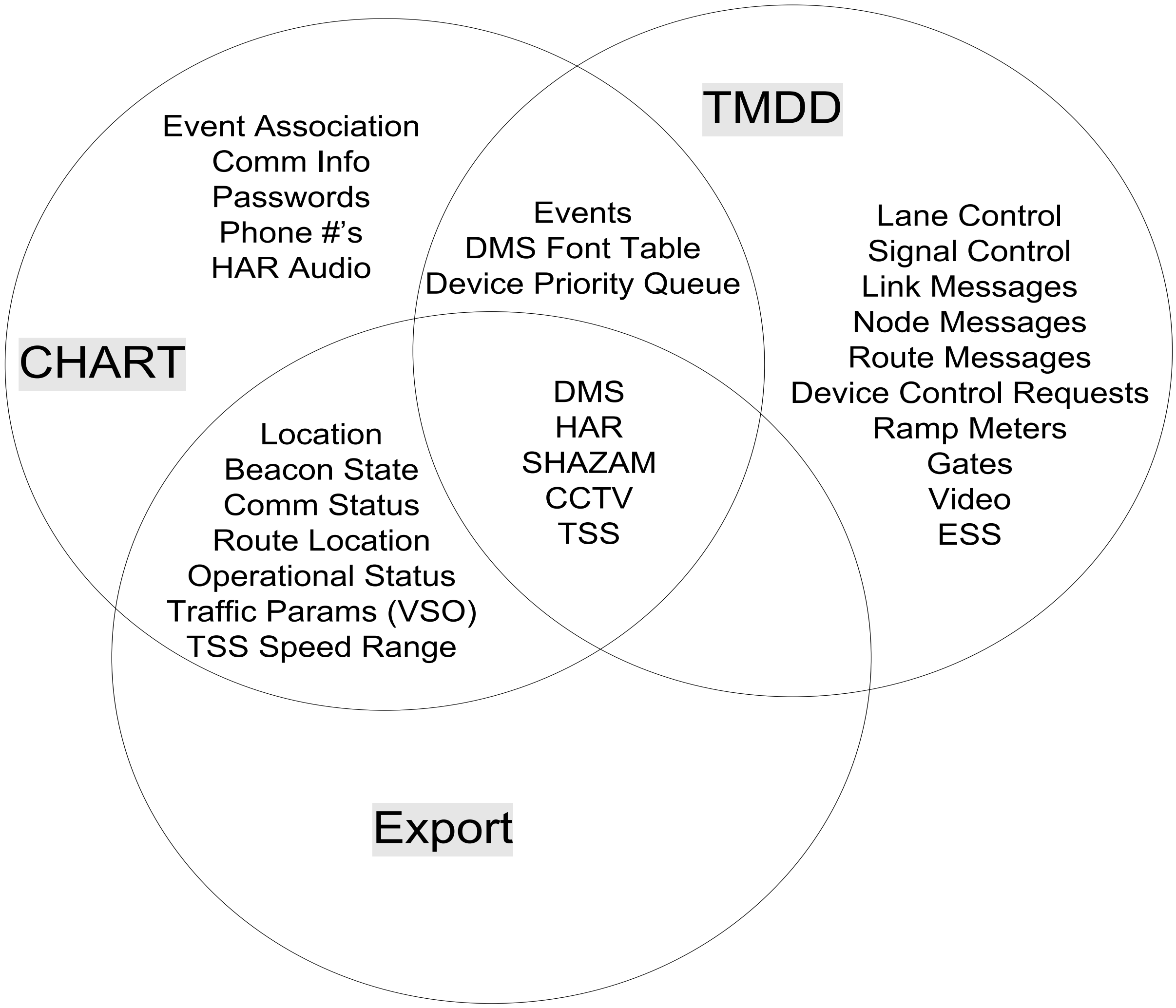


Figure 3-5. Export TMDD Devices

The Device specific export ICDs provide additional details on how each field is exported.

3.39 User Management Web Service Interface

3.39.1 Background

The User Management Web Service interface provides clients external to the CHART ATMS with the ability to query the CHART ATMS for their access rights. CHART Mapping uses this mechanism to control what data users logged into the Intranet Map may see, as there is some data (speed data from certain TSSs) which is restricted and must be controlled by user rights, as explained below.

There are three mapping components within the overall CHART Program:

- CHART ATMS Map – the map within the CHART ATMS, provides tactical maps to aid CHART ATMS operators in geo-locating events and devices.

- Intranet Map – internal map within CHART Mapping, for CHART operators and other agencies connected to the CHART network.
- CHART Web Map – external (public) map within CHART Mapping and displayed by CHART Web for external users.

The CHART ATMS Map is the only map that this document is generally concerned with; however, there is a point of contact between the CHART ATMS and the CHART Mapping, in that CHART ATMS provides data to CHART Mapping (and CHART Web) – and provides a user authentication and authorization process for the CHART Mapping.

Generally, only internal objects are displayed on the Intranet and CHART Web Maps; however, external detectors can be displayed on the Intranet Map as well. This need originally arose specifically for NAVTEQ detectors, which were "external" to CHART even though they physically exist within the State of Maryland. The point to be made here is that an external detector is defined as one that is not controlled by the CHART ATMS, regardless of whether it is located within the State of Maryland or not.

The display of external detector data came with complexity. Due to contract restrictions, only actual Maryland State Highway Administration (MDSHA) employees were permitted to view detailed speeds from some of the external detectors; specifically NAVTEQ detectors. Other users may view which range the speed falls in (e.g., under 30 mph, 30-50 mph, 50+ mph); however, they must be prevented from seeing precise speeds from these detectors.

Since the CHART ATMS has already for many years supported the granting of detailed rights to manage the display of detector data to its users, the same ability to manage user rights has been made available to the Intranet Map so that it may apply those same rights to its users. This was accomplished by creating a User Management Web Service that the Intranet Map can use to access back-end User Management functions. Only a little of the back-end service's features are exposed at this time, namely the validation of a username and password and the retrieval of an authorized user's rights. The design supports the easy addition of the remaining features to the User Management Web Service as they are needed in future releases. This design also makes it easier for other systems (e.g., LCP) to use the same User Management rights in the future possibly leading to a single sign-on for all CHART systems.

3.39.2 Impact on Intranet Mapping

When users first open the Intranet Map they are given rights associated with a default user. This default user is defined by the CHART ATMS administrator and is expected to always be configured to allow viewing all the CHART events and all CHART devices and their corresponding data, but no external detector data (or at least no external detector data that is subject to limited distribution). Some external detectors available on the Intranet Map used to require special rights in order to view their data (e.g., NAVTEQ detectors). For these, the default user saw either no speed or only a speed range, depending on how the CHART ATMS administrator configures the default user's rights. To view more information for these detectors, the user was required to log in to the Intranet Map using their normal CHART ATMS username and password. Then, based on any rights they gain by logging in, they might be able to view more or better information for these detectors. Because all detectors (internal as well as external) use the existing CHART ATMS rights mechanism, the CHART ATMS administrator can even control how users may view internal detectors on the Intranet Map. This feature could be expanded in future releases to provide additional restricted features on the Intranet Map.

It is conceivable that the act of logging in could actually remove rights if it happens that the user's CHART ATMS login provides fewer rights than the default user. This unlikely scenario would be in error in setting up the user's rights, and could be quickly remedied by the CHART ATMS administrator.

3.40 External System Connection Status

CHART ATMS includes the ability to view the status of all external connections, including those connections from the CHART ATMS to RITIS and to INRIX, and connections to the CHART ATMS from Vector and from clients using the CHART Data Exporter web service. For clients using the Data Exporter, each external client's connection for each data type they subscribe to is monitored and reported separately. Likewise, for the CHART ATMS's connection to RITIS for incoming data, the connections for each data type is monitored and reported separately.

The CHART ATMS also allows the administrator to configure alerts and notifications for each external connection. The administrator can configure the system to alert a specified operations center when a connection failure is detected. Notification groups can also be specified to receive a notification when a connection failure is detected. Optionally, the administrator can also configure the system to send alerts or notifications when warning conditions are detected, on a per-connection basis. Finally the administrator can specify that notifications also be sent when any connection transitions back to OK status. This setting is global: it affects all external connections at once. The system employs an administrator-specified threshold time to prevent a flood of alerts and/or notifications from being sent if a connection is in a state where it is frequently transitioning between OK and Failed.

3.41 Intranet Map Interfaces

This document is not about CHART Mapping, but since there are interface points between CHART ATMS and CHART Mapping, a few words are in order. Some interfaces have already been discussed. Other interfaces are discussed below.

The CHART Mapping system design utilizes a web-based multi-tier system architecture. The application is partitioned into the data tier, the business tier and the user (presentation) tier. The data storage is managed at the data tier by the databases using Microsoft SQL Server and ESRI ArcSDE platforms. The main business logic is hosted in the two applications (Internet and Intranet Maps) in the web server. They are implemented using the ASP.Net platform. The final user interface is implemented with the ASP.Net with client side JavaScript. Because mapping is an area in which there are many requirements related to client side interactions with the graphic content of the application, application logic is partitioned based on the most appropriate location to execute them. The client side JavaScript on the web browsers help provide instantaneous feedback to the user.

The CHART Exporter, the CHART Data Export Client, and the CHART Mapping Synchronization Application have already been covered in Data Exporter discussions above. Other applications include the CHART Spatial Web Service and the Satellite Imagery WMS. The Spatial Web Service hosts an HTTP/XML interface for the CHART ATMS GUI. The Intranet Map connects to the Satellite Imagery Web Map Service (WMS) on an HTTP/JSON interface.

CHART Mapping provides a number of interfaces for use by other CHART applications (e.g., CHART ATMS). The CHART Mapping GIS Web Service provides the ability to serve and update roadway lane configuration data for other CHART applications. CHART ATMS and the Lane Closure Permit (LCP) system are the only user of this data. The CHART Mapping GIS Service provides the capability to serve and write Area of Responsibility related polygon data for use in other applications, provides FITM data, and provides proximity information (including exits and milepost proximity data) to the CHART ATMS for the purpose of locating events or supporting decision support capabilities within the CHART ATMS. The CHART Mapping GIS Service also provides routing information ("driving directions") for ATMS Decision Support functionality. The CHART Mapping provides cached map tiles for map background data and exits and mileposts to the CHART ATMS.

3.42 Watchdog

CHART ATMS includes "watchdog" services that monitor other services for availability. A watchdog service is installed on each CHART ATMS server and is configured to periodically query each of the other CHART ATMS services on that server to determine if the service is available and to collect runtime statistics from the service. A second watchdog service is installed on each server to allow the primary watchdog service to also be monitored. Likewise, the first watchdog is configured to monitor the second watchdog among all the other services it monitors, so all services, including both watchdogs, are monitored by one watchdog. The watchdog service can be configured to automatically restart a service that has failed, and can also be configured to send alerts and/or notifications. The watchdog can also restart a service which provides a warning indication. Currently the only warning indication provided is one of low heap memory available. The GUI allows the status of each service, as determined by the watchdog monitoring the service, to be viewed in detail. Details about watchdog services themselves can also be viewed in the GUI, such as the list of services they are monitoring and the monitoring configuration for each. The GUI also allows commands to be issued to a watchdog to have it stop, start, or restart any service which it monitors, or to ping (query on demand) any service it monitors, or all those services at once.

3.43 CHART NTCIP Compliance Testers

CHART has developed NTCIP Compliance Testers to test NTCIP-compliance and compatibility with CHART ATMS for NTCIP DMSs and NTCIP Cameras. These compliance testers can be used in-house by SHA or support personnel, or they can easily be delivered to the device vendors for them to use themselves. These testers have been used in both these ways.

The NTCIP DMS Compliance Tester is a standalone application that allows sign vendors to test if their sign they believe is NTCIP-compliant sign is compatible with the CHART ATMS. This tester application makes use of actual CHART ATMS application code to ensure that all low level interactions between the tester application and an NTCIP compliant DMS are identical to the interactions made between the CHART ATMS and an NTCIP compliant DMS. The NTCIP DMS Compliance Tester utilizes a graphical user interface to allow the user to configure the tester for communications with the sign being tested, and to allow the user to execute tests, see the test results, and optionally save the test results. Note that this tester is not in any way connected to the live CHART ATMS – it is completely standalone, and it interacts directly with the DMS being tested.

The NTCIP Camera Compliance Tester is a separate standalone application that allows camera vendors to verify that their camera they believe is NTCIP-compliant will work with the CHART ATMS. The design of this tester is based on the design of the NTCIP DMS Compliance tester. It differs in the user commands it supports and the protocol handler it uses, however, the design of the basic framework of the tester, such as the base application and communications features are similar. Like the DMS Compliance Tester, the Camera Tester uses actual CHART ATMS code wherever possible, so that all interactions with the tester are guaranteed to be the same way the interactions will occur within the live CHART ATMS system later. These Compliance Testers are rebuilt and redelivered with each CHART ATMS release, to ensure the latest operational CHART ATMS code is included within the Compliance Testers.

3.44 Maintenance GUI

The Maintenance GUI is a portal into the existing CHART ATMS GUI that provides a view of the system tailored to device maintenance personnel. Upon login, the user can choose to view the maintenance portal instead of the normal CHART ATMS GUI pages. Users use their normal CHART ATMS username and password to log into the maintenance portal, and the user rights assigned within the normal CHART ATMS GUI apply to use of the maintenance portal. In fact, the code used to log into the maintenance portal is the same as that used to log into the standard GUI.

Upon login, if the user has selected to view the maintenance portal, the GUI sets a flag that causes all pages displayed to the user in the main browser window to utilize a custom framing template which is used to display all pages shown while logged into the portal. This framing template contains only information useful to maintenance personnel and does not contain features such as the communications log, site search, or links to various areas of the system or external systems.

After the user is logged into the maintenance portal, the system directs the user to a custom home page. The maintenance portal does not make use of a separate home page window and working window like the standard GUI. Instead, when the user logs into the maintenance portal, the same window they used to log into the system is used to display content.

The content of pages shown in the maintenance portal, other than the home page, is mostly the same as when the user logs into the standard GUI. The device lists, device details pages, and search results (for the search from the maintenance portal home page), however, are customized. The content of other pages is unchanged (other than the different framing template). Most pages that are normally displayed in pop-up windows in the standard GUI are not pop-ups in the maintenance GUI; most pages appear within the main browser window. (Certain pages such as those used to listen to HAR audio must remain as pop-up windows due to technical issues).

To support customized pages for the maintenance portal (and other portals that may be required in the future), the CHART ATMS GUI Servlet was changed to include generic processing that can customize pages just prior to rendering the page for display to the user. This processing allows a customized outer (framing) template and request-specific page content templates to be defined for each portal (the maintenance GUI being the one and only portal at this time). The generic processing also allows the portal type to specify whether or not pop-up windows are preferred when the user is logged into the portal.

3.45 Access Control

Users gain access to the system through a login process. As a result of this process each user is provided an access token which contains a description of the functional rights that the user has previously been granted by a system administrator. The token also contains information describing the operations center that they are acting on behalf of. Each restricted system operation requires this token to be passed for functional right verification purposes. If the token contains the appropriate functional right to perform the operation the system then verifies that the user is logged in to the operations center that is currently responsible for any targeted shared resources.

The system provides for the concept of a shared resource. A shared resource is any resource that can be “controlled” (“owned” in a sense) by a particular organization. Each shared resource is allowed to be controlled by only one operations center at a time. Access to a shared resource is controlled through the functional rights of the user attempting to gain control of the resource and through an arbitration scheme that prioritizes requests to the resource.

3.45.1 Security Management

Administrator privileges are required in order to modify user login information. A record of all changes that are made to user login information is logged in the operations log. Also, user login/logout actions and failed login attempts are logged in the operations log.

All CHART systems are located behind firewalls to protect them from unauthorized access through the network. The presentation of data from CHART to the outside world is through a push of the data from the CHART ATMS to external systems responsible for handling public access.

Because CHART ATMS is a system that resides on the MDOT Enterprise Network, all remote access is governed by the policies and procedures approved at the MDOT Security Working Group.

Access to CHART ATMS objects is controlled at the application level. The implementation of additional levels of access control for objects will be evaluated as necessary.

Physical security of installation sites is the responsibility of the site owners and is not within the scope of this document.

3.46 Shift Handoff Report

The Shift Handoff Report is a means of sharing important operations information with operators. When a user logs into the system, their operations center report shows the Shift Handoff Report for their center at the top of the page. This includes the name of the user that last edited the Shift Handoff Report and the date/time the last edit was made. After the Shift Handoff Report is automatically shown to the user one time, subsequent views of the operations center report will hide the Shift Handoff Report and provide a link to allow the user to view the report when needed. A user with appropriate rights can edit the content of the Shift Handoff Report for their center.

3.47 Areas of Responsibility

An Area of Responsibility represents a geographic area on a map that defines an area for which a certain CHART entity is responsible (e.g., an operations center or a monitor). Currently the CHART ATMS is the only CHART system employing Areas of Responsibility, although the facility is available for incorporation into other CHART systems.

Server-side rendering. Areas of responsibility are displayed on the map using server-side rendering. Server-side rendering was chosen due to the potential size of the data required to display an area of responsibility and the expected number of areas of responsibility. Area of responsibility data is expected to seldom change, but it can become very large if boundaries are drawn with many data points.

Web Service. Areas of responsibility are managed by a web service. The data is stored directly in the Mapping GIS database. This would allow other systems (outside of CHART ATMS) to define and use areas of responsibility if the need were to arise.

AOR Manager. An AORManager class exists in the CHART2.webservices.util package to manage AORs. This class is a Singleton and can be used by any CHART ATMS application code (GUI and/or server). The class maintains an updated cache of areas of responsibility. The class uses a synch API to keep the cache up to date. The AOR Manager can be configured with or without a cache. In non-caching mode, the AOR Manager can be used to determine if an area of responsibility still exists in the system.

Generic AOR Associations. The association of areas of responsibility with other CHART ATMS objects is generic. Currently, Areas of Responsibility can be associated only with Monitors and Operations Centers. A generic form is used to associate areas of responsibility with CHART ATMS objects, and a generic CHART ATMS database table stores the associations of areas of responsibility to CHART ATMS objects.

Filtering. Location aliases and device lists are filtered for users based on areas of responsibility. The list of location aliases available to the operator when setting an object location is initially filtered by the areas of responsibility associated with the user's operations center. The filter can be removed to view all location aliases in the system. If no areas of responsibility are associated with a user's operations center, the location aliases will not be filtered. Device lists are initially filtered using both the system folders and the areas of responsibility associated with the user's operations center. The initial set of devices presented is the union of all devices associated with the user's center's AOR plus the devices in the system folder associated with the user's center. This filtering can be removed to view all devices in the system. If no areas of responsibility are associated with a user's operations center, the device lists will be filtered based on the system folders only (unless no system folders are associated to the operations center either in which case all devices will be displayed.

3.48 Patrol Areas

Patrol Areas define an area that a field unit such as a CHART Unit can be assigned to patrol. Each patrol area has a defined geographic area along with a name and description. The Patrol Area's geographic area functionality is based on the Area of Responsibility functionality described above; each Patrol Area contains an Area of Responsibility. These Areas of Responsibility used for Patrol Areas are separate from the stand alone Areas of Responsibility and are not used for Area of Responsibility filtering functionality described above. The Areas of Responsibility contained in Patrol Areas can be viewed on the Home Page Map, however.

Patrol Areas can be assigned to operations centers, and when a user at an operations center chooses to indicate a field unit is "in service", the system allows the user to choose one or more patrol areas to assign to that field unit. The list of patrol areas available for assignment includes only those patrol areas assigned to the user's operations center. The system also allows a user to edit the assigned patrol area(s) of an "in service" field unit. The patrol area assigned to a field unit appears in various lists, such as the list of traffic event participants available for assignment to an event.

3.49 Exception Processing

Since CHART ATMS is a distributed object system, it is expected that any call to a remote object could cause an exception to be thrown. The system provides two levels of exception handling. The first is aimed at providing the user with immediate feedback on the failure status of the requested operation. The second is aimed at maintaining a log of system errors to enable system administrators to trace and correct problems. Each application maintains a running log file of software system status. Exceptions thrown by the applications contain a user displayable text status and a more detailed debug text status that is recorded in the application log file.

3.50 Long Running Operations

Many device control operations cannot be executed in a user responsive manner. Therefore, the software has been designed to perform these operations in an asynchronous fashion. The initiator of a long running operation is provided the opportunity to supply a callback status object. This allows the application to supply progress information back to the initiating client as the operation proceeds. Each operation provides a final status that indicates overall success or failure. This is indicated in the Command Status window by final success or failure indication and bright green (success) or red (failure) bars across the top and bottom of the Command Status page. All operators are intimately familiar with the "green bars" and (less frequently) the "red bars".

A typical example is putting a message on a device such as a telephony connected HAR. The system must dial up the device, wait for the HAR to answer, send the message to the device (which takes a long to send as the length of the message itself, as it is played in real time), and finally disconnect the communications path. At each point in this process status information is available to the initiator via the callback status object. This allows, for example, the display of a progress window to inform an operator of the status of their request to put a message on a HAR.

Another example of a long running operation is changing the color balance on a SurveyorVFT camera. The camera interface requires a long running macro be used to navigate through a menu system as though an operator were manually stepping through the camera menu. Queuing a request to control a camera is a long running operation. (Once a camera control session is established, routine camera control operations such as panning and tilting are instantaneous operations, not subject to queuing, and therefore not classified as long running operations.) There are countless other examples of long running operations.

3.51 Replication

SQL Server Replication is used to provide the University of Maryland with current versions of the CHART ATMS operational and archive databases. SQL Server Replication is a form of data replication from a principal site to one or more secondary sites. The principal database publishes its data and multiple receivers can subscribe to this publication.

CHART ATMS publishes both the CHART ATMS operational and archive databases and two subscribers have been set up at the University of Maryland. These two subscribers act as a backup for each other. A distributor database has also been set up as part of the SQL Server Replication. This distributor database acts as a reliable store-and-forward mechanism to transfer all the database transactions from the publisher to the subscriber. To facilitate replication over the Internet, the distributor database is set up in the DMZ part of the CHART network.

There are multiple versions of SQL Server Replication available. CHART ATMS has implemented the transaction replication version. This choice is dictated by the requirement to constantly copy all database changes to the subscribers, with all data moving in one direction from CHART ATMS to the University of Maryland. At a high level, as each database transaction in committed at the CHART ATMS database it is also written to the database logs. The logs are subsequently read, on a near realtime basis, and the data is copied to the store-and-forward distributor database. The subscribers, on a separate polling pattern, then pull the data from distributor database and apply it to their local databases.

Replication enables the reporting system developed by the University of Maryland to be accomplished near real time using the databases instances local to the University of Maryland CATT Lab. This is accomplished with standard database features with no custom coding. The reporting system uses a combination of data acquired via replication and data acquired via the data exporter to generate its reports. Aside from CHART ATMS providing the data, this reporting system is beyond the scope of the CHART ATMS. Early within the design of each release, discussions are held to determine what new reports might be necessary and what new data may need to be created and provided by CHART in order to support those new reports. Then CHART ensures that the data is created and provided as necessary, and University of Maryland develops the reports. The CHART and RITIS development and operations teams meet monthly to ensure these and other activities are coordinated properly.

4 SYSTEM VIEW

4.1 View Description and Typical Stakeholders

The System View describes what the CHART ATMS hardware components are, how they are configured, what they support, and how they connect to each other. This view focuses on the internal structure of the system and its components (the view from within), whereas the Interface View focuses on external interfaces (the view from outside). This view will be of primary use to system administrators, software developers and architects and others interested in the system-level architecture.

4.2 System Overview

4.2.1 CHART Description

Figure 4-1 presents an overview of the CHART Program Architecture organized according to the Enterprise Architecture Framework as defined by the National Institute of Standards and Technology and how the CHART ATMS fits within it. This approach gives a holistic view of the enterprise and is organized into 5 layers:

- Enterprise Business Architecture Layer
- Enterprise Information Architecture Layer
- Enterprise Application Architecture Layer
- Enterprise Application Integration Architecture Layer
- Enterprise Infrastructure Architecture Layer

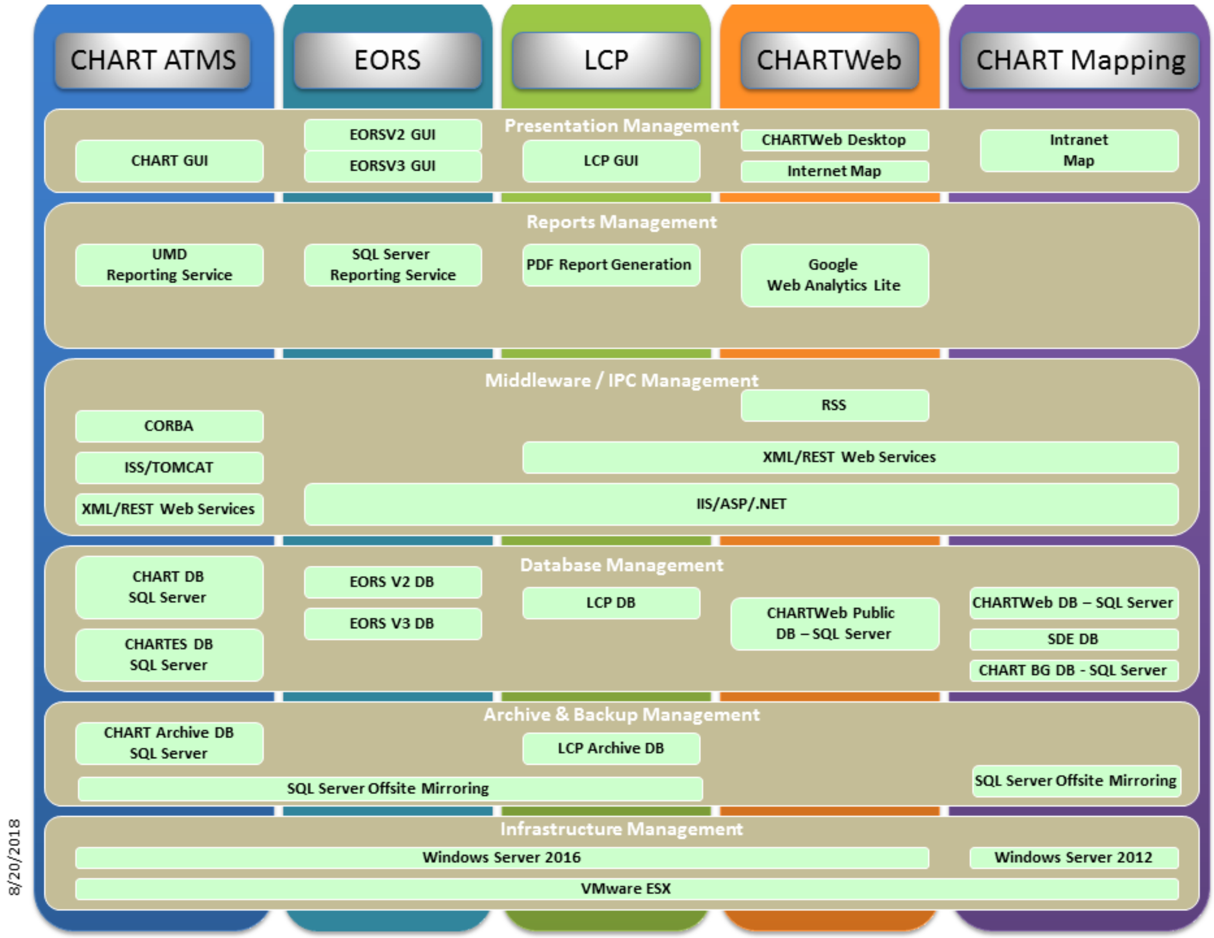


Figure 4-1. CHART Architectural Overview

The CHART ATMS consists of three major software systems.

- **Core Services –** The heart and brain of the CHART ATMS. It provides the interface for the CHART ATMS GUI, traffic management functions, and CCTV distribution and control. This includes web services written by the CHART ATMS development team, which run on the CHART ATMS server and on a CHART Mapping server.
- **GUI Services –** This server provides access to CHART ATMS functionality to users via a web interface.
- **Database Instance and Database Archive –** This system stores CHART ATMS event data and all other operations data, both immediate operational and log-term archive, and provides query and maintenance functionality. This system also provides data to the CHART Reporting function done at University of Maryland.

These software systems are supported by the MDOT Enterprise network infrastructure. The network infrastructure is a key supporting ingredient of the CHART systems (of which the CHART ATMS is one), but is not itself part of the CHART Program.

The next two diagrams show various views of the CHART system architecture and how the CHART ATMS fits within it. Figure 4-2 presents a high-level connection-oriented architecture diagram showing how all of the internal and external systems connect to each other. Figure 4-3 presents a more detailed view of the components specific to the CHART system.

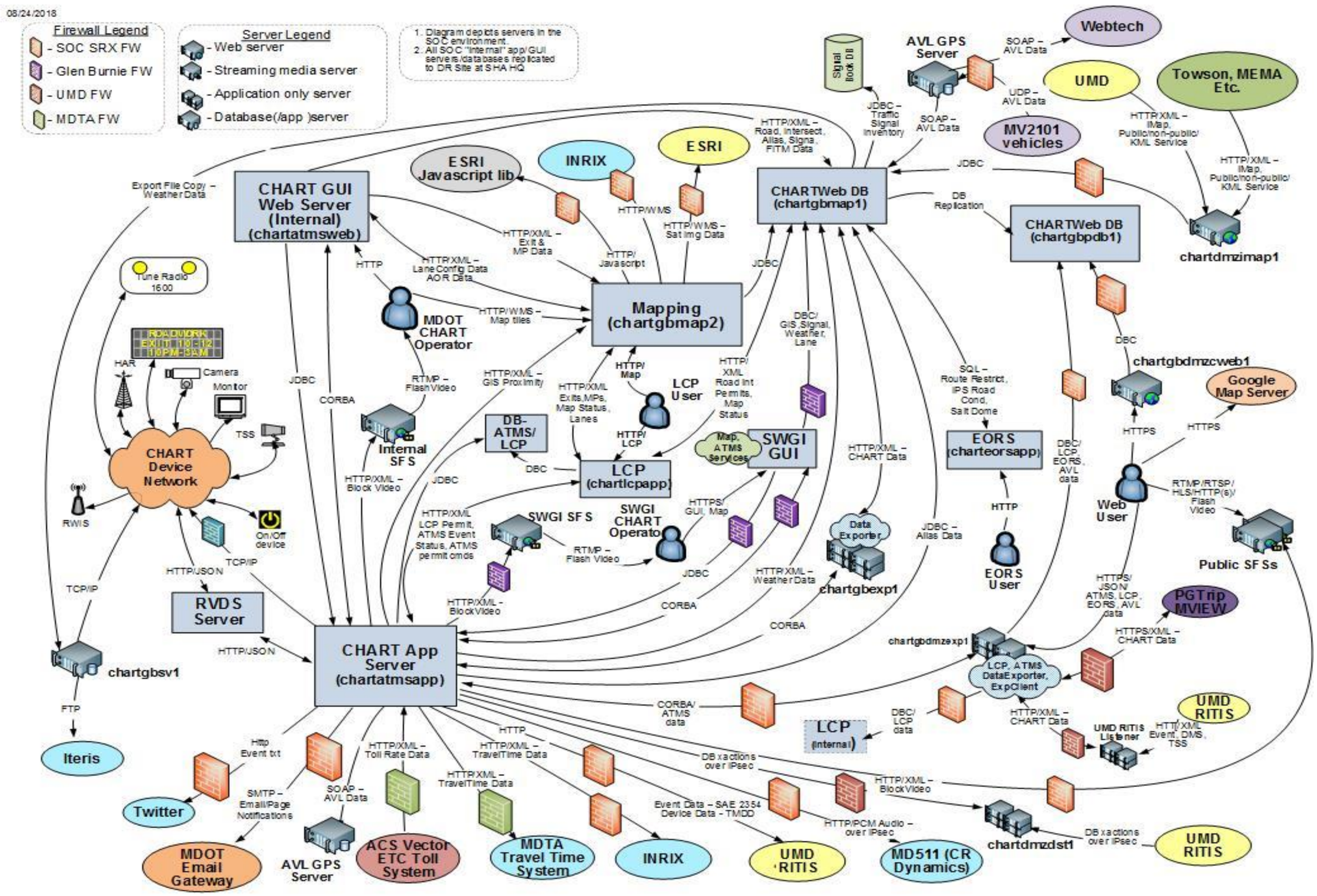


Figure 4-2. High Level CHART Systems Architecture

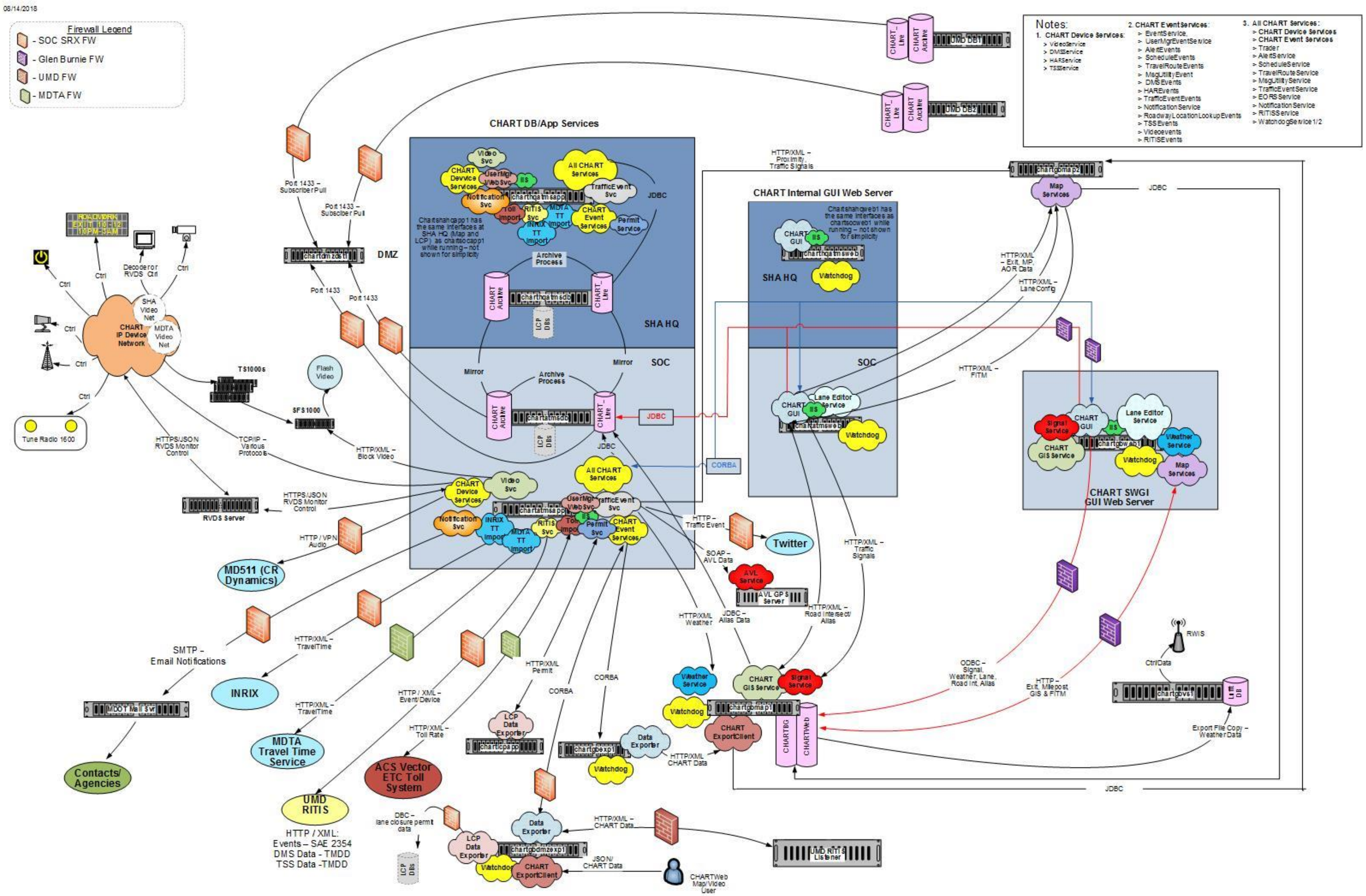


Figure 4-3. CHART ATMS Detailed System Architecture

4.3 Software components

4.3.1 Software CIs

There are five software CIs comprising the CHART ATMS.

- **CHART –** This CI consists of those subsystems providing direct support to the CHART operations staff. This includes the backend applications and the GUI.
-
- **COTS –** This CI is a collection of all the COTS packages used by the CHART ATMS. These are collected into a CI for configuration control purposes.
- **CHART ATMS Archive –** This CI consists of the archive database itself, plus subsystems supporting the duplication and archiving of CHART ATMS data.
- **Database Instance –** This CI consists of only the database for the live CHART ATMS database.

4.3.2 Communications

4.3.2.1 Interprocess Communications

The CHART ATMS GUI and application services are able to locate needed software objects through the use of the CORBA Trading Service. Each CHART ATMS service that publishes CORBA objects offers the objects through the CORBA Trading Service. The general approach is that a service publishes one manager type object that then provides access to objects under its purview. The GUI collects knowledge of virtually all objects in the system, and provides a unified view of the system.

In addition to showing the software objects throughout the system on a single interface, it is also necessary to reflect the current state of the software objects as they are changed during real time operations. The CORBA Event Service is used to allow objects to push changes in their state to the GUI, other backend CHART ATMS services, the CHART Data Exporter, or any other interested CORBA clients. The CORBA Event Channel Factory is an extension of the CORBA Event Service that allows multiple event channels. Each CHART ATMS service whose objects are subject to real time changes creates one or more Event Channels in its local Event Channel Factory. Each event channel is earmarked for a specific class of events (such as DMS events). Each service that creates channels in the CORBA Event Channel Factory publishes the event channel in the CORBA Trading Service and then uses the channel to push events relating to object state, configuration updates, etc.

An interface that wishes to listen for events at a system wide level discovers all of the event channels via the CORBA Trading Service and registers itself as a consumer on each of the event channels. Using this scheme, an interface uses the Trading Service to discover all software objects and Event Channels. The interface may then provide the user with a unified view of the system, both in the objects presented and the ability to show near real time updates of these objects. Since the nature of the system is dynamic, processes periodically rediscover new objects and event channels via the Trading Service. The GUI can also be commanded to discover new objects on demand. This is generally not necessary, as changes are pushed dynamically. Figure 4-4 illustrates the relationship between the CORBA and Trading Event Services.

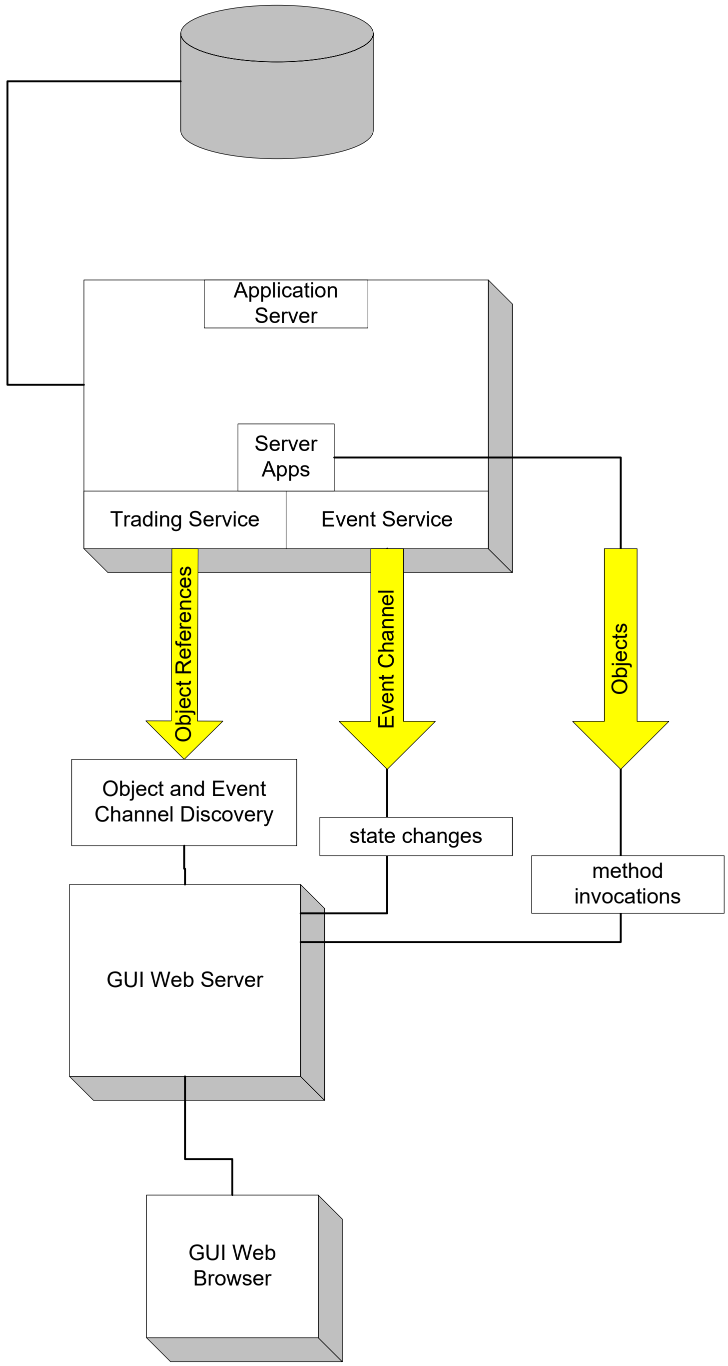


Figure 4-4. CORBA Trading and Event Services

Most CHART ATMS software objects used in this system are typical distributed software objects. The data inside an object pertains only to the instance of the object and operations pertain only to the instance of the object on which they are performed. Other parts of the system must go to the instance of an object to view the object's data or perform operations (via method invocations) on the object. For example, there is one and only one software object in the system that represents a specific DMS in the field. If an operation such as setting the message needs to be done to the field

DMS, the user interface must perform the operations on the one and only software object that represents the DMS.

4.3.2.2 Device Communications

CHART ATMS background services which communicate with physical devices deployed along Maryland highways do so via TCP/IP for DMSs, TSSs, HARs, SHAZAMs, and On/Off devices.

The remaining CHART ATMS background service controlling physical field devices is the Video Service. Video communication is accomplished via TCP/IP. Communication to Core Tec decoders is accomplished via proprietary Core Tec protocol via DCOM. Communication to Impath decoders is accomplished via SNMP over TCP/IP, with published Management Information Bases (MIBs). The CHART ATMS does not directly command either the Impath or the Core Tec encoders; they are used only as a pass-through to pass camera control commands and responses to/from the attached cameras. CHART ATMS's communication with the encoders, then, is via TCP/IP with no proprietary protocol involved. Once a video connection is established, the video stream is directed from encoder to decoder via MPEG2 or MPEG4 over TCP/IP. The CHART ATMS software also has support for multiple transmission devices for cameras. This was done to support the ongoing effort to transcode video into multiple formats in order to more effectively share video with various CHART partner organizations and the public. This infrastructure allows an MPEG2 encoded video source to be viewed on a monitor attached to an MPEG2 decoder, a monitor attached to an MPEG4 compatible SHA decoder, and as a Flash video stream on the CHART ATMS GUI desktop, Intranet map, Public web site, and video web page on the SWGI. The RVDS Video Streaming Devices (VSDs) are communicated to via the RVDS Video Streamer Service (VSS). The CHART ATMS Video Service commands the VSS, which commands the VSD, both paths implemented by passing JSON data over an HTTPS web interface.

4.3.2.3 Web Services Description and Diagrams

External entities receive CHART data via an HTTPS/XML interface rather than by the CORBA interface. The HTTPS/XML interface provides security features and data filtering capabilities not possible via the CORBA interface.

4.4 Database

The overall CHART ATMS database architecture is shown in Figure 4-5.

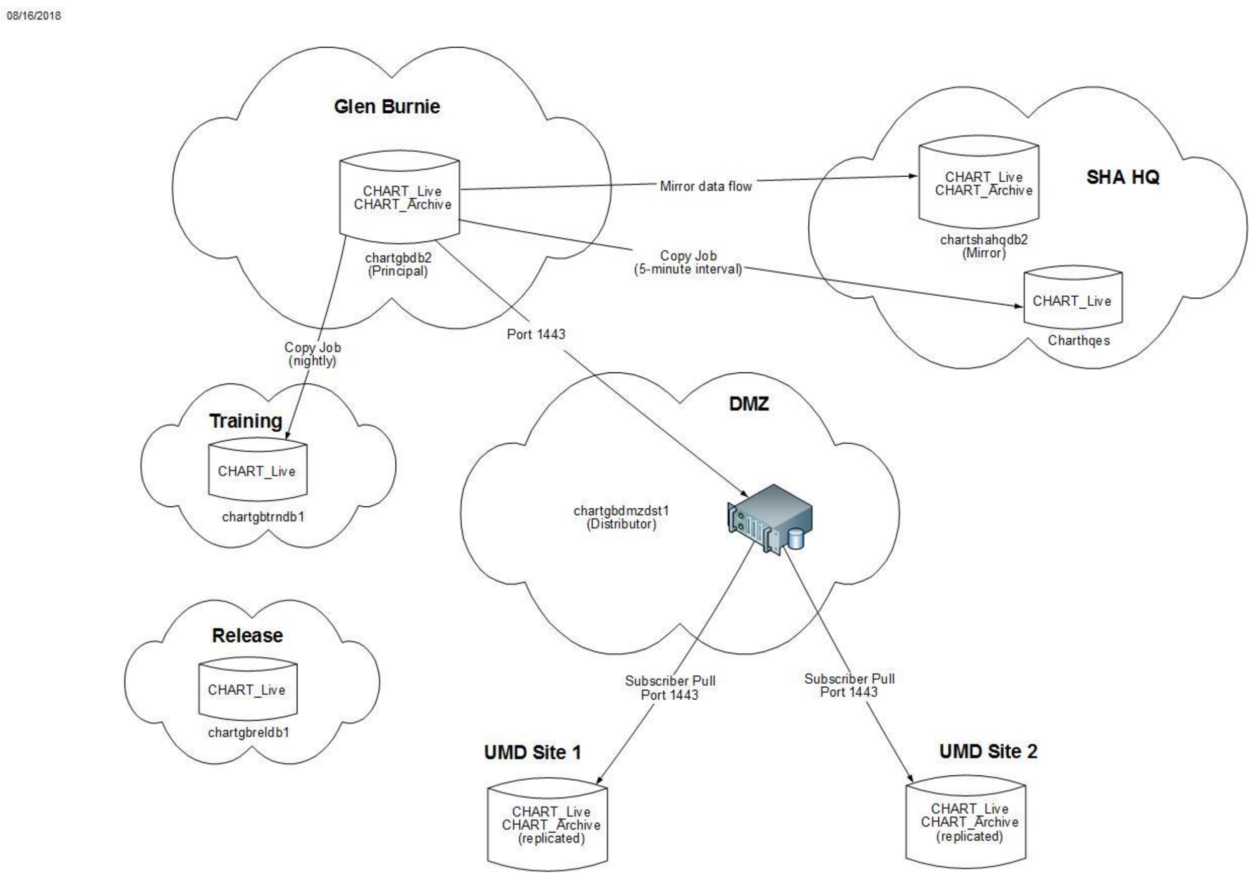


Figure 4-5. Database Architecture

The production CHART_Live and CHART_Archive databases are mirrored to SHA Headquarters. The mirror databases are used for disaster recovery scenarios. Database replication is used to provide query and reporting capabilities to the University of Maryland reporting system and is described in Section 4.4.3. The training environment hosting the current release and CHART-ES are both kept up to date via copy jobs. The training environment hosting the next future release is not regularly updated at all,but is updated as necessary when the environment gets a new build. Archiving is discussed in the following section.

4.4.1 Archiving

The Data Management subsystem handles the archiving of CHART ATMS data into the CHART ATMS Archive database. The CHART ATMS Archive database stores data from the CHART ATMS operational system as part of a permanent archive. Periodic database jobs are run to move data from the CHART ATMS operational system to the CHART ATMS Archive database. Most of the data which is archived is archived once a day, in the early hours of the morning after midnight when the system is otherwise least busy.

The CHART ATMS Archive database design bears some semblance to the CHART ATMS operational system, but is structured differently and contains only that information necessary to run the various required reports. For instance, very little device configuration data is included in the archive database: information about how to communicate to the devices, display configurations of signs, etc., is not needed for the various device reports, which are generally limited to what messages were posted when, what speed/volume/occupancy data came from detectors, etc. The information required to be stored for devices is generally limited to mapping internal CHART ATMS IDs of devices to device names, so that reports can identify devices by name rather than by unfriendly CHART ATMS ID. Therefore, all devices are stored in a single lookup table in the archive database, whereas they are stored in type-specific tables in the live database (DMSs in a DMS table, HARs in a HAR table, etc.) Status information is not stored for devices, as these statuses are constantly fluctuating anyway (the status of a device at the time it was last archived is meaningless).

One set of device status data from devices which is stored in its entirety is speed, volume, and occupancy data reported by detectors (TSSs). Detectors are polled every five minutes, and data is generally collected per lane. The major output of the CHART ATMS is accumulated information about all the traffic events which transpire across the state on a continual basis. Virtually every piece of information about all the CHART traffic events is archived nightly. Traffic events are archived no sooner than twelve hours after they are closed, so that CHART ATMS operators can review and update traffic events within the CHART ATMS even after they are closed. All this data is accumulated and archived from the live system into the archive database as part of the nightly archive jobs. Closed alerts are also

Most data archived into the archive database is stored indefinitely, including all traffic event related data and detector data. The CHART ATMS archive database holds data going back to the year 2001. However, information pertaining to travel times, as reported by INRIX and as displayed on DMSs, is archived for only three months. INRIX provides a long term archive of all collected data. CHART's use of archived travel time data is primarily concerned with what travel time was posted on a DMS at a particular time in the recent past, or, if no travel time was posted, why not? Beyond a certain point, such questions are unlikely to be asked. Including all travel times for individual roadway links and accumulated travel routes, and status data that can explain the myriad reasons why a travel time was not posted are quite voluminous.

Data required to run and manage the CHART ATMS is generally not archived. This includes data pertaining to user management, system profile, libraries, and plans

4.4.2 Mirroring

The two CHART databases, CHART_Live and CHART_Archive, are mirrored from the Principal location at the MDOT Glen Burnie Data Center (GB-DC) to the Mirror location at SHA Headquarters (HQ). This provides a duplicate copy of each database at SHA Headquarters, to be used by CHART services running at the SHA Headquarters failover site. These services are not running routinely. Before they can run, the mirrored databases at SHA Headquarters must be set to be Principal.

4.4.3 Replication

CHART publishes both the CHART ATMS operational and archive databases and two subscribers are set up at the University of Maryland. These two subscribers act as a backup for each other. A distributor server is set up as part of the SQL Server Replication. This distributor acts as a reliable store-and-forward mechanism to transfer all the database transactions from the publishers to the subscribers. To facilitate replication over the Internet the distributor database runs in the DMZ part of the CHART network.

4.4.4 Copy Jobs

Hand-written copy jobs are used to keep the CHART_Live database in the current CHART Training environment and in CHART-ES up to date. The Current Training copy job runs nightly and the CHART-ES copy job runs every five minutes.

4.5 Hardware components

This section presents the hardware CIs that make up the CHART ATMS. Each hardware CI is described and a list of major components is provided.

4.5.1 Hardware CIs

There are seven hardware CIs.

- **CHART ATMS Application Server –** Supports CHART ATMS applications.
- **CHART ATMS Database Server –** Supports the CHART ATMS Database Instance and CHART ATMS Archive software CI subsystems
- **CHART ATMS GUI Web Server –** Provides the conduit between the CHART ATMS services and the browser-based interface GUI.
- **CHART ATMS Data Exporter Server –** Supports export of CHART ATMS data – both internally and externally. Note that one instance of this server also hosts the Lane Closure Permits (LCP) Data Exporter (which is *not* an ATMS component)..
- **CHART ATMS Emergency Server –** Provides a degraded CHART ATMS when the primary system is not available, and the backup system is not available or is not being used electively. Elements of the CHART ATMS Application Server, CHART ATMS GUI Web Server, and CHART ATMS Database Server all run on this one server.
- **CHART ATMS Training Servers –** CHART provides two types of training servers: one type runs the current version of software, and is designed for ongoing training, and the other type runs the upcoming future version of software, designed for forward-looking training for a new release of software before it is officially released. From a Hardware/VM perspective, Training Servers are configured identically to the servers they are intended to emulate. From an ATMS perspective, both training system includes a Database Server, and a combined Application and Web Server.
- **CHART ATMS Workstation –** Supports CHART ATMS client-side functions for operations users. The need for maintaining this item as a CI has been reduced by the adoption of the browser-based CHART ATMS GUI as the one and only supported CHART ATMS GUI. However, this CI is still maintained for historical purposes, if nothing else.

4.5.2 CHART ATMS Application Server Description

The CHART ATMS application server system supports the CHART ATMS software CIs. This system consists of a server along with associated storage array and network connection devices. These systems are currently deployed in a virtual environment at the GB-DC, and on an identical backup at SHA Headquarters in Baltimore.

The CHART ATMS Application Server system configuration is:

- Intel XEON X5650 2 processor 8 Virtual CPU (vCPU) 2.67 GHz

- 16 GB Total SDRAM
- 80 GB D: drive, 200 GB E: drive
- DVD Drive
- Gigabit NIC card

4.5.3 CHART ATMS Database Server Description

The CHART ATMS Database Server supports the CHART_Live database used to store all data relating to the CHART ATMS, and also the CHART_Archive database used to archive all CHART ATMS data deemed to be historically significant. It also hosts the other CHART ATMS Archive subsystems. The system accepts queries related to operations of the CHART ATMS and support operations performed by maintenance personnel. There are two CHART ATMS Database Servers: a primary one at the GB-DC and an identical backup at SHA Headquarters in Baltimore.

The CHART ATMS Database Server system configuration is:

- Intel XEON X5650 2 processor 8 vCPU 2.67 GHz
- 48 GB Total SDRAM
- 100 GB C: drive, 250 GB D: drive, 40 GB E: Drive, 300GB F: Drive, 300GB G: Drive, 1.5 TB H: drive
- DVD Drive
- Gigabit NIC card

4.5.4 CHART ATMS GUI Web Server Description

The CHART ATMS GUI Web servers are currently deployed in a virtual environment at the GB-DC with a backup capability at SHA headquarters. There are two CHART ATMS GUI systems in normal use: the standard GUI system at the GB-DC and the SWGI GUI located at Glen Burnie. There is also a backup standard GUI system at SHA Headquarters in Baltimore.

The standard CHART ATMS GUI Web Server system configuration is:

- Intel XEON X5650 4 processor 4 vCPU 2.67 GHz
- 8 GB SDRAM
- 80 GB C: drive, 50 GB E: drive
- Gigabit NIC card

The SWGI CHART ATMS GUI Web Server system configuration is:

- Intel XEON X5680 2 vCPUs 2.67 GHz
- 6 GB SDRAM
- 20 GB C: drive, 50 GB D: drive, 200 GB E: drive
- DVD Drive
- Gigabit NIC card

The SWGI CHART ATMS GUI Web Server also runs CHART Mapping services that serve map tiles to the CHART ATMS GUI, since regular CHART Mapping services cannot be easily accessed from this SWGI GUI network.

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4.5.5 CHART ATMS Data Exporter Server Description

The CHART ATMS Data Exporter Server supports the export of all CHART ATMS traffic event management, detector, DMS, HAR, SHAZAM, and CCTV operational data. There are two CHART ATMS Data Exporter Servers, both located at the GB-DC, and both of which run together at the same time. One CHART ATMS Data Exporter Server supports export of data within the internal CHART realm to the CHARTWeb database (where it is used by CHARTWeb and the CHART Mapping (Intranet Map). This is known as the "Internal" exporter. The other CHART ATMS Data Exporter Server supports export of data to "external" entities. There are five external consumers of exported CHART ATMS data. These are: RITIS, located at the University of Maryland, Maryland 511, Prince George's County's TRIP Center, MVIEW, and CHART Mapping (Internet Map). The external CHART Data Exporter Server resides on the DMZ. There is no dedicated backup server for the external CHART Data Exporter, so external Data Exporter services may not be available in certain failover scenarios.

The CHART Data Exporter Server system configuration is:

- Intel® XEON X5650 2 processor 4 CPU 2.67 GHz
- 6 GB SDRAM
- 80 GB C: drive, 40 GB E: drive
- Gigabit NIC card

4.5.6 CHART ATMS Emergency Server Description

The CHART ATMS emergency server system supports software CIs for the CHART ATMS Emergency System. This system consists of a single virtual server located at the SHA Headquarters. Because only selected elements of the full CHART ATMS services run on this server there are resources available to also run CHART ATMS database services and a specially configured GUI web service which makes it clear that it is the CHART Emergency System (often abbreviated as CHART-ES). The database has identical structure to the operational CHART ATMS database, but only selected portions of it are populated, as necessary. The database content is kept current while CHART-ES is not running by database scripts which run on this server. Despite the name, CHART-ES is not used exclusively during emergencies; it has also been used during scheduled system upgrades.

The CHART ATMS Emergency Server system configuration is:

- Intel XEON E5640 8 CPU 2.67 GHz
- 8 GB Total SDRAM
- 80 GB D: drive, 300 GB D: drive
- DVD Drive
- Gigabit NIC card

4.5.7 CHART ATMS Workstation Description

Since CHART ATMS became a web-based application which can run on any workstation with a browser, the CHART ATMS Workstation is no longer maintained as a Hardware CI under the purview of CHART ATMS. Many CHART ATMS Workstations located at numerous locations across the state may come in a large variety of configurations. Their numbers and configurations not actively tracked.

5 INTERFACE VIEW

5.1 View Description and Typical Stakeholders

The Interface view describes connections to systems and users outside of the CHART ATMS. Most of CHART's external connections are to systems that then re-package the information for presentation to their end-users. In some cases the consumers are actually other CHART systems such as users of the Intranet Map and LCP who need CHART ATMS information on a read-only basis and do not actually manage incidents.

CHART ATMS imports information from agencies and systems within Maryland and from systems outside of Maryland to gain a regional perspective.

Typical stakeholders of this section are representatives from other agencies interested in CHART ATMS's capabilities, specifically software and system architects who may be looking to interface with CHART ATMS.

5.2 External Interfaces

Figure 5-1 shows the external interfaces to the CHART ATMS. The inner cloud is the CHART ATMS proper whose mission is the active management of traffic on Maryland roadways. The larger CHART cloud includes other systems that CHART ATMS communications with to complete its mission. These other systems often interface with each other as well however as the focus of this diagram is CHART ATMS those interfaces are not included here.

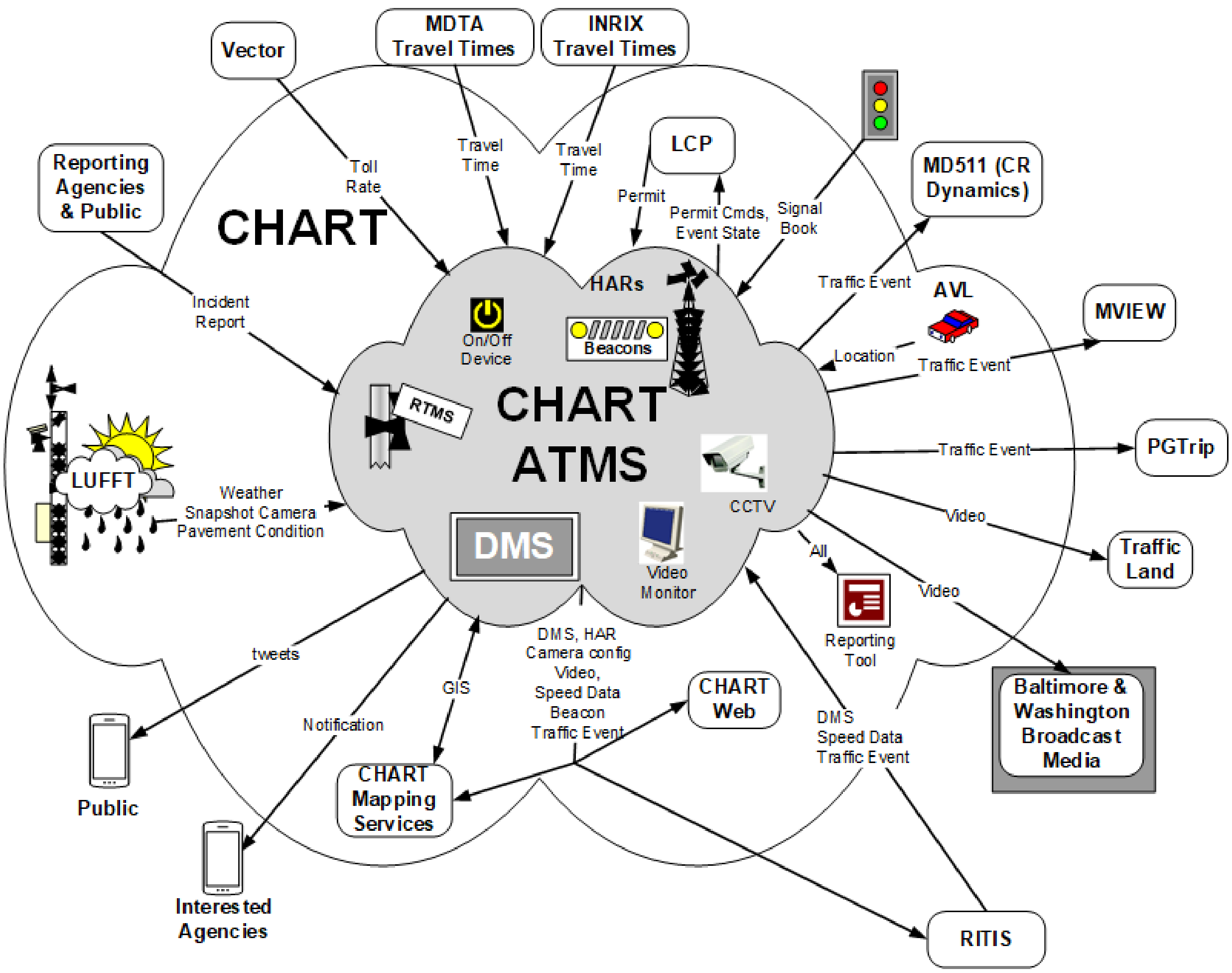

Figure 5-1. CHART ATMS External Interfaces

CHART ATMS's external interfaces consist of:

- **CHARTWeb** – This public-facing site displays incident reports, lane closures, speed data, DMS messages, and camera configurations obtained from the CHART ATMS via an HTTPS/XML interface. CHARTWeb also displays map and video data from other CHART sources.
- **CHART Mapping Services** – These services provide GIS support for CHART ATMS and other CHART systems. Included in these services is support for location aliases, roadway intersection/exit/milepost lookup, roadway lane configurations, object proximity, AOR configurations, and map background tile overlays. The Intranet Map is included in this suite which provides a geographical view of CHART ATMS objects including incident reports, lane closures, speed sensors, DMS data and camera configurations.
- **Lane Closure Permits (LCP)** – System providing permit information on planned and active road closures and road status. CHART ATMS sends commands to LCP as initiated by CHART ATMS users to perform actions on permits. CHART ATMS also sends LCP messages related to changes made to traffic events that are associated with LCP permits.

- **TrafficLand, Baltimore Media, and Washington Media** –These external media organizations receive video from CHART. CHART ATMS users control where the cameras are pointed and are able to selectively block these video feeds on demand.
- **Lufft** – System to supply weather sensor data including pavement conditions to CHART applications.
- **CHART Reporting tool** – Developed and maintained by the UMD CATT Lab, this web site generates reports from replicated copies of the archive CHART ATMS database.
- **Regional Integrated Transportation Information System (RITIS)** –

  This system was developed by the University of Maryland Center for Advanced Transportation Technology (CATT) Lab. It both imports and exports CHART ATMS information:
  - **Export** – RITIS receives Society of Automotive Engineers (SAE) ATIS standard incident and TMDD standard device configuration and status updates from CHART ATMS via an HTTPS/XML interface. RITIS also receives video feeds from CHART which can be dynamically blocked/unblocked from within CHART ATMS.
  - **Import** – RITIS provides CHART ATMS with SAE ATIS standard regional traffic events and TMDD standard DMS and TSS data via Java messaging service connections. These data are collected from Northern Virginia, Washington Metropolitan Area Transit Authority (WMATA), District of Columbia Department of Transportation (DCDOT), SpeedInfo and even MDOT.
- **Interested Agencies** – Requesting agencies receive notifications from CHART ATMS about occurrences of interest via e-mail or text messages. Text messages are sent out as SMTP messages and converted to text by the email provider.
- **INRIX Travel Times**–Provides roadway travel times to CHART ATMS for display on selected DMSs. CHART ATMS connects to INRIX via an HTTP/XML interface.
- **MDTA Travel Times**–Provides roadway travel times to CHART ATMS for display on selected DMSs from the MDTA OnTime system. CHART ATMS connects to OnTime via an HTTP/XML interface.
- **Vector** – MDTA system provides dynamic toll rates to the CHART ATMS. The Vector system connects to CHART ATMS via an HTTP/XML interface.
- **MVIEW, PGTrip** – Receives traffic event reports from ATMS.
- **Signal Book** – CHART ATMS accesses the SHA Signal Book database containing locations of non-CHART, state-owned arterial devices including traffic signals, cameras, beacons (school, bridge, and warning), pre-emption signals (fire, bus, and rail), reversible lane signals, and weigh station devices.
- **AVL** – Automatic Vehicle Location system provides real-time vehicle locations over a SOAP interface which CHART ATMS uses to identify the closest incident responders. CHART ATMS also uses it to track when responders actually arrive and depart an incident.
- **Reporting Agencies and Public** – In addition to incident reports coming from the general public, CHART ATMS also receives incident reports from many agencies including SHA and MDTA personnel, local and state police, and CHART's own Safety Service Patrol (also called CHART Units).

- **MD511 (CR Dynamics)** – This interface enables ATMS operators to post audio versions of important traffic events to an unattended phone system. Callers can hear the audio event descriptions by dialing 511 from any phone in the state.
- **Public** – The Social Media module in ATMS enables ATMS operators to post a text version of important events to Twitter.

6 DATA VIEW

6.1 View Description and Typical Stakeholders

This view into the CHART ATMS shows how data move into, out of, and around the CHART ATMS and describes at a high level how CHART ATMS data is stored in the operational and archive databases associated with the CHART ATMS. This view is useful for CHART ATMS DBAs, management, developers, and stakeholders affiliated with the various systems with which the CHART ATMS interfaces.

6.2 Data Flow

Data flows for the CHART ATMS are illustrated in Figures 6-1, 6-2, and 6-3.

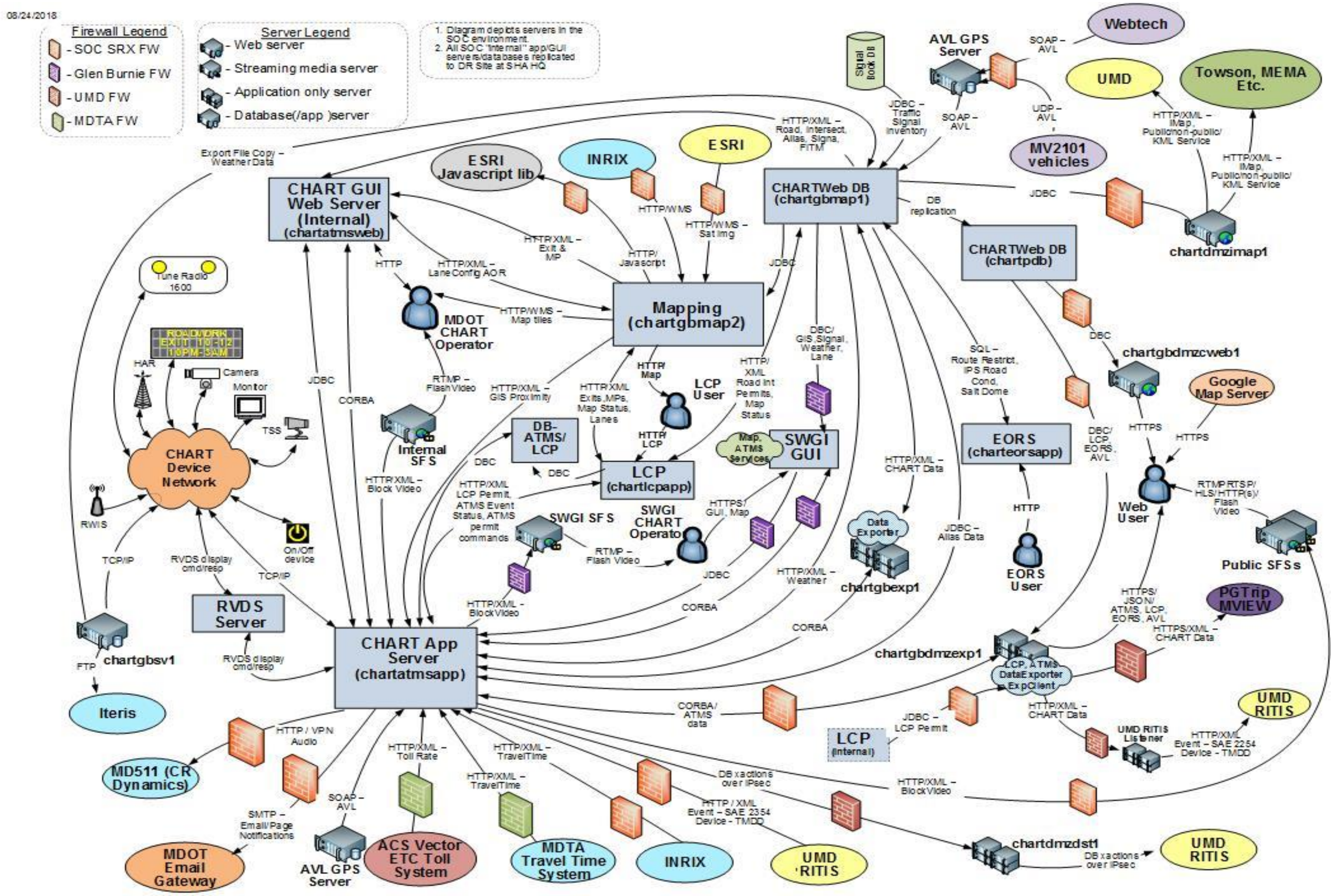

Figure 6-1. CHART High Level Data Flow

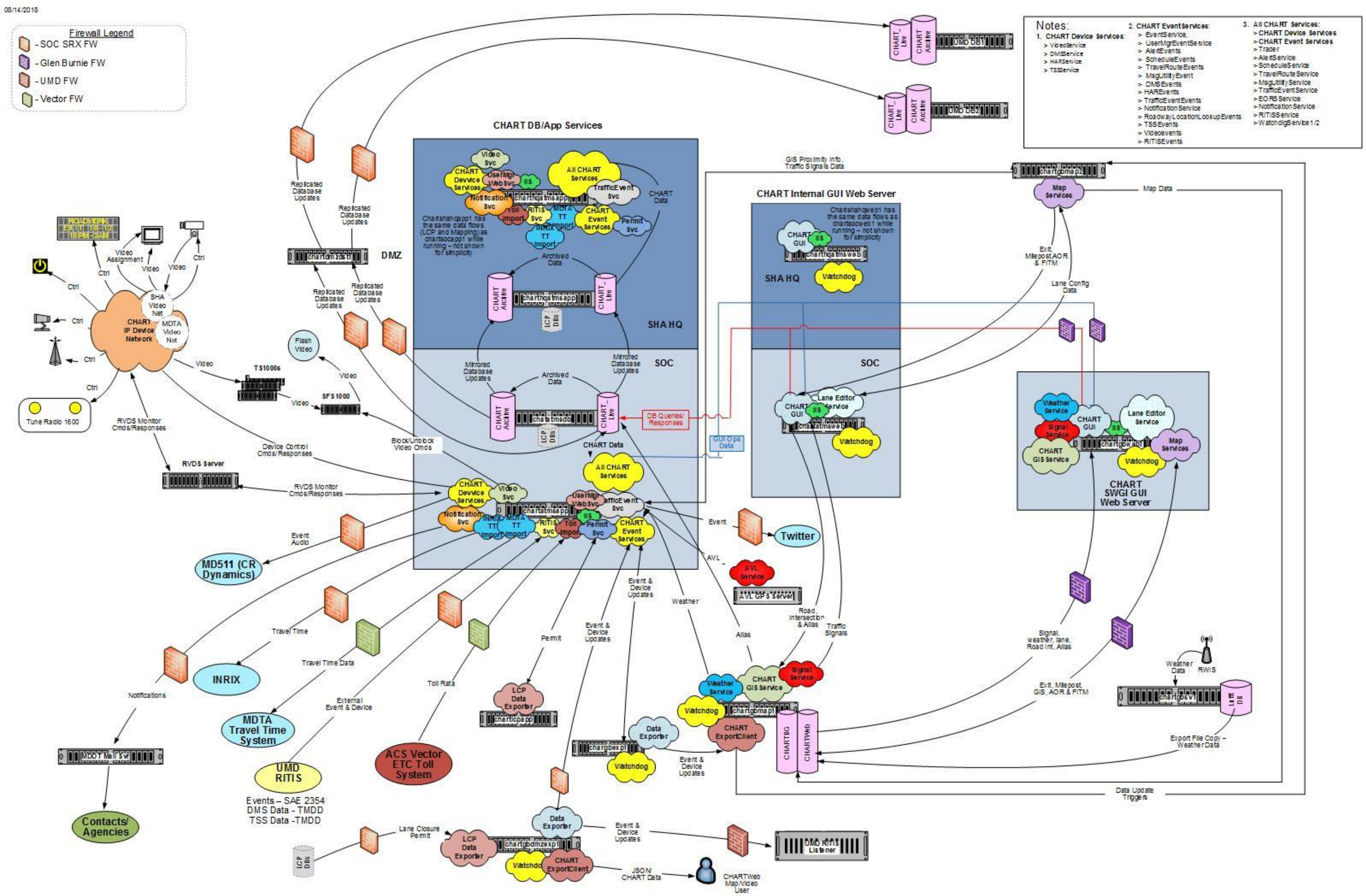

Figure 6-2. CHART ATMS Detailed Data Flow

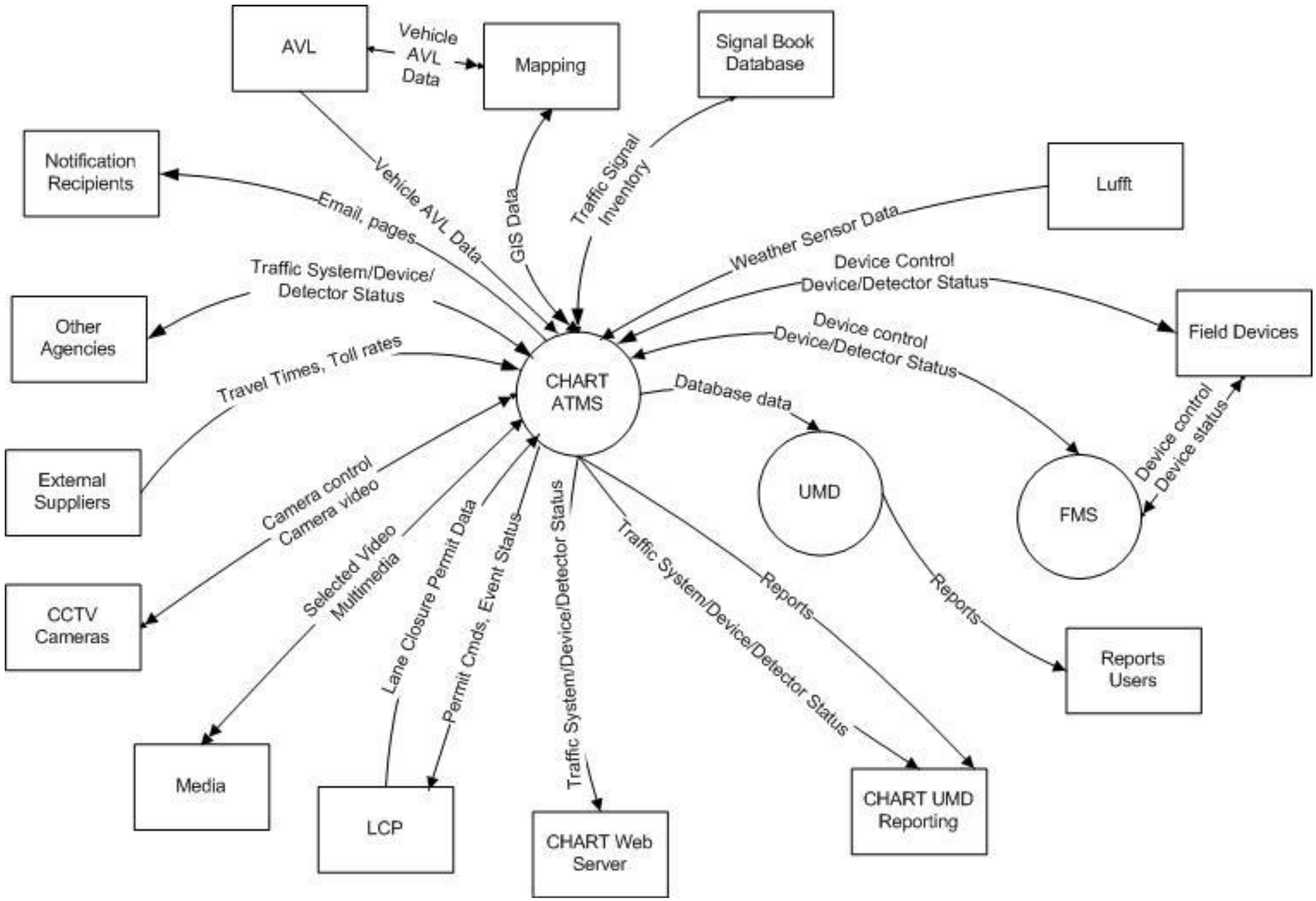

Figure 6-3. CHART ATMS System High Level Data Flow

6.3 Database

This section describes the CHART ATMS operational database design, at a high level. The design is based on the CHART Business Area Architecture and the CHART System requirements. The database design consists of these major areas:

- System/Configuration Management
- User Management
- Device Configuration
- Device Status
- Audio Data
- Device Support
- Traffic Event Management
- Traffic Event Response Planning
- Decision Support
- Data Import
- Log Data
- Alert Management
- Contact Management
- Notification Management
- Schedule Management
- Travel Route Management
- TSS detector Data Management

6.3.1 System/Configuration Management

The System/Configuration Management area encompasses system level data, including system profile settings, user profile settings, operations centers, geographical area definitions, location aliases, organizations, camera regions, and standard lane configurations. This data is generally static, in the sense that it is updated by users, on a fairly infrequent basis (as opposed to dynamic data which is updated directly by system software on a steady recurring basis). Most of this data is not archived. Operations centers are archived nightly, and a history of changes to operations centers is maintained in the archive.

6.3.2 User Management

The user/system management area consists of the complete suite of information to tie together the users and external applications approved to log into and use the system, roles, and functional rights. This also included folder information, which aids operators by showing (by default) only devices and objects associated to their operations center. All this data is generally static. While users may be added or removed on a weekly basis, this data is input via CHART administrators, and is relatively infrequent. Roles and external applications change very rarely (generally only after a new release of the CHART ATMS is deployed). The data in this area is not archived.

6.3.3 Device Configuration

The DMS, HAR, SHAZAM, TSS, On/Off device, Camera, Monitor, and other CCTV video entities include data that define the configuration of the devices themselves. This includes device names, locations, organization, communications configuration data, etc. This area also includes the configuration of static video tours, which can be displayed on monitors in place of a solitary camera. Device configuration data is generally static. While this data is changeable to reflect configuration changes in the fielded equipment and the addition of new devices, these changes occur infrequently.

For the most part, the data in this area is not archived. Device names and IDs are archived (in one conglomerated device table), but the numerous configuration items for each device are not archived. The only exception is anything to do with displaying travel routes on DMSs, for the purposes of reviewing why a travel route message was not displayed on a particular DMS at a particular time, is archived for 90 days (then discarded from the archive).

6.3.4 Device Status

The DMS, HAR, SHAZAM, TSS, On/Off device, Camera, and Monitor entities include data that define the status or state of the devices. This data is fairly dynamic. Some status information (e.g. last poll time, last polled detector speed data) changes very frequently, on a regular, time-driven basis. Other status information (e.g., the message on a DMS) changes less frequently (although even travel time data is updated on a machine-driven, regular cycle).

The data in this area is not archived. The only exception is any status information which could help review why a travel route message was not displayed (or what travel route message was displayed) on a particular DMS at a particular time is archived for 90 days (then discarded from the archive). Note that the operations log, from which some status information can be gleaned (what messages were displayed on DMSs, device communications mode changes) is archived, however.

6.3.5 Audio Data

There are several tables within the system responsible for maintaining recorded audio data. This data is used by HARs, traffic events, and message libraries. This data is relatively static. Most HAR messages created on the fly are created as text messages rather than recorded audio, and, in any case, this data can be generated only as fast as an operator can talk, and only as traffic conditions warrant HAR message changes. This data is not archived.

6.3.6 Device Support

This area consists of "Arbitration Queues" which are maintained by devices (and generally written by traffic event and travel route entities) to store messages, potentially multiple prioritized messages which must undergo an arbitration process which determines which message(s) go on a field device at a given time. This area also includes dictionaries, which prevent banned words from going to devices, helping operators to use standard, and correct, words on devices, and to help the CHART Text to Speech entities pronounce words and numbers correctly. Dictionary and pronunciation data is quite static. Arbitration queue data update frequency varies – messages generated by operators occur only as fast as events occur and operators queue up messages for DMSs, HARs, and On/Off devices, but messages generated by travel times can change up to every two minutes, for several dozen signs. The data in this area is not archived.

6.3.7 Traffic Event Management

Traffic Event Management data is the primary data which CHART is designed to produce. This area includes all data associated with traffic events, including basic event details, location, queue length, response plan data, participation, etc. This area also includes the traffic event history, queue length history, a record of all system, device, and user generated log entries pertaining to the creation, management, and cleanup of the event, and the Communications Log, a record of telephone/radio voice communications between CHART operators and other people, such as participants at or potentially targeted to travel to specific roadside events, police, CHART units, etc.

The Event History Log and Communications Log are the two types of log data that do not fall under the Log Data area discussed further on in this section, as the Event History Log and Communications Log hold the primary mission data (or data directly ancillary to the primary mission data) which the CHART ATMS is designed to manage and produce. All other logs are concerned more with the operation and maintenance of the system rather than being a part of the primary data output of the system.

This area also includes weather data, gathered from weather devices near a newly created traffic event; participant/AVL data, from managed locations of participants and the associations of participants with locations; and signal data, which can be associated with action events pertaining to traffic signal problems. All this data (and the event history as much as any of it) is moderately dynamic. Weather data, participant/location data, and signal data does not add much to the dynamic nature of this data, as weather data is collected only when a new traffic event is created, participant/location data is not stored unless a participant is associated with a specific CHART event, and signal data is generally associated to an event only as an event is created. Traffic signal data is also stored at its source in a database which is outside of the CHART ATMS. The CHART ATMS team wrote a Signals Web Service which reads the source database and provides the data to the CHART ATMS (Traffic Event Service).

This area also includes Pending Traffic Events. Although Pending Events might more logically be thought of as "Traffic Event Response Planning", the tables used to store Pending Events are in fact the same tables used within this area to store live traffic events. The tables in this area generally grow continuously. Records in these tables are generally inserted, occasionally updated, and infrequently deleted.

Traffic Event data is archived indefinitely, as one of the primary historical outputs of the CHART ATMS. Archive jobs periodically remove older records, and move them to the archive database. This includes external events imported from RITIS. Although external events share the same tables as CHART events within the operational database, within the archive database external events are stored in a separate set of tables from CHART events. Traffic Event data is not archived and removed from the operational database until some number of hours after the events have been closed, to allow operators to review and update traffic events in the system after they have been closed.

6.3.8 Traffic Event Response Planning

The CHART ATMS includes libraries and plans to use in support of traffic event management. Libraries are pre-canned DMS and HAR messages which are created in advance to aid operators in managing the response plans of traffic events when the planned-for situations actually occur. Operators do not use library messages directly, but use "plans" which pre-associate the generic library messages with specific local DMSs, HARs, and On/Off devices in the vicinity where the preconceived situations are expected to occur. This data is considered to be fairly static, although libraries and plans are easily updated. Plans and libraries are generally created and updated only by administrators and senior operators. The data in this area is not archived.

6.3.9 Decision Support

The CHART ATMS includes Decision Support components which help operators by proposing DMSs, HARs, and Cameras recommended to be used for a given traffic event, and by proposing messages to be put on the DMSs and HARs, all based on the type, details, and location of the traffic event, and the locations of the proposed devices. This area includes the data which provides the table-driven "intelligence" for the decision support function. This data is fairly static. When new decision support functionality is released, some activity is required to update the decision support tables, but these updates occur only as fast as the CHART ATMS administrators create them. The data in this area is not archived.

6.3.10 Data Import

This area includes some of the data the CHART ATMS collects from various external entities, including RITIS, INRIX, and Vector. The data imported from RITIS is stored in the Traffic Event Management area or the Device Configuration and Device Status areas, but the data used to manage the import process is stored within this area. This includes support data used to determine which data is to be imported and what to do with it when it is imported. (Travel time data collected from INRIX and toll rate data collected from Vector is stored within the Travel Routes area, and data collected from AVL and Weather services are stored within the Traffic Event Management area.) Data used to manage the RITIS interface and what is imported is quite static – it is rarely changed. The data in this area is not archived.

6.3.11 Log Data

The events entity includes all ongoing log data not related to traffic events. None of the logs within this area are accessible within the CHART ATMS. These records are written for only offline analysis. This includes, most significantly, the Operations Log, the historical log of everything significant that happens within the CHART ATMS. It can be used for troubleshooting purposes or for reporting purposes. This also includes the Communications Failure Log, a record of failed communications to field devices, logs regarding the management of temporary video tours on auto-mode monitors in the context of traffic events, logs related to the display of travel times and toll rates on DMSs (or why they were not displayed). This data is fairly dynamic, and is continuously growing. Records in these tables are inserted only, never updated or deleted.

The data in this area is archived. Nightly archive jobs remove older records, and move them to the archive database as necessary. Since these logs are not needed by the system, these logs are completely cleared out every night when the archive jobs run.

6.3.12 Alert Management

The alerts entity includes all informational data related to alerts. Alerts are dynamic data. Most alerts are created by the system automatically, although manually generated generic alerts are also supported. Alerts within the system are generally well controlled and efficiently managed, so there is generally not a large volume of alert data created. Alert data is generally continuously growing. The data in this area is archived nightly.

6.3.13 Contact Management

The Contact Management area includes all data related to contacts. Contacts include both ATMS notification contacts (those eligible to receive ATMS notifications) and non-notification contacts. Contact Management also includes all data related to call out lists. Contacts are dynamic data, although contacts do not change extremely frequently. The data in this area is not archived.

6.3.14 Notification Management

The Notification Management area includes all data related notifications (the notification message itself) and notification groups. Notifications are texts or emails that are sent out via an SHA SMTP server. There are two primary types of notifications: those sent by operators (generally, though not exclusively within the context of a specific traffic event), and those sent by the system to alert personnel who may not be logged into or monitoring the system of a problem within the system that the system has detected. Notifications are dynamic data, although notifications are not sent out extremely frequently. Data concerning notifications is generally continuously growing.

The data in this area is archived. Nightly archive jobs archive off notifications which are sufficiently old, and whose associated traffic event (if any) is also closed and sufficiently old enough to be archived.

6.3.15 Schedule Management

The Schedule Management area includes all data related to schedules. Schedules can be used within the system to remind or notify operators of actions that may need to be taken within the system. Currently, such actions consist of only one type of action: opening a pending traffic event as a live traffic event. (The pending events themselves are stored within the Traffic Event Management area.) Schedules are dynamic data, but of very low volume due to their limited use within the system. Users add schedules to the system and delete them when they are done. Schedules have minimal dynamic associated status or history data. The data in this area is not archived.

6.3.16 Travel Route Management

The travel routes area includes all data related to travel routes, used to provide travel time and/or toll rate data for use in traveler information messages. Administrators add travel routes to the system in preparation for displaying travel times or toll rates on DMSs. Travel time data collected from INRIX and MDTA, and toll rate data collected from Vector, is also stored within this area. Although the configurations of the travel routes themselves are fairly static, in general this area is very dynamic. Some of the tables in this area are continuously growing. Records in such tables are inserted only, never updated or deleted. Toll rate data and especially travel time data is quite voluminous. Toll rate data is updated for approximately 30 toll routes every 10 minutes. Travel time data is updated every 2 minutes, for approximately 1000 roadway links currently used in CHART travel routes, and for approximately 7400 roadway links which may be needed at any time for queue length calculations.

The data in this area is archived multiple times per day. Archive jobs periodically remove older records, and move them to the archive database as necessary. Although all other archive jobs run nightly, archive jobs for this area run every 4 hours, due to the volume of data. This data is archived for 90 days, and then discarded, due to its volume.

6.3.17 Trigger Management

The trigger management area includes all data related to triggers, which activate and deactivate based on one or more trigger conditions. Triggers are used by DMS, HAR, and On/Off devices to automatically display a message (or in the case of an on/off device, automatically activate) when certain conditions are present, as defined in a trigger. An example is a trigger that contains a trigger condition for a pavement sensor. The trigger can activate when the pavement is at or below a specified temperature, and in turn the devices that utilize the trigger can automatically display a message or activate. Trigger management data is generally static. While this data is changeable and new triggers can be added to the system, these changes occur infrequently. The data in this area is not archived.

6.3.18 TSS Detector Data Management

The CHART ATMS polls its detectors (approximated 200 of them) every five minutes. This data is stored in the CHART ATMS database and archived off nightly. Most detectors collect data on a per-lane basis, so speed, volume, and occupancy are collected for every lane for 200 detectors every five minutes. This data is archived indefinitely.

7 DEPLOYMENT VIEW

7.1 View Description and Typical Stakeholders

The deployment view describes the physical locations of servers and services. This view is useful for Operations and Maintenance personnel to identify relationships within and between servers. Network engineers may be particularly interested when identifying which protocols are expected between any pair of servers in the system.

7.2 Deployment Configurations

The nominal CHART ATMS software service configuration is shown in the table below. Under normal conditions the primary server executes all CHART ATMS software subsystems. In a fail-over situation, the failover virtual environment supports all CHART ATMS software subsystems. The required COTS packages to support CHART ATMS are also installed on each server per the CHART ATMS Operations and Maintenance Guide.

Table 7-1. CHART ATMS Deployed Services and Modules Per Site

Site	Server	Purpose	Service Name (Modules)
GB-DC	chartgbapp1	Alert Management	AlertService (AlertModule)
		DMS Control	DMSService (DMSControlModule)
		LCP Interface	PermitService (PermitModule)
		Geographical Information Service	RoadwayLocationLookupService (GeoAreaModule)
		HAR Control, HAR Notification	HARService (HARControlModule, SHAZAMControlModule)
		On/Off Device Control	OnOffDeviceService (OnOffDeviceControlModule)
		INRIX Import Management	INRIXImportService (INRIXDataImportModule)
		MDTA Travel Time Import Management	MDTATravelTimeImportService (INRIXDataImportModule)
		Notification Management	NotificationService (NotificationModule)
		RITIS Import Management	RITISService (EventImportModule, DMSImportModule, TSSImportModule)
		Schedule and Trigger Management	ScheduleService (ScheduleModule, TriggerModule)
		System Monitor	(2) WatchdogService (WatchdogModule)
		Toll Rate Import Management	Toll Rate Import Service under Apache Tomcat
		Traffic Event Management	TrafficEventService (TrafficEventModule, CommLogModule)
		Traffic Sensor System Management	TSSService (TSSManagementModule)
		Traveler Information Management	TravelRouteService (TravelRouteModule)

Site	Server	Purpose	Service Name (Modules)
		User Management	UserManagerService (UserManagementModule, ResourcesModule)
		User Management Web Service	UserManagerWebService under Tomcat (WSUserManagerModule)
		Utilities	MsgUtilityService (DictionaryModule, AudioClipModule, TTSControlModule, MessageLibraryModule, PlanModule, MessageTemplateModule)
		Video Management	VideoService (CommandProcessorModule, CameraControlModule, MonitorControlModule, VideoFabricModule)
		CORBA Object Request Broker	TradingService, EventService, AlertEventService, DMSEventService, HAREventService, MsgUtilityEventService, NotificationEventService, RITISEventService, RoadwayLocationLookupEventService, ScheduleEventService, TravelRouteEventService, TrafficEventEventService, TSSEventService, UserManagerEventService, VideoEventService
	chartgbweb2	CHART User Interface	chartlite under Apache Tomcat
		Lane Configuration	LaneEditorService under Apache Tomcat
		System Monitor	(2) WatchdogService (WatchdogModule)
	chartgbmap1	Weather Import Management	WeatherService under Apache Tomcat
		Intranet Map and CHARTWeb Data Collection	CHARTExportClientService under Apache Tomcat
		CHART ATMS GUI Alias and Roadway Location/Intersection Lookup	GISService under Apache Tomcat
		Signal Service	SignalService under Apache Tomcat
		System Monitor	(2) WatchdogService (WatchdogModule)
		<failover only> CHART Mapping GIS Service (lane config, milepost & exit lookup, AOR support)*	IIS(MapGISService/MapGISService.aspx) *

Site	Server	Purpose	Service Name (Modules)
		<failover only> CHART ATMS Map Tiles Service (background tiles and map layers for exit and milepost tiles) *	ArcGIS(CHARTBG_Cache, CHART_Exits_Mileposts_Cache) *
	chartgbmap2	CHART Mapping GIS Service (lane config, milepost & exit lookup, AOR support)	IIS(MapGISService/MapGISService.aspx)
		CHART ATMS Map Tile Service (background tiles and map layers for exit and milepost tiles)	ArcGIS(CHARTBG_Cache, CHART_Exits_Mileposts_Cache)
		<failover only> Weather Import Management *	WeatherService under Apache Tomcat *
		<failover only> Intranet Map and CHARTWeb Data Collection *	CHARTExportClientService under Apache Tomcat *
		<failover only> CHART ATMS GUI Alias and Roadway Location/Intersection Lookup *	GISService under Apache Tomcat *
		<failover only> System Monitor *	(2) WatchdogService (WatchdogModule) *
	chartgbexp1	Internal Export (within MDOT)	DataExportService
		System Monitor	(2) WatchdogService (WatchdogModule)
	Chartgbdmzexp 1	External Export (out of MDOT)	DataExportService CHARTExportClientService
		System Monitor	(2) WatchdogService (WatchdogModule)
		System Monitor	(2) WatchdogService (WatchdogModule)
		System Monitor	(2) WatchdogService (WatchdogModule)
	RVDS Server	Display streaming flash content on RVDS monitors	RVDS Service
Glen Burnie - TSO	chartgbweb1	CHART User Interface	chartlite under Apache Tomcat
		Lane Configuration	LaneEditorService under Apache Tomcat
		System Monitor	(2) WatchdogService (WatchdogModule)
		CHART ATMS Map Tile Service (background tiles and map layers for exit and milepost tiles)	ArcGIS(CHARTBG_Cache, CHART_Exits_Mileposts_Cache)
		CHART Mapping GIS Service (lane config, milepost & exit lookup, AOR support)	IIS(MapGISService/MapGISService.aspx)
		Signal Service	SignalService under Apache Tomcat
		Weather Import Management	WeatherService under Apache Tomcat

Site	Server	Purpose	Service Name (Modules)
		CHART ATMS GUI Alias and Roadway Location/Intersection Lookup	GISService under Apache Tomcat
Baltimore SHA HQ	charthqes	CHART-ES User Interface	CHART GUI
		DMS Control *	DMSService(DMSControlModule) *
		On/Off Device Control *	OnOffDeviceService(OnOffDeviceControlModule) *
		Notification Management *	NotificationService (NotificationModule) *
		Toll Rate Interface	Toll Rate Import Service
		Traveler Information Management *	TravelRouteService (TravelRouteModule) *
		User Manager	UserMgrService (UserManagementModule, ResourcesModule)
		Utilities	MsgUtilityService (DictionaryModule, MessageTemplateModule) *
		Video Management *	VideoService (CommandProcessorModule, CameraControlModule, MonitorControlModule, VideoSwitchControlModule) *
		CORBA Object Request Broker Services	TradingService, DMSEventService *, TravelRouteEventService *, NotificationEventService *, MsgUtilityEventService *, VideoEventService *, OnOffDeviceEventService *, EventService
Baltimore SHA HQ	Chartshahqapp2	<failover only> * (See –GB-DC chartgbapp1 for details.)	* (See GB-DC chartgbapp1 for details.)
	Chartshahqweb2	<failover only> *(See –GB-DC chartgbweb1 for details.)	* (See –GB-DC chartgbweb1 for details.)
* Note: Items marked with a * are not normally executed (only during failover/emergency situations).			

7.3 Deployment Diagram

Figure 7-1 shows the CHART ATMS Application Server Deployment, depicting the physical allocation of services to servers. The arrows are annotated with the network transport used to communicate between services pointing from the initiator of the connection to the target of the connection – not necessarily the direction of data flow. The focus here is on the CHART ATMS Application Server, however, external servers and services are included for clarity. Generally, any server that communicates through a firewall is external to the CHART network. Figure 7-2 shows the CHART GUI Server Deployment.

7.4 Network Diagram

Figure 7-3 shows the network diagram for the CHART ATMS. Training Systems are not shown, due to space considerations.

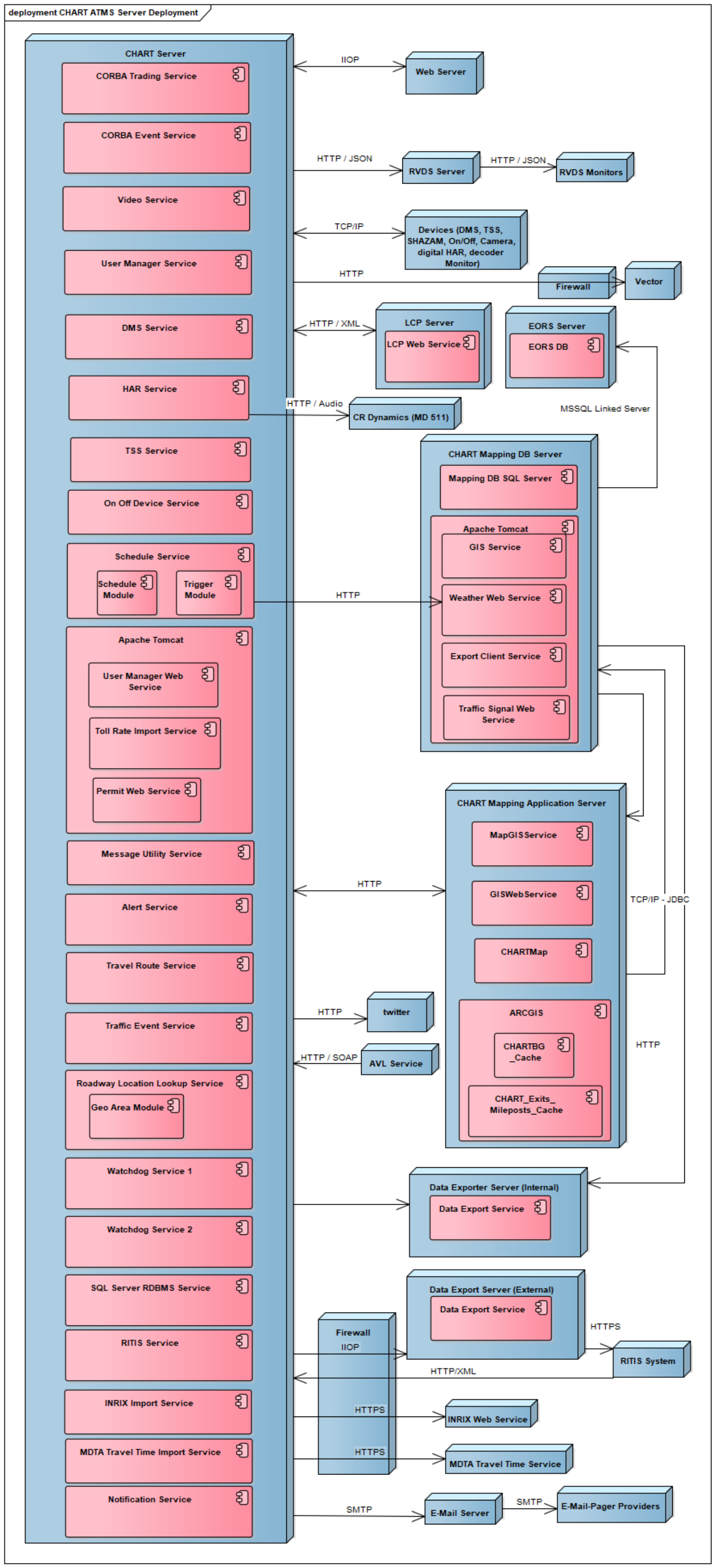

Figure 7-1. CHART ATMS Application Server Deployment

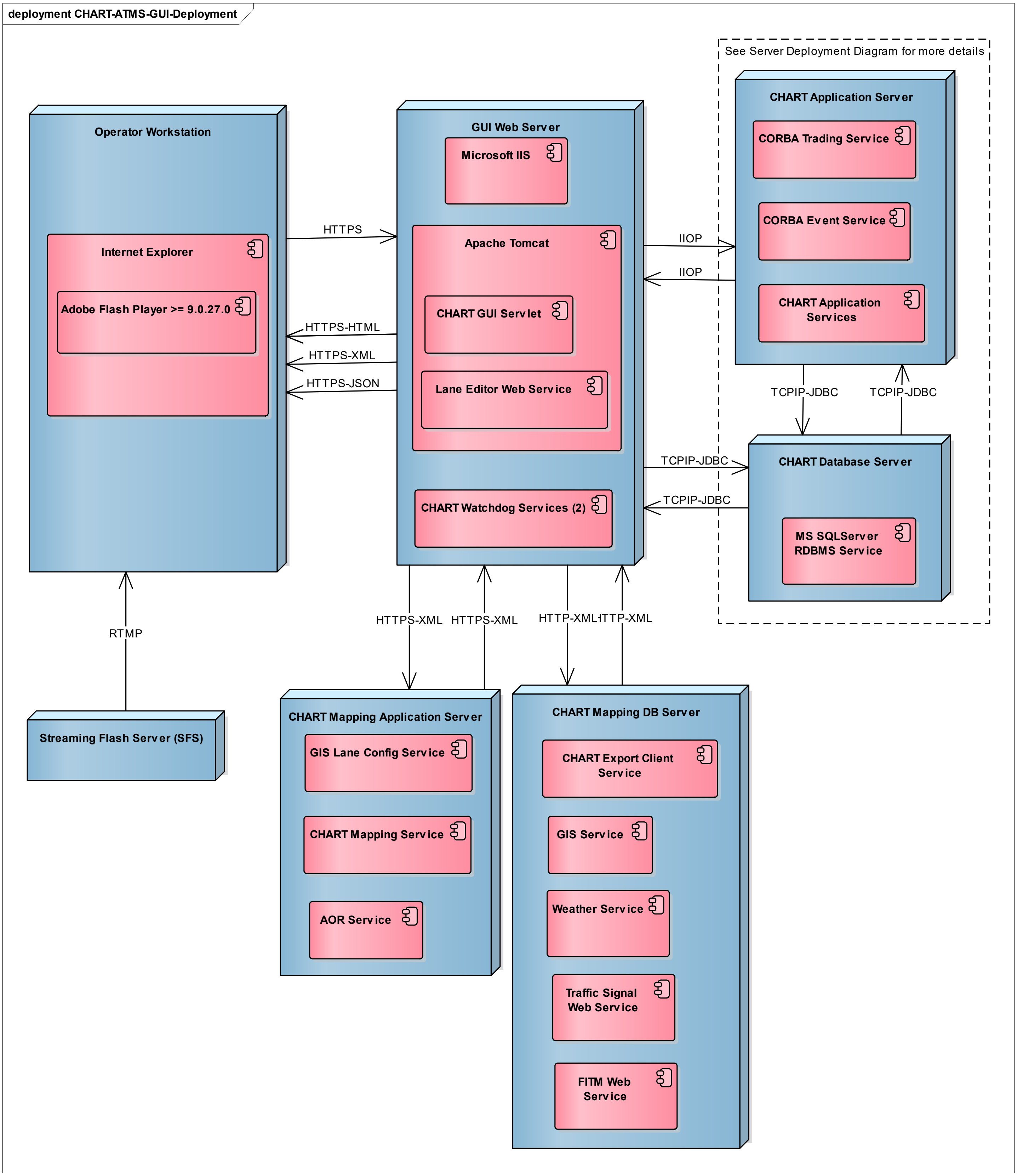

Figure 7-2. CHART ATMS GUI Server Deployment

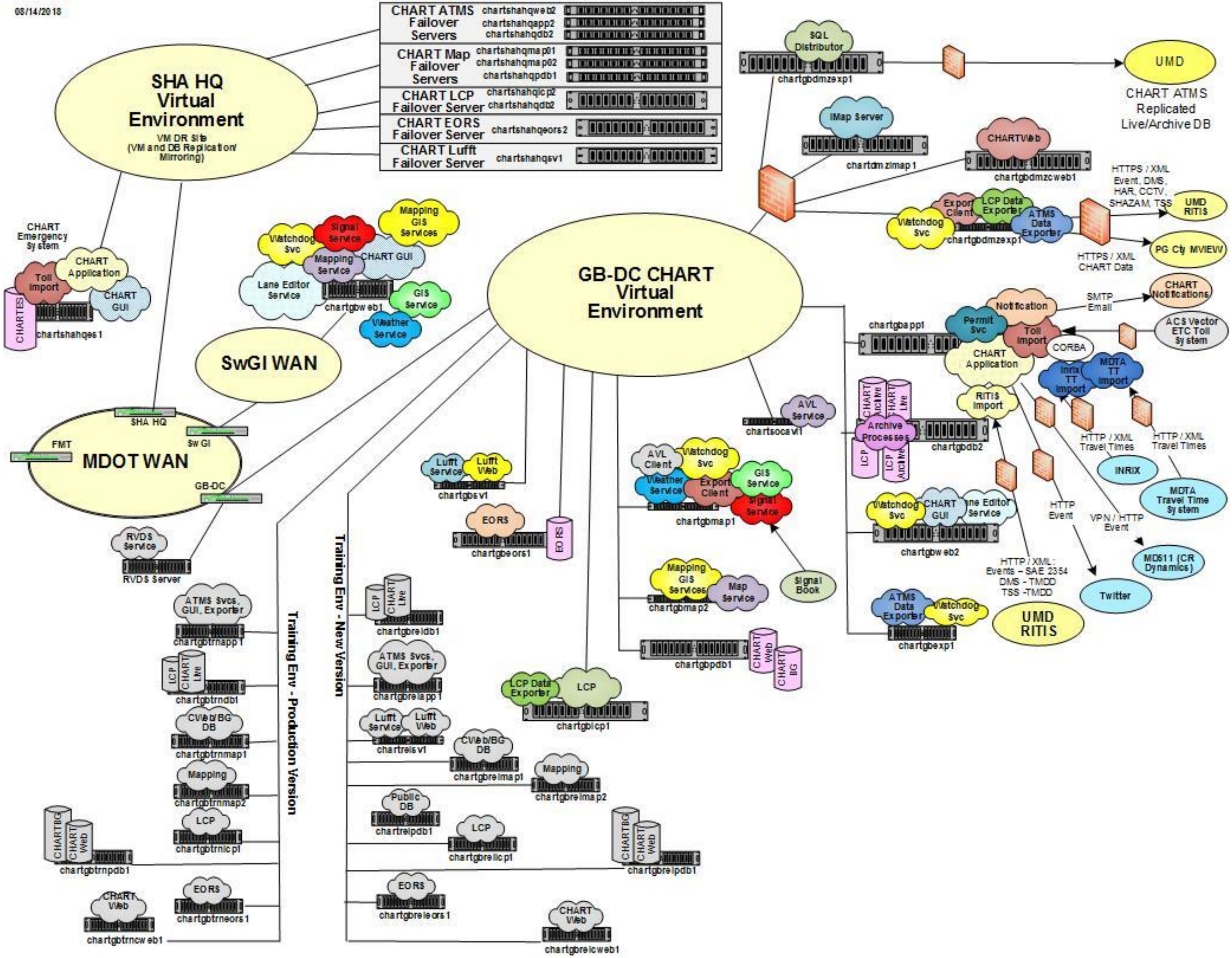

Figure 7-3. CHART Server Deployment

7.5 Facilities

This section presents the recommended deployment of hardware at each facility.

7.5.1 Node Sites

CHART ATMS application and GUI web servers are primarily located at the MDOT Glen Burnie Data Center (GB-DC). The GB-DC houses the CHART ATMS virtual environment and is the central site for the coordination of CHART ATMS activities. The list below describes the equipment to be deployed at each site. Training Systems are not shown.

1. MDOT Glen Burnie Data Center (GB-DC) –
   - Virtualized CHART ATMS application system
   - Virtualized CHART ATMS GUI Web Server
   - Virtualized SQL Server Database Servers (2)
     - SQL Server Engine
     - SQL Server Distributor
   - Virtualized CHART ATMS Mapping Server
   - Virtualized CHART ATMS Mapping Database Server
   - Data Exporter Servers (one internal to MDOT, one external)
2. Glen Burnie SWGI
   - One CHART ATMS GUI / Mapping Web Server
3. SHA Headquarters
   - CHART ATMS Emergency System (CHART ES)
   - Virtualized CHART ATMS application system
   - Virtualized CHART ATMS GUI Web Server
   - Virtualized SQL Server Engine Database Server

7.5.2 Traffic Operations Centers

Each TOC, including the Statewide Operations center (SOC) has the capability to run the CHART ATMS GUI on its workstations. The number and configuration of the workstations is determined on a case by case basis depending upon the activity level at the TOC and the available space.

7.5.3 Other CHART ATMS Client sites

The implementation of the SWGI has allowed CHART ATMS Applications to run on agency owned computers on networks that are connected together and protected by firewalls. Previously CHART ATMS would have to extend the MDOT Network to agencies that wanted to use CHART applications and provide workstations. Gradually CHART partners have been converting to SWGI and CHART has been removing workstations. The level of access to CHART ATMS applications and functionality are determined on a case by case basis depending upon the user's needs at the site.

7.5.4 Equipment and Vehicle AVL Installation

In addition to CHART interest in AVL, other SHA offices have deployed AVL equipped 1vehicles (e.g. dump trucks, state and contractor operated snowplows). The actual number of AVL installations has reached several hundred.

7.6 System Management and Support

This section discusses CHART system management activities and support provided for system monitoring and problem tracking.

7.6.1 Data Backup and Recovery

vRanger is used to create snapshots of the virtual machines then copies them to the failover site (Baltimore SHA HQ). The procedures responsible for performing the backups run automatically and require only periodic checks from CHART personnel to verify correct operation.

The system architecture and design minimizes the likelihood of having to recover an entire disk volume. The use of RAID 1 and RAID 5 arrays means that the system can perform self-recovery in most instances. A more likely scenario would be the recovery of data due to corruption of some type. By taking periodic snapshots of the mission critical data and maintaining the Virtual Machine (VM) snapshots for a reasonable period of time a corrupted file could be restored to its last uncorrupted state.

7.6.2 System Monitoring

There are several levels of monitoring routinely performed on the CHART ATMS. The CHART ATMS Monitor (Watchdog) subsystem monitors CHART ATMS services for availability and performs automatic restart attempts for non-responsive services. The System Monitor (as configured) generates Alerts and Notifications when an automatic restart has been completed or when an automatic restart fails to correct a non-responsive service. Transportation Business Unit (TBU) personnel monitor CHART Mapping server performance using Veeam ONE.

7.6.3 Performance Monitoring

Device failure status information is logged and can be reported on to provide device communications performance measures. Additional system level and network performance data are gathered by the Network Operations Center (NOC). CHART ATMS operational performance measures such as traffic event response time, incident cleared, etc are reported from the CHART ATMS Reporting Tool maintained by the UMD CATT Lab.

7.6.4 Problem Identification and Tracking

The CHART project uses the problem tracking tool JIRA to support CHART system problem reporting and tracking. Problems discovered prior to delivery of a release to operations are handled as described in “CHART Project Standards and Procedures, Configuration Change Request, Revision 0.2, 02/12/2012”. Problems discovered in production are handled as described in the same document. Although the CHART Program has switched issue tracking systems, from IBM/Rational ClearQuest to MantisBT to JIRA, the essence of the workflow described in this document is generally unchanged.

Problems discovered by operations personnel are logged by TBU or NOC personnel in the NOC's Maximo system. Problems determined to be CHART Mapping software problems are documented in JIRA for tracking and resolution.

8 SUBSYSTEM VIEW

8.1 View Description and Typical Stakeholders

The Subsystem View describes the subsystems of the CHART ATMS, their purpose, and how they are used. It describes all the COTS used in the system, and the source, version, usage, and redistributability of all the COTS. This view will be of primary use to developers, configuration managers, and management of CHART.

8.2 Software Subsystems

Table 8-1 lists each software and hardware Configuration Item (CI) and the subsystems comprising the CI. The sections that follow provide functional descriptions for each CI.

The CHART ATMS is dependent upon network services provided through the MDOT backbone network. The management and control of the network is outside the scope of this document.

Table 8-1. CHART ATMS Configuration Items and Subsystems

CI Name	Subsystems
Core Services	Alert Management Audio Management AVL Management Communications Log Management Contact Management Data Export Management Data Import Management Decision Support Device Management Dictionary Management DMS Control HAR Control HAR Notification Message Library Management Message Template Management Notification Management On/Off Device Control Permit Management Plan Management Resource Management Schedule Management Signals Management Simulation (future) System Monitor (Watchdog) Traffic Event Management Traffic Sensor System Management Traveler Information Management Trigger Management User Management Utility Video Management Weather Station Management
GUI Services	GUI Management Map Management
FMS Services	Port Manager Port Configuration Utility
Database Instance	Operational DB
Database Archive	Archive DB

CI Name	Subsystems
	Mirroring Query Report Generation (UMD) Replication
COTS	Angular Java Script Library Apache ActiveMQ Apache Ant Apache Commons Apache Log4j Apache Tomcat Apache XML-RPC CLOC (Count Lines of Code) Core Tec Decoder Control Datatables Java Script Library Dialogic API Eclipse GIF89 Encoder GNU Bison GNU Flex iText Jackson JacORB Event Service JacORB ORB JacORB Trader Java SDK Java Runtime Environment (JRE) JavaHelp JavaMail JavaService JAXB Jaxen JDOM JIRA joeSNMP JQuery Java Script Library JQuery-UI Java Script Library JSON-simple Java Topology Suite (JTS) Microsoft SQL Server Microsoft SQL Server JDBC Driver

CI Name	Subsystems
	Microsoft Visual C++ (legacy C++ compiler)
	Microsoft Visual Studio 2012 Ultimate (current C++ compiler)
	Microsoft Windows
	NeoSpeech Text To Speech Engine
	NullSoft Scriptable Install System (NSIS)
	OpenLayers
	O"Reilly Servlet
	Prototype JavaScript Library
	RedGate DBA Bundle
	Robohelp
	SAXPath
	Sparx Enterprise Architect
	Subversion
	Subversion browser TortoiseSVN
	Tritonus
	Turnkey-RVDS
	Velocity Template Engine
	VideoJS JavaScript library
	vRanger Backup & Replication
	Wordpress
	XML Spy

8.2.1 Core Services Subsystems

The software subsystems comprising the Core Services CI are briefly described below. The detailed descriptions of the business processes that are to be implemented in each subsystem are presented in Table 10-1 of this document. (See Section 4.3 of the BAA for descriptions of all the business processes and sub-processes.)

8.2.1.1 Alert Management

This subsystem provides alert management and processing functions. It provides the methods to support the creation and delivery of alerts and maintains the status of alerts in the system. Alerts may be automatically created by applications or manually created by users. Alerts, if enabled, are directed to an operations center where acknowledgement by a user is required.

Some example CHART ATMS alerts are listed below.

- Device Failure – used to alert centers of device failures (hardware or comms failures)
- Event Still Open – used to alert centers of events that have been left open past a reminder time
- Duplicate Event – used to alert centers that there are multiple open events at the same location

- Travel Time – used to alert centers that a travel time has exceeded a configurable threshold
- Toll Rate – used to alert centers that there is a problem with the Toll Rate interface
- External Interface – used to alert centers that there is a problem with one of the CHART ATMS external interfaces
- External Event – used to alert the centers that there is an external event of particular interest
- Execute Scheduled Actions – alerts operators that it is time to open a scheduled event
- Event Opened and Activated / Deactivated and Closed - alerts operators when a schedule has been used to automatically open and activate an event or when the system has automatically deactivated and closed such an event
- Unhandled Resource – used to alert centers that there are unhandled resources such as open traffic events or devices in maintenance mode that are controlled by center that has no logged in users
- Service – alerts operators that the watchdog has detected a service non-responsive, or restarted a service
- Manual Alert – operators can send alerts manually by typing a message and providing a list of centers to which to deliver the alert
- Transfer of Responsibility (future) – provides an alert to the receiving center of a transfer of responsibility to that center (e.g. transfer of responsibility for an open event)
- Incident from Detector (future)– alerts a center that detector data indicates a possible incident
- Mayday from AVL (future)– generated when an AVL equipped vehicle sends a Mayday message
- Weather Sensor (future) – generated when a weather sensor reports data outside of a set range (e.g. temperature below freezing)

Alerts that require a response within a specified time period can be configured to escalate up a configurable operations center hierarchy if not acknowledged within a configurable time period.

The client side of alert management provides the user with the capability to manually generate an alert and to respond to alerts they receive.

8.2.1.2 Audio Management

This subsystem provides distributed access to a text-to-speech engine that is utilized by the HAR subsystem for the conversion of text format messages into audible data that can be downloaded to the HAR device for broadcast. It also provides the ability to store and stream recorded audio data. Audio can be sent to users for listening purposes or to HARs to load messages onto the HARs.

8.2.1.3 AVL Management

AVL data from CHART and District vehicles is read by the CHART ATMS to support managing participation of AVL vehicles in traffic events. (AVL vehicle position and status data is also fed directly into the CHART Mapping Intranet map application for display.)

8.2.1.4 Communications Log Management

This subsystem provides a general logging mechanism for operators to record communications and activities in a central repository. All recorded communications are made available to all other operators in near real time through the user interface. The communications log also provides a filtered searching capability that allows an operator to select entries for viewing. Users may select entries to convert to a traffic event. These entries will become the base entries in the traffic event's history log.

8.2.1.5 Contact Management

This subsystem provides the ability to configure CHART contacts. Contacts include both ATMS notification recipients and non-notification contacts. Non-notification contacts can be standalone contacts, can be organized into call out lists, and may be participants in traffic events.

8.2.1.6 Data Export Management

The Data Export Management subsystem provides a mechanism to make CHART ATMS data available to external entities. This subsystem generates standards-based, XML-formatted data streams with pre-defined content. This data is provided via a secure HTTP interface using both an on-demand (pull) and subscription (push) model. CHART ATMS exports ATIS J2354-based Traffic Event data, and TMDD-based status and configuration data for TSS and DMS. CHART ATMS also exports CCTV, HAR, and SHAZAM configuration data.

8.2.1.7 Data Import Management

The Data Import Management subsystem provides a mechanism for CHART ATMS to ingest data from external entities. This data is currently made available by RITIS and includes Traffic event, DMS, and TSS data.

8.2.1.8 Decision Support

The Decision Support subsystem helps users manage traffic events by suggesting DMSs, HARs, and cameras which should be used by traffic events, and it also suggests messages which should go onto the DMSs and HARs. This subsystem also suggests which DMSs and HARs currently in use by the traffic event might no longer be needed – for instance, as lanes reopen.

8.2.1.9 Device Management

This subsystem handles the control of device state change functions (to online, offline, or maintenance mode) and the management of device arbitration queue entries.

8.2.1.10 Dictionary Management

This subsystem provides administrator managed collections of banned and known words. Banned words are those words that are not allowed to be displayed or broadcast on traveler information devices. Known words are used to provide spell checking and rudimentary substitution suggestions when unknown words are detected.

8.2.1.11 DMS Control

This subsystem provides DMS control capabilities. It supplies support for multiple device manufacturer protocols. In addition, this subsystem provides the business logic required for arbitration of a particular DMS between competing traffic events.

The following types of Dynamic Message Sign are supported:

- NTCIP (subset of version 2, specifically version 2.35)
- FP9500

8.2.1.12 HAR Control

This subsystem provides HAR control capabilities. It supplies support for manufacturer protocols used by SHA HAR devices. In addition, this subsystem provides the business logic required for arbitration of a particular HAR between competing traffic events.

The following types of Highway Advisory Radio are supported:

- Information Station Specialists (ISS) AP55
- Highway Information Systems (HIS) DR1500
    - Includes Highway Information Systems (HIS) DR1500 telephony protocol and DCC IP protocol
- MD511 ("HAR-like" telephone system modeled as a HAR)

8.2.1.13 HAR Notification

This subsystem provides management functions for the control of HAR notification devices such as SHAZAMs and DMS devices used as SHAZAMs.

The following types of SHAZAM are supported

- Viking RC2A remote on/off controller based SHAZAM
- HWG ER02a IP Relay controlled SHAZAM

8.2.1.14 Message Library Management

This subsystem provides message library management capabilities. It supports the creation of multiple message libraries for user-defined stored messages for use on DMS and HAR messages. (Unlike message templates, stored messages are pure text – there is no replaceable meta-data in library messages.) Each message in a library can be assigned a category for user classification purposes.

8.2.1.15 Message Template Management

The Message Template Management subsystem manages storage, editing, and use of templatized messages for DMSs and HARs, including for DMS toll rate messages, DMS travel time messages, and Decision Support templates for DMS and HAR usage with traffic events. Message templates include "placeholder" parameters to be replaced with actual data during execution of the template, for instance, for toll rate data, travel time data, and traffic event data (including location, and which lanes are closed, etc.).

8.2.1.16 Notification Management

This subsystem provides capabilities for managing the notification of personnel via text, page or email. (All messages go out via an SMTP email service, but most texting and paging services provide an email address which translates to a text or paging recipient.). This subsystem encompasses all relevant notification functionalities except the actual configuration of the contacts themselves. Configuration of contacts is handled within the Contact Management subsystem.

8.2.1.17 On/Off Device Control

This subsystem provides management functions for the control of On/Off devices.

The following models of On/Off devices are supported:

- HWG ER02a IP Relay controlled On/Off device
- HWG ER02b IP Relay controlled On/Off device

The following on/off device types are supported and pre-populated in the system:

- Fog Beacon
- Fog Horn

Other types of on/off devices may be defined by an administrator and CHART ATMS will support them as long as they are controlled by one of the supported IP relay models.

8.2.1.18 Permit Management

This subsystem provides an interface with the Lane Closure Permit (LCP) system. It provides ATMS permit data retreived from the LCP system, allows CHART ATMS users to perform actions on permits that exist in the LCP system, and notifies the LCP system of changes to traffic event status for traffic events associated with permits.

8.2.1.19 Plan Management

This subsystem provides the ability to associate library messages with devices (DMSs and HARs). Each item in a plan associates a stored message with one or more devices. These plans can be used to quickly construct traffic event response plans for traffic events that are recurring in nature or can be planned for ahead of time.

8.2.1.20 Resource Management

This subsystem provides for management of user login sessions and the control of shared resources. This subsystem also monitors the system for resources which should have a responsible owning center but do not.

8.2.1.21 Schedule Management

This subsystem supports the creation, management, and execution of lists of actions to be performed at predetermined times. Currently the only actions which can be scheduled is the "Open Event" action, which alerts the user when it is time to open a pending traffic event, or the "Open and Activate Event" action, which automatically opens a copy of a pending safety message event or special event, activates its response plan, and alerts the user.

8.2.1.22 Signals Management

This subsystem provides an interface to the signals database in order to obtain traffic signal inventory and location information from the Signal Book for use by the CHART ATMS. This includes a web service which runs on one of the CHART Mapping servers. The extent of the use of this data now is to associate one or more (malfunctioning) traffic signals with an action event, and to use a traffic signal location to assign the location of an action event. (The CHART ATMS operator has to know the signal is malfunctioning – the signals database does not provide this information.)

8.2.1.23 Simulation (future)

The Simulation subsystem is to be provided by the University of Maryland and integrates with the CHART ATMS.

8.2.1.24 System Monitor (Watchdog)

This subsystem provides system health monitoring processes that run on each CHART ATMS application server. Each service application is monitored to determine if it is currently available. Alerts and/or Notifications can be generated when services are found to be unavailable and self-recovery is attempted.

8.2.1.25 Traffic Event Management

This subsystem provides for the management and recording of information pertaining to traffic events that are currently being worked on by system operators. It also provides for the control of traveler information devices via a traffic event's response plan. The response plan is composed of system actions, including device control commands. When the plan is executed, the system actions are performed and any device control actions result in an entry being placed on the arbitration queue for the target device. Traffic Event Management also includes decision support capabilities for selecting appropriate traveler information devices and the messages that will be utilized by those devices. The decision support capabilities also include facilities for selecting CCTV cameras for display.

Each traffic event maintains a running history log of actions performed and user comments. Additionally, each traffic event maintains records of devices controlled, queue length history, resources notified and utilized, when resources arrived and departed the scene, and related events, among other historical data. This data can be used (outside of the CHART ATMS) for offline reporting and statistical analysis purposes through tools maintained externally by the University of Maryland.

The Traffic Event Management services also handles public outreach activities for selected events such as the posting of audio messages to the 511 phone number and the tweeting of event descriptions.

8.2.1.26 Traffic Sensor System Management

This subsystem provides control and data handling functions for traffic detector and speed measurement devices. Historical data summaries are compiled and archived. In the future, current traffic detector information may be compared with historical traffic detector information and alerts may be generated for conditions exceeding specified tolerances.

8.2.1.27 Traveler Information Management

This subsystem ingests traveler information, including travel time data and toll rate data, from external sources, assimilates it, and makes it available to the CHART ATMS for display in the CHART ATMS GUI and on DMS signs. Alerts can be configured for travel times above a certain threshold, toll rates missing, and loss of data feeds. This subsystem also computes queues for Traffic Events.

8.2.1.28 Trigger Management

This subsystem allows for triggers to be configured that activate and deactivate based on one or more trigger conditions contained within the trigger. For example, a trigger may contain a trigger condition for a pavement sensor's temperature reading and become active when the pavement temperature is below 32 degrees Fahrenheit.

8.2.1.29 User Management

This subsystem provides the capability to create and manage user profiles and access rights.

8.2.1.30 Utility

The Utility subsystem provides various utility functions for the CHART ATMS and collects processes that do not have a home elsewhere.

8.2.1.31 Video Management

This subsystem manages cameras and their configurations and status, and coordinates access to camera control functions. This subsystem also provides the ability for managing monitors, monitor configurations, and display of camera video on monitors and desktops. This subsystem also provides control access to video the public, including Internet users and media outlets.

8.2.1.32 Weather Station Management

This subsystem collects weather data from weather sensors along the roadways and provides the data to traffic events.

8.2.2 GUI Services Subsystems

The GUI Services CI provides the user interface for the CHART ATMS. The GUI Services CI, like the Core Services CI, communicates via CORBA to provide a highly available system. There are two GUIs which run within the CHART ATMS normally: one is used to provide access to the CHART ATMS to SWGI users; the other supports all other users. GUI Services communicate to Core Services via CORBA, and also connects to Web Services over HTTP/XML.

The software subsystems comprising the GUI Services CI are described below.

8.2.2.1 GUI Management

This subsystem provides the user interface for the CHART ATMS. It runs as an Apache Tomcat service. The GUI includes the Lane Editor Service, a service developed separately for use by other CHART applications such as LCP.

8.2.2.2 Map Management

This subsystem retrieves and displays the CHART ATMS map and provides management of the map, its layers and icons, and associated callouts and callout actions. This subsystem runs as part of the overall CHART ATMS GUI. It provides the home page map, object location maps, and the nearby devices map and response preview map that appear in Traffic Event Details Pages.

8.2.3 Database Instance Subsystems

There is only one software subsystem comprising the Database Instance CI. This subsystem is briefly described below.

8.2.3.1 Operational DB

This subsystem comprises the live Microsoft SQL Server database used by the CHART ATMS, which is named “CHART_Live”. The live database stores and manages access to all data used by the live Core Services and GUI Services CIs, including configuration data, status data, collected statistical data, log data, traffic event data, etc. The CHART_Live database is mirrored to SHA Headquarters backup site for redundancy purposes, and is replicated to University of Maryland for reporting and statistical analysis purposes. This database is also copied (with modifications) to CHART-ES and the Current Training system.

8.2.4 Database Archive Subsystems

The software subsystems comprising the Database Archive CI are briefly described below.

8.2.4.1 Archive DB

This subsystem comprises the archive SQL Server database used to archive selected data from the CHART_Live database, and the scripts which actually perform the archiving. The archive database is named “CHART_Archive”. The CHART_Archive database includes all data which has been deemed to be of historical significance. The CHART_Archive database is mirrored to the SHA Headquarters backup site for redundancy purposes by the Mirroring subsystem, and is replicated to University of Maryland for reporting and statistical analysis purposes by the Replication subsystem.

8.2.4.2 Mirroring

This subsystem comprises the Microsoft SQL Server functionality that mirrors the CHART ATMS databases between the primary CHART ATMS site located at the MDOT Glen Burnie Data Center (GB-DC) and the backup CHART ATMS site located at State Highway Administration (SHA) Headquarters in Baltimore. Although this subsystem is listed within the Database Archive CI, both the CHART_Live and CHART_Archive databases are mirrored. Mirroring is configured, monitored, and managed by the CHART ATMS DBAs.

8.2.4.3 Query

This subsystem provides the ability to query the database, for purposes of examining the database and manipulating data in the database, from a program perspective and via the SQL Management Studio, and also, not formally part of the CHART ATMS, by the Report Generation subsystem for the purpose of generating reports on the system. Report Generation is under the purview of the University of Maryland.

8.2.4.4 Replication

This subsystem comprises the Microsoft SQL Server functionality that replicates the CHART ATMS databases to the University of Maryland for reporting purposes. Although listed in the Archive DB CI, both the CHART_Live and CHART_Archive databases are mirrored. Replication is configured, monitored, and managed jointly by the CHART ATMS DBAs and University DBAs.

8.2.4.5 Report Generation

This subsystem, not part of the CHART ATMS per se, is employed by the University of Maryland to perform reporting and statistical analysis functions.

8.2.5 COTS

The COTS CI collects all COTS packages into a single CI for configuration control purposes. This CI will be used to track the COTS packages and versions used. Rather than list each subsystem in paragraphs, the COTS packages used throughout the system are described in Table 8-2 below. Package redistributability is designated as Open source, Free (freely available, but without source), or Proprietary (purchased or otherwise restricted). Usage is listed as Development, Runtime, both Development and Runtime, or Administrative. For COTS that is both Development and Runtime, the predominant usage, if that makes sense, is listed first. Administrative usage is listed when the product is not required to build the system, even if the product is a key part of the development effort, such as Sparx Enterprise Architect, which developers use extensively.

Table 8-2. COTS Packages

Product Name	Version	Description/Purpose	Redistributability	Usage
Apache ActiveMQ	5.5	CHART ATMS uses ActiveMQ to connect to RITIS JMS queues for import from RITIS and to export to CHARTWeb for CHART Mapping / CHARTWeb and to RITIS and MD511.	Open source	Runtime
Apache Ant	1.9.6	CHART ATMS uses Apache Jakarta Ant to build CHART applications and deployment jars.	Open source	Development
Apache Commons Lang3	3-3.3.2	CHART uses commons-lang for various string utility methods provided by this library. For example RandomStringUtils class is used to generate random passwords for password reset requests.	Open source	Development
Apache Commons HTTP Components	4.5.3	Components for communicating via multipart forms with CR Dynamics for MD511 telephone system control: httpclient 4.5.3, httpcore 4.4.6, httpmime 4.5.3	Open source	Runtime Development
Apache Log4j	1.2.15	CHART uses log4j for logging purposes	Open Source	Development
Apache Tomcat	9.0.5	CHART ATMS uses Apache Tomcat as its web server container. This is used to host the CHART ATMS GUI and all the various CHART ATMS Web Services. The 64-bit (x64) build is used if hosting the GUI and Lane Editor Service only; if any other services are hosted, the 32-bit (x86) build is used.	Open source	Runtime
Apache XML-RPC	3.1.2	CHART ATMS uses the apache xmlrpc java library that uses XML over HTTP to implement remote procedure calls. The video Flash streaming “red button” (“kill switch”) API uses XML over HTTP remote procedure calls.	Open source	Runtime
CLOC (Count Lines of Code)	1.7.2	CHART ATMS uses CLOC for source code metrics.	Open Source	Administrative
Core Tec Decoder Control	1.0	CHART ATMS uses a Core Tec supplied decoder control API for commanding Core Tec decoders.	Proprietary	Runtime Development

Product Name	Version	Description/Purpose	Redistributability	Usage
Datatables JavaScript Library	1.10.13	The CHART ATMS GUI uses the Datatables JavaScript Library, a cross-browser compatible JavaScript library, which provides many features, which provide easy support for display of tabular data..	Open source	Development
Dialogic API	6.0	CHART ATMS uses the Dialogic API for sending and receiving Dual Tone Multi Frequency (DTMF) tones for HAR communications.	Proprietary	Runtime Development
Eclipse	4.4 and higher	The standard Java development environment. CHART ATMS developers collectively use a variety of versions and are free to update at their discretion. However, 4.4 is the minimum required to support Java 8	Open source	Development
GIF89 Encoder	0.90 beta	Utility classes that can create .gif files with optional animation. This utility is used for the creation of DMS True Display windows.	Open source	Development
GNU Bison	2.1	CHART ATMS uses Bison and Flex as part of the process of compiling binary macro files used for performing camera menu operations on Vicon Surveyor VFT cameras.	Open source	Development
GNU Flex	2.5.4a-1	CHART ATMS uses Bison and Flex as part of the process of compiling binary macro files used for performing camera menu operations on Vicon Surveyor VFT cameras.	Open source	Development
iText	2.1.7	CHART ATMS uses iText for PDF document generation	Proprietary	
Jackson	2.1.0	CHART ATMS uses the Jackson Java library to encode/decode strings that use JSON (JavaScript Object Notation).	Open source	Runtime
JacORB Event Service	2.3.1 (as patched for CHART ATMS)	CHART ATMS uses a compiled, patched version of JacORB 2.3.1. The JacORB source code, including the custom patched code updated by the CHART ATMS software development team, is kept in the CHART ATMS source repository.	Open source (enhanced with custom CHART ATMS patches)	Runtime Development
JacORB ORB				

Product Name	Version	Description/Purpose	Redistributability	Usage
JacORB Trader				
Java Runtime Environment (JRE)	1.8.0_162 (a.k.a. 8u162)	The Java Runtime Environment (JRE) is the runtime environment for the CHART ATMS.	Open source	Runtime Installation
JavaHelp	1.1	The JavaHelp system is used to develop the online help system for the CHART ATMS. The text thus developed for the online help is also ported verbatim into the CHART ATMS User's Guide.	Open source	Development Runtime
JavaMail	1.4.4	The CHART ATMS Notification Service uses this API to deliver SMTP mail (notifications).	Open source	Development Runtime
Java SDK	1.8.0_162 (a.k.a. 8u74)	The Oracle Java Software Development Kit (SDK) is the Java compiler for the CHART ATMS.	Open source	Runtime Installation
JavaService	2.0.10.0	CHART ATMS uses JavaService to install the server side Java software components as Windows services.	Open source	Runtime
Java Topology Suite (JTS)	1.8.0	CHART ATMS uses the Java Topology Suite (JTS) for geographical utility classes.	Open source	Runtime Development
JAXB	hudson-jaxb-ri-2.1-833	CHART ATMS uses the jaxb Java library to automate the tedious task of hand-coding field-by-field XML translation and validation for exported data.	Open source	Runtime Development
Jaxen	1.0-beta-8 dated 2002-01-09	The Jaxen project is a Java XPath Engine. Jaxen is a universal object model walker, capable of evaluating XPath expressions across multiple models.	Open source	Runtime Development
JDOM	b7 (beta-7) dated 2001-07-07	CHART ATMS uses JDOM as a way to represent an XML document for easy and efficient reading, manipulation, and writing.	Open source	Development
JIRA	6.4.11	The CHART Program uses JIRA for tracking problem reports (PRs)	Proprietary	Development

Product Name	Version	Description/Purpose	Redistributability	Usage
joeSNMP	0.2.6 dated 2001-11-11	The joeSNMP project is a Java-based implementation of the SNMP protocol. CHART ATMS uses for commanding Impath MPEG-2 decoders and for communications with NTCIP DMSs.	Open source	Runtime Development
JQuery JavaScript Library	3.1.1	The CHART ATMS GUI uses the JQuery JavaScript Library, a cross-browser compatible JavaScript library, which provides many features, including easy Ajax support.	Open source	Development Runtime
JQuery-UI JavaScript Library	1.12.1	The CHART ATMS GUI uses the JQuery-UI JavaScript Library, a cross-browser compatible JavaScript library, which provides many features, primarily for specialty gui controls including tabbed displays.	Open source	Development Runtime
JSON-simple	1.1	CHART ATMS uses the JSON-simple Java library to encode/decode strings that use JSON (JavaScript Object Notation).	Open source	Runtime Development
Microsoft SQL Server	2016	CHART ATMS and EORS use Microsoft SQL Server 2016 to host their databases. They use the same version for retrieving roadway location, weather, and traffic signal data from CHART Mapping and lane closure permits from LCP.	Proprietary	Runtime
Microsoft SQL Server JDBC Driver	4.0	CHART ATMS Java software accesses the Microsoft SQL Server database using the JDBC Driver 4.0 produced by Microsoft for this purpose.	Proprietary	Development Runtime
Microsoft Visual C++	6, Service Pack (SP) 6	Although for the most part CHART ATMS has migrated to Visual Studio 2012 Ultimate for C++, CHART ATMS still uses Visual C++ Version 6, Service Pack 6 C++ library files for the previously compiled legacy V1500 Manager. Necessary library files are used in the runtime environment.	Proprietary	Runtime
Microsoft Visual Studio	2012 Ultimate	CHART ATMS uses Microsoft Visual Studio 2012 Ultimate for C++ source code development. Necessary library files are used in the runtime environment. These include elements of earlier versions as well (2010, 2008, and 2005).	Proprietary	Development Runtime

Product Name	Version	Description/Purpose	Redistributability	Usage
Microsoft Windows	2016 Server	CHART ATMS uses Microsoft Windows 2016 Server as its standard runtime platform for the CHART ATMS application servers, database servers, and GUI servers.	Proprietary	Runtime
NeoSpeech	3.11.5	Text to Speech Engine	Proprietary	Runtime
Nullsoft Scriptable Install System	2.20	CHART ATMS uses the Nullsoft Scriptable Install System (NSIS) as the installation package for CHART NTCIP Conformance Test components, for NTCIP DMS and NTCIP cameras.	Open source	Development Installation
OpenLayers	2.13.1	The CHART ATMS Map feature uses the OpenLayers JavaScript API 2.8 (http://openlayers.org/) in order to render interactive maps within a web application without relying on vendor specific software. OpenLayers is an open source product released under a BSD style license which can be found at (http://svn.openlayers.org/trunk/openlayers/license.txt).	Open source	Development Runtime
O'Reilly Servlet	1.11	Provides classes that allow the CHART ATMS GUI to handle file uploads via multi-part form submission.	Open source	Development Runtime
Prototype JavaScript Library	1.7.2	The CHART ATMS GUI uses the Prototype JavaScript Library, a cross-browser compatible JavaScript library, which provides many features, including easy Ajax support.	Open source	Development Runtime
RedGate SQL Backup Pro	6	CHART ATMS uses these parts of the RedGate DBA Bundle monitoring tools to support the backup and restore processes and to monitor database performance	Proprietary	Runtime
RedGate SQL Monitor	2.3.0			
Robohelp	10	CHART ATMS developers use Robohelp to author the online help and to generate the CHART ATMS User's Guide, which is a Word document generated from the online help.	Proprietary	Development

Product Name	Version	Description/Purpose	Redistributability	Usage
SAXPath	1.0-beta-6 dated 2001-09-27	CHART ATMS uses SAXPath, an event-based API for XPath parsers, that is, for parsers which parse XPath expressions.	Open source	Runtime Development
Sparx Enterprise Architect	9.3.934	CHART ATMS developers use Enterprise Architect by Sparx for UML modeling and design tool.	Proprietary	Development
Subversion	1.6	CHART ATMS uses Apache Subversion for source code control.	Open source	Development
Subversion browser TortoiseSVN	1.6.15	Official CHART ATMS builds use TortoiseSVN subversion browser. Some developers may use TortoiseSVN as well.	Open source	Development
Tritonus	0.3.6	The CHART ATMS uses the Tritonus implementation of the Java Sound API for manipulating audio files.	Open source	Development Runtime
Turnkey-RVDS	2.0.4	The CHART ATMS uses the Turnkey-RVDS to display Streaming Flash video on physical monitors.	Proprietary	Runtime
Twitter-core	4.04	CHART ATMS uses the Twitter core library for posting of social media messages to Twitter.	Open source	Development Runtime
Velocity Template Engine	1.6.1	Provides classes that CHART ATMS GUI uses in order to create dynamic web pages using velocity templates.	Open source	Runtime Development
VideoJS	6.2.0	The CHART ATMS GUI uses the VideoJS JavaScript library to display streaming video on the desktop.	Open source	Runtime
VideoJS-flash	2.0.0	A VideoJS plugin library allowing VideoJS to use the VideoJS-SWF Flash binary library to support RTMP video.	Open source	Runtime
VideoJS-swf	5.4.0 (patched for CHART ATMS)	A Flash binary library that allows VideoJS to play streaming video using the RTMP protocol. This is customized for CHART ATMS to support a configurable buffer time setting.	Open source	Runtime

Product Name	Version	Description/Purpose	Redistributability	Usage
vRanger Backup & Replication	5.3.1	The CHART Program uses vRanger Backup & Replication by Quest Software to maintain system backups. This subsystem is not part of the CHART ATMS per se, but serves in a support role. Therefore, it is listed as having Administrative usage, rather than Runtime usage.	Proprietary	Administrative
XML Spy	2009 Pro SP 1	CHART ATMS developers use XMLSpy to visualize, edit, and generate XML and XSLT used by the CHART ATMS and by some of the external systems which interface with the CHART ATMS.	Proprietary	Development

9 STANDARDS VIEW

9.1 View Description and Typical Stakeholders

This view into the CHART ATMS describes how the CHART ATMS conforms to various national standards, in multiple contexts. This view is useful for MDSHA management, CHART ATMS developers, and those looking to interface with the CHART ATMS, from either a Center to Center or device level perspective.

9.2 Standards Overview

The CHART ATMS has been and is being designed to be as compliant with ITS national standards where possible and practical. The system design utilizes existing standards, within four contexts of the system: data storage, external communications, internal communications, and field communications.

9.2.1 Data Storage

In the early years of the project, the CHART ATMS development team made an effort to utilize the TMDD to define attributes stored in the CHART ATMS database. The TMDD contains the national ITS standard data definitions for data elements. Wherever practical, data elements existing in the TMDD and needed by the application were created with TMDD definitions. Additional attributes needed to implement the CHART ATMS system requirements were added to these standard table definitions. These elements, of course, do not interfere with the ability to access the TMDD-standard elements. This effort reached its height during the incorporation of video processing into the CHART ATMS. During this phase several extra CCTV-related TMDD attributes which had no purpose in the planned CHART ATMS processing were nevertheless added to the CHART ATMS graphical user interface and the CHART ATMS database for the sole purpose of achieving the goal of fully conforming to the TMDD: among them, horizontal and vertical datum type, latitude and longitude (back before the CHART ATMS populated these otherwise), height, vertical level, control type, and supported command set. However, in practice, these extra attributes generally have never been populated, and today they are generally ignored, so hence this objective was no longer emphasized and the focus on the TMDD has fallen out of favor.

9.2.2 External Communications

This section describes interfaces CHART ATMS has with other system outside of the CHART ATMS Program.

9.2.2.1 Center-to-Center Communications

Export

The CHART ATMS Data Exporter provides a broad selection of ITS data in XML format using both an on-demand and a subscription-based HTTP transport.

Traffic event messages are compliant with the SAE ATIS J2354 STANDARD (ATIS-Draft-03-00-79.xsd) and include extensive customizations. The customizations are implemented per the standard's localization feature so the resulting messages remain compliant with the standard.

Device messages are compliant with the TMDD standard (TMDD v3.0 Design v2.0) and also include extensive customizations. Like the Traffic Event messages, the device messages also include extensive customizations but again these were accomplished using TMDDs localization feature so the resulting messages remain compliant with the standard. Device information available over this interface included DMS, HAR, TSS, Beacons, and CCTV configuration; video is not available.

Both traffic event and device messages are currently consumed by the University of Maryland's RITIS system and by MDSHA's MD511 traveler advisory system.

Import

CHART ATMS imports traffic and device data from the University of Maryland's RITIS system using messages similar to the export messages.

Like CHART ATMS's export messages, the RITIS traffic event messages follow the SAE ATIS J2354 STANDARD (ATIS-Draft-03-00-79.xsd) however their customizations are more modest than CHART's.

Also, like CHART ATMS's export messages, the RITIS device messages follow the TMDD standard (TMDD v3.0 Design v2.0) with modest customizations. Currently CHART ATMS imports DMS and TSS data from RITIS using this mechanism.

9.2.2.2 Data-Specific Communications

CHART ATMS collects roadway travel times from INRIX for displaying travel times on DMSs. Although INRIX messages do not follow a standard themselves, they do include TMC codes in their messages which is an international standard (ISO-14819).

The remaining external interfaces simply follow an HTTP/XML interface standard, however, the content of the messages themselves do not follow any specific standard.

9.2.2.3 Inter-CHART Communications

CHART ATMS shares messages with other CHART systems such as weather systems, AVL, LCP, Mapping, and CHART Web (indirectly via the CHART ATMs ExportClient). These interfaces are not compliant with any recognized standard primarily because no standard exists for these interfaces.

9.2.3 Internal Communications

This section describes interfaces within the CHART ATMS itself. There are two major varieties of interfaces: interfaces between the many processes which make up the CHART ATMS, and communications to CHART field devices.

9.2.3.1 Interprocess Communications

In general, the older CHART ATMS design components use CORBA for transactions between internal software components. When the CHART ATMS (then known as CHART2) was just getting underway, CORBA had been chosen as one of two approved methods of communication between ITS software components by the NTCIP Center to Center committee. So when the CHART ATMS was originally developed, the design team referenced the burgeoning object model being developed by the Center to Center committee. At that time, however, it had not yet defined the system interfaces. Thus, the CHART ATMS was developed to isolate standard interfaces from those that are clearly CHART ATMS specific. (For instance, CHART ATMS includes a class called a "CHART2DMS," which contains data and interfaces thought to be specific to Maryland's implementation of an ATMS, and "CHART2DMS" extends a base class called a "DMS," which contains data and methods considered more universal). CORBA has been dismissed within the IT industry since the original center to center communications standards were defined. As a result, the CHART ATMS has moved towards an HTTPS/XML interface for receiving and sending data from/to entities outside of the CHART ATMS. These interfaces are described in later sections.

9.2.4 Field Communications

In the area of field communications, the CHART ATMS design has been and continues to move towards conformance with NTCIP, which defines the current national standards for communications with field devices in the ITS industry. NTCIP is the National Transportation Communications for ITS Protocol (ITS itself of course being an acronym for Intelligent Transportation Systems). The CHART ATMS currently supports NTCIP communications for DMSs and CCTV cameras. Currently within the CHART ATMS some 99% of the 300+ DMSs communicate via NTCIP. DMS manufacturers were the first to embrace the NTCIP standard. Only about 1% of the approximately 800 CCTV cameras managed by CHART ATMS support the NTCIP standard. The CHART ATMS is designed to add support for NTCIP (and other) protocols with minimal effort. Separate protocol handlers are designed and coded separately from the base code which manages the devices themselves, thus, adding support for a new protocol does not require significant amounts of code to be written to manage devices that communicate via a new protocol. Prior to development and widespread support of NTCIP, this design was used initially to add support for non-NTCIP devices. Lately this approach has been used to add support for NTCIP communications, by adding an NTCIP protocol handler for DMSs and an NTCIP protocol handler for cameras.

10 BUSINESS ARCHITECTURE VIEW

10.1 View Description and Typical Stakeholders

This section provides a view into how the CHART Program aligns with the CHART Business Area Architecture, which lays out the business case and business objectives for CHART, and attempts to align those with current and desired future capabilities. This section lays out a business strategy for achieving those goals, in line with available and long-term resources. Interested stakeholders would include MDSHA management and CHART Program Management, especially those who participated in the BAA process, or those would like to learn more about CHART's business plan and its mapping to CHART capabilities.

10.2 Business Area Architecture

The CHART System concept of operations encompasses of four major categories of business objectives:

- CHART is intended to be a statewide traffic management system, not limited to one or two specific corridors of high traffic volumes, but expandable to cover the entire state as funds, resources, and roadside equipment become available to support traffic management.
- CHART is intended to be a coordination focal point, able to identify incidents, congestion, construction, road closures and other emergency conditions; and then able to direct the resources from various agencies, as necessary, to respond to recurring and nonrecurring congestion and emergencies. It should also manage traffic flow with traveler advisories and signal controls, and coordinate or aid in the cleanup and clearance of obstructions.
- CHART is intended to be an information provider, providing real-time traffic flow and road condition information to travelers and the media broadcasters, as well as providing real-time and archived data to other state agencies and local, regional, inter-state, and private sector partners.
- CHART is intended to be a 7 day per week, 24 hours per day operation with the system performing internal processing and status checks to detect failed system components and resetting or reconfiguring itself where appropriate, or notifying operators and/or maintenance staff where necessary for service.

Figure 10-1, from the BAA, summarizes the Business Process Model. For more detail, see the full breakdown in Appendix B of the 2016 Business Area Architecture Revision 17, March 15, 2017, CHART-OPS-014-v17.

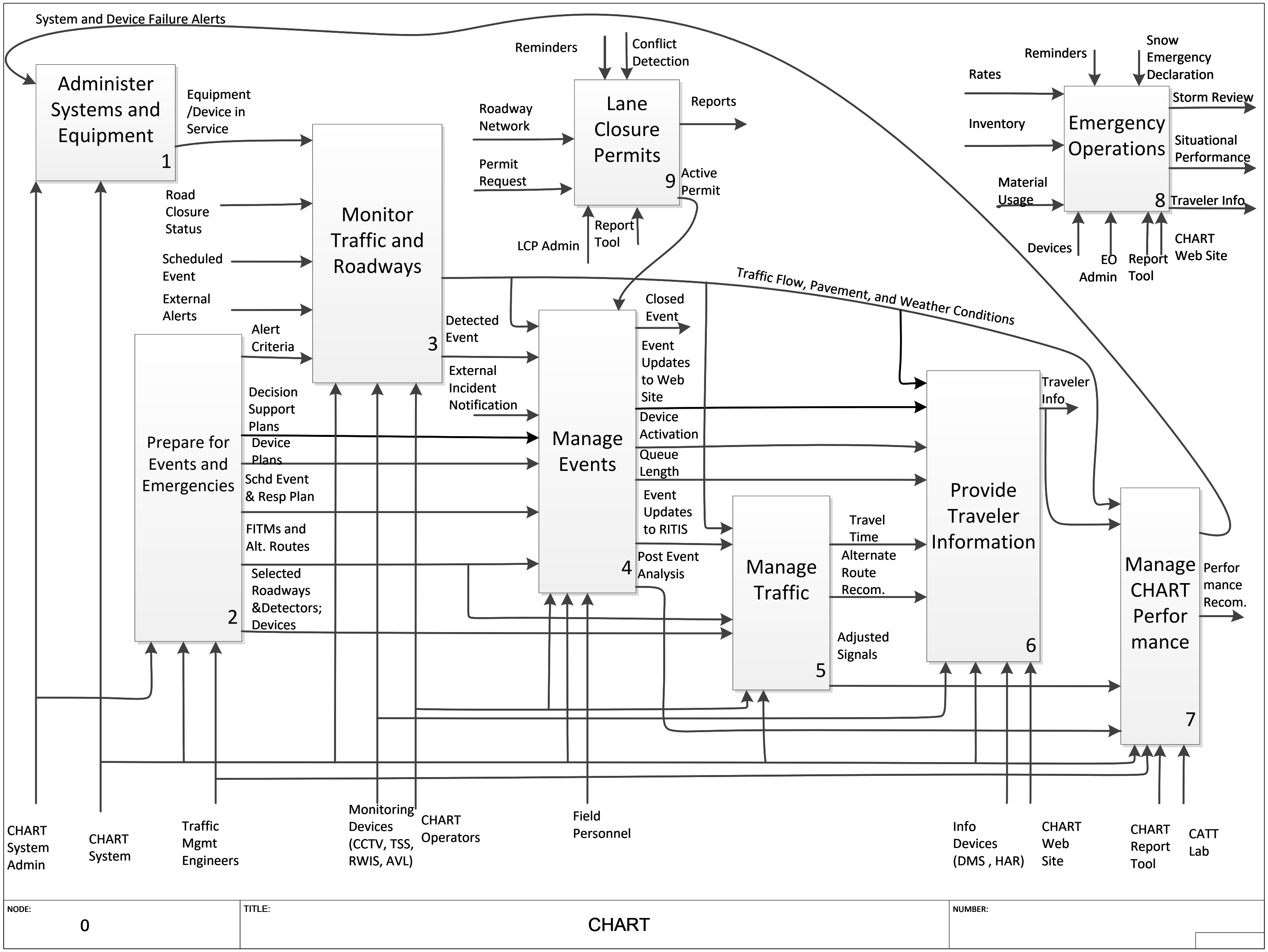

Figure 10-1. CHART High Level Business Process Model

10.3 BAA Process to Subsystem Matrix

A mapping between the business processes identified in the BAA and the CHART system CIs and subsystems appears in Table 10-1. This table presents the Business Process to Configuration Item matrix as aligned with the most recent BAA revision (March 2017). Note that GUI Management is involved in virtually every process, and is not listed. Note that the true intent of the items listed cannot always be ascertained by merely reading the name of the process. (For instance, "Manage CHART Performance" might appear to involve the CHART System Monitor (Watchdog), but it has nothing to do with monitoring the performance of the various CHART executables; it has to do with analyzing the archive of traffic events generated within CHART to determine CHART's effectiveness and efficiency. The last group of processes is especially prone to misinterpretation.) **It is recommended that the mappings below should not be reviewed or re-evaluated in a vacuum, without consulting the process descriptions from the BAA.**

Table 10-1. Business Process to Configuration Item Matrix

BAA Process				CI	Subsystem(s)
Administer systems and equipment				various; see below	various; see below
	Administer CHART organizations, locations, and users			Core Services	User Management, Contact Management
		Maintain CHART organizations and geographic areas of responsibility		Core Services	User Management
			Maintain organization types	(Not implemented)	(Not yet implemented)
		Maintain geographic Areas of Responsibility		Core Services	User Management
		Maintain organizations		Database Instance	MS SQL Server
		Maintain CHART functional rights		Database Instance	MS SQL Server
		Maintain CHART roles		Core Services	User Management
		Maintain users		Core Services	User Management, Contact Management
	Maintain dictionaries			Core Services	Dictionary Management
	Create message library entry			Core Services	Message Library Management
	Create DMS/HAR message template			Core Services	Message Template Management
	Maintain map			GUI Services	Map Management
	Manage CHART control			various; see below	various; see below
		Control login		Core Services	Resource Management
		Perform shift hand-off (incoming)		Core Services	Resource Management
		Maintain shift hand off report		Core Services	User Management
		Control logout and transfer control		Core Services	Resource Management
	Install and maintain devices			Core Services	Device Management
		Install equipment/ devices		Core Services	Device Management

BAA Process			CI	Subsystem(s)
		Put equipment/ devices on-line	Core Services	Device Management
		Perform routine maintenance	Core Services	Device Management
		Respond to equipment/ device outage	Core Services	Device Management
Prepare for events and emergencies			various; see below	various; see below
	Maintain decision support plan		various; see below	various; see below
		Name decision support (DS) plan	Core Services	Decision Support
		Select DS plan conditions	Core Services	Decision Support
		Associate devices to DS plan	Core Services	Decision Support, Traffic Event Management
		Associate notifications and resources to DS plan	Core Services	Traffic Event Management, Decision Support, AVL Management
		Associate FITM or alternate route	Partially implemented in Core Services	Partially implemented in Traffic Event Management
		Set DS plan status	(Not implemented)	(Not yet implemented)
	Simulate emergencies and other scenarios		(Not implemented)	(Not yet implemented)
	Maintain traffic plans		various; see below	various; see below
		Maintain roadway plans - FITMs and alternate routes	(Not implemented)	(Not yet implemented)
		Identify roadways for signal control and travel time	Partially implemented in Core Services	Partially implemented in Plan Management, Traveler Information Management, DMS Control
		Maintain device plans	Core Services	Plan Management, Audio Management
	Define alert criteria		Core Services	Alert Management

BAA Process				CI	Subsystem(s)
	Schedule events			Core Services	Schedule Management
Monitor traffic and roadways				various; see below	various; see below
	Detect conditions			Core Services	Video Monitor Management, Traveler Information Management, Traffic Sensor System Management
	Record conditions			Core Services	Traffic Event Management
	Issue alert or post information			Core Services	Alert Management, Notification Management, Resource Management, DMS Control, HAR Control, On/Off Device Control, Traveler Information Management, Traffic Event Management, Data Import Management, Data Export Management, System Monitor (Watchdog), Schedule Management
	Receive and respond to alert			Core Services	Alert Management, Trigger Management
Manage events				various; see below	various; see below
	Open event			various; see below	various; see below
		Record event details		various; see below	various; see below
			Specify location and impact	Core Services, GUI Services	Traffic Event Management, Map Management
			Capture day/date/time	Core Services	Traffic Event Management

BAA Process					CI	Subsystem(s)
			Capture weather conditions		Core Services	Traffic Event Management, Weather Station Management
			Identify event source		Core Services	Traffic Event Management
			Capture related events		Core Services	Traffic Event Management
			Specify nature of problem		Core Services	Traffic Event Management
			Determine event type		Core Services	Traffic Event Management
		Deploy resources			various; see below	various; see below
			Verify event location and specifics		Core Services	Traffic Event Management
			Evaluate event response recommendations		Core Services	Traffic Event Management
			Select/ modify course of action		Core Services	Traffic Event Management
				Select/ deselect resource or device	Core Services	Traffic Event Management, AVL Management
				Enter reference/ charge numbers	(Not implemented)	(Not yet implemented)
				Select or enter appropriate message	Core Services	Traffic Event Management, Decision Support, Plan Management, Audio Management
				Adjust camera parameters and monitor assignment	Core Services	Decision Support, Traffic Event Management, Camera Control, Video Monitor Management

BAA Process				CI	Subsystem(s)
			Execute course of action	Core Services	Traffic Event Management, DMS Control, HAR Control, On/Off Device Control, Video Monitor Management, Camera Control
	Respond to and monitor event			various; see below	various; see below
		Monitor event		various; see below	various; see below
			Monitor resource status	Core Services	Traffic Event Management, AVL Management
			Monitor activities	Core Services	Traffic Event Management, Decision Support, AVL Management, Video Monitor Management, Camera Control, Traveler Information Management
			Monitor device status	Core Services	DMS Control, HAR Control, On/Off Device Control, Traffic Event Management
		Control on-scene traffic		Not a CHART ATMS function	Not a CHART ATMS function
		Manage affected area traffic		(Not implemented)	(Not yet implemented)
		Perform scene activities		Not a CHART ATMS function	Not a CHART ATMS function
	Close event			various; see below	various; see below

BAA Process			CI	Subsystem(s)
		Verify scene clear	Partially implemented in Core Services	Partially implemented in Video Monitor Management, Camera Control
		Determine event closure or transfer	Core Services	Traffic Event Management, Resource Management, Decision Support
		Change event type	Core Services	Traffic Event Management
		Record event closure	Core Services	Traffic Event Management
		Conduct post-event analysis	Database Archive	Replication, Query, Report Generation
Manage traffic			various; see below	various; see below
	Control signals and roadway access		(Not implemented)	(Not yet implemented)
	Recommend alternate routes		(Not implemented)	(Not yet implemented)
	Calculate travel times		Core Services	Traveler Information Management, DMS Control, Message Template Management
Provide traveler information			various; see below	various; see below
	Broadcast information		Core Services	Traveler Information Management, DMS Control, Message Template Management

BAA Process		CI	Subsystem(s)
	Maintain [external] web site information	Supported by Core Services	Supported by Traffic Event Management, DMS Control, HAR Control, Traveler Information Management, Data Export Management
	Provide recorded information	Supported by Core Services	Supported by Traffic Event Management, DMS Control, HAR Control, Traveler Information Management, Data Export Management
	Provide CHART info to third parties for public dissemination	Core Services	Video Monitor Management, Traffic Event Management, Data Export Management
	Provide camera video feeds	Core Services	Video Monitor Management, Camera Control
Manage CHART performance		various; see below	various; see below
	Measure CHART operations performance	Database Archive	Replication, Query, Report Generation
	Measure traffic management	Database Archive	Replication, Query, Report Generation
	Manage and measure device performance	various; see below	various; see below

BAA Process			CI	Subsystem(s)
		Check and validate system and status	Partially implemented in Core Services	Partially implemented in DMS Control, HAR Control, Traffic Sensor System Management, Camera Control
		Update device/ system status	Core Services	DMS Control, HAR Control, On/Off device Control, Traffic Sensor System Management, Camera Control, Video Monitor Management
		System/device attempt corrective action	Partially implemented in Core Services	Partially implemented in System Monitor (Watchdog)
		Notify NOC of device/ system status	Partially implemented in Core Services	Partially implemented in DMS Control, HAR Control, On/Off device Control
		Initiate corrective action and follow to closure	(Not implemented)	(Not yet implemented)
		Generate device reports	Database Archive	Replication, Query, Report Generation
	Simulate CHART operations and traffic management performance		(Not implemented)	(Not yet implemented)
	Analyze performance and develop CHART recommendations for improvement		Not a Core Services function	Not a CHART ATMS function
Lane Closure Permits			various; see below	various; see below
	Manage Operations			

BAA Process			CI	Subsystem(s)
		Manage roadway permits		
		Maintain logs, report status		
		Monitor automated permits		
		Monitor resources		
	Administer system			
		Manage users		
		Manage system		
		Manage archive		
		Generate reports		
Emergency Operations			various; see below	various; see below
	Administer system and equipment			
		User management		
		Page security		
	Prepare for emergencies			
		Manage resource rates		
		Manage hurricane preparedness		
		Manage and archive EOC plans		
	Monitor Traffic and Roadways			
		Manage route restrictions		
		Assign RWIS to shop		
	Manage Storm Response			
		Allocate resources		
		Snow emergency plans		

BAA Process			CI	Subsystem(s)
		Assign roadway conditions		
		Situational reporting		
		Post storm information		
		Event shop reporting reminder		
	Provide traveler information			
		Post public messages		
	Evaluate Performance			
		Post storm review & archive		
		Generate reports		

10.4 Future CHART Releases

Future releases include a wide variety of features as specified in the BAA. Table 10-2 below shows some of the major functionality planned for upcoming releases and the subsystems affected.

Table 10-2. CHART Future Release Functions

CI	Subsystem	Function
Core Services	Monitor traffic and roadways (TBD subsystem)	Implement I-270 Active Traffic Management (ATM)
	Device	Implement Lane Control
	Traffic Event Management	Improve workflow and business rules for how contacts, resources, and participants are managed
	Map Management	Lane configuration improvements
	Map Management	Improve Mapping – accuracy and new features (e.g., street address lookup, county line as intersecting feature)
		Improve SHA HQ backup capability/reduce downtime during patching and deployments
	Monitor traffic and roadways (TBD subsystem)	Support US 1 Innovative Technology Pilot - Collect DSRC Basic Safety Messages
	Traffic Event Management	Allow field units to add events (smart phone app)

10.5 Near Term Goals

10.5.1 NTCIP Device Control

CHART would like to enhance its support for NTCIP DMS and NTCIP Cameras, such as needs for additional DMS and camera control protocols are identified.

A long term goal is that CHART would move away from proprietary protocols for all field devices: elimination of non-NTCIP DMSs and non-NTCIP cameras, development of NTCIP protocols for HARs, SHAZAMs, and TSSs such as those protocols are refined and widely adopted by the industry.

10.5.2 Further Automation Improvements for Operators

A general objective is to reduce the burden on CHART ATMS operators to make and implement decisions, so Decision Support functionality is expected to be enhanced in coming releases. Improvements which can reduce the amount of operator typing and can streamline navigation of the system and execution of desired actions is also a target. Operators are very cognizant of every mouse click and keystroke they have to make. Reducing clicks and keystrokes is a desired objective for the system.

10.5.3 Implement I-270 ATM

The I-270 Innovative Congestion Management project is underway and it is expected that Variable Speed Limit (VSL) data and Queue Warning DMS suggested messages will be sent to CHART ATMS from the I-270 ATM system by Fall of 2019. CHART ATMS should be able to monitor this managed corridor.

11 SYSTEM MAINTENANCE VIEW

11.1 View Description and Typical Stakeholders

This section provides a view into the high-level CHART ATMS maintenance tasks. This includes system maintenance (including backup and recovery), database maintenance, and routine software maintenance. The CHART ATMS Operations and Maintenance Guide contains much more detailed information on these routine maintenance tasks. Roadside device and other hardware and network maintenance tasks are outside of the scope of both this document and the CHART ATMS Operations and Maintenance Guide. Interested stakeholders would be system administrators, software and system architects, and any other parties interested in a high-level view of maintenance tasks for the CHART ATMS.

11.2 Data Backup and Recovery

Data backup and recovery are implemented at both the system level and the database level. Database level backups are needed in order to guarantee transactional integrity and to prevent database backup corruption.

11.2.1 Data Backup

11.2.1.1 Virtual Environment

Procedures for backing up the virtual environment are not covered in the CHART Operations and Maintenance Guide. These tasks are performed by Transportation Business Unit (TBU) personnel following procedures maintained by TBU staff. Most of these procedures can be found in the CHART Virtualization Operations and Maintenance Guide.

- The ability to "snapshot" a virtual server provides the ability to roll back a server to a previous state should an issue occur with that server, and simplifies maintenance and administration by allowing patches and upgrades to be easily and quickly backed out if necessary.
- Full image snapshots are taken nightly and copied to an offsite location at SHA Headquarters (HQ) in Baltimore. Included in these snapshots are local snapshots with file and image-level restore functionality.

11.2.1.2 Database

Database backup tasks and the procedures for executing those tasks are detailed in Section 3.9 of the CHART Operations and Maintenance Guide. There are procedures for both the active (CHART_Live) database and the archive (CHART_Archive) database. Backup jobs are run using the SQL Backup tool by Redgate. Those tasks include:

- Full database backup
- Transactional database backup
- Differential backup

In addition, the CHART ATMS databases are mirrored from the MDOT Glen Burnie Data Center (GB-DC) to the backup site at SHA HQ. The database mirroring procedures are described in Section 3.9 of the CHART Operations and Maintenance Guide. The mirrored databases can be recovered to the prime site at the GB-DC or utilized at SHA HQ in a failover scenario.

11.2.2 Data Recovery

11.2.2.1 Virtual environment

The site at SHA HQ exists as a redundant and disaster recovery capable location where individual pieces or the entire suite of CHART applications (CHART ATMS, CHART Mapping, LCP, etc.) can exist if necessary. All CHART servers may be instantiated at SHA HQ, including both the CHART ATMS servers and other servers within the CHART enterprise, including a number of applications that the CHART ATMS interfaces with. Should a full site recovery at SHA HQ be necessary, all non-database data would be recovered within a datastore replication window. For the CHART ATMS itself, all relevant data is stored in the database and the database recovery process is executed as an additional step after servers have been instantiated at SHA HQ.

11.2.2.2 Database

Database recovery can be accomplished through these mechanisms as detailed in Section 3.9 of the CHART Operations and Maintenance Guide:

- Recovering database backup
- Recovering mirrored database from SHA HQ
- Utilizing mirrored database at SHA HQ

11.3 System Monitoring

Cern Virtual Infrastructure (CVI) administrators will access the environment through a variety of tools, depending upon the task and required method of access.

11.3.1 Virtual environment

- The vSphere Web Client provides the most comprehensive access to the VMware environment, allowing administrators to add, delete, modify, move, and monitor the physical and virtual machines. “Console” access is granted through this tool, as well as providing basic monitoring and environmental health visible through the client. A traditional “thick” client may be downloaded via web browser using the address of the vCenter server, one of the individual hosts, or from www.vmware.com.
- A Secure Shell (SSH) client, such as Putty, may be used for access into the root console of the VMware hosts for administration or maintenance that is not available within the vSphere Client. This typically is used for application of hotfixes and upgrades to the physical hosts, detailed log viewing, or high-level administrator activities.
- Veeam provides monitoring capabilities with limited access to virtual machines and physical hosts. Veeam is accessed via web browser through a specific port for both monitoring and configuration. Veeam is used to monitor CPU usage, memory usage, disk usage, and I/O statistics, etc. Veeam can generate alarms and notifications based on defined thresholds.
- Integrated Lights-Out (iLO) provides access to the HP hardware, which can be managed from the Blade Enclosure management connection, or from a web browser pointed to the correct IP address. In addition, hardware can be managed from a Liquid Crystal Display (LCD) screen on the front of the blade enclosure, directly connecting into the blade via a

dongle connection, or through keyboard-video-mouse (KVM) switch connection to the Storage Area Network (SAN) or Blade hardware.

11.3.2 Database

Database backup jobs are monitored using Red Gate SQL Backup tools. These tasks are detailed in Section 3.9 of the CHART Operations and Maintenance Guide. Specific tasks include:

- Observing last backup run time and status
- Check of physical file backup on the appropriate server

The database mirroring process is also monitored using Red Gate tools. These procedures also are described in detail in Section 3.9 of the CHART Operations and Maintenance Guide.

11.3.3 CHART ATMS

The CHART ATMS itself provides some system related monitoring, alerting, and notification capabilities. CHART ATMS Alerts are indications of various conditions displayed to operators directly within the CHART ATMS GUI. Notifications are emails which are received by email or text messages. These include:

- Ability to send alerts and/or notifications when various conditions occur including roadside device hardware and communications failure, external interface failure (e.g., RITIS connection failure or Toll rate failure), and CHART ATMS service failures and automatic restarts.
- A Monitor Services capability which reports on CHART ATMS application service status through a Watchdog service. The Watchdog communicates via CORBA with CHART ATMS services. This provides an additional layer of service health monitoring. Types of monitoring include up time, number of service failures, service restarts, heap usage, and number of service failure and restart notifications and alerts.

11.4 High Availability

The CHART system design provides high availability through these methods.

- Redundancy within virtual environment
- Redundancy of communications paths
- Database mirroring
- Offsite backup capabilities for the CHART ATMS and the entire virtual environment
- CHART Emergency System (CHART-ES), a limited functionality off-site CHART ATMS installation
- Automatic recovery within the CHART ATMS application

Each of these methods will be discussed in more detail below.

11.4.1 Redundancy within the Virtual Environment

The CHART Virtual Infrastructure provides redundancy through the implementation of a cluster of hardware and software packages.

The CHART Virtual Infrastructure provides redundancy through the implementation of a cluster of hardware and software packages.

- Storage is provided by a SAN cluster with redundant network connections accessible by all devices. This storage is replicated regularly to the SHA HQ site. The current configuration allows several individual component failures within the SAN without loss of data or the need to fail over, as well as the ability to perform file-level recovery and full image restoration if needed.
- Hardware hosting the virtual servers provides protection against data and service loss with several components having 100% redundancy. For instance, the “Flex 10 networking modules” are completely redundant. The physical hosts themselves can tolerate the loss of 1/3 of the available physical hosts and still maintain full capabilities when the impacted virtual hosts are moved to the remaining physical hosts(s).
- Network and power redundancy are also at 100% with the ability to lose a full network or power feed without adversely affecting the environment.
- VM Application and hardware configuration provides automatic failover of many components, including the ability to distribute resources, re-locate virtual servers on demand, take snapshots of servers prior to updates/upgrades, etc.

11.4.2 Redundancy of Communications Paths

There are redundant or backup communications paths for communicating with field devices, supporting video and CHART Backbone network traffic.

11.4.3 Database Mirroring

SQL Server mirroring has been established between the databases at the principal node at the GB-DC and mirror node at the SHA HQ data center. Both the CHART operational and CHART Archive databases are mirrored. Two identically configured servers reside at each of the nodes from both a hardware (virtual) and software perspective.

As database transactions are committed in the principal node these transactions are copied over to the mirror node. The copying happens in real time and the data is in a synchronized state between the nodes. The level of synchronization can be set to be either dual commit or single commit mode. In a dual commit mode, the database transaction is written to both nodes and only then will the relevant locks be released. In a single commit synchronization mode, transactions are committed at the principal node and locks are released. As a follow-on action these transactions are forwarded to the mirror node.

The CHART ATMS database is configured in a single commit synchronization mode. In a future release, the CHART ATMS application could be modified to take advantage of automatic failover, in which case the dual commit synchronization mode with automatic failover could be used.

In case of a database failure at the principal node, the CHART ATMS database will be manually failed over to the mirrored node. A pre-configured CHART ATMS application installation exists at the mirrored node to point to the mirrored database. This allows failover to a secondary site in minimal time as the data will be copied in real time to the secondary site.

Additionally, in case of a database failure at both the primary and secondary SHA sites, the replicated database instances at the University of Maryland can be backed up and restored at a CHART site.

11.4.4 Offsite Backup Capabilities for the Virtual Environment

Full image snapshots are taken nightly and copied to the SHA HQ location in Baltimore. Included in these snapshots are local snapshots with file and image-level restore functionality.

The site at SHA HQ exists as a redundant and disaster recovery capable location where individual pieces or the entire CHART system can exist if necessary. Currently, the entire CHART network at the GB-DC can be failed over to SHA HQ. Details are provided in the CHART Virtualization Operations and Maintenance Guide. It is also possible for just the CHART ATMS core processes to be run at SHA HQ. The CHART ATMS core processes include all CHART ATMS application services and the CHART ATMS GUI. At a minimum, this allows operators to work with Traffic Events and perform administrative functions. Operators may also send Notifications and control, and receive status from roadside devices when network access to those assets has not been compromised due the conditions that caused the need to fail over in the first place. Other CHART ATMS functionality and interfaces may or may not be available depending on the conditions that led to the manual failover.

Details of the CHART ATMS manual failover procedure can be found in Section 3 of the CHART Operations and Maintenance Guide.

Additional details on CHART ATMS failover to SHA HQ can also be found in the CHART Application Recovery Plan.

11.4.5 CHART-ES

CHART-ES is a standalone single-node system which runs at the SHA Headquarters. This can be used during maintenance periods or unscheduled downtime in the standard CHART ATMS system when it is not desired or possible to use the full backup CHART system at SHA Headquarters. CHART-ES consists of a database, a complete set of CHART back-end services (only some of which will be configured to run, and a slightly modified CHART ATMS GUI installation. The CHART-ES system is designed to allow operators to send notifications, control DMSs, receive Toll Rate data to post on DMSs, to switch video, and to control cameras.

11.4.6 Automatic Recovery within the CHART ATMS Application

The CHART ATMS itself provides some recovery capabilities through its Watchdog functionality. The Watchdog services can be configured to poll CHART ATMS application services via CORBA, receive status, and automatically restart those services if the services are non-responsive. Currently, most CHART ATMS application services are configured to be automatically restarted if they are non-responsive. The Watchdog also provides some alerting and notification capabilities described in section 11.3.

11.5 CHART ATMS Administrator Maintenance Tasks

There are a number of routine maintenance type tasks that can be performed through the CHART GUI, generally by those users that are granted the Adminstrator role. Those tasks include:

- User management. This includes adding, editing and deleting users, resetting passwords, creating roles, and assigning users to roles.
- Notification management. This includes adding, editing, and deleting contacts, creating groups, and assigning contacts to groups.

- External Client management. This includes providing security credentials for clients wishing to consume CHART data feeds (e.g., RITIS).
- System profile. The system profile includes a large number of user configurable CHART ATMS system parameters. Most change very infrequently.

11.6 Software Distribution

This section presents the procedures and processes used to control and manage the development and distribution of the CHART ATMS software.

11.6.1 Configuration Management and Version Control

The overall Configuration Management (CM) plan for CHART is presented in the document "CHART Configuration Management Plan, PM-PL-004 R6, July 2015." The specific objectives of the CHART CM program are to ensure that:

- CHART hardware, software, and data configuration items (CIs) are appropriately selected and identified
- CHART project baselines are established at the correct time
- Changes to the CHART baselines are authorized, evaluated, implemented as approved, verified, and tracked in accordance with established procedures
- Commercial off-the-shelf (COTS) tool upgrades are fully assessed and their impact evaluated
- The status of CHART baselines and proposed and approved changes is accounted for and reported
- Baseline and other required CM audits are carried out and the results reported
- The integrity of the system design is maintained
- The delivered system and all accompanying deliverables are accurately defined and described

The CHART ATMS development team is using Subversion as the configuration management tool to support CHART ATMS software development. The configuration management policies and procedures for the CHART ATMS software are defined in a set of standards and procedures documents. These standards and procedures documents are listed below.

- CHART Project Standards and Procedures, Configuration Change Request, Revision 0.2, 02/12/2012

11.6.2 Software Installation

The installation of new versions of CHART ATMS software components is controlled as described in the CHART Configuration Management Plan. The detailed plan for executing the installation is contained in the CHART ATMS Implementation Plan that is customized for each CHART ATMS software release. For new site installations the software components are installed and configured prior to integration of the system into the operational environment. Appendix A of the CHART ATMS Operations and Maintenance Guide presents instructions for performing software installations on operational system components. This includes installation of both COTS and of the CHART ATMS software proper.

11.7 Training

Training of CHART operations staff in the use of the CHART ATMS is provided via several means.

The CHART ATMS is installed in two separate training environments where users can operate the system without interfering with production. One environment runs the current version of CHART software (this is referred to as the “Training” environment, and one can be configured to run the “next” version of CHART software (this is referred to as the “Release” environment). Both systems support an online training capability in the form of field device simulators. Field device simulators or actual field devices set up for test purposes (e.g. a portable DMS) may be connected to the system and controlled by operations personnel in a training exercise.

A training plan is developed for each CHART ATMS software release. Training sessions are conducted by MDSHA at their discretion.

LIST OF ACRONYMS

The following table lists the acronyms used in the document.

Acronym	Description
AOC	Authority Operations Center
AOR	Area of Responsibility
API	Applications Programming Interface
ATIS	Advanced Traveler Information System
ATM	Active Traffic Management
ATMS	Advanced Traffic Management System
AVCM	ATM Video Control Manager
AVL	Automatic Vehicle Location
BAA	Business Area Architecture
BHT	Baltimore Harbor Tunnel
CATT	Center for Advanced Transportation Technology
CCTV	Closed Circuit Television
CHART	Coordinated Highways Action Response Team
CM	Configuration Management
CMC	Centralized Management Console
CORBA	Common Object Request Broker Architecture
COTS	Commercial Off-The-Shelf
CVI	Cern Virtual Infrastructure
DB	Database
DBA	Database Administrator
DCDOT	District of Columbia Department of Transportation
DCOM	Distributed Component Object Model
DMS	Dynamic Message Sign
EIS	Electronic Integrated Systems
EORS	Emergency Operations Reporting System (the former name of LCP)
ER	Entity Relationship
ERD	Entity Relationship Diagram
ESRI	Environmental Systems Research Institute
FC	Fibre Channel

Acronym	Description
FITM	Freeway Incident Traffic Management
FMS	Field Management Station
FMT	Fort McHenry Tunnel
FSK	Francis Scott Key [Bridge]
GB-DC	MDOT Glen Burnie Data Center
GUI	Graphical User Interface
HA	High Availability
HAR	Highway Advisory Radio
HIS	Highway Information Systems
HP	Hewlett-Packard
HQ	Headquarters
HTTP	Hyper Text Transfer Protocol
HTTPS	Hyper Text Transfer Protocol Secure
I	Interstate
ICD	Interface Control Document
iLO	Integrated Lights-Out
IP	Internet Protocol
iSCSI	Internet Small Computer System Interface
ISDN	Integrated Services Digital Network
ITS	Intelligent Transportation Society
JSON	JavaScript Object Notation
KVM	Keyboard-Video-Mouse [Switch]
LATA	Local Access Transport Area
LCD	Liquid Crystal Display
LCP	Lane Closure Permits
MD	Maryland
MD511	Maryland 511 (Maryland's 511 Traffic information System)
MDOT	Maryland Department of Transportation
MDSHA	Maryland State Highway Administration
MDTA	Maryland Transportation Authority
MIB	Management Information Base
NOC	Network Operations Center
NTCIP	National Transportation Communication for ITS Protocol

Acronym	Description
ORB	Object Request Broker
POTS	Plain Old Telephone System
PR	Problem Report
PTZ	Pan, Tilt, Zoom
REST	Representational State Transfer
RITIS	Regional Integrated Transportation Information System
RSS	Really Simple Syndication
RTMS	Remote Traffic Microwave Sensor
RVDS	Remote Video Display Solution
SAE	Society of Automotive Engineers
SAN	Storage Area Network
SCSI	Small Computer System Interface
SFS	Streaming Flash Server
SHA	State Highway Administration
SHAZAM	Sign with controllable beacons to indicate a message of significance is playing on a nearby HAR. (SHAZAM is not an acronym.)
SNMP	Simple Network Management Protocol
SOC	Statewide Operations Center
SOP	Standard Operating Procedure(s)
SP	Service Pack
SSH	Secure Shell
SSP	Safety Service Patrol
SWGI	Statewide Government Intranet
TCP	Transmission Control Protocol
TMDD	Transportation Management Data Dictionary
TOC	Traffic Operations Center
TSS	Transportation Sensor System
TTS	Text-to-Speech
UMD	University of Maryland
US	United States
vCPU	Virtual CPU
VM	Virtual Machine
WAN	Wide Area Network

Acronym	Description
WMATA	Washington Metropolitan Area Transit Authority
WMS	Web Map Service
WYSIWYG	What You See Is What You Get
XML	Extensible Markup Language

A DESIGN STUDIES

This section provides information on analysis, prototyping, and trade studies dating from the initial system design effort to the current time.

A.1 C++/Java Performance Comparison

The purpose of this study was to compare the performance of the Java and C++ languages as they pertain to the development of an ITS control system. The tests included in this comparison were developed to investigate the performance characteristics of those language features that are most frequently utilized in the creation of an ITS control system. The study demonstrated that either language was a suitable candidate for the development of an ITS control system. The details of the study are found in the document, "C++/Java Performance Comparison for Distributed ITS Control Systems", M361-AR-002R0, March 30, 1999.

A.2 Java Feasibility

This study was originally conducted to investigate the feasibility of using the Java programming environment to develop the CHART ATMS. The investigation was targeted at resolving what were identified as high-risk tasks for Java programming, specifically some areas related to the GUI. The details of the study are found in the document, "CHART II Java Feasibility Investigation", M361-AR-003R0, July 1, 1999. (Note: the CHART ATMS was once known as "CHART II".)

A.3 CORBA ORB

This study was conducted to evaluate vendors of Common Object Request Broker Architecture (CORBA) Object Request Broker (ORB) products for use in the implementation of the CHART ATMS. An initial field of twenty potential vendors was reduced to three candidates for evaluation. Based on how well each vendor scored on a set of ten criteria it was determined that the ORBacus product from Object Oriented Concepts best served the needs of the CHART ATMS. This product is now owned by IONA Corporation. The details of the study are found in the document, "CORBA ORB Evaluation for CHART II", M361-AR-004R0, March 19, 1999.

A decision was made to replace ORBacus as part of CHART R2B3. The CHART ATMS now uses a customized version of JacORB, a freely available ORB. CHART ATMS developers have made numerous patches to JacORB, both to correct and enhance it.

A.4 Text-to-Speech Conversion

The generation of audio for download to Highway Advisory Radios (HARs) was identified as an area of improvement in the CHART ATMS. It was desirable to have the capability in the CHART ATMS to generate speech from text files in order to free CHART ATMS operations personnel from having to manually record the audio for HARs. An evaluation of available text-to-speech (TTS) conversion applications was conducted to determine if the generation of speech from text files could be performed at a high enough quality for use in the CHART ATMS.

There are two methods in general use in the industry for the conversion of text to speech. Rule-based systems use a set of rules for creating computer-generated speech from input text. Applications based on the concatenation algorithm method use a library of pre-recorded phonemes (speech fragments) to build audio from input text.

The quality of audio output was the main criteria for the evaluation of TTS applications. A number of rule-based applications and two concatenation-based applications were surveyed as potential candidates. A text file with a sample HAR message was created and a wav file generated from the text using each of the potential TTS applications. Based on a review of the output wav files by development and SHA personnel it was determined that none of the rule-based applications generated audio of sufficient quality for consideration. The product currently in use for the CHART ATMS is the NeoSpeech text to speech engine.

A.5 Storage Area Network

A Storage Area Network (SAN) is an approach to data storage that moves storage systems from captive devices connected to dedicated servers to network devices in a peer-to-peer topology. The main purpose behind the installation of a SAN is to facilitate the growth of storage and servers independently of each other. A SAN uses Fibre Channel (FC) connections to provide higher transfer rates between devices than Small Computer System Interface (SCSI), and all SAN traffic runs independently of Local Area Network (LAN) traffic. In addition to the higher transfer rates, a SAN FC can operate over distances of 10km. A SAN can also serve as a key element in High Availability (HA) systems. By implementing a Tape Library as a SAN device, backups and restores can be done at any time of the day without affecting LAN performance. For these reasons a SAN was implemented to support the CHART ATMS and other elements of the CHART Program.

A.6 High Availability Architectures

A High Availability study was conducted to evaluate the options for providing increased availability in the CHART ATMS. The details of the study are found in the document, "CHART II High Availability Study", M361-AR-009R0. Three options were evaluated and compared with a CHART ATMS baseline system. The three options were:

- Use Oracle Advanced Replication services to replicate the CHART ATMS database at CHART ATMS server sites.
- Use a Storage Area Network to maintain mirror copies of CHART ATMS server disks at the SOC.
- Use the Microsoft Cluster Server based solution to cluster two servers together for load-sharing and redundancy.

Each of the three options has its advantages and disadvantages. As a result of the High Availability study, an interim configuration of Legato Co-Standby Advanced Availability Manager was implemented at the SOC. In December 2007, a Microsoft Cluster Services solution was implemented in conjunction with a SAN. Subsequently, however, a decision was made to not continue with any HA architecture at the SOC. This decision was primarily made because the CHART ATMS had become more fully realized as a truly distributed system across multiple nodes, thereby de-emphasizing the importance of the SOC in terms of the CHART ATMS system architecture.

A.7 Node Consolidation

In the spring of 2010, an effort to consolidate some of the CHART ATMS application server nodes was initiated. There were multiple reasons for that effort including system stability, licensing costs, and a de-emphasis on the need for a distributed architecture to protect against network failure on the MDOT Wide Area Network (WAN). With that in mind, the initial node consolidation began in the summer of 2010. The number of CHART ATMS application nodes was reduced from eight to five. Further efforts to reduce the number of nodes from five to one were initiated in 2012. This required a robust backup solution for the application and the database, and encompassed a transition from an Oracle database solution to a Microsoft SQL Server database solution. This solution was deployed as R9S in September of 2012.

The CHART ATMS application is designed to be fully distributed and scalable and can theoretically be expanded by adding additional nodes to the system. However, an increased communications overhead comes with that expansion. The CHART ATMS services must all communicate amongst each other via CORBA and adding additional nodes causes an exponential growth in the number of CORBA connections in the overall system. Each such connection introduces possible communications failure into the system which in turn creates potential stability problems.

At the time of the study, each application server node hosted an Oracle database instance and each Oracle instance carried a substantial licensing cost. After delivery of R9S, there is one SQL Server installation at the SOC, and a complete, mirrored backup installation at SHA Headquarters in downtown Baltimore.

Part of the reason for the distributable architecture had been to allow nodes to function autonomously in the event that they were cut off from the rest of the nodes. Operators homed to an isolated node would still be able to operate their roadside devices and perform their traffic management tasks. However, over time, the WAN has proved to be very stable. The isolated node scenario has not occurred.

A.8 CHART Systems Database Strategic Plan

The purpose of this study, completed in April 2011, was to identify database options for the full CHART Program that would maximize technical and financial benefit to SHA's business goals. The subsequent CHART Work Order Scope and Estimate Request Form requested the production of a white paper document to recommend a 5 year strategic plan for the CHART systems databases and also, after a checkpoint with SHA, to create a plan including a schedule, assumptions and risks to implement the approved recommendations.

The assessment was approached using the Enterprise Architecture Framework as defined by the National Institute of Standards and Technology. This approach gives a holistic view of the enterprise. The Enterprise Architecture has 5 layers. The five layers are:

- Enterprise Business Architecture Layer
- Enterprise Information Architecture Layer
- Enterprise Application Architecture Layer
- Enterprise Application Integration Architecture Layer
- Enterprise Infrastructure Architecture Layer

The Enterprise Business Architecture Layer review for SHA was carried out previously by CSC and is reflected in the Business Area Architecture document: BAA Report Revision 6, January 2011. The recommendation for this layer was to continue on those specified in BAA.

The Enterprise Information Architecture Layer is comprised of the Presentation Management and Reports Management layers. In the Presentation Management layer of SHA, there are several Graphical User Interfaces identified. These are CHART GUI, EORS V2 GUI, LCP (known as EORS Legacy at the time) GUI, CHARTWeb Desktop, CHARTWeb Mobile and the Intranet Map.

The recommendation for this layer was to establish a single EORS (LCP) GUI, establish CHART Analytics GUI, establish an Attention Admin GUI and continue to use the following GUIs; CHARTWeb Mobile, CHARTWeb Desktop, CHART GUI, Intranet Map (ArcGIS) and implement a portal tool that will unify and enable a role-based Single-sign on.

In the Reports Management portion of the Enterprise Information Architecture, several report conduits were identified: SREE, SQL Server Reporting Service, Legacy Reporting Service, and Google Web Analytics Lite. The recommendation for this layer was to retire SREE, consolidate all SQL Server Reporting services, establish CHART dashboards, CHART Analytics (Business Intelligence tool) and use Google Urchin.

The Enterprise Application Architecture Layer is comprised of four core applications, which are the CHART ATMS, LCP (EORS at that time), CHARTWeb and CHART Mapping. The recommendation at this layer was to continue to have the applications remain independent of each other and integrate in the middleware layer.

The Enterprise Application Integration Architecture Layer is comprised of the middleware/IPC management layer. The CHART middleware management is using CORBA, Apache Tomcat, IIS, ASP, .NET, RSS, XML Web Services, and REST Web Services. The recommendation for this layer was that CHART is already on a good path and should continue to use Tomcat, IIS, ASP, .NET, RSS, and Apache. It was recommended that CHART implement an Enterprise Service Bus (ESB), establish web orchestration using BPEL, establish a form of Workflow mechanism using BPM, and establish a Web Services Manager and Service Registry. These middleware upgrades could possibly lead to the replacement of CORBA as an IPC solution for the CHART ATMS at some point in the future.

The Enterprise Infrastructure Architecture Layer is comprised of Database Management; Archive and Backup Management; and the physical Infrastructure Management. The recommendation for the Database Management portion was for SHA to use web services for communication and take the “Federated Option” which consists of the following components:

- Attention Database (paging system)
- A consolidated CHART Database
- CHART BG Database (SDE & Mapping)
- A consolidated database for LCP (EORS at that time)
- CHART Web Cache Database
- CHART Analytics Database (CHART-A)

This recommended approach would give SHA flexibility for growth, while systems and development cycles remain independent. It also provides a quicker patching cycle and keeps all application communication at the middleware layer. At the database layer, the recommendation is to consolidate databases where possible and implement an enterprise data governance strategy. The recommendation for the physical Infrastructure Management portion is for SHA to continue on the path of establishing VMware ESXi and upgrading to a more recent version of the Windows Server operating system. The ArcServe Backup product recommended by CHART’s infrastructure team will be implemented

B MAJOR PROTOTYPES

One of the key elements in our approach to designing the CHART ATMS is prototyping. Prototyping is a valuable tool to establish proof of concept before implementation, it provides an opportunity for SHA to experience the look and feel of parts of the system in order to validate the design, and reduces risk by verifying technological solutions before committing funds for full deployment. Several prototypes have already been developed as part of the design process and several more prototype efforts are planned for the future. These are described below.

B.1 Event Logs

An Event Log prototype was developed to verify the user interface for event log management. This prototype consisted of a portion of the GUI for event management along with logic for performing some of the event management functions such as event creation, adding event entries, and closing out events. This work was performed as part of the high-level design for CHART Release 1 Build 2 (R1B2). User feedback from the prototype was used to further refine the design.

B.2 HAR

A HAR prototype was developed to test the quality of broadcast for the latest generation of text to speech engines. Actual generated audio files and to verify the interface to the HAR. An actual HAR device was used in the prototype. Audio files were downloaded to the HAR and the quality of output monitored using the dial-up monitor port on the HAR (actual broadcast was not allowed with this device). Some of this work was later repeated when testing the quality of the Nuance and NeoSpeech text to speech products.

B.3 CCTV Distribution

A CCTV distribution prototype was developed to test the feasibility of a statewide system for the distribution of video. This prototype was also used to validate the architectural principal of CHART video being viewed by many different centers simultaneously. The prototype was also used to validate the ability to simultaneously control multiple camera types from a single user interface. The feasibility of this prototype was so successful that it was operational for 7 years. Release 2 of the CHART ATMS included the distribution of video into the CHART ATMS, along with the decommissioning of the prototype system.

B.4 Automatic Vehicle Location

An Automatic Vehicle Location (AVL) capability for the CHART Program was studied in calendar year 2000. A pilot program sponsored by the Department of Budget and Management (DBM) [now known as DoIT] evaluated two AVL products paired with two wireless communications providers.

B.5 Oracle to SQL Server

In 2011, some prototyping work was done to convert the CHART ATMS database from Oracle to SQL Server. The prototype converted DMS related tables and data from Oracle to SQL Server and then the CHART ATMS DMS service database driver was switched to work with SQL server. This work was done to help estimate the entire effort of using SQL Server for the entire CHART ATMS.

B.6 Future Prototypes

A key element of the CHART ATMS design approach is prototyping. Prototyping has been a key part of the development process for every CHART ATMS release, and prototyping will be used throughout the implementation of the CHART ATMS whenever technology evaluation is needed or when early customer experience and feedback with a portion of the system is desired.

C DATABASE DETAILS

This appendix provides Entity Relationship Diagrams (ERDs) and data dictionary for the database schema used in the current release of the CHART ATMS. Figures C-1 and C-2 are full ERD diagrams for the entire CHAT_LIVE and CHART_Archive databases.

Table C-1 contains a data dictionary. This data dictionary includes every database table and every column (and its type) in those tables.

CHART_LIVE-R19.3.svg

Figure C-1. CHART Live ATMS Entity Relationship Diagram (double click to open)

CHART_ARCHIVE-R19.3.svg

Figure C-1. CHART Archive ATMS Entity Relationship Diagram (double click to open)

Table C-1. CHART Database Tables & Columns

Table_Name	Column_Name	Type	Size	Nullable
ALERT	ALERT_ID	char	32	No
ALERT	DESCRIPTION	varchar	1024	No
ALERT	ALERT_TYPE	numeric	5	No
ALERT	ALERT_STATE	numeric	5	No
ALERT	CREATION_TIME	datetime2	6	No
ALERT	RESPONSIBLE_USER	varchar	32	Yes
ALERT	RESPONSIBLE_CENTER_ID	char	32	Yes
ALERT	RESPONSIBLE_CENTER_NAME	varchar	16	Yes
ALERT	NEXT_ACTION_TIME	datetime2	6	Yes
ALERT	LAST_STATE_CHANGE_TIME	datetime2	6	No
ALERT	PREV_ESCALATION_RESET_TIME	datetime2	6	Yes
ALERT	DETAIL_ID1	char	32	Yes
ALERT	DETAIL_ID2	char	32	Yes
ALERT	DETAIL_TEXT1	varchar	33	Yes
ALERT	OFFLINE_INDICATOR	numeric	5	Yes
ALERT	DB_CODE	varchar	1	Yes
ALERT	DETAIL_TEXT2	varchar	20	Yes
ALERT	DETAIL_TEXT3	varchar	20	Yes
ALERT_AMG	AL_ALERT_ID	char	32	No
ALERT_AMG	ALERT_AMG_LIST_TYPE	numeric	5	No
ALERT_AMG	HIST_RECORD_INDEX	numeric	5	No
ALERT_AMG	SORT_ORDER_NUM	numeric	5	No
ALERT_AMG	AMG_TYPE	numeric	5	No
ALERT_AMG	AMG_ID	char	32	No
ALERT_AMG	AMG_NAME	varchar	16	Yes

Table_Name	Column_Name	Type	Size	Nullable
ALERT_AMG	DB_CODE	varchar	1	Yes
ALERT_HISTORY	AL_ALERT_ID	char	32	No
ALERT_HISTORY	RECORD_INDEX	numeric	5	No
ALERT_HISTORY	CHART_TIMESTAMP	datetime2	6	No
ALERT_HISTORY	ALERT_STATE	numeric	5	No
ALERT_HISTORY	ALERT_ACTION	numeric	5	No
ALERT_HISTORY	CENTER_ID	varchar	32	Yes
ALERT_HISTORY	USER_NAME	varchar	32	No
ALERT_HISTORY	USER_COMMENT	varchar	128	Yes
ALERT_HISTORY	NEXT_ACTION_TIME	datetime2	6	Yes
ALERT_HISTORY	DB_CODE	varchar	1	Yes
APPLICATION_ROLE_ASSIGNMENT	APP_APPLICATION_ID	char	32	No
APPLICATION_ROLE_ASSIGNMENT	ROL_ROLE_ID	char	32	No
ARB_QUEUE_ENTRY	DEVICE_ID	char	32	No
ARB_QUEUE_ENTRY	OWNER_ID	char	32	No
ARB_QUEUE_ENTRY	OWNER_SUB_ID	char	32	No
ARB_QUEUE_ENTRY	ENTRY_TYPE	numeric	5	No
ARB_QUEUE_ENTRY	HM_HAR_MSG_PK	char	32	Yes
ARB_QUEUE_ENTRY	DMS_MESSAGE_TEXT	varchar	1024	Yes
ARB_QUEUE_ENTRY	USE_BEACONS	numeric	5	Yes
ARB_QUEUE_ENTRY	IS_MULTI	numeric	5	Yes
ARB_QUEUE_ENTRY	USE_ALL_DEVICES	numeric	5	No
ARB_QUEUE_ENTRY	PRIORITY	numeric	17	No
ARB_QUEUE_ENTRY	CENTER_ID	char	32	No
ARB_QUEUE_ENTRY	CENTER_NAME	varchar	16	No
ARB_QUEUE_ENTRY	USER_NAME	varchar	32	No
ARBQ_ENTRY_EVENT_DATA	AQE_DEVICE_ID	char	32	No
ARBQ_ENTRY_EVENT_DATA	AQE_OWNER_ID	char	32	No
ARBQ_ENTRY_EVENT_DATA	AQE_OWNER_SUB_ID	char	32	No

Table_Name	Column_Name	Type	Size	Nullable
ARBQ_ENTRY_EVENT_DATA	EVENT_ID	char	32	No
ARBQ_ENTRY_HAR_NOTIFIER	AQE_DEVICE_ID	char	32	No
ARBQ_ENTRY_HAR_NOTIFIER	AQE_OWNER_ID	char	32	No
ARBQ_ENTRY_HAR_NOTIFIER	AQE_OWNER_SUB_ID	char	32	No
ARBQ_ENTRY_HAR_NOTIFIER	NOTIFIER_ID	char	32	No
ARBQ_ENTRY_SUB_DEVICE	AQE_DEVICE_ID	char	32	No
ARBQ_ENTRY_SUB_DEVICE	AQE_OWNER_ID	char	32	No
ARBQ_ENTRY_SUB_DEVICE	AQE_OWNER_SUB_ID	char	32	No
ARBQ_ENTRY_SUB_DEVICE	SUB_DEVICE_ID	char	32	No
Archive_Chart_Live_log	jobId	int	4	Yes
Archive_Chart_Live_log	message	varchar	8000	Yes
Archive_Chart_Live_log	rowID	int	4	No
Archive_Chart_Live_seq	ChartLiveSequenceID	int	4	No
Archive_purge_data_log	jobId	int	4	Yes
Archive_purge_data_log	message	varchar	8000	Yes
Archive_purge_data_log	rowId	int	4	No
Archive_purge_data_seq	purgeSequenceID	int	4	No
ASSOCIATED_EVENT	EVENT_EVENT_ID_ASSOC_TO	char	32	No
ASSOCIATED_EVENT	EVENT_EVENT_ID	char	32	No
ASSOCIATED_EVENT	CREATED_TIMESTAMP	datetime2	6	Yes
ASSOCIATED_EVENT	DB_CODE	varchar	1	Yes
ASSOCIATED_TRAFFIC_SIGNAL	EVENT_EVENT_ID_ASSOC_TO	char	32	No
ASSOCIATED_TRAFFIC_SIGNAL	SIGNAL_ID	char	32	No
ASSOCIATED_TRAFFIC_SIGNAL	SIGNAL_DESC	varchar	200	No
ASSOCIATED_TRAFFIC_SIGNAL	USER_DEFINED_FLAG	numeric	5	No
AVL_VEHICLE	AVL_VEHICLE_ID	varchar	100	No
AVL_VEHICLE	AVL_DRIVER_ID	varchar	100	No
AVL_VEHICLE	LAST_UPDATE	datetime2	8	No
CALL_LIST	CALL_LIST_ID	char	32	No

Table_Name	Column_Name	Type	Size	Nullable
CALL_LIST	ER_EVENT_RESOURCE_ID	char	32	Yes
CALL_LIST	ERT_EVENT_RESOURCE_TYPE_ID	char	32	Yes
CALL_LIST	CREATED_TIMESTAMP	datetime2	6	No
CALL_LIST	UPDATED_TIMESTAMP	datetime2	6	No
CALL_LIST_CONTACT	CL_CALL_LIST_ID	char	32	No
CALL_LIST_CONTACT	SORT_ORDER_NUMBER	smallint	2	No
CALL_LIST_CONTACT	CON_CONTACT_ID	char	32	No
CALL_LIST_CONTACT	CREATED_TIMESTAMP	datetime2	6	No
CALL_LIST_CONTACT	UPDATED_TIMESTAMP	datetime2	6	No
CAMERA	DEVICE_ID	char	32	No
CAMERA	CAMERA_MODEL_ID	numeric	5	No
CAMERA	ORG_ORGANIZATION_ID	char	32	No
CAMERA	DEVICE_NAME	varchar	100	No
CAMERA	LOCATION_PROFILE_TYPE	numeric	5	Yes
CAMERA	LOCATION_PROFILE_ID	char	32	Yes
CAMERA	TMDD_CCTV_IMAGE	numeric	5	Yes
CAMERA	CAMERA_NUMBER	numeric	5	Yes
CAMERA	CAMERA_CONTROLLABLE	numeric	5	No
CAMERA	TMDD_CONTROL_TYPE	numeric	5	Yes
CAMERA	TMDD_REQUEST_COMMAND_TYPES	numeric	5	No
CAMERA	ENABLE_DEVICE_LOG	numeric	5	No
CAMERA	NO_VIDEO_AVAIL_INDICATOR	numeric	5	No
CAMERA	DEVICE_LOCATION_DESC	varchar	50	Yes
CAMERA	TMDD_DEVICE_NAME	varchar	100	Yes
CAMERA	POLL_INTERVAL_CONTROLLED_SECS	numeric	5	Yes
CAMERA	POLLING_ENABLED_UNCONTROLLED	numeric	5	Yes
CAMERA	DEFAULT_CAMERA_TITLE	varchar	24	Yes
CAMERA	DEFAULT_CAMERA_TITLE_LINE2	varchar	24	Yes
CAMERA	CONTROL_CONNECTION_TYPE	numeric	5	Yes

Table_Name	Column_Name	Type	Size	Nullable
CAMERA	CONTROL_CONNECTION_ID	char	32	Yes
CAMERA	POLL_INTERVAL_UNCTRLD_SECS	numeric	5	Yes
CAMERA	DB_CODE	varchar	1	Yes
CAMERA	CREATED_TIMESTAMP	datetime2	6	Yes
CAMERA	UPDATED_TIMESTAMP	datetime2	6	Yes
CAMERA	DSP_STATUS_ENABLED	numeric	5	Yes
CAMERA	DSP_STATUS_LENGTH	numeric	5	Yes
CAMERA	MAINT_ORGANIZATION_ID	char	32	Yes
CAMERA	SMNP_COMMUNITY_STRING	varchar	30	Yes
CAMERA	HDLC_FRAME_REQUIRED	numeric	5	Yes
CAMERA	MINIMUM_PAN_SPEED	numeric	5	Yes
CAMERA	MAXIMUM_PAN_SPEED	numeric	5	Yes
CAMERA	MINIMUM_TILT_SPEED	numeric	5	Yes
CAMERA	MAXIMUM_TILT_SPEED	numeric	5	Yes
CAMERA	ZOOM_SPEED	numeric	5	Yes
CAMERA	FOCUS_SPEED	numeric	5	Yes
CAMERA	MIN_ZOOM_POSITION	numeric	5	Yes
CAMERA	MAX_ZOOM_POSITION	numeric	5	Yes
CAMERA	DS_ELIGIBLE	numeric	5	Yes
CAMERA	MOBILE	bit	1	No
CAMERA	COMMISSIONED_DATE	date	3	Yes
CAMERA	MANAGED_EXPORT	bit	1	Yes
CAMERA_CATEGORY_ENTRY	CAM_CAMERA_ID	char	32	No
CAMERA_CATEGORY_ENTRY	CATEGORY_NAME	varchar	50	No
CAMERA_CATEGORY_ENTRY	CREATED_TIMESTAMP	datetime2	6	No
CAMERA_CATEGORY_ENTRY	UPDATED_TIMESTAMP	datetime2	6	No
CAMERA_MONITOR	CAMERA_DEVICE_ID	char	32	No
CAMERA_MONITOR	TOUR_ID	char	32	Yes
CAMERA_MONITOR	TOUR_SUSPENDED_INDICATOR	numeric	5	Yes

Table_Name	Column_Name	Type	Size	Nullable
CAMERA_MONITOR	MONITOR_DEVICE_ID	char	32	No
CAMERA_PRESET	CAMERA_DEVICE_ID	char	32	No
CAMERA_PRESET	PRESET_NUM	numeric	5	No
CAMERA_PRESET	DESCRIPTION	varchar	24	Yes
CAMERA_PRESET	FOCUS	numeric	5	Yes
CAMERA_PRESET	ZOOM	numeric	5	Yes
CAMERA_PRESET	PAN	numeric	5	Yes
CAMERA_PRESET	TILT	numeric	5	Yes
CAMERA_REGION_ENTRY	CAM_CAMERA_ID	char	32	No
CAMERA_REGION_ENTRY	REGION_NAME	varchar	50	No
CAMERA_REVOKED_CONTROL	CAM_CAMERA_ID	char	32	No
CAMERA_REVOKED_CONTROL	REVOKED_CONTROL_ORGID	char	32	No
CAMERA_REVOKED_DISPLAY	CAM_CAMERA_ID	char	32	No
CAMERA_REVOKED_DISPLAY	REVOKED_DISPLAY_ORGID	char	32	No
CAMERA_STATUS	CAMERA_DEVICE_ID	char	32	No
CAMERA_STATUS	SHORT_ERROR_STATUS	numeric	5	Yes
CAMERA_STATUS	AUTO_FOCUS_INDICATOR	numeric	5	Yes
CAMERA_STATUS	AUTO_IRIS_INDICATOR	numeric	5	Yes
CAMERA_STATUS	AUTO_COLOR_INDICATOR	numeric	5	Yes
CAMERA_STATUS	TMDD_CCTV_STATUS	numeric	5	Yes
CAMERA_STATUS	POWER_STATE	numeric	5	Yes
CAMERA_STATUS	LENS_SPEED	numeric	5	Yes
CAMERA_STATUS	COMM_MODE	numeric	5	No
CAMERA_STATUS	TMDD_CCTV_ERROR	numeric	5	Yes
CAMERA_STATUS	DEVICE_STATUS_CHANGE_SECS	datetime2	6	Yes
CAMERA_STATUS	CONTROL_INDICATOR	numeric	5	Yes
CAMERA_STATUS	USER_DISPLAY_STATUS	numeric	5	Yes
CAMERA_STATUS	MONITOR_STAT_CHANGE_TIME_SECS	datetime2	6	Yes
CAMERA_STATUS	CURRENT_CAMERA_TITLE	varchar	24	Yes

Table_Name	Column_Name	Type	Size	Nullable
CAMERA_STATUS	CURRENT_CAMERA_TITLE_LINE2	varchar	24	Yes
CAMERA_STATUS	LAST_ATTEMPTED_POLL_TIME_SECS	datetime2	6	Yes
CAMERA_STATUS	LAST_SUCCESSFUL_POLL_TIME_SECS	datetime2	6	Yes
CAMERA_STATUS	LAST_CONTACT_TIME_SECS	datetime2	6	Yes
CAMERA_STATUS	USER_CONTROL_STATUS	numeric	5	Yes
CAMERA_STATUS	CONTROLLING_MONITOR_GROUP_ID	char	32	Yes
CAMERA_STATUS	CONTROLLING_USER_NAME	varchar	50	Yes
CAMERA_STATUS	CONTROLLING_OP_CENTER_ID	char	32	Yes
CAMERA_STATUS	OP_STATUS	numeric	5	Yes
CAMERA_STATUS	LAST_COMMAND_TIME_SECS	datetime2	6	Yes
CAMERA_STATUS	BLOCKED_TO_PUBLIC	numeric	5	Yes
CAMERA_STATUS	CURRENT_CAMERA_PRESET	numeric	5	Yes
CAMERA_STATUS	CONTROL_MONITOR_REQUIRED	numeric	5	Yes
CAMERA_TEMP_PRESET	TEMP_PRESET_ID	char	32	No
CAMERA_TEMP_PRESET	CAMERA_DEVICE_ID	char	32	No
CAMERA_TEMP_PRESET	OWNER_ID	char	32	No
CAMERA_TEMP_PRESET	OWNER_TYPE	numeric	5	Yes
CAMERA_TEMP_PRESET	PRESET_NUM	numeric	5	Yes
CAMERA_TEMP_PRESET	DESCRIPTION	varchar	24	Yes
CAMERA_TEMP_PRESET	FOCUS	numeric	5	Yes
CAMERA_TEMP_PRESET	ZOOM	numeric	5	Yes
CAMERA_TEMP_PRESET	PAN	numeric	5	Yes
CAMERA_TEMP_PRESET	TILT	numeric	5	Yes
CAMERA_VIDEO_CONNECTION	CONNECTION_ID	char	32	No
CAMERA_VIDEO_CONNECTION	CAMERA_DEVICE_ID	char	32	No
CAMERA_VIDEO_CONNECTION_BAK	CONNECTION_ID	char	32	No
CAMERA_VIDEO_CONNECTION_BAK	CONNECTION_TYPE	numeric	5	No
CAMERA_VIDEO_CONNECTION_BAK	CAMERA_DEVICE_ID	char	32	No
CAMERA_VIDEO_CONNECTION_BAK2	CONNECTION_ID	char	32	No

Table_Name	Column_Name	Type	Size	Nullable
CAMERA_VIDEO_CONNECTION_BAK2	CONNECTION_TYPE	numeric	5	No
CAMERA_VIDEO_CONNECTION_BAK2	CAMERA_DEVICE_ID	char	32	No
CAMERA_VIDEO_CONNECTION_DROPPED_ROWS	CONNECTION_ID	char	32	No
CAMERA_VIDEO_CONNECTION_DROPPED_ROWS	CONNECTION_TYPE	numeric	5	No
CAMERA_VIDEO_CONNECTION_DROPPED_ROWS	CAMERA_DEVICE_ID	char	32	No
CENTER	CENTER_ID	char	32	No
CENTER	CENTER_NAME	varchar	16	No
CENTER	CREATED_TIMESTAMP	datetime2	6	Yes
CENTER	UPDATED_TIMESTAMP	datetime2	6	Yes
CENTER	DB_CODE	varchar	1	Yes
CENTER	MG_DEFAULT_MONITOR_GROUP_ID	char	32	Yes
CENTER	CENTER_OWNING_ORGANIZATION	char	32	Yes
CENTER	MAX_VIDEO_SESSIONS	numeric	5	Yes
CENTER_BACKUP_CENTER	CEN_CENTER_ID	char	32	No
CENTER_BACKUP_CENTER	BACKUP_CENTER_ID	char	32	No
CENTER_BACKUP_CENTER	DB_CODE	varchar	1	Yes
CENTER_EVENT_RESOURCE	CEN_CENTER_ID	char	32	No
CENTER_EVENT_RESOURCE	ER_EVENT_RESOURCE_ID	char	32	No
CENTER_EVENT_RESOURCE_TYPE	CEN_CENTER_ID	char	32	No
CENTER_EVENT_RESOURCE_TYPE	ERT_EVENT_RESOURCE_TYPE_ID	char	32	No
CENTER_HANDOFF_REPORT	CENTER_ID	char	32	No
CENTER_HANDOFF_REPORT	SAVED_BY_USER	varchar	32	No
CENTER_HANDOFF_REPORT	SAVED_TIMESTAMP	datetime2	6	No
CENTER_HANDOFF_REPORT	REPORT_TEXT	varchar	2048	Yes
CENTER_HISTORY	CEN_CENTER_ID	char	32	No
CENTER_HISTORY	PREVIOUS_CENTER_NAME	varchar	16	No
CENTER_HISTORY	FIRST_USED_TIMESTAMP	datetime2	6	No
CENTER_HISTORY	LAST_USED_TIMESTAMP	datetime2	8	No
CENTER_HISTORY	DELETED_INDICATOR	numeric	5	Yes

Table_Name	Column_Name	Type	Size	Nullable
CENTER_HISTORY	DB_CODE	varchar	1	Yes
CENTER_LOGIN	CEN_CENTER_ID	char	32	No
CENTER_LOGIN	LOGIN_SESSION_IOR	varchar	1024	No
CENTER_LOGIN	USER_NAME	varchar	32	Yes
CENTER_LOGIN	LOGIN_SESSION_ID	varchar	32	No
CENTER_LOGIN	CLIENT_LOCATION	varchar	128	Yes
CENTER_LOGIN	SESSION_START_TIMESTAMP	datetime2	6	No
CENTER_PATROL_AREA	CEN_CENTER_ID	char	32	No
CENTER_PATROL_AREA	PA_PATROL_AREA_ID	char	32	No
CENTER_PATROL_AREA	CREATED_TIMESTAMP	datetime2	6	No
CENTER_PATROL_AREA	UPDATED_TIMESTAMP	datetime2	6	No
CENTER_PERMIT_FILTER	CEN_CENTER_ID	char	32	No
CENTER_PERMIT_FILTER	TRACKING_NUM_BEGINS_WITH	varchar	50	No
CENTER_PERMIT_FILTER	CREATED_TIMESTAMP	datetime2	6	No
CENTER_PERMIT_FILTER	UPDATED_TIMESTAMP	datetime2	6	No
CH2_DICTIONARY	DICTIONARY_ID	char	32	No
CH2_DICTIONARY	DICTIONARY_DESC	varchar	255	Yes
CH2_DICTIONARY	DB_CODE	varchar	1	Yes
CHART_ACTION	EVENT_EVENT_ID	char	32	No
CHART_ACTION	ACTION_EVENT_CODE	numeric	5	No
CHART_ACTION	CREATED_TIMESTAMP	datetime2	6	Yes
CHART_ACTION	DB_CODE	varchar	1	Yes
CHART_ACTION	DESCRIPTION	varchar	60	Yes
CHART_PLAN	PLAN_ID	char	32	No
CHART_PLAN	PLAN_NAME	varchar	60	No
CHART_PLAN	DB_CODE	varchar	1	Yes
CHART_PLAN	CREATE_NAME	varchar	40	Yes
CHART_PLAN	CREATE_TIME	datetime2	6	Yes
CHART_PLAN	LAST_USED_TIME	datetime2	6	Yes

Table_Name	Column_Name	Type	Size	Nullable
CHART_PLAN	DS_ELIGIBLE	numeric	5	No
CHART_ROLE	ROLE_ID	char	32	No
CHART_ROLE	ROLE_NAME	varchar	32	No
CHART_ROLE	ROLE_DESCRIPTION	varchar	255	Yes
CHART_ROLE	DB_CODE	varchar	1	Yes
CHART_TRIGGER	TRIGGER_ID	char	32	No
CHART_TRIGGER	TRIGGER_NAME	varchar	100	No
CHART_TRIGGER	TRIGGER_ENABLED	bit	1	No
CHART_TRIGGER	TRIGGER_LAST_ACTIVE	datetime2	6	Yes
CHART_TRIGGER	CREATED_TIMESTAMP	datetime2	6	No
CHART_TRIGGER	UPDATED_TIMESTAMP	datetime2	6	No
CODE_LIST	CODE_TYPE_NAME	varchar	30	No
CODE_LIST	CREATED_TIMESTAMP	datetime2	6	Yes
CODE_LIST	UPDATED_TIMESTAMP	datetime2	6	Yes
CODE_LIST	DB_CODE	varchar	1	Yes
CODE_LIST_ITEM	CDL_CODE_TYPE_NAME	varchar	30	No
CODE_LIST_ITEM	TYPE_CODE	numeric	5	No
CODE_LIST_ITEM	TYPE_NAME	varchar	240	No
CODE_LIST_ITEM	ACTIVE_INDICATOR	numeric	5	Yes
CODE_LIST_ITEM	SORT_ORDER_NUMBER	numeric	5	Yes
CODE_LIST_ITEM	CREATED_TIMESTAMP	datetime2	6	Yes
CODE_LIST_ITEM	UPDATED_TIMESTAMP	datetime2	6	Yes
CODE_LIST_ITEM	DB_CODE	varchar	1	Yes
CODEC	CODEC_ID	char	32	No
CODEC	CONNECTION_MODEL_TYPE	numeric	5	No
CODEC	CODEC_HOST	varchar	16	No
CODEC	CODEC_COMMAND_PORT	numeric	5	No
CODEC	CODEC_VIDEO_PORT	numeric	5	Yes
CODEC	RVDS_MAC_ADDR	char	17	Yes

Table_Name	Column_Name	Type	Size	Nullable
CODEC	RVDS_VIRT_MON_NUM	tinyint	1	Yes
CODEC_CONTROL_CONNECTION	CODEC_CONTROL_CONNECTION_ID	char	32	No
CODEC_CONTROL_CONNECTION	COD_CODEC_ID	char	32	No
CODEC_CONTROL_CONNECTION	CONTROL_PORT	numeric	5	No
CODEC_CONTROL_CONNECTION	BAUD_RATE	numeric	5	No
CODEC_CONTROL_CONNECTION	DATA_BITS	numeric	5	No
CODEC_CONTROL_CONNECTION	FLOW_CONTROL	numeric	5	No
CODEC_CONTROL_CONNECTION	PARITY	numeric	5	No
CODEC_CONTROL_CONNECTION	STOP_BITS	numeric	5	No
CODEC_STREAMING_SERVER	COD_CODEC_ID	char	32	No
CODEC_STREAMING_SERVER	SSC_ID	char	32	No
CODEC_VIDEO_CONNECTION	CODEC_VIDEO_CONNECTION_ID	char	32	No
CODEC_VIDEO_CONNECTION	COD_CODEC_ID	char	32	No
CODEC_VIDEO_CONNECTION	VIDEO_MULTICAST_ADDRESS	varchar	16	Yes
CODEC_VIDEO_CONNECTION	VIDEO_MULTICAST_PORT	numeric	5	Yes
CODEC_VIDEO_CONNECTION	FABRIC_ID	char	32	No
CODEC_VIDEO_CONNECTION_BAK	CODEC_VIDEO_CONNECTION_ID	char	32	No
CODEC_VIDEO_CONNECTION_BAK	COD_CODEC_ID	char	32	No
CODEC_VIDEO_CONNECTION_BAK	VIDEO_MULTICAST_ADDRESS	varchar	16	Yes
CODEC_VIDEO_CONNECTION_BAK	VIDEO_MULTICAST_PORT	numeric	5	Yes
CODEC_VIDEO_CONNECTION_BAK	FABRIC_ID	char	32	No
COM_PORT_CONTROL_CONNECTION	COM_PORT_CONTROL_CONNECTION_ID	char	32	No
COM_PORT_CONTROL_CONNECTION	COM_PORT_NAME	varchar	16	No
COM_PORT_CONTROL_CONNECTION	BAUD_RATE	numeric	5	No
COM_PORT_CONTROL_CONNECTION	DATA_BITS	numeric	5	No
COM_PORT_CONTROL_CONNECTION	FLOW_CONTROL	numeric	5	No
COM_PORT_CONTROL_CONNECTION	PARITY	numeric	5	No
COM_PORT_CONTROL_CONNECTION	STOP_BITS	numeric	5	No
COMMUNICATIONS_FAILURE_LOG	COM_FAIL_LOG_ID	int	4	No

Table_Name	Column_Name	Type	Size	Nullable
COMMUNICATIONS_FAILURE_LOG	PORT_MANAGER_NAME	varchar	30	No
COMMUNICATIONS_FAILURE_LOG	PORT_TYPE	numeric	5	No
COMMUNICATIONS_FAILURE_LOG	PORT_NAME	varchar	30	Yes
COMMUNICATIONS_FAILURE_LOG	FAILURE_CODE	numeric	5	No
COMMUNICATIONS_FAILURE_LOG	MODEM_RESPONSE_CODE	numeric	5	Yes
COMMUNICATIONS_FAILURE_LOG	SYSTEM_TIMESTAMP	datetime2	6	No
COMMUNICATIONS_FAILURE_LOG	LOG_TEXT	varchar	1024	No
COMMUNICATIONS_LOG	LOG_ENTRY_ID	char	32	No
COMMUNICATIONS_LOG	EVENT_EVENT_ID	char	32	Yes
COMMUNICATIONS_LOG	DB_CODE	varchar	1	Yes
COMMUNICATIONS_LOG	SYSTEM_TIMESTAMP	datetime2	6	No
COMMUNICATIONS_LOG	USER_TIMESTAMP	datetime2	6	No
COMMUNICATIONS_LOG	SOURCE_CODE	numeric	5	No
COMMUNICATIONS_LOG	AUTHOR	varchar	32	No
COMMUNICATIONS_LOG	CEN_CENTER_ID	char	32	No
COMMUNICATIONS_LOG	CENTER_NAME	varchar	16	No
COMMUNICATIONS_LOG	HOST_NAME	varchar	255	No
COMMUNICATIONS_LOG	UPDATED_TIMESTAMP	datetime2	6	Yes
COMMUNICATIONS_LOG	LOG_SEQ	numeric	9	No
COMMUNICATIONS_LOG	SOURCE_DESCRIPTION	varchar	60	Yes
COMMUNICATIONS_LOG	LOG_TEXT	varchar	1024	No
COMMUNICATIONS_LOG	MESSAGE_TYPE	numeric	5	No
CONSTITUENT_HAR	MASTER_HAR_ID	char	32	No
CONSTITUENT_HAR	HAR_ID	char	32	No
CONTACT	CONTACT_ID	char	32	No
CONTACT	FIRST_NAME	varchar	50	Yes
CONTACT	LAST_NAME	varchar	50	Yes
CONTACT	AGENCY_NAME	varchar	128	Yes
CONTACT	ATMS_USER_NAME	varchar	32	Yes

Table_Name	Column_Name	Type	Size	Nullable
CONTACT	BUSINESS_ADDRESS	varchar	256	Yes
CONTACT	MEMO	varchar	256	Yes
CONTACT	OFFICE_OR_SHOP	varchar	128	Yes
CONTACT	RADIO_CALL_SIGN	varchar	32	Yes
CONTACT	TITLE	varchar	128	Yes
CONTACT	OFFLINE_IND	bit	1	No
CONTACT	CREATED_TIMESTAMP	datetime2	6	No
CONTACT	UPDATED_TIMESTAMP	datetime2	6	No
CONTACT	ALLOW_RESOURCE	bit	1	No
CONTACT_AOR	CON_CONTACT_ID	char	32	No
CONTACT_AOR	AOR_ID	char	32	No
CONTACT_AOR	CREATED_TIMESTAMP	datetime2	6	No
CONTACT_AOR	UPDATED_TIMESTAMP	datetime2	6	No
CONTACT_CENTER	CON_CONTACT_ID	char	32	No
CONTACT_CENTER	CEN_CENTER_ID	char	32	No
CONTACT_CENTER	CREATED_TIMESTAMP	datetime2	6	No
CONTACT_CENTER	UPDATED_TIMESTAMP	datetime2	6	No
CONTACT_DNC_SCHEDULE_ENTRY	CON_CONTACT_ID	char	32	No
CONTACT_DNC_SCHEDULE_ENTRY	SORT_ORDER_NUMBER	tinyint	1	No
CONTACT_DNC_SCHEDULE_ENTRY	BEGIN_DATE	date	3	Yes
CONTACT_DNC_SCHEDULE_ENTRY	THROUGH_DATE	date	3	Yes
CONTACT_DNC_SCHEDULE_ENTRY	SUN	bit	1	No
CONTACT_DNC_SCHEDULE_ENTRY	MON	bit	1	No
CONTACT_DNC_SCHEDULE_ENTRY	TUE	bit	1	No
CONTACT_DNC_SCHEDULE_ENTRY	WED	bit	1	No
CONTACT_DNC_SCHEDULE_ENTRY	THU	bit	1	No
CONTACT_DNC_SCHEDULE_ENTRY	FRI	bit	1	No
CONTACT_DNC_SCHEDULE_ENTRY	SAT	bit	1	No
CONTACT_DNC_SCHEDULE_ENTRY	AFTER_TIME_OF_DAY	time	3	Yes

Table_Name	Column_Name	Type	Size	Nullable
CONTACT_DNC_SCHEDULE_ENTRY	UNTIL_TIME_OF_DAY	time	3	Yes
CONTACT_DNC_SCHEDULE_ENTRY	CREATED_TIMESTAMP	datetime2	6	No
CONTACT_DNC_SCHEDULE_ENTRY	UPDATED_TIMESTAMP	datetime2	6	No
CONTACT_EMAIL	CON_CONTACT_ID	char	32	No
CONTACT_EMAIL	SORT_ORDER_NUMBER	tinyint	1	No
CONTACT_EMAIL	EMAIL_TYPE	tinyint	1	No
CONTACT_EMAIL	EMAIL_ADDRESS	varchar	128	No
CONTACT_EMAIL	ALLOW_NOTIFICATION	bit	1	No
CONTACT_EMAIL	CREATED_TIMESTAMP	datetime2	6	No
CONTACT_EMAIL	UPDATED_TIMESTAMP	datetime2	6	No
CONTACT_PHONE_NUMBER	CON_CONTACT_ID	char	32	No
CONTACT_PHONE_NUMBER	SORT_ORDER_NUMBER	tinyint	1	No
CONTACT_PHONE_NUMBER	PHONE_NUMBER_TYPE	tinyint	1	No
CONTACT_PHONE_NUMBER	PHONE_NUMBER	varchar	32	No
CONTACT_PHONE_NUMBER	CREATED_TIMESTAMP	datetime2	6	No
CONTACT_PHONE_NUMBER	UPDATED_TIMESTAMP	datetime2	6	No
CONTACT_PHONE_NUMBER	PHONE_EXTENSION	varchar	6	Yes
DDCF_FONT_CHAR	DDC_DISPLAY_CONF_ID	varchar	32	No
DDCF_FONT_CHAR	FONT_NUMBER	numeric	5	No
DDCF_FONT_CHAR	CHARACTER	numeric	5	No
DDCF_FONT_CHAR	WIDTH_PIXELS	numeric	5	No
DDCF_FONT_CHAR	BITMAP	varchar	4000	No
DEVICE_EVENT	DEVICE_ID	char	32	No
DEVICE_EVENT	EVENT_EVENT_ID	char	32	No
DEVICE_EVENT	RPI_RPI_ID	char	32	No
DEVICE_EVENT	DEVICE_USAGE_CODE	numeric	5	No
DICTIONARY_PASSWORD_WORD	DICTIONARY_WORD	varchar	40	No
DICTIONARY_PASSWORD_WORD	WORD_SOURCE	numeric	5	No
DICTIONARY_WORD	CD_DICTIONARY_ID	char	32	No

Table_Name	Column_Name	Type	Size	Nullable
DICTIONARY_WORD	DICTIONARY_WORD	varchar	255	No
DICTIONARY_WORD	DEVICE_APPLICABILITY	numeric	5	No
DICTIONARY_WORD	APPROVED_CODE	numeric	5	No
DICTIONARY_WORD	DB_CODE	varchar	1	Yes
DISABLED_VEHICLE_INDICATOR	EVENT_EVENT_ID	char	32	No
DISABLED_VEHICLE_INDICATOR	DISABLED_VEHICLE_INDICATOR_COD	numeric	5	No
DISABLED_VEHICLE_INDICATOR	DB_CODE	varchar	1	Yes
DISABLED_VEHICLE_INDICATOR	CREATED_TIMESTAMP	datetime2	6	Yes
DMS	DEVICE_ID	char	32	No
DMS	DMS_MODEL_ID	numeric	5	No
DMS	ORG_ORGANIZATION_ID	char	32	No
DMS	DB_CODE	varchar	1	Yes
DMS	DEVICE_NAME	varchar	15	No
DMS	HAR_DEVICE_ID	char	32	Yes
DMS	COMM_LOSS_TIMEOUT	numeric	9	No
DMS	DROP_ADDRESS	numeric	5	No
DMS	INITIAL_RESPONSE_TIMEOUT	numeric	9	No
DMS	BEACON_TYPE	numeric	5	Yes
DMS	SIGN_TYPE	numeric	5	Yes
DMS	DEFAULT_PHONE_NUMBER	varchar	25	Yes
DMS	POLL_INTERVAL	numeric	5	No
DMS	POLLING_ENABLED	numeric	5	No
DMS	PORT_TYPE	numeric	5	Yes
DMS	PORT_MANAGER_TIMEOUT	numeric	5	Yes
DMS	BAUD_RATE	numeric	5	Yes
DMS	DATA_BITS	numeric	5	Yes
DMS	FLOW_CONTROL	numeric	5	Yes
DMS	PARITY	numeric	5	Yes
DMS	STOP_BITS	numeric	5	Yes

Table_Name	Column_Name	Type	Size	Nullable
DMS	ENABLE_DEVICE_LOG	numeric	5	No
DMS	VMS_CHARACTER_HEIGHT_PIXELS	numeric	5	Yes
DMS	VMS_CHARACTER_WIDTH_PIXELS	numeric	5	Yes
DMS	VMS_MAX_PAGES	numeric	5	Yes
DMS	VMS_SIGN_HEIGHT_PIXELS	numeric	5	Yes
DMS	VMS_SIGN_WIDTH_PIXELS	numeric	5	Yes
DMS	CREATED_TIMESTAMP	datetime2	6	Yes
DMS	UPDATED_TIMESTAMP	datetime2	6	Yes
DMS	SHAZAM_BEACON_STATE	numeric	5	No
DMS	SHAZAM_IS_MESSAGE_TEXT_MULTI	numeric	5	No
DMS	DMS_SHAZAM_MSG	varchar	1024	Yes
DMS	COMMUNITY_STRING	varchar	16	Yes
DMS	TRAVEL_TIME_QUEUE_LEVEL	numeric	5	Yes
DMS	TOLL_RATE_QUEUE_LEVEL	numeric	5	Yes
DMS	OVERRIDE_SCHEDULE_IND	numeric	5	Yes
DMS	ENABLED_SPECIFIC_TIMES_IND	numeric	5	Yes
DMS	TCP_HOST	varchar	16	Yes
DMS	TCP_PORT	numeric	5	Yes
DMS	EXT_ID_SYSTEM_ID	varchar	35	Yes
DMS	EXT_ID_AGENCY_ID	varchar	35	Yes
DMS	EXT_ID_DMS_ID	varchar	256	Yes
DMS	HDLC_FRAME_REQUIRED	numeric	5	Yes
DMS	MAINT_ORGANIZATION_ID	char	32	Yes
DMS	DDC_DMS_DISPLAY_CONF_ID	char	32	No
DMS	DS_ELIGIBLE	numeric	5	No
DMS	COMMISSIONED_DATE	date	3	Yes
DMS	MANAGED_EXPORT	bit	1	Yes
DMS	NTCIP_FONT_MGMT_OPTION	tinyint	1	Yes
DMS_COMM_LOSS_TIMEOUT_BACKUP	BACKUP_ID	char	32	No

Table_Name	Column_Name	Type	Size	Nullable
DMS_COMM_LOSS_TIMEOUT_BACKUP	CENTER_NAME	varchar	16	No
DMS_COMM_LOSS_TIMEOUT_BACKUP	USERNAME	varchar	32	No
DMS_COMM_LOSS_TIMEOUT_BACKUP	BACKUP_COMMENT	varchar	256	No
DMS_COMM_LOSS_TIMEOUT_BACKUP	BACKUP_TIME	datetime2	6	No
DMS_COMM_LOSS_TIMEOUT_BACKUP_ENTRY	BACKUP_ID	char	32	No
DMS_COMM_LOSS_TIMEOUT_BACKUP_ENTRY	DMS_DMS_ID	char	32	No
DMS_COMM_LOSS_TIMEOUT_BACKUP_ENTRY	TIMEOUT_MINS	int	4	No
DMS_DISPLAY_CONF_FONT	DDC_DISPLAY_CONF_ID	varchar	32	No
DMS_DISPLAY_CONF_FONT	FONT_NUMBER	numeric	5	No
DMS_DISPLAY_CONF_FONT	CHAR_SPACING_PIXELS	numeric	5	No
DMS_DISPLAY_CONF_FONT	LINE_SPACING_PIXELS	numeric	5	No
DMS_DISPLAY_CONF_FONT	NAME	varchar	50	No
DMS_DISPLAY_CONF_FONT	HEIGHT_PIXELS	numeric	5	No
DMS_DISPLAY_CONF_FONT	DEFAULT_CHAR_SPACING_PIXELS	numeric	5	No
DMS_DISPLAY_CONF_FONT	DEFAULT_LINE_SPACING_PIXELS	numeric	5	No
DMS_DISPLAY_CONFIG	DMS_DISPLAY_CONF_ID	varchar	32	No
DMS_DISPLAY_CONFIG	DMS_DISPLAY_CONF_NAME	varchar	120	Yes
DMS_DISPLAY_CONFIG	SOURCE_TYPE	numeric	5	No
DMS_DISPLAY_CONFIG	VMS_SIGN_HEIGHT_PIXELS	numeric	5	No
DMS_DISPLAY_CONFIG	VMS_SIGN_WIDTH_PIXELS	numeric	5	No
DMS_DISPLAY_CONFIG	VMS_CHARACTER_HEIGHT_PIXELS	numeric	5	No
DMS_DISPLAY_CONFIG	VMS_CHARACTER_WIDTH_PIXELS	numeric	5	No
DMS_DISPLAY_CONFIG	DEFAULT_JUSTIFICATION_LINE	numeric	5	No
DMS_DISPLAY_CONFIG	DEFAULT_JUSTIFICATION_PAGE	numeric	5	No
DMS_DISPLAY_CONFIG	DEFAULT_PAGE_ON_TIME_TENTHS	numeric	5	No
DMS_DISPLAY_CONFIG	DEFAULT_PAGE_OFF_TIME_TENTHS	numeric	5	No
DMS_DISPLAY_CONFIG	HAS_BEACONS	numeric	5	No
DMS_DISPLAY_CONFIG	MAX_ROWS_PER_PAGE_ALLOWED	numeric	5	No
DMS_DISPLAY_CONFIG	MAX_CHARACTERS_PER_ROW_ALLOWED	numeric	5	No

Table_Name	Column_Name	Type	Size	Nullable
DMS_DISPLAY_CONFIG	MAX_PAGES_ALLOWED	numeric	5	No
DMS_DISPLAY_CONFIG	LAST_UPDATE_TIME	datetime2	8	No
DMS_PHONE_NUMBER	DMS_DEVICE_ID	char	32	No
DMS_PHONE_NUMBER	PORT_MANAGER_NAME	varchar	30	No
DMS_PHONE_NUMBER	PHONE_NUMBER	varchar	25	No
DMS_PHONE_NUMBER	SORT_ORDER_NUMBER	numeric	5	No
DMS_PHONE_NUMBER	DB_CODE	varchar	1	Yes
DMS_RELATED_ROUTE	DMS_DEVICE_ID	char	32	No
DMS_RELATED_ROUTE	TRAVEL_ROUTE_ID	char	32	No
DMS_STATUS	CEN_CENTER_ID	char	32	Yes
DMS_STATUS	DEVICE_STATE_CODE	numeric	5	No
DMS_STATUS	BEACON_STATE	numeric	5	No
DMS_STATUS	PIXEL_TEST	numeric	5	No
DMS_STATUS	DMS_INITIALIZED	numeric	5	No
DMS_STATUS	COMM_STATUS	numeric	5	No
DMS_STATUS	LAST_CONTACT_TIME	datetime2	6	Yes
DMS_STATUS	SHORT_ERROR_STATUS	numeric	5	No
DMS_STATUS	STATUS_CHANGE_TIME	datetime2	6	Yes
DMS_STATUS	STATUS_LOG_DATE	datetime2	6	Yes
DMS_STATUS	LAST_ATTEMPTED_POLL_TIME	datetime2	6	Yes
DMS_STATUS	CURRENT_MESSAGE_TEXT	varchar	1024	Yes
DMS_STATUS	TRAV_MSG_ID	char	32	Yes
DMS_STATUS	TRAV_MSG_STATE	numeric	5	Yes
DMS_STATUS	TRAV_MSG_REASON	varchar	4000	Yes
DMS_STATUS	CONTROL_MODE	numeric	5	Yes
DMS_STATUS	MESSAGE_SOURCE	numeric	5	Yes
DMS_STATUS	DETECTED_SIZE_HORIZ_PIXELS	numeric	5	Yes
DMS_STATUS	DETECTED_SIZE_VERT_PIXELS	numeric	5	Yes
DMS_STATUS	FONT_VERSION_ID	int	4	Yes

Table_Name	Column_Name	Type	Size	Nullable
DMS_TRAV_ROUTE_MSG	DMS_DEVICE_ID	char	32	No
DMS_TRAV_ROUTE_MSG	MSG_ID	char	32	No
DMS_TRAV_ROUTE_MSG	TEMPLATE_ID	char	32	No
DMS_TRAV_ROUTE_MSG	AUTO_ROW_POSITIONING_IND	numeric	5	No
DMS_TRAV_ROUTE_MSG	HOLIDAY_APPLICABILITY	numeric	5	No
DMS_TRAV_ROUTE_MSG	DOW_MON	numeric	5	No
DMS_TRAV_ROUTE_MSG	DOW_TUE	numeric	5	No
DMS_TRAV_ROUTE_MSG	DOW_WED	numeric	5	No
DMS_TRAV_ROUTE_MSG	DOW_THU	numeric	5	No
DMS_TRAV_ROUTE_MSG	DOW_FRI	numeric	5	No
DMS_TRAV_ROUTE_MSG	DOW_SAT	numeric	5	No
DMS_TRAV_ROUTE_MSG	DOW_SUN	numeric	5	No
DMS_TRAV_ROUTE_MSG	ENABLED	numeric	5	No
DMS_TRAV_ROUTE_MSG	SORT_ORDER	numeric	5	No
DMS_TRAV_ROUTE_MSG_CONFIG_LOG	DMS_DEVICE_ID	varchar	32	No
DMS_TRAV_ROUTE_MSG_CONFIG_LOG	DEVICE_NAME	varchar	15	No
DMS_TRAV_ROUTE_MSG_CONFIG_LOG	SCHEDULE_CONFIG_FLAG	numeric	5	No
DMS_TRAV_ROUTE_MSG_HOLIDAY	HOLIDAY_DESCRIPTION	varchar	512	No
DMS_TRAV_ROUTE_MSG_HOLIDAY	HOLIDAY_DATE	date	3	No
DMS_TRAV_ROUTE_MSG_MSGS_LOG	SYSTEM_TIMESTAMP	datetime2	6	No
DMS_TRAV_ROUTE_MSG_MSGS_LOG	MSGS_LOG_SEQUENCE	numeric	9	No
DMS_TRAV_ROUTE_MSG_MSGS_LOG	DMS_DEVICE_ID	varchar	32	No
DMS_TRAV_ROUTE_MSG_MSGS_LOG	DMS_TRAV_ROUTE_MSG_ID	varchar	32	No
DMS_TRAV_ROUTE_MSG_MSGS_LOG	DMS_TRAV_ROUTE_MSG_TEMPLATE_ID	varchar	4000	No
DMS_TRAV_ROUTE_MSG_MSGS_LOG	AUTO_ROW_POSITIONING_IND	numeric	5	Yes
DMS_TRAV_ROUTE_MSG_MSGS_LOG	HOLIDAY_APPLICABILITY	numeric	5	Yes
DMS_TRAV_ROUTE_MSG_MSGS_LOG	DOW_MON	numeric	5	Yes
DMS_TRAV_ROUTE_MSG_MSGS_LOG	DOW_TUE	numeric	5	Yes
DMS_TRAV_ROUTE_MSG_MSGS_LOG	DOW_WED	numeric	5	Yes

Table_Name	Column_Name	Type	Size	Nullable
DMS_TRAV_ROUTE_MSG_MSGS_LOG	DOW_THU	numeric	5	Yes
DMS_TRAV_ROUTE_MSG_MSGS_LOG	DOW_FRI	numeric	5	Yes
DMS_TRAV_ROUTE_MSG_MSGS_LOG	DOW_SAT	numeric	5	Yes
DMS_TRAV_ROUTE_MSG_MSGS_LOG	DOW_SUN	numeric	5	Yes
DMS_TRAV_ROUTE_MSG_MSGS_LOG	ENABLED	numeric	5	Yes
DMS_TRAV_ROUTE_MSG_MSGS_LOG	SORT_ORDER	numeric	5	Yes
DMS_TRAV_ROUTE_MSG_ROUTE	DTRM_MSG_ID	char	32	No
DMS_TRAV_ROUTE_MSG_ROUTE	TRAVEL_ROUTE_ID	char	32	No
DMS_TRAV_ROUTE_MSG_ROUTE	SORT_ORDER_NUM	numeric	5	No
DMS_TRAV_ROUTE_MSG_ROUTE_LOG	SYSTEM_TIMESTAMP	datetime2	6	No
DMS_TRAV_ROUTE_MSG_ROUTE_LOG	MSG_ROUTE_LOG_SEQUENCE	numeric	9	No
DMS_TRAV_ROUTE_MSG_ROUTE_LOG	DMS_DEVICE_ID	varchar	32	No
DMS_TRAV_ROUTE_MSG_ROUTE_LOG	DMS_TRAV_ROUTE_MSG_ID	varchar	32	No
DMS_TRAV_ROUTE_MSG_ROUTE_LOG	TR_ROUTE_ID	varchar	32	No
DMS_TRAV_ROUTE_MSG_STATUS_LOG	SYSTEM_TIMESTAMP	datetime2	6	No
DMS_TRAV_ROUTE_MSG_STATUS_LOG	STAT_LOG_SEQUENCE	numeric	5	No
DMS_TRAV_ROUTE_MSG_STATUS_LOG	DMS_DEVICE_ID	varchar	32	No
DMS_TRAV_ROUTE_MSG_STATUS_LOG	DEVICE_NAME	varchar	15	No
DMS_TRAV_ROUTE_MSG_STATUS_LOG	COMMUNICATION_MODE	numeric	5	No
DMS_TRAV_ROUTE_MSG_STATUS_LOG	OPERATIONAL_STATUS	numeric	5	No
DMS_TRAV_ROUTE_MSG_STATUS_LOG	SCHEDULE_ENABLED_INDICATOR	numeric	5	Yes
DMS_TRAV_ROUTE_MSG_STATUS_LOG	ACTIVE_DMS_TRAV_ROUTE_MSG_ID	varchar	32	No
DMS_TRAV_ROUTE_MSG_STATUS_LOG	DMS_MESSAGE	varchar	1024	Yes
DMS_TRAV_ROUTE_MSG_STATUS_LOG	DMS_TRAV_ROUTE_MSG_STATE	numeric	5	Yes
DMS_TRAV_ROUTE_MSG_STATUS_LOG	DMS_TRAV_ROUTE_MSG_REASON	varchar	4000	Yes
DMS_TRAV_ROUTE_MSG_STATUS_LOG	LOG_MSG_SOURCE	varchar	128	Yes
DMS_TRAV_TIME_SCHEDULE	DMS_DEVICE_ID	char	32	No
DMS_TRAV_TIME_SCHEDULE	START_HOUR	numeric	5	No
DMS_TRAV_TIME_SCHEDULE	START_MIN	numeric	5	No

Table_Name	Column_Name	Type	Size	Nullable
DMS_TRAV_TIME_SCHEDULE	END_HOUR	numeric	5	No
DMS_TRAV_TIME_SCHEDULE	END_MIN	numeric	5	No
DMS_TRAVEL_INFO_MSG_TEMPLATE	MESSAGE_TEMPLATE_ID	char	32	No
DMS_TRAVEL_INFO_MSG_TEMPLATE	TEMPLATE_DESCRIPTION	varchar	50	No
DMS_TRAVEL_INFO_MSG_TEMPLATE	NUMBER_ROWS	numeric	5	No
DMS_TRAVEL_INFO_MSG_TEMPLATE	NUMBER_COLUMNS	numeric	5	No
DMS_TRAVEL_INFO_MSG_TEMPLATE	NUMBER_PAGES	numeric	5	No
DMS_TRAVEL_INFO_MSG_TEMPLATE	TEMPLATE_MESSAGE	varchar	1024	Yes
DMS_TRAVEL_INFO_MSG_TEMPLATE	DESTINATION_ALIGNMENT	numeric	5	No
DMS_TRAVEL_INFO_MSG_TEMPLATE	MISSING_DATA_OPTION	numeric	5	No
DMS_TRIG_MSG	DMS_TRIG_MSG_ID	char	32	No
DMS_TRIG_MSG	DMS_DEVICE_ID	char	32	No
DMS_TRIG_MSG	SORT_ORDER_NUM	tinyint	1	No
DMS_TRIG_MSG	TRIG_TRIGGER_ID	char	32	No
DMS_TRIG_MSG	DMS_TRIG_MSG_ENABLED	bit	1	No
DMS_TRIG_MSG	DMS_ARB_QUEUE_LEVEL	tinyint	1	No
DMS_TRIG_MSG	DMS_MESSAGE_TEXT	varchar	1024	No
DMS_TRIG_MSG	IS_MULTI	bit	1	No
DMS_TRIG_MSG	BEACON_INDICATOR	bit	1	No
DMS_TRIG_MSG	CREATED_TIMESTAMP	datetime2	6	No
DMS_TRIG_MSG	UPDATED_TIMESTAMP	datetime2	6	No
DMS_TRIG_MSG_CONFIG_LOG	SYSTEM_TIMESTAMP	datetime2	6	No
DMS_TRIG_MSG_CONFIG_LOG	DMS_DEVICE_ID	varchar	32	No
DMS_TRIG_MSG_CONFIG_LOG	DEVICE_NAME	varchar	15	No
DMS_TRIG_MSG_MSGS_LOG	SYSTEM_TIMESTAMP	datetime2	6	No
DMS_TRIG_MSG_MSGS_LOG	MSGS_LOG_SEQUENCE	int	4	No
DMS_TRIG_MSG_MSGS_LOG	DMS_DEVICE_ID	varchar	32	No
DMS_TRIG_MSG_MSGS_LOG	DMS_TRIGGERED_MSG_ID	varchar	32	No
DMS_TRIG_MSG_MSGS_LOG	TRIGGER_ID	varchar	32	No

Table_Name	Column_Name	Type	Size	Nullable
DMS_TRIG_MSG_MSGS_LOG	ENABLED_FLAG	bit	1	No
DMS_TRIG_MSG_MSGS_LOG	DMS_ARB_QUEUE_LEVEL	tinyint	1	No
DMS_TRIG_MSG_MSGS_LOG	DMS_MESSAGE_TEXT	varchar	1024	No
DMS_TRIG_MSG_STATUS_LOG	SYSTEM_TIMESTAMP	datetime2	6	No
DMS_TRIG_MSG_STATUS_LOG	STAT_LOG_SEQUENCE	int	4	No
DMS_TRIG_MSG_STATUS_LOG	DMS_DEVICE_ID	char	32	No
DMS_TRIG_MSG_STATUS_LOG	DEVICE_NAME	varchar	15	No
DMS_TRIG_MSG_STATUS_LOG	COMMUNICATION_MODE	numeric	5	No
DMS_TRIG_MSG_STATUS_LOG	OPERATIONAL_STATUS	numeric	5	No
DMS_TRIG_MSG_STATUS_LOG	DMS_MESSAGE	varchar	1024	Yes
DMS_TRIG_MSG_STATUS_LOG	DMS_TRIG_ACTION_STATE	numeric	5	Yes
DMS_TRIG_MSG_STATUS_LOG	DMS_TRIG_MSG_REASON	varchar	4000	Yes
DMS_TRIG_MSG_STATUS_LOG	LOG_MSG_SOURCE	varchar	128	Yes
DMS_TRIG_MSG_STATUS_MSGS_LOG	SYSTEM_TIMESTAMP	datetime2	6	No
DMS_TRIG_MSG_STATUS_MSGS_LOG	STAT_MSGS_LOG_SEQUENCE	int	4	No
DMS_TRIG_MSG_STATUS_MSGS_LOG	DMS_DEVICE_ID	char	32	No
DMS_TRIG_MSG_STATUS_MSGS_LOG	TRIG_MSG_ID	char	32	No
DMS_TRIG_MSG_STATUS_MSGS_LOG	TRIGGER_ID	char	32	No
DMS_TRIG_MSG_STATUS_MSGS_LOG	ENABLED	bit	1	No
DMS_TRIG_MSG_STATUS_MSGS_LOG	QUEUED	bit	1	No
DMS_TRIG_MSG_STATUS_MSGS_LOG	STAT_LOG_SEQUENCE	int	4	No
DS_CACHE_ROADWAY_DIRECTIONS	REL_OBJECT_ID	char	32	No
DS_CACHE_ROADWAY_DIRECTIONS	REL_OBJECT_TYPE	numeric	1	No
DS_CACHE_ROADWAY_DIRECTIONS	REL_LAT_UDEG	numeric	10	No
DS_CACHE_ROADWAY_DIRECTIONS	REL_LONG_UDEG	numeric	10	No
DS_CACHE_ROADWAY_DIRECTIONS	MAX_TURNS_ALLOWED	numeric	1	No
DS_CACHE_ROADWAY_DIRECTIONS	UTURN_ALLOWED	bit	1	No
DS_CACHE_ROADWAY_DIRECTIONS	REF_ROUTE_PREFIX	varchar	10	No
DS_CACHE_ROADWAY_DIRECTIONS	REF_ROUTE_NUMBER	numeric	4	No

Table_Name	Column_Name	Type	Size	Nullable
DS_CACHE_ROADWAY_DIRECTIONS	REF_ROUTE_SUFFIX	varchar	4	No
DS_CACHE_ROADWAY_DIRECTIONS	REF_DIRECTION_CODE	numeric	3	No
DS_CACHE_ROADWAY_DIRECTIONS	REF_LAT_UDEG	numeric	10	No
DS_CACHE_ROADWAY_DIRECTIONS	REF_LONG_UDEG	numeric	10	No
DS_CACHE_ROADWAY_DIRECTIONS	MAX_DISTANCE_FROM_LOCATION_MILLIMILES	numeric	7	No
DS_CACHE_ROADWAY_DIRECTIONS	IDENTIFIABLE_ROADWAY_DIRECTIONS_XML	varchar	max	Yes
DS_CACHE_ROADWAY_DIRECTIONS	XML_TURNS	numeric	2	Yes
DS_CACHE_ROADWAY_DIRECTIONS	XML_UTURN	bit	1	Yes
DS_CACHE_ROADWAY_DIRECTIONS	XML_DISTANCE_MILLIMILES	numeric	7	Yes
DS_CACHE_ROADWAY_DIRECTIONS	XML_HAS_DRIVING_DIRECTIONS	bit	1	No
DS_CACHE_ROADWAY_DIRECTIONS	XML_DRIVING_DIRECTIONS_NUM_STEPS	numeric	2	Yes
DS_CACHE_ROADWAY_DIRECTIONS	XML_HAS_ROADWAY_DIRECTIONS	bit	1	No
DS_CACHE_ROADWAY_DIRECTIONS	LAST_USED_TIMESTAMP	Datetime2	7	Yes
DS_CACHE_ROADWAY_DIRECTIONS	CREATED_TIMESTAMP	Datetime2	7	Yes
DS_CACHE_ROADWAY_DIRECTIONS	USE_COUNT	int	4	Yes
DS_DISABLED_DEVICES	DEVICE_ID	char	32	No
DS_DISABLED_DEVICES	EVENT_ID	char	32	No
DS_DMS_MSG_TEMPLATE	MESSAGE_TEMPLATE_ID	char	32	No
DS_DMS_MSG_TEMPLATE	TEMPLATE_DESCRIPTION	varchar	50	No
DS_DMS_MSG_TEMPLATE	TEMPLATE_MESSAGE	varchar	1024	No
DS_DMS_MSG_TEMPLATE	SHOW_BEACONS	numeric	5	No
DS_HAR_MSG_TEMPLATE	MESSAGE_TEMPLATE_ID	char	32	No
DS_HAR_MSG_TEMPLATE	TEMPLATE_DESCRIPTION	varchar	50	No
DS_HAR_MSG_TEMPLATE	TEMPLATE_MESSAGE	varchar	-1	No
DS_MSG_TEMPL_FILTER	MSG_TEMPLATE_ENTRY_ID	int	4	No
DS_MSG_TEMPL_FILTER	MSG_TEMPLATE_ID	char	32	No
DS_MSG_TEMPL_FILTER	FILTER_TYPE_ID	numeric	5	No
DS_MSG_TEMPL_FILTER	EVENT_TYPE	numeric	5	Yes

Table_Name	Column_Name	Type	Size	Nullable
DS_MSG_TEMPL_FILTER	DIST_TYPE	numeric	5	Yes
DS_MSG_TEMPL_FILTER	MAX_COLUMNS	numeric	5	Yes
DS_MSG_TEMPL_FILTER	TEMPLATE_TYPE	numeric	5	No
DS_MSG_TEMPL_FILTER	ROADWAY_DIR_MAX_TURNS	numeric	5	Yes
DS_MSG_TEMPL_FILTER	ROADWAY_DIR_UTURN	numeric	5	Yes
DS_MSG_TEMPL_FILTER	ROADWAY_DIR_ROUTE_TYPE	numeric	5	Yes
DS_MSG_TEMPL_FILTER_TYPES	FILTER_TYPE_ID	numeric	5	No
DS_MSG_TEMPL_FILTER_TYPES	DESCRIPTION	varchar	50	No
DS_ROUTE_SYNONYM	ROUTE_COUNTY_CODE	varchar	3	No
DS_ROUTE_SYNONYM	ROUTE_TYPE	numeric	5	No
DS_ROUTE_SYNONYM	ROUTE_PREFIX	varchar	10	No
DS_ROUTE_SYNONYM	ROUTE_NUMBER	varchar	10	No
DS_ROUTE_SYNONYM	ROUTE_SUFFIX	varchar	10	Yes
DS_ROUTE_SYNONYM	ROUTE_DIRECTION_CODE	numeric	5	No
DS_ROUTE_SYNONYM	SYN_ROUTE_TYPE	numeric	5	No
DS_ROUTE_SYNONYM	SYN_ROUTE_PREFIX	varchar	10	No
DS_ROUTE_SYNONYM	SYN_ROUTE_NUMBER	varchar	10	No
DS_ROUTE_SYNONYM	SYN_ROUTE_SUFFIX	varchar	10	Yes
DS_ROUTE_SYNONYM	SYN_ROUTE_DIRECTION_CODE	numeric	5	No
EVENT	EVENT_ID	char	32	No
EVENT	LANE_CONFIG_ID	char	32	Yes
EVENT	DB_CODE	varchar	1	Yes
EVENT	EVENT_CODE	numeric	5	No
EVENT	LCP_TRACKING_NUMBER	varchar	255	Yes
EVENT	CEN_CENTER_ID	char	32	Yes
EVENT	CEN_ORIGINATING_CENTER_ID	char	32	Yes
EVENT	PRIMARY_FLAG	numeric	5	Yes
EVENT	LICENSE_PLATE_INFO	varchar	52	Yes
EVENT	VEHICLE_INFO	varchar	40	Yes

Table_Name	Column_Name	Type	Size	Nullable
EVENT	OFFLINE_IND	numeric	5	Yes
EVENT	EVENT_STATUS_CODE	numeric	5	Yes
EVENT	SCENE_CLEARED_TIMESTAMP	datetime2	6	Yes
EVENT	DELAY_CLEARED_TIMESTAMP	datetime2	6	Yes
EVENT	CONFIRMED_TIMESTAMP	datetime2	6	Yes
EVENT	FALSE_ALARM_IND	numeric	5	Yes
EVENT	EVENT_CLOSED_DATE	datetime2	6	Yes
EVENT	EVENT_OPEN_DATE	datetime2	6	Yes
EVENT	SOURCE_CODE	numeric	5	No
EVENT	HAZMAT_CODE	numeric	5	Yes
EVENT	INCIDENT_CODE	numeric	5	Yes
EVENT	WEATHER_CLEANUP_INDICATOR	numeric	5	Yes
EVENT	WEATHER_EVACUATION_INDICATOR	numeric	5	Yes
EVENT	PAVEMENT_CONDITION_CODE	numeric	5	Yes
EVENT	UPDATED_TIMESTAMP	datetime2	6	Yes
EVENT	OTHER_DESCRIPTION	varchar	60	Yes
EVENT	DESCRIPTION	varchar	512	Yes
EVENT	SOURCE_DESCRIPTION	varchar	60	Yes
EVENT	LANE_STATE_DESCRIPTION	varchar	1024	Yes
EVENT	EVENT_STILL_OPEN_REMINDER_TIME	datetime2	6	Yes
EVENT	SOCIAL_MEDIA_ADDITIONAL_TEXT	varchar	500	Yes
EVENT	WEB_ALERT_TEXT	varchar	3000	Yes
EVENT	DESCRIPTION_OVERRIDDEN	numeric	5	Yes
EVENT	AUX_DESCRIPTION	varchar	512	Yes
EVENT	EVENT_INIT_USER_NAME	varchar	40	Yes
EVENT	EVENT_INIT_CENTER_ID	char	32	Yes
EVENT	EVENT_INIT_SCHEDULE_ID	char	32	Yes
EVENT	EVENT_INIT_EXT_SYSTEM	varchar	35	Yes
EVENT	EVENT_INIT_EXT_AGENCY	varchar	35	Yes

Table_Name	Column_Name	Type	Size	Nullable
EVENT	EVENT_INIT_EXT_EVENT	varchar	35	Yes
EVENT	EVENT_STILL_OPEN_REL_REM_TIME	numeric	5	Yes
EVENT	PENDING_EVENT_CREATION_TIME	datetime2	6	Yes
EVENT	PENDING_EVENT_LAST_USED_TIME	datetime2	6	Yes
EVENT	EXTERNAL_EVENT_IND	numeric	5	Yes
EVENT	EXTERNAL_INTERESTING_IND	numeric	5	Yes
EVENT	PUBLIC_DESCRIPTION	varchar	512	Yes
EVENT	OWNING_ORGANIZATION	char	32	Yes
EVENT	PUBLIC_INCIDENT_CODE	numeric	5	Yes
EVENT	PRIORITY_LIST_ORDER	numeric	5	Yes
EVENT	EST_TIME_TO_CLEAR_MINS	numeric	5	Yes
EVENT	OP_CENTER_POC	varchar	80	Yes
EVENT	ON_SCENE_POC	varchar	80	Yes
EVENT	COMMENTS	varchar	1000	Yes
EVENT	REGIONAL_FLAG	numeric	1	Yes
EVENT	WEATHER_INFO_JSON	varchar	2048	Yes
EVENT	VIDEO_TOUR_RPI_ID	char	32	Yes
EVENT	AUTO_AVL_DETECTION_ENABLED	numeric	5	Yes
EVENT	AUTO_PUBLISH_MODE	numeric	1	Yes
EVENT	LAST_TWEET_TEXT	varchar	3000	Yes
EVENT	LAST_TWEET_TIME	datetime2	6	Yes
EVENT	LICENSE_PLATE_USPS_STATE_CODE	char	2	Yes
EVENT	LICENSE_PLATE_STATE_FULL_NAME	varchar	32	Yes
EVENT	LICENSE_PLATE_STATE_FIPS_CODE	char	2	Yes
EVENT	MAX_LANES_CLOSED	tinyint	1	Yes
EVENT	PENDING_EVENT_FIRST_OPEN_TIME	datetime2	6	Yes
EVENT	EVENT_INIT_PERMIT_TRACKING_NO	varchar	255	Yes
EVENT	SCHEDULED_CLOSURE_TIME	datetime2	6	Yes
EVENT_CAMERA_USAGE_LOG	EVENT_EVENT_ID	char	32	No

Table_Name	Column_Name	Type	Size	Nullable
EVENT_CAMERA_USAGE_LOG	CAMERA_DEVICE_ID	char	32	No
EVENT_CAMERA_USAGE_LOG	DATE_TIME	datetime2	8	No
EVENT_DEVICE_PROXIMITY	DEVICE_ID	char	32	No
EVENT_DEVICE_PROXIMITY	EVENT_ID	char	32	No
EVENT_DEVICE_PROXIMITY	DEVICE_TYPE	numeric	5	No
EVENT_DEVICE_PROXIMITY	IMMED_DIST	numeric	5	No
EVENT_DEVICE_PROXIMITY	SAME_ROUTE	numeric	5	No
EVENT_DEVICE_PROXIMITY	DIR_TYPE	numeric	5	No
EVENT_DEVICE_PROXIMITY	NUM_TURNS	numeric	9	No
EVENT_DEVICE_PROXIMITY	HAS_UTURN	numeric	5	No
EVENT_HISTORY	LOG_ENTRY_ID	char	32	No
EVENT_HISTORY	EVENT_EVENT_ID	char	32	No
EVENT_HISTORY	DB_CODE	varchar	1	Yes
EVENT_HISTORY	SYSTEM_TIMESTAMP	datetime2	6	No
EVENT_HISTORY	USER_TIMESTAMP	datetime2	6	No
EVENT_HISTORY	SOURCE_CODE	numeric	5	No
EVENT_HISTORY	CEN_CENTER_ID	char	32	No
EVENT_HISTORY	CENTER_NAME	varchar	16	No
EVENT_HISTORY	AUTHOR	varchar	128	No
EVENT_HISTORY	HOST_NAME	varchar	255	No
EVENT_HISTORY	ACTION_CODE	numeric	5	Yes
EVENT_HISTORY	UPDATED_TIMESTAMP	datetime2	6	Yes
EVENT_HISTORY	DEVICE_ID	char	32	Yes
EVENT_HISTORY	DEVICE_NAME	varchar	15	Yes
EVENT_HISTORY	BEACON_STATE	numeric	5	Yes
EVENT_HISTORY	LOG_SEQ	numeric	9	No
EVENT_HISTORY	SOURCE_DESCRIPTION	varchar	60	Yes
EVENT_HISTORY	LOG_TEXT	varchar	2048	No
EVENT_HISTORY	MESSAGE_TYPE	numeric	5	No

Table_Name	Column_Name	Type	Size	Nullable
EVENT_NOTIFICATION	NOTIF_ID	char	32	No
EVENT_NOTIFICATION	EVENT_ID	char	32	No
EVENT_PARTICIPATION	EVENT_EVENT_ID	char	32	No
EVENT_PARTICIPATION	PARTICIPATION_ID	char	32	No
EVENT_PARTICIPATION	NOTIFIED_TIMESTAMP	datetime2	8	Yes
EVENT_PARTICIPATION	ARRIVED_RESPONDED_TIMESTAMP	datetime2	8	Yes
EVENT_PARTICIPATION	DEPARTED_TIMESTAMP	datetime2	8	Yes
EVENT_PARTICIPATION	STATUS_ALTERED_BY_USER	numeric	5	No
EVENT_PARTICIPATION	CALL_SIGN	varchar	128	Yes
EVENT_PARTICIPATION	DRIVER_FIRST_NAME	varchar	128	Yes
EVENT_PARTICIPATION	DRIVER_LAST_NAME	varchar	128	Yes
EVENT_PARTICIPATION	NOTE	varchar	128	Yes
EVENT_PARTICIPATION	PARTICIPATION_DATA_TYPE	tinyint	1	No
EVENT_PARTICIPATION_CONTACT	EVENT_PARTICIPATION_ID	char	32	No
EVENT_PARTICIPATION_CONTACT	CON_CONTACT_ID	char	32	No
EVENT_PARTICIPATION_CONTACT	PHONE_NUMBER_LAST_USED_TYPE	tinyint	1	Yes
EVENT_PARTICIPATION_CONTACT	PHONE_NUMBER_LAST_USED	varchar	32	Yes
EVENT_PARTICIPATION_CONTACT	CREATED_TIMESTAMP	datetime2	6	No
EVENT_PARTICIPATION_CONTACT	UPDATED_TIMESTAMP	datetime2	6	No
EVENT_PARTICIPATION_CONTACT	PHONE_EXTENSION_LAST_USED	varchar	6	Yes
EVENT_PARTICIPATION_RESOURCE_OR_TYPE	EVENT_PARTICIPATION_ID	char	32	No
EVENT_PARTICIPATION_RESOURCE_OR_TYPE	PARTICIPANT_ID	char	32	No
EVENT_PARTICIPATION_RESOURCE_OR_TYPE	PARTICIPANT_TYPE	tinyint	1	No
EVENT_PARTICIPATION_RESOURCE_OR_TYPE	ORIGINAL_PARTICIPANT_ID	char	32	No
EVENT_PARTICIPATION_RESOURCE_OR_TYPE	ORIGINAL_PARTICIPANT_TYPE	tinyint	1	No
EVENT_PARTICIPATION_RESOURCE_OR_TYPE	PARTICIPANT_CHANGED_BY_USER	bit	1	No
EVENT_PARTICIPATION_RESOURCE_OR_TYPE	CON_CONTACT_ID	char	32	Yes
EVENT_PARTICIPATION_RESOURCE_OR_TYPE	OPT_PHONE_NUMBER_LAST_USED_TYPE	tinyint	1	Yes
EVENT_PARTICIPATION_RESOURCE_OR_TYPE	OPT_PHONE_NUMBER_LAST_USED	varchar	32	Yes

Table_Name	Column_Name	Type	Size	Nullable
EVENT_PARTICIPATION_RESOURCE_OR_TYPE	CREATED_TIMESTAMP	datetime2	6	No
EVENT_PARTICIPATION_RESOURCE_OR_TYPE	UPDATED_TIMESTAMP	datetime2	6	No
EVENT_PARTICIPATION_RESOURCE_OR_TYPE	OPT_PHONE_EXTENSION_LAST_USED	varchar	6	Yes
EVENT_QUEUE	EVENT_EVENT_ID	char	32	No
EVENT_QUEUE	EFFECTIVE_TIME	datetime2	6	No
EVENT_QUEUE	QUEUE_TYPE_CODE	tinyint	1	No
EVENT_QUEUE	QUEUE_LENGTH_METERS	int	4	No
EVENT_QUEUE	DIRECTION_CODE	tinyint	1	No
EVENT_QUEUE	QUEUE_SOURCE_CODE	tinyint	1	No
EVENT_QUEUE	QUEUE_WARNING_CODE	tinyint	1	No
EVENT_QUEUE	CREATED_TIMESTAMP	datetime2	6	No
EVENT_QUEUE	UPDATED_TIMESTAMP	datetime2	6	No
EVENT_QUEUE_HISTORY	EVENT_EVENT_ID	char	32	No
EVENT_QUEUE_HISTORY	EFFECTIVE_TIME	datetime2	6	No
EVENT_QUEUE_HISTORY	QUEUE_TYPE_CODE	tinyint	1	No
EVENT_QUEUE_HISTORY	QUEUE_LENGTH_METERS	int	4	No
EVENT_QUEUE_HISTORY	DIRECTION_CODE	tinyint	1	No
EVENT_QUEUE_HISTORY	QUEUE_SOURCE_CODE	tinyint	1	No
EVENT_QUEUE_HISTORY	QUEUE_WARNING_CODE	tinyint	1	No
EVENT_QUEUE_HISTORY	CREATED_TIMESTAMP	datetime2	6	No
EVENT_QUEUE_HISTORY	UPDATED_TIMESTAMP	datetime2	6	No
EVENT_RESOURCE	EVENT_RESOURCE_ID	char	32	No
EVENT_RESOURCE	ERT_EVENT_RESOURCE_TYPE_ID	char	32	No
EVENT_RESOURCE	AVL_SUPPORT	numeric	5	No
EVENT_RESOURCE	AVL_VEHICLE_ID	varchar	128	Yes
EVENT_RESOURCE	AVL_DRIVERID	varchar	128	Yes
EVENT_RESOURCE	AVL_AUTO_CONFIGURED	numeric	5	Yes
EVENT_RESOURCE	UNIT_NAME_SUPPORT	numeric	5	No
EVENT_RESOURCE	UNIT_NAME	varchar	128	Yes

Table_Name	Column_Name	Type	Size	Nullable
EVENT_RESOURCE	IN_SERVICE_SUPPORT	numeric	5	No
EVENT_RESOURCE	IN_SERVICE	numeric	5	Yes
EVENT_RESOURCE	CAMERA_SUPPORT	numeric	5	No
EVENT_RESOURCE	CAMERA_ID	char	32	Yes
EVENT_RESOURCE	ALL_OP_CENTERS	numeric	5	No
EVENT_RESOURCE	REMOVED	numeric	5	No
EVENT_RESOURCE	OFFLINE_IND	numeric	5	No
EVENT_RESOURCE	CON_ASSIGNED_CONTACT_ID	char	32	Yes
EVENT_RESOURCE	PHONE_NUMBER	varchar	32	Yes
EVENT_RESOURCE	CREATED_TIMESTAMP	datetime2	6	Yes
EVENT_RESOURCE	UPDATED_TIMESTAMP	datetime2	6	Yes
EXECUTABLE_ACTION	OWNER_ID	char	32	No
EXECUTABLE_ACTION	SORT_ORDER_NUM	numeric	5	No
EXECUTABLE_ACTION	OWNER_TYPE	numeric	5	No
EXECUTABLE_ACTION	ACTION_TYPE	numeric	5	No
EXECUTABLE_ACTION	DETAIL1_ID	char	32	No
EXECUTABLE_ACTION	DB_CODE	varchar	1	Yes
EXECUTABLE_ACTION	DETAIL2_INT	int	4	Yes
EXTERNAL_APPLICATION	APPLICATION_ID	char	32	No
EXTERNAL_APPLICATION	EXTERNAL_ID	varchar	128	No
EXTERNAL_APPLICATION	IS_DATA_CONSUMER	numeric	5	No
EXTERNAL_APPLICATION	IS_DATA_SUPPLIER	numeric	5	No
EXTERNAL_APPLICATION	APPLICATION_DESCRIPTION	varchar	1024	Yes
EXTERNAL_APPLICATION	PUBLIC_KEY	varchar	2048	Yes
EXTERNAL_APPLICATION	CONTACT_FIRST_NAME	varchar	128	Yes
EXTERNAL_APPLICATION	CONTACT_LAST_NAME	varchar	128	Yes
EXTERNAL_APPLICATION	CONTACT_PRIMARY_PHONE	varchar	64	Yes
EXTERNAL_APPLICATION	CONTACT_EMAIL_ADDRESS	varchar	128	Yes
EXTERNAL_EVENT_FILTER	RULE_ID	char	32	No

Table_Name	Column_Name	Type	Size	Nullable
EXTERNAL_EVENT_FILTER	CHART_RULE	varchar	4000	Yes
EXTERNAL_OBJECT_EXCLUSION	EXCLUSION_ID	char	32	No
EXTERNAL_OBJECT_EXCLUSION	EXTERNAL_OBJECT_ID	char	256	No
EXTERNAL_OBJECT_EXCLUSION	EXTERNAL_OBJECT_TYPE	numeric	5	No
EXTERNAL_OBJECT_EXCLUSION	EXTERNAL_SYSTEM	varchar	35	No
EXTERNAL_OBJECT_EXCLUSION	EXTERNAL_AGENCY	varchar	35	No
FLASH_VIDEO_STREAM_CONTROL	CAMERA_DEVICE_ID	char	32	No
FLASH_VIDEO_STREAM_CONTROL	STREAM_BLOCKED	numeric	5	Yes
FLASH_VIDEO_STREAM_CONTROL	ALT_STREAM_ID	varchar	128	Yes
FLASH_VIDEO_STREAM_CONTROL	STREAMING_SERVER_CONFIG_ID	char	32	No
FOLDER	ID	char	32	No
FOLDER	NAME	varchar	255	No
FOLDER_OBJECT	FOLDER_ID	char	32	No
FOLDER_OBJECT	OBJECT_ID	char	32	No
FOLDER_OP_CENTER	FOLDER_ID	char	32	No
FOLDER_OP_CENTER	CENTER_ID	char	32	No
FUNCTIONAL_RIGHT	FR_ID	numeric	5	No
FUNCTIONAL_RIGHT	FR_NAME	varchar	50	No
FUNCTIONAL_RIGHT	FR_DESCRIPTION	varchar	255	Yes
FUNCTIONAL_RIGHT	DB_CODE	varchar	1	Yes
GEO_AREA	GEO_ID	char	32	No
GEO_AREA	NAME	varchar	64	No
GEO_AREA	DESCRIPTION	varchar	256	No
GEO_AREA_POINT	GA_GEO_ID	char	32	No
GEO_AREA_POINT	POINT_ORDER	numeric	5	No
GEO_AREA_POINT	LATITUDE	numeric	9	No
GEO_AREA_POINT	LONGITUDE	numeric	9	No
GUI_ACTION_USAGE	ACTION_NAME	varchar	128	No
GUI_ACTION_USAGE	REQ_HDLR_SIMPLE_NAME	varchar	128	No

Table_Name	Column_Name	Type	Size	Nullable
GUI_ACTION_USAGE	REQ_HDLR_CLASS_NAME	varchar	256	No
GUI_ACTION_USAGE	REGISTRATION_TIME	datetime2	6	No
GUI_ACTION_USAGE	LAST_USAGE_TIME	datetime2	6	Yes
GUI_ACTION_USAGE	INVOCATION_COUNT	bigint	8	No
H264_TMP	CAM_ID	char	32	No
H264_TMP	CAM_DESC	varchar	256	No
H264_TMP	MULTICAST_ADDR	varchar	128	No
H264_TMP	PORT	numeric	5	No
H264_TMP	CODEC_ID	char	32	No
H264_TMP	CONN_ID	char	32	No
HAR	DEVICE_ID	char	32	No
HAR	HAR_MODEL_ID	numeric	5	No
HAR	ORG_ORGANIZATION_ID	char	32	No
HAR	DB_CODE	varchar	1	Yes
HAR	DEVICE_NAME	varchar	15	No
HAR	DEVICE_LOCATION	varchar	60	Yes
HAR	HAR_ACCESS_PIN	varchar	7	Yes
HAR	DEFAULT_PHONE_NUMBER	varchar	25	Yes
HAR	DEFAULT_MONITOR_PHONE_NUMBER	varchar	25	Yes
HAR	MAX_TIME	numeric	5	Yes
HAR	PORT_TYPE	numeric	5	Yes
HAR	PORT_MANAGER_TIMEOUT	numeric	9	Yes
HAR	MONITOR_PORT_TYPE	numeric	5	Yes
HAR	MONITOR_PORT_MANAGER_TIMEOUT	numeric	9	Yes
HAR	DEFAULT_HEADER_CLIP_PK	char	32	Yes
HAR	DEFAULT_BODY_CLIP_PK	char	32	No
HAR	DEFAULT_TRAILER_CLIP_PK	char	32	Yes
HAR	CREATED_TIMESTAMP	datetime2	6	Yes
HAR	UPDATED_TIMESTAMP	datetime2	6	Yes

Table_Name	Column_Name	Type	Size	Nullable
HAR	ENABLE_DEVICE_LOG	numeric	5	No
HAR	MASTER_HAR_ID	char	32	No
HAR	FREQUENCY_KHZ	numeric	5	No
HAR	BAND	char	2	No
HAR	CALL_SIGN	varchar	64	Yes
HAR	DISABLE_DTMF_RESPONSE_MODE	numeric	5	No
HAR	MAINT_ORGANIZATION_ID	char	32	Yes
HAR	TCP_HOST	varchar	16	Yes
HAR	TCP_PORT	numeric	5	Yes
HAR	MIN_DC_VOLTAGE	numeric	5	Yes
HAR	MAX_VSWR	numeric	5	Yes
HAR	POLL_INTERVAL_SECONDS	numeric	5	Yes
HAR	POLL_ENABLED	numeric	5	Yes
HAR	DS_ELIGIBLE	numeric	5	No
HAR	COMMISSIONED_DATE	date	3	Yes
HAR	MANAGED_EXPORT	bit	1	Yes
HAR	MD511_WEBSERVICE_URL	varchar	256	Yes
HAR_AUDIO_OWNER	HCA_HAR_CLIP_AUDIO_ID	char	32	No
HAR_AUDIO_OWNER	DB_CODE	varchar	1	Yes
HAR_AUDIO_OWNER	LAST_INTEREST_TIMESTAMP	datetime2	6	Yes
HAR_AUDIO_OWNER	OWNER_ID	varchar	32	No
HAR_CLIP_AUDIO	HAR_CLIP_AUDIO_ID	char	32	No
HAR_CLIP_AUDIO	HAR_AUDIO	varbinary	-1	No
HAR_CLIP_AUDIO	DB_CODE	varchar	1	Yes
HAR_MSG	HAR_MSG_PK	char	32	No
HAR_MSG	USE_HEADER	numeric	5	No
HAR_MSG	USE_TRAILER	numeric	5	No
HAR_MSG	DB_CODE	varchar	1	Yes
HAR_MSG_CLIP	HAR_CLIP_PK	char	32	No

Table_Name	Column_Name	Type	Size	Nullable
HAR_MSG_CLIP	HCA_HAR_CLIP_AUDIO_ID	char	32	Yes
HAR_MSG_CLIP	CLIP_POSITION_CODE	numeric	5	Yes
HAR_MSG_CLIP	RUN_LENGTH	numeric	5	No
HAR_MSG_CLIP	RUN_LENGTH_CODE	numeric	5	No
HAR_MSG_CLIP	CLIP_TYPE_CODE	numeric	5	No
HAR_MSG_CLIP	DB_CODE	varchar	1	Yes
HAR_MSG_CLIP	PRESTORED_SLOT_NUMBER	numeric	5	Yes
HAR_MSG_CLIP	CLIP_DESCRIPTION	varchar	240	Yes
HAR_MSG_CLIP	CLIP_TEXT	varchar	-1	Yes
HAR_MSG_CLIP	AUDIO_CLIP_MANAGER_NAME	varchar	32	Yes
HAR_NOTIFIER	HAR_DEVICE_ID	char	32	No
HAR_NOTIFIER	HN_DEVICE_ID	char	32	No
HAR_NOTIFIER	DEVICE_CODE	numeric	5	No
HAR_NOTIFIER	ACTIVE_INDICATOR	numeric	5	No
HAR_NOTIFIER	DB_CODE	varchar	1	Yes
HAR_PHONE_NUMBER	HAR_DEVICE_ID	char	32	No
HAR_PHONE_NUMBER	PORT_MANAGER_NAME	varchar	30	No
HAR_PHONE_NUMBER	PHONE_NUMBER	varchar	25	No
HAR_PHONE_NUMBER	SORT_ORDER_NUMBER	numeric	5	No
HAR_PHONE_NUMBER	MONITOR_INDICATOR	numeric	5	No
H HAR_PHONE_NUMBER	DB_CODE	varchar	1	Yes
HAR_SLOT_CONFIG	HAR_DEVICE_ID	char	32	No
HAR_SLOT_CONFIG	HAR_DEVICE_ID	char	32	No
HAR_SLOT_CONFIG	SLOT_NUMBER	numeric	5	No
HAR_SLOT_CONFIG	HMC_HAR_CLIP_PK	char	32	No
HAR_SLOT_CONFIG	SLOT_USAGE_CODE	numeric	5	No
HAR_SLOT_CONFIG	DB_CODE	varchar	1	Yes
HAR_STATUS	HAR_DEVICE_ID	char	32	No
HAR_STATUS	CEN_CENTER_ID	char	32	Yes

Table_Name	Column_Name	Type	Size	Nullable
HAR_STATUS	DEVICE_STATE_CODE	numeric	5	No
HAR_STATUS	TRANSMITTER_STATE	numeric	5	No
HAR_STATUS	HAR_INITIALIZED	numeric	5	No
HAR_STATUS	COMM_STATUS	numeric	5	No
HAR_STATUS	LAST_CONTACT_TIME	datetime2	6	Yes
HAR_STATUS	STATUS_CHANGE_TIME	datetime2	6	Yes
HAR_STATUS	LAST_DATESTAMP_REFRESH_TIME	datetime2	6	Yes
HAR_STATUS	HM_HAR_MSG_PK	char	32	No
HAR_STATUS	LAST_SETUP_TIME	datetime2	6	Yes
HAR_STATUS	LAST_STATUS_MISMATCH_TIME	datetime2	6	Yes
HAR_STATUS	POWER_STATUS	numeric	5	Yes
HAR_STATUS	DC_VOLTAGE	numeric	5	Yes
HAR_STATUS	BROADCAST_MONITOR_PCT	numeric	5	Yes
HAR_STATUS	HAR_MODE	numeric	5	Yes
HAR_STATUS	HAR_SUB_MODE	numeric	5	Yes
HAR_STATUS	HAR_SYNC_MODE	numeric	5	Yes
HAR_STATUS	XMIT_SET_POWER	numeric	5	Yes
HAR_STATUS	XMIT_FORWARD_POWER	numeric	5	Yes
HAR_STATUS	XMIT_REFLECTED_POWER	numeric	5	Yes
HAR_STATUS	XMIT_VSWR	numeric	5	Yes
HAR_STATUS	XMIT_MODULATION_PCT	numeric	5	Yes
HAR_STATUS	DCC_VERSION_INFO	varchar	128	Yes
HAR_STATUS	HAR_VERSION_INFO	varchar	128	Yes
HAR_STATUS	HAR_TIMESTAMP	datetime2	6	Yes
HAR_TRIG_MSG	HAR_TRIG_MSG_ID	char	32	No
HAR_TRIG_MSG	HAR_DEVICE_ID	char	32	No
HAR_TRIG_MSG	SORT_ORDER_NUM	tinyint	1	No
HAR_TRIG_MSG	TRIG_TRIGGER_ID	char	32	No
HAR_TRIG_MSG	HAR_TRIG_MSG_ENABLED	bit	1	No

Table_Name	Column_Name	Type	Size	Nullable
HAR_TRIG_MSG	HAR_ARB_QUEUE_LEVEL	tinyint	1	No
HAR_TRIG_MSG	HMC_HAR_MSG_CLIP_PK	char	32	No
HAR_TRIG_MSG	CREATED_TIMESTAMP	datetime2	6	No
HAR_TRIG_MSG	UPDATED_TIMESTAMP	datetime2	6	No
HAR_TRIG_MSG_CONSTITUENT	HAR_TRIG_MSG_ID	char	32	No
HAR_TRIG_MSG_CONSTITUENT	HAR_CONSTITUENT_DEVICE_ID	char	32	No
HAR_TRIG_MSG_CONSTITUENT	CREATED_TIMESTAMP	datetime2	6	No
HAR_TRIG_MSG_CONSTITUENT	UPDATED_TIMESTAMP	datetime2	6	No
HAR_TRIG_MSG_NOTIFIER	HAR_TRIG_MSG_ID	char	32	No
HAR_TRIG_MSG_NOTIFIER	HN_DEVICE_ID	char	32	No
HAR_TRIG_MSG_NOTIFIER	CREATED_TIMESTAMP	datetime2	6	No
HAR_TRIG_MSG_NOTIFIER	UPDATED_TIMESTAMP	datetime2	6	No
hm_seq	hm_seq_id	int	4	No
INCIDENT	EVENT_EVENT_ID	char	32	No
INCIDENT	INCIDENT_CODE	numeric	5	No
INCIDENT	CREATED_TIMESTAMP	datetime2	6	No
INCIDENT	DB_CODE	varchar	1	Yes
INCIDENT_SUBTYPES	SUBTYPE_ID	char	32	No
INCIDENT_SUBTYPES	INCIDENT_CODE	numeric	5	No
INCIDENT_SUBTYPES	SUBTYPE_NAME	varchar	100	No
INCIDENT_SUBTYPES	CREATED_TIMESTAMP	datetime2	6	No
INCIDENT_SUBTYPES	UPDATED_TIMESTAMP	datetime2	6	No
INCIDENT_VEHICLES_INVOLVED	VEHICLES_INVOLVED_PK	numeric	13	No
INCIDENT_VEHICLES_INVOLVED	EVENT_EVENT_ID	char	32	No
INCIDENT_VEHICLES_INVOLVED	VEHICLES_INVOLVED_CODE	numeric	5	No
INCIDENT_VEHICLES_INVOLVED	VEHICLE_SUBCATEGORY_CODE	numeric	5	Yes
INCIDENT_VEHICLES_INVOLVED	VEHICLE_QTY	numeric	5	Yes
INCIDENT_VEHICLES_INVOLVED	CREATED_TIMESTAMP	datetime2	6	Yes
INCIDENT_VEHICLES_INVOLVED	DB_CODE	varchar	1	Yes

Table_Name	Column_Name	Type	Size	Nullable
LANE_STATE	LANE_STATE_PK	numeric	13	No
LANE_STATE	LANE_CONFIG_ID	char	32	No
LANE_STATE	EVENT_EVENT_ID	char	32	No
LANE_STATE	LANE_NUMBER	numeric	5	No
LANE_STATE	LANE_DIR_TRAVEL_CODE	numeric	5	No
LANE_STATE	LANE_STATE_CODE	numeric	5	No
LANE_STATE	LANE_CODE	numeric	5	No
LANE_STATE	SYSTEM_TIMESTAMP	datetime2	6	No
LANE_STATE	USER_TIMESTAMP	datetime2	6	No
LANE_STATE	LANE_DESCRIPTION	varchar	10	No
LANE_STATE	DB_CODE	varchar	1	Yes
LANE_STATE	LANE_REFERENCE_DIRECTION	numeric	5	Yes
LANE_STATE	LANE_ORIENTATION	numeric	5	Yes
LINK_CONNECTION	EXT_SYS_NAME	varchar	10	No
LINK_CONNECTION	EXT_LINK_ID	varchar	9	No
LINK_CONNECTION	EXT_SYS_NAME_UPSTREAM	varchar	10	No
LINK_CONNECTION	EXT_LINK_ID_UPSTREAM	varchar	9	No
LINK_CONNECTION	GAP_LENGTH_MILLI_MILES	smallint	2	No
LINK_CONNECTION	CREATED_TIMESTAMP	datetime2	6	No
LINK_CONNECTION	UPDATED_TIMESTAMP	datetime2	6	No
LINK_DATA_IMPORT	IMPORT_ID	numeric	9	No
LINK_DATA_IMPORT	SYSTEM_TIMESTAMP	datetime2	6	No
LINK_DATA_IMPORT	EXT_SYS_NAME	varchar	10	No
link_data_import_seq	link_data_import_seq_id	int	4	No
LINK_QUEUE_EXCLUSION	EXT_SYS_NAME	varchar	10	No
LINK_QUEUE_EXCLUSION	EXT_LINK_ID	varchar	9	No
LINK_QUEUE_EXCLUSION	CREATED_TIMESTAMP	datetime2	6	No
LINK_QUEUE_EXCLUSION	UPDATED_TIMESTAMP	datetime2	6	No
LINK_RAW_DATA	LINK_DATA_IMPORT_ID	numeric	9	No

Table_Name	Column_Name	Type	Size	Nullable
LINK_RAW_DATA	EXT_LINK_ID	char	9	No
LINK_RAW_DATA	LINK_TRAVEL_TIME_EFF_TIME	datetime2	6	No
LINK_RAW_DATA	LINK_TRAVEL_TIME_SECS	numeric	5	No
LINK_RAW_DATA	LINK_TRAVEL_TIME_QUAL	numeric	5	No
LINK_RAW_DATA	LINK_SPEED_MPH	numeric	5	No
LINK_RAW_DATA	LINK_HIST_AVG_SPEED_MPH	tinyint	1	Yes
LINK_SMOOTHED_DATA	LINK_DATA_IMPORT_ID	numeric	9	No
LINK_SMOOTHED_DATA	EXT_LINK_ID	char	9	No
LINK_SMOOTHED_DATA	LINK_TRAVEL_TIME_EFF_TIME	datetime2	6	No
LINK_SMOOTHED_DATA	LINK_TRAVEL_TIME_SECS	numeric	5	No
LINK_SMOOTHED_DATA	LINK_TRAVEL_TIME_QUAL	numeric	5	No
LINK_SMOOTHED_DATA	LINK_SPEED_MPH	numeric	5	No
LINK_SMOOTHED_DATA	LINK_HIST_AVG_SPEED_MPH	tinyint	1	Yes
LINK_TRAVEL_TIME	RL_LINK_ID	char	32	No
LINK_TRAVEL_TIME	LINK_TRAVEL_TIME_EFF_TIME	datetime2	6	No
LINK_TRAVEL_TIME	LINK_TRAVEL_TIME_SECS	numeric	5	No
LINK_TRAVEL_TIME	LINK_TRAVEL_TIME_QUAL	numeric	5	No
LINK_TRAVEL_TIME	LINK_TRAVEL_TIME_TREND	numeric	5	No
LINKED_EVENT	EVENT_EVENT_ID_CHART	char	32	No
LINKED_EVENT	EVENT_EVENT_ID_EXTERNAL	char	32	No
LINKED_EVENT	GENINFO_OVERRIDE	numeric	5	No
LINKED_EVENT	LOC_OVERRIDE	numeric	5	No
LINKED_EVENT	INCINFO_OVERRIDE	numeric	5	Yes
LINKED_EVENT	LANECONFIG_OVERRIDE	numeric	5	Yes
LINKED_EVENT	UPD_GENINFO_TIMESTAMP	datetime2	6	No
LINKED_EVENT	ACK_GENINFO_TIMESTAMP	datetime2	6	No
LINKED_EVENT	UPD_LOC_TIMESTAMP	datetime2	6	No
LINKED_EVENT	ACK_LOC_TIMESTAMP	datetime2	6	No
LINKED_EVENT	UPD_INCINFO_TIMESTAMP	datetime2	6	Yes

Table_Name	Column_Name	Type	Size	Nullable
LINKED_EVENT	ACK_INCINFO_TIMESTAMP	datetime2	6	Yes
LINKED_EVENT	UPD_LANECONFIG_TIMESTAMP	datetime2	6	Yes
LINKED_EVENT	ACK_LANECONFIG_TIMESTAMP	datetime2	6	Yes
LINKED_EVENT	_LAST_UPDATED_TIMESTAMP	datetime2	6	No
log_seq	log_seq_id	int	4	No
LRMS_GEOMETRY	TMDD_LOCATION_ID	char	32	No
LRMS_GEOMETRY	TMDD_LOC_EXT_LRMS_LATITUDE	numeric	5	No
LRMS_GEOMETRY	TMDD_LOC_EXT_LRMS_LONGITUDE	numeric	9	No
LRMS_GEOMETRY	TMDD_LOC_EXT_HORIZONTAL_DATUM	numeric	5	No
LRMS_GEOMETRY	TMDD_LOC_EXT_VERTICAL_DATUM	numeric	5	No
LRMS_GEOMETRY	TMDD_LOC_EXT_LRMS_HEIGHT	numeric	5	No
LRMS_GEOMETRY	TMDD_LOC_VERTICAL_LEVEL	numeric	5	Yes
MESSAGE_LIBRARY	ML_ID	char	32	No
MESSAGE_LIBRARY	ML_NAME	varchar	32	No
MESSAGE_LIBRARY	CREATED_BY	varchar	32	Yes
MESSAGE_LIBRARY	DB_CODE	varchar	1	Yes
MONITOR	DEVICE_ID	char	32	No
MONITOR	ORG_ORGANIZATION_ID	char	32	No
MONITOR	DEVICE_NAME	varchar	50	No
MONITOR	PUBLIC_FLAG	numeric	5	No
MONITOR	CONNECTION_ID	char	32	No
MONITOR	CREATED_TIMESTAMP	datetime2	6	Yes
MONITOR	UPDATED_TIMESTAMP	datetime2	6	Yes
MONITOR	DB_CODE	varchar	1	Yes
MONITOR	MAINT_ORGANIZATION_ID	char	32	Yes
MONITOR	AUTO_MODE_ENABLED	numeric	5	No
MONITOR	AUTO_MODE_DWELL_TIME	numeric	5	No
MONITOR	COMMISSIONED_DATE	date	3	Yes
MONITOR_AUTO_MODE_TOUR_ENTRY	MONITOR_DEVICE_ID	char	32	No

Table_Name	Column_Name	Type	Size	Nullable
MONITOR_AUTO_MODE_TOUR_ENTRY	OWNER_ID	char	32	No
MONITOR_AUTO_MODE_TOUR_ENTRY	SEQ_NUM	numeric	5	No
MONITOR_AUTO_MODE_TOUR_ENTRY	OWNER_TYPE	numeric	5	No
MONITOR_AUTO_MODE_TOUR_ENTRY	CAMERA_ID	char	32	No
MONITOR_AUTO_MODE_TOUR_ENTRY	PRESET_NUMBER	numeric	5	No
MONITOR_AUTO_MODE_TOUR_ENTRY	TEMP_PRESET_ID	char	32	Yes
MONITOR_GROUP	MONITOR_GROUP_ID	char	32	No
MONITOR_GROUP	MONITOR_GROUP_NAME	varchar	50	No
MONITOR_GROUP	ORG_ORGANIZATION_ID	char	32	No
MONITOR_GROUP_CAMERA_STATUS	MONITOR_GROUP_ID	char	32	No
MONITOR_GROUP_CAMERA_STATUS	CAM_DEVICE_ID	char	32	No
MONITOR_GROUP_ENTRY	MONITOR_GROUP_ENTRY_ID	int	4	No
MONITOR_GROUP_ENTRY	MONITOR_GROUP_ID	char	32	No
MONITOR_GROUP_ENTRY	MON_DEVICE_ID	char	32	Yes
MONITOR_GROUP_ENTRY	MONITOR_GROUP_RECORD	numeric	5	No
MONITOR_STATUS	MONITOR_DEVICE_ID	char	32	No
MONITOR_STATUS	OP_STATUS	numeric	5	No
MONITOR_STATUS	COMM_MODE	numeric	5	No
MONITOR_STATUS	STATUS_CHANGE_TIME	datetime2	6	Yes
MONITOR_STATUS	CURRENT_CAM_DEVICE_ID	char	32	Yes
MONITOR_STATUS	CURRENT_TOUR_TOUR_ID	char	32	Yes
MONITOR_STATUS	LAST_CONTACT_TIME	datetime2	6	Yes
MONITOR_STATUS	TOUR_SUSPENDED_INDICATOR	numeric	5	Yes
MONITOR_STATUS	CURRENT_PROVIDER_DEVICE_ID	char	32	Yes
MONITOR_STATUS	PRIOR_DISPLAY_ID	char	32	Yes
MSG_CLIP_LIST	HM_HAR_MSG_PK	char	32	No
MSG_CLIP_LIST	HMC_HAR_CLIP_PK	char	32	No
MSG_CLIP_LIST	BODY_SEQUENCE	numeric	5	Yes
MSG_CLIP_LIST	DB_CODE	varchar	1	Yes

Table_Name	Column_Name	Type	Size	Nullable
msg_clip_seq	msg_clip_seq_id	int	4	No
MSG_FORMATS_DISTANCE	MESSAGE_FORMAT_ID	char	32	No
MSG_FORMATS_DISTANCE	MESSAGE_TEMPLATE_ID	char	32	No
MSG_FORMATS_DISTANCE	NAME	varchar	50	No
MSG_FORMATS_DISTANCE	FORMAT	varchar	50	Yes
MSG_FORMATS_DISTANCE	EXAMPLE	varchar	22	Yes
MSG_FORMATS_DISTANCE	FORMAT_LENGTH	numeric	5	No
MSG_FORMATS_DISTANCE	MILES_START_INDEX	numeric	5	Yes
MSG_FORMATS_DISTANCE	MILES_END_INDEX	numeric	5	Yes
MSG_FORMATS_DISTANCE	TENTHS_MILE_START_INDEX	numeric	5	Yes
MSG_FORMATS_DISTANCE	TENTHS_MILE_END_INDEX	numeric	5	Yes
MSG_FORMATS_DISTANCE	SUPPRESS_LEAD_ZEROS_NO_MILES	numeric	5	Yes
MSG_FORMATS_TOLL_RATE	MESSAGE_FORMAT_ID	char	32	No
MSG_FORMATS_TOLL_RATE	MESSAGE_TEMPLATE_ID	char	32	No
MSG_FORMATS_TOLL_RATE	NAME	varchar	50	No
MSG_FORMATS_TOLL_RATE	FORMAT	varchar	50	No
MSG_FORMATS_TOLL_RATE	EXAMPLE	varchar	22	Yes
MSG_FORMATS_TOLL_RATE	FORMAT_LENGTH	numeric	5	No
MSG_FORMATS_TOLL_RATE	DOLLARS_START_INDEX	numeric	5	Yes
MSG_FORMATS_TOLL_RATE	DOLLARS_END_INDEX	numeric	5	Yes
MSG_FORMATS_TOLL_RATE	CENTS_START_INDEX	numeric	5	No
MSG_FORMATS_TOLL_RATE	CENTS_END_INDEX	numeric	5	No
MSG_FORMATS_TOLL_RATE	DOLLAR_SIGN_INDEX	numeric	5	Yes
MSG_FORMATS_TOLL_RATE	SUPPRESS_DOLLAR_SIGN	numeric	5	Yes
MSG_FORMATS_TOLL_RATE	SUPPRESS_LEAD_ZEROS_IN_DOLLAR	numeric	5	Yes
MSG_FORMATS_TOLL_RATE_TIME	MESSAGE_FORMAT_ID	char	32	No
MSG_FORMATS_TOLL_RATE_TIME	MESSAGE_TEMPLATE_ID	char	32	No
MSG_FORMATS_TOLL_RATE_TIME	NAME	varchar	50	No
MSG_FORMATS_TOLL_RATE_TIME	FORMAT	varchar	50	No

Table_Name	Column_Name	Type	Size	Nullable
MSG_FORMATS_TOLL_RATE_TIME	EXAMPLE	varchar	22	Yes
MSG_FORMATS_TOLL_RATE_TIME	FORMAT_LENGTH	numeric	5	No
MSG_FORMATS_TOLL_RATE_TIME	HOUR_START_INDEX	numeric	5	Yes
MSG_FORMATS_TOLL_RATE_TIME	HOUR_END_INDEX	numeric	5	Yes
MSG_FORMATS_TOLL_RATE_TIME	MINUTES_START_INDEX	numeric	5	Yes
MSG_FORMATS_TOLL_RATE_TIME	MINUTES_END_INDEX	numeric	5	Yes
MSG_FORMATS_TOLL_RATE_TIME	AM_PM_START_INDEX	numeric	5	Yes
MSG_FORMATS_TOLL_RATE_TIME	AM_PM_END_INDEX	numeric	5	Yes
MSG_FORMATS_TRAVEL_TIME	MESSAGE_FORMAT_ID	char	32	No
MSG_FORMATS_TRAVEL_TIME	MESSAGE_TEMPLATE_ID	char	32	No
MSG_FORMATS_TRAVEL_TIME	NAME	varchar	50	No
MSG_FORMATS_TRAVEL_TIME	FORMAT	varchar	50	No
MSG_FORMATS_TRAVEL_TIME	EXAMPLE	varchar	22	Yes
MSG_FORMATS_TRAVEL_TIME	FORMAT_LENGTH	numeric	5	No
MSG_FORMATS_TRAVEL_TIME	HOUR_START_INDEX	numeric	5	Yes
MSG_FORMATS_TRAVEL_TIME	HOUR_END_INDEX	numeric	5	Yes
MSG_FORMATS_TRAVEL_TIME	SUPPRESS_HRS_LEAD_ZEROS	numeric	5	Yes
MSG_FORMATS_TRAVEL_TIME	MINUTES_START_INDEX	numeric	5	Yes
MSG_FORMATS_TRAVEL_TIME	MINUTES_END_INDEX	numeric	5	Yes
MSG_FORMATS_TRAVEL_TIME	SUPPRESS_MIN_LEAD_ZEROS	numeric	5	Yes
MSG_FORMATS_TRAVEL_TIME	START_HR_LITERAL_INDEX	numeric	5	Yes
MSG_FORMATS_TRAVEL_TIME	END_HR_LITERAL_INDEX	numeric	5	Yes
MSG_FORMATS_TRAVEL_TIME	SUPPRESS_HR_LITERAL	numeric	5	Yes
MSG_FORMATS_TRAVEL_TIME	COLON_INDEX	numeric	5	Yes
MSG_FORMATS_TRAVEL_TIME	SUPPRESS_COLON_LITERAL	numeric	5	Yes
MSG_FORMATS_TRAVEL_TIME	CENTER_IN_ALLOTTED_SPACE	numeric	5	Yes
MSG_FORMATS_TRAVEL_TIME_RANGE	MESSAGE_FORMAT_ID	char	32	No
MSG_FORMATS_TRAVEL_TIME_RANGE	MESSAGE_TEMPLATE_ID	char	32	No
MSG_FORMATS_TRAVEL_TIME_RANGE	NAME	varchar	50	No

Table_Name	Column_Name	Type	Size	Nullable
MSG_FORMATS_TRAVEL_TIME_RANGE	FORMAT	varchar	50	No
MSG_FORMATS_TRAVEL_TIME_RANGE	EXAMPLE	varchar	22	Yes
MSG_FORMATS_TRAVEL_TIME_RANGE	FORMAT_LENGTH	numeric	5	No
MSG_FORMATS_TRAVEL_TIME_RANGE	LOW_START_INDEX	numeric	5	Yes
MSG_FORMATS_TRAVEL_TIME_RANGE	LOW_END_INDEX	numeric	5	Yes
MSG_FORMATS_TRAVEL_TIME_RANGE	HIGH_START_INDEX	numeric	5	Yes
MSG_FORMATS_TRAVEL_TIME_RANGE	HIGH_END_INDEX	numeric	5	Yes
MSG_FORMATS_TRAVEL_TIME_RANGE	SUPPRESS_LEADING_ZEROS	numeric	5	Yes
MSG_LOG_SEQ	msg_log_seq_id	int	4	No
MSG_ROUTE_LOG_SEQ	msg_route_log_seq_id	int	4	No
NOTIFICATION_GROUP	NOTIFICATION_GROUP_ID	char	32	No
NOTIFICATION_GROUP	NOTIFICATION_GROUP_NAME	nvarchar	100	No
NOTIFICATION_GROUP	CREATED_timestamp	datetime2	6	No
NOTIFICATION_GROUP	UPDATED_timestamp	datetime2	6	No
NOTIFICATION_GROUP_CONTACT_ENTRY	NG_NOTIFICATION_GROUP_ID	char	32	No
NOTIFICATION_GROUP_CONTACT_ENTRY	NC_NOTIFICATION_CONTACT_ID	char	32	No
NOTIFICATION_RECORD	NOTIF_ID	char	32	No
NOTIFICATION_RECORD	NOTIF_TYPE	numeric	5	No
NOTIFICATION_RECORD	EVENT_ID	char	32	Yes
NOTIFICATION_RECORD	AUTHOR	varchar	40	No
NOTIFICATION_RECORD	NOTIF_OP_CENTER_ID	char	32	No
NOTIFICATION_RECORD	NOTIF_INIT_OP_CENTER_NAME	varchar	16	No
NOTIFICATION_RECORD	NOTIF_CREATE_DATE	datetime2	6	No
NOTIFICATION_RECORD	NOTIF_MESSAGE	varchar	3000	No
NOTIFICATION_RECORD	OFFLINE_IND	numeric	5	No
NOTIFICATION_RECORD	NOTIF_SUBJECT	varchar	512	Yes
NOTIFICATION_REQUEST	NOTIF_ID	char	32	No
NOTIFICATION_REQUEST	RECIPIENT_ID	char	32	No
NOTIFICATION_REQUEST	TARGET_TYPE	numeric	5	Yes

Table_Name	Column_Name	Type	Size	Nullable
NOTIFICATION_REQUEST	RECIPIENT_NAME	varchar	256	No
NOTIFICATION_STATUS	NOTIF_ID	char	32	No
NOTIFICATION_STATUS	NOTIF_STATUS_TYPE	numeric	5	No
NOTIFICATION_STATUS	NOTIF_STATUS_TEXT	varchar	255	No
NOTIFICATION_STATUS	STATUS_CREATE_TIME	datetime2	6	No
NOTIFICATION_STATUS	RECIPIENT_ID	char	32	No
OBJECT_ALERT	OBJECT_ID	varchar	32	No
OBJECT_ALERT	OBJECT_TYPE	numeric	5	No
OBJECT_ALERT	ALERT_TYPE	numeric	5	No
OBJECT_ALERT	ALERT_CENTER_ID	char	32	No
OBJECT_AOR	OBJECT_ID	char	32	No
OBJECT_AOR	OBJECT_TYPE	numeric	5	No
OBJECT_AOR	AOR_ID	char	32	No
OBJECT_LOCATION	OBJECT_ID	varchar	32	No
OBJECT_LOCATION	LOCATION_TEXT	varchar	1024	Yes
OBJECT_LOCATION	LOCATION_DESC_OVERRIDDEN	numeric	5	Yes
OBJECT_LOCATION	COUNTY_NAME	varchar	50	Yes
OBJECT_LOCATION	COUNTY_FIPS_CODE	char	3	Yes
OBJECT_LOCATION	COUNTY_CODE	varchar	3	Yes
OBJECT_LOCATION	USPS_STATE_CODE	char	2	Yes
OBJECT_LOCATION	STATE_FULL_NAME	varchar	32	Yes
OBJECT_LOCATION	STATE_FIPS_CODE	char	2	Yes
OBJECT_LOCATION	REGION_NAME	varchar	32	Yes
OBJECT_LOCATION	ROUTE_SPEC_TYPE	numeric	5	Yes
OBJECT_LOCATION	ROUTE_FREE_FORM_TEXT	varchar	50	Yes
OBJECT_LOCATION	ROUTE_TYPE	numeric	5	Yes
OBJECT_LOCATION	ROUTE_PREFIX	varchar	10	Yes
OBJECT_LOCATION	ROUTE_NUMBER	varchar	10	Yes
OBJECT_LOCATION	ROUTE_SUFFIX	varchar	10	Yes

Table_Name	Column_Name	Type	Size	Nullable
OBJECT_LOCATION	INT_FEAT_TYPE	numeric	5	Yes
OBJECT_LOCATION	INT_FEAT_PROX_TYPE	numeric	5	Yes
OBJECT_LOCATION	ROAD_NAME	varchar	50	Yes
OBJECT_LOCATION	INT_ROUTE_SPEC_TYPE	numeric	5	Yes
OBJECT_LOCATION	INT_ROUTE_FREE_FORM_TEXT	varchar	50	Yes
OBJECT_LOCATION	INT_ROUTE_TYPE	numeric	5	Yes
OBJECT_LOCATION	INT_ROAD_NAME	varchar	50	Yes
OBJECT_LOCATION	INT_ROUTE_PREFIX	varchar	10	Yes
OBJECT_LOCATION	INT_ROUTE_NUMBER	varchar	10	Yes
OBJECT_LOCATION	INT_ROUTE_SUFFIX	varchar	4	Yes
OBJECT_LOCATION	INT_FEAT_MILEPOST_TYPE	numeric	5	Yes
OBJECT_LOCATION	INT_FEAT_MILLI_MILEPOST_DATA	numeric	5	Yes
OBJECT_LOCATION	ROADWAY_LOC_ALIAS_PUB_NAME	varchar	90	Yes
OBJECT_LOCATION	ROADWAY_LOC_ALIAS_INT_NAME	varchar	90	Yes
OBJECT_LOCATION	LATITUDE_UDEG	numeric	9	Yes
OBJECT_LOCATION	LONGITUDE_UDEG	numeric	9	Yes
OBJECT_LOCATION	GEOLOC_SOURCE_TYPE	numeric	5	Yes
OBJECT_LOCATION	GEOLOC_SOURCE_DESC	varchar	35	Yes
OBJECT_LOCATION	SHOW_ROUTE_NAME	numeric	5	Yes
OBJECT_LOCATION	SHOW_INT_ROUTE_NAME	numeric	5	Yes
OBJECT_LOCATION	DIRECTION_CODE	numeric	5	Yes
OBJECT_LOCATION	OBJECT_TYPE	numeric	5	Yes
OBJECT_LOCATION	INT_FEAT_EXIT_NUMBER	numeric	5	Yes
OBJECT_LOCATION	INT_FEAT_EXIT_SUFFIX	varchar	16	Yes
OBJECT_LOCATION	INT_FEAT_EXIT_ROAD_NAME	varchar	96	Yes
OBJECT_LOCATION	SEC_INT_FEAT_TYPE	numeric	5	Yes
OBJECT_LOCATION	SEC_INT_ROUTE_SPEC_TYPE	numeric	5	Yes
OBJECT_LOCATION	SEC_INT_ROUTE_FREE_FORM_TEXT	varchar	50	Yes
OBJECT_LOCATION	SEC_INT_ROUTE_TYPE	numeric	5	Yes

Table_Name	Column_Name	Type	Size	Nullable
OBJECT_LOCATION	SEC_INT_ROAD_NAME	varchar	50	Yes
OBJECT_LOCATION	SEC_INT_ROUTE_PREFIX	varchar	10	Yes
OBJECT_LOCATION	SEC_INT_ROUTE_NUMBER	varchar	10	Yes
OBJECT_LOCATION	SEC_INT_ROUTE_SUFFIX	varchar	4	Yes
OBJECT_LOCATION	SEC_INT_FEAT_MILEPOST_TYPE	numeric	5	Yes
OBJECT_LOCATION	SEC_INT_FEAT_MILLI_MPOST_DATA	numeric	5	Yes
OBJECT_LOCATION	SEC_INT_FEAT_EXIT_NUMBER	numeric	5	Yes
OBJECT_LOCATION	SEC_INT_FEAT_EXIT_SUFFIX	varchar	16	Yes
OBJECT_LOCATION	SEC_INT_FEAT_EXIT_ROAD_NAME	varchar	96	Yes
OBJECT_LOCATION	SHOW_SEC_INT_ROUTE_NAME	numeric	5	Yes
OBJECT_LOCATION_ALIAS	OBJECT_ID	char	32	No
OBJECT_LOCATION_ALIAS	PUBLIC_NAME	varchar	50	No
OBJECT_LOCATION_ALIAS	INTERNAL_NAME	varchar	50	No
OBJECT_NOTIFICATION	OBJECT_ID	varchar	32	No
OBJECT_NOTIFICATION	OBJECT_TYPE	numeric	5	No
OBJECT_NOTIFICATION	NOTIF_TYPE	numeric	5	No
OBJECT_NOTIFICATION	NOTIFICATION_GROUP_ID	char	32	No
ON_OFF_DEVICE	DEVICE_ID	char	32	No
ON_OFF_DEVICE	MODEL_ID	numeric	5	No
ON_OFF_DEVICE	DEVICE_TYPE_ID	char	32	No
ON_OFF_DEVICE	DEVICE_NAME	varchar	50	No
ON_OFF_DEVICE	ORG_ORGANIZATION_ID	char	32	No
ON_OFF_DEVICE	MAINT_ORGANIZATION_ID	char	32	Yes
ON_OFF_DEVICE	POLLING_ENABLED	numeric	5	No
ON_OFF_DEVICE	POLLING_INTERVAL	numeric	5	Yes
ON_OFF_DEVICE	TCP_HOST	varchar	16	Yes
ON_OFF_DEVICE	TCP_PORT	numeric	5	Yes
ON_OFF_DEVICE	RELAY_NUMBER	numeric	5	No
ON_OFF_DEVICE	CREATED_TIMESTAMP	datetime2	6	No

Table_Name	Column_Name	Type	Size	Nullable
ON_OFF_DEVICE	UPDATED_TIMESTAMP	datetime2	6	No
ON_OFF_DEVICE	COMMISSIONED_DATE	date	3	Yes
ON_OFF_DEVICE_STATUS	OOD_DEVICE_ID	char	32	No
ON_OFF_DEVICE_STATUS	CEN_CENTER_ID	char	32	Yes
ON_OFF_DEVICE_STATUS	STATE_COMMANDED	numeric	5	No
ON_OFF_DEVICE_STATUS	STATE_ACTUAL	numeric	5	No
ON_OFF_DEVICE_STATUS	OP_STATUS	numeric	5	No
ON_OFF_DEVICE_STATUS	COMM_STATUS	numeric	5	No
ON_OFF_DEVICE_STATUS	LAST_CONTACT_TIME	datetime2	6	Yes
ON_OFF_DEVICE_STATUS	STATUS_CHANGE_TIME	datetime2	6	Yes
ON_OFF_DEVICE_STATUS	CREATED_TIMESTAMP	datetime2	6	No
ON_OFF_DEVICE_STATUS	UPDATED_TIMESTAMP	datetime2	6	No
ON_OFF_DEVICE_TYPE	DEVICE_TYPE_ID	char	32	No
ON_OFF_DEVICE_TYPE	DEVICE_TYPE_NAME	varchar	50	No
ON_OFF_DEVICE_TYPE	USE_CUSTOM_ICON	numeric	5	No
ON_OFF_DEVICE_TYPE	CUSTOM_ICON_DIR	varchar	100	Yes
ON_OFF_DEVICE_TYPE	CUSTOM_ICON_PREFIX	varchar	50	Yes
ON_OFF_DEVICE_TYPE	CUSTOM_ICON_WIDTH_PX	numeric	5	Yes
ON_OFF_DEVICE_TYPE	CUSTOM_ICON_HEIGHT_PX	numeric	5	Yes
ON_OFF_DEVICE_TYPE	CREATED_TIMESTAMP	datetime2	6	No
ON_OFF_DEVICE_TYPE	UPDATED_TIMESTAMP	datetime2	6	No
OOD_TRIG_ACTIVATION	OOD_TRIG_ACT_ID	char	32	No
OOD_TRIG_ACTIVATION	OOD_DEVICE_ID	char	32	No
OOD_TRIG_ACTIVATION	SORT_ORDER_NUM	tinyint	1	No
OOD_TRIG_ACTIVATION	TRIG_TRIGGER_ID	char	32	No
OOD_TRIG_ACTIVATION	TRIGGER_ENABLED	bit	1	No
OOD_TRIG_ACTIVATION	CREATED_TIMESTAMP	datetime2	6	No
OOD_TRIG_ACTIVATION	UPDATED_TIMESTAMP	datetime2	6	No
OPERATIONS_LOG	OPS_LOG_ID	int	4	No

Table_Name	Column_Name	Type	Size	Nullable
OPERATIONS_LOG	SYSTEM_TIMESTAMP	datetime2	6	No
OPERATIONS_LOG	ACTION_CODE	numeric	5	No
OPERATIONS_LOG	AUTHOR	varchar	32	No
OPERATIONS_LOG	DEVICE_NAME	varchar	50	Yes
OPERATIONS_LOG	CEN_CENTER_ID	char	32	No
OPERATIONS_LOG	HOST_NAME	varchar	255	No
OPERATIONS_LOG	LOG_TEXT	varchar	1024	No
OPERATIONS_LOG	DEVICE_NAME2	varchar	50	Yes
OPERATIONS_LOG	DEVICE_ID	char	32	Yes
OPERATIONS_LOG	DEVICE_ID2	char	32	Yes
ORGANIZATION	ORGANIZATION_ID	char	32	No
ORGANIZATION	ORGANIZATION_NAME	varchar	128	No
ORGANIZATION	DB_CODE	varchar	1	Yes
ORGANIZATION	IMPATH_H264_DECODER_USERNAME	varchar	20	Yes
ORGANIZATION	IMPATH_H264_DECODER_PASSWORD	varchar	20	Yes
ORGANIZATION	TRAVEL_TIME_MSGS_ENABLED	numeric	5	No
PATROL_AREA	PATROL_AREA_ID	char	32	No
PATROL_AREA	AOR_ID	char	32	No
PATROL_AREA	NAME	varchar	100	No
PATROL_AREA	ROUTE_DESCRIPTION	varchar	100	Yes
PATROL_AREA	CREATED_TIMESTAMP	datetime2	6	No
PATROL_AREA	UPDATED_TIMESTAMP	datetime2	6	No
PLAN_FILTER	PLA_PLAN_ENTRY_ID	int	4	No
PLAN_FILTER	PLA_PLAN_ID	char	32	No
PLAN_FILTER	PLAN_FILTER_TYPE	numeric	5	No
PLAN_FILTER	ID_FILTER_VALUE	char	32	Yes
PLAN_FILTER	STRING_FILTER_VALUE	varchar	40	Yes
PLAN_FILTER	NUMERIC_FILTER_VALUE	numeric	5	Yes
PLAN_FILTER	DB_CODE	varchar	1	Yes

Table_Name	Column_Name	Type	Size	Nullable
PLAN_ITEM	PLAN_ITEM_ID	char	32	No
PLAN_ITEM	DEVICE_ID	char	32	No
PLAN_ITEM	SM_MSG_ID	char	32	No
PLAN_ITEM	PLA_PLAN_ID	char	32	No
PLAN_ITEM	MSG_TYPE_CODE	numeric	5	No
PLAN_ITEM	PLAN_ITEM_NAME	varchar	60	No
PLAN_ITEM	DB_CODE	varchar	1	Yes
PLAN_ITEM_DIRECTION	PI_PLAN_ITEM_ID	char	32	No
PLAN_ITEM_DIRECTION	HAR_DIRECTIONAL_CODE	numeric	5	No
PROFILE_BINARY_PROPERTY	UI_USER_NAME	varchar	32	No
PROFILE_BINARY_PROPERTY	CHART_KEY	varchar	128	No
PROFILE_BINARY_PROPERTY	CHART_VALUE	varbinary	-1	Yes
PROFILE_BINARY_PROPERTY	DB_CODE	varchar	1	Yes
PROFILE_PROPERTY	CHART_KEY	varchar	128	No
PROFILE_PROPERTY	UI_USER_NAME	varchar	32	No
PROFILE_PROPERTY	CHART_VALUE	varchar	2048	No
PROFILE_PROPERTY	DB_CODE	varchar	1	Yes
PRONUNCIATIONS	CD_DICTIONARY_ID	char	32	No
PRONUNCIATIONS	PRONUNCIATION	varchar	255	No
PRONUNCIATIONS	DICTIONARY_WORD	varchar	255	No
PRONUNCIATIONS	APPROVED_CODE	varchar	5	No
PROVIDER_COLLECTOR	PROVIDER_ID	char	32	No
PROVIDER_COLLECTOR	COLLECTOR_ID	char	32	No
REGION	REGION_NAME	varchar	50	No
RESPONSE_PLAN_ITEM	RPI_ID	char	32	No
RESPONSE_PLAN_ITEM	TARGET_ID	char	32	No
RESPONSE_PLAN_ITEM	DEVICE_CODE	numeric	5	No
RESPONSE_PLAN_ITEM	DB_CODE	varchar	1	Yes
RESPONSE_PLAN_ITEM	EVENT_EVENT_ID	char	32	No

Table_Name	Column_Name	Type	Size	Nullable
RESPONSE_PLAN_ITEM	IS_MESSAGE_TEXT_MULTI	numeric	5	Yes
RESPONSE_PLAN_ITEM	RPI_BEACON_STATE	numeric	5	Yes
RESPONSE_PLAN_ITEM	HM_HAR_MSG_PK	char	32	Yes
RESPONSE_PLAN_ITEM	RPI_MSG_DESCRIPTION	varchar	255	Yes
RESPONSE_PLAN_ITEM	RPI_MESSAGE_TEXT	varchar	1024	Yes
RESPONSE_VIDTOUR_ACTIVATION_LOG	ACTIVATION_ID	char	32	No
RESPONSE_VIDTOUR_ACTIVATION_LOG	EVENT_ID	char	32	No
RESPONSE_VIDTOUR_ACTIVATION_LOG	DATE_TIME	datetime2	8	No
RESPONSE_VIDTOUR_CAM_ACTIVATION_LOG	ACTIVATION_ID	char	32	No
RESPONSE_VIDTOUR_CAM_ACTIVATION_LOG	CAMERA_ID	char	32	No
RESPONSE_VIDTOUR_ENTRY	EVENT_VIDEO_TOUR_RPI_ID	char	32	No
RESPONSE_VIDTOUR_ENTRY	CAMERA_DEVICE_ID	char	32	No
RESPONSE_VIDTOUR_ENTRY	CAMERA_ORDER	numeric	5	No
RESPONSE_VIDTOUR_ENTRY	PRESET_ID	numeric	5	No
RESPONSE_VIDTOUR_ENTRY	TEMP_PRESET_ID	char	32	No
RESPONSE_VIDTOUR_ENTRY	ACTIVE	numeric	5	No
RESPONSE_VIDTOUR_MON_ACTIVATION_LOG	ACTIVATION_ID	char	32	No
RESPONSE_VIDTOUR_MON_ACTIVATION_LOG	MONITOR_ID	char	32	No
RESPONSE_VIDTOUR_MONITOR	EVENT_VIDEO_TOUR_RPI_ID	char	32	No
RESPONSE_VIDTOUR_MONITOR	MONITOR_DEVICE_ID	char	32	No
RESPONSE_VIDTOUR_MONITOR	ACTIVE	numeric	5	No
ROADWAY_LINK	LINK_ID	char	32	No
ROADWAY_LINK	EXT_SYS_NAME	varchar	10	No
ROADWAY_LINK	EXT_LINK_ID	varchar	9	No
ROADWAY_LINK	LINK_NAME	varchar	100	Yes
ROADWAY_LINK	USPS_STATE_CODE	char	2	Yes
ROADWAY_LINK	STATE_FIPS_CODE	char	2	Yes
ROADWAY_LINK	COUNTY_NAME	varchar	50	Yes
ROADWAY_LINK	COUNTY_FIPS_CODE	varchar	3	Yes

Table_Name	Column_Name	Type	Size	Nullable
ROADWAY_LINK	ROUTE_SPEC_TYPE	numeric	5	Yes
ROADWAY_LINK	ROUTE_FREE_FORM_TEXT	varchar	60	Yes
ROADWAY_LINK	ROUTE_TYPE	numeric	5	Yes
ROADWAY_LINK	ROUTE_PREFIX	varchar	10	Yes
ROADWAY_LINK	ROUTE_NUMBER	varchar	100	Yes
ROADWAY_LINK	ROUTE_SUFFIX	varchar	10	Yes
ROADWAY_LINK	MILLI_MILES	numeric	5	Yes
ROADWAY_LINK	START_LAT_UDEG	numeric	5	Yes
ROADWAY_LINK	START_LONG_UDEG	numeric	9	Yes
ROADWAY_LINK	END_LAT_UDEG	numeric	5	Yes
ROADWAY_LINK	END_LONG_UDEG	numeric	9	Yes
ROADWAY_LINK	ROAD_NAME	varchar	100	Yes
ROADWAY_LINK	DIRECTION_CODE	numeric	5	Yes
ROADWAY_LOCATION_COUNTY	NAME	varchar	50	No
ROADWAY_LOCATION_COUNTY	CHART_MAPPING_CODE	char	2	Yes
ROADWAY_LOCATION_COUNTY	FIPS_CODE	char	3	No
ROADWAY_LOCATION_COUNTY	USPS_STATE_CODE	char	2	No
ROADWAY_LOCATION_COUNTY	DESCRIPTION	varchar	1024	Yes
ROADWAY_LOCATION_REGION	NAME	varchar	32	No
ROADWAY_LOCATION_REGION	USPS_STATE_CODE	char	2	No
ROADWAY_LOCATION_REGION	DESCRIPTION	varchar	1024	Yes
ROADWAY_LOCATION_ROUTE_PREFIX	ROUTE_PREFIX	varchar	10	No
ROADWAY_LOCATION_ROUTE_PREFIX	USPS_STATE_CODE	char	2	No
ROADWAY_LOCATION_ROUTE_PREFIX	ROUTE_TYPE	numeric	5	No
ROADWAY_LOCATION_ROUTE_PREFIX	DESCRIPTION	varchar	128	Yes
ROADWAY_LOCATION_STATE	NAME	varchar	20	No
ROADWAY_LOCATION_STATE	USPS_CODE	char	2	No
ROADWAY_LOCATION_STATE	FIPS_CODE	char	2	No
ROADWAY_LOCATION_STATE	DESCRIPTION	varchar	1024	Yes

Table_Name	Column_Name	Type	Size	Nullable
ROLE_ASSIGNMENT	UI_USER_NAME	varchar	32	No
ROLE_ASSIGNMENT	ROL_ROLE_ID	char	32	No
ROLE_ASSIGNMENT	DB_CODE	varchar	1	Yes
ROLE_FUNCTION	ROLE_FUNCTION_PK	numeric	13	No
ROLE_FUNCTION	DB_CODE	varchar	1	Yes
ROLE_FUNCTION	FR_FR_ID	numeric	5	No
ROLE_FUNCTION	ROL_ROLE_ID	char	32	No
ROLE_FUNCTION	ORG_ORGANIZATION_ID	char	32	Yes
ROUTE_TOLL_RATE	TR_ROUTE_ID	char	32	No
ROUTE_TOLL_RATE	TOLL_RATE_EFF_TIME	datetime2	6	No
ROUTE_TOLL_RATE	TOLL_RATE_EXP_TIME	datetime2	6	Yes
ROUTE_TOLL_RATE	TOLL_RATE_CENTS	numeric	5	No
ROUTE_TOLL_RATE	TOLL_RATE_REASON_CODE	numeric	5	No
ROUTE_TOLL_RATE	TOLL_RATE_INAPPLICABLE_IND	numeric	5	No
ROUTE_TOLL_RATE_TEXT	TR_ROUTE_ID	char	32	No
ROUTE_TOLL_RATE_TEXT	ROUTE_TOLL_RATE_EFF_TIME	datetime2	6	No
ROUTE_TOLL_RATE_TEXT	ROUTE_TOLL_RATE_REASON_STR	varchar	1000	Yes
ROUTE_TRAVEL_TIME	TR_ROUTE_ID	char	32	No
ROUTE_TRAVEL_TIME	ROUTE_TRAVEL_TIME_EFF_TIME	datetime2	6	No
ROUTE_TRAVEL_TIME	ROUTE_TRAVEL_TIME_SECS	numeric	5	No
ROUTE_TRAVEL_TIME	ROUTE_TRAVEL_TIME_TREND	numeric	5	No
ROUTE_TRAVEL_TIME	TRAVEL_TIME_INAPPLICABLE_IND	numeric	5	No
ROUTE_TRAVEL_TIME	ROUTE_ACT_TRAVEL_TIME_SECS	numeric	5	No
ROUTE_TRAVEL_TIME_TEXT	TR_ROUTE_ID	char	32	No
ROUTE_TRAVEL_TIME_TEXT	ROUTE_TRAVEL_TIME_EFF_TIME	datetime2	6	No
ROUTE_TRAVEL_TIME_TEXT	ROUTE_TRAVEL_TIME_CALC	varchar	1000	No
ROUTE_TRAVEL_TIME_TEXT	ROUTE_TRAVEL_TIME_REASON_CODE	numeric	5	No
ROUTES	ID	char	32	No
ROUTES	SERVER	varchar	50	Yes

Table_Name	Column_Name	Type	Size	Nullable
ROUTES	PARTICIPATING_CKT_ID	char	32	No
ROUTES	PARTICIPATING_CKT_TYPE	numeric	9	No
ROUTES	PARTICIPATING_CKT_INDEX	numeric	9	No
ROUTES	CHART_TIMESTAMP	datetime2	6	No
ROUTES	SOURCE_CONNECTION_ID	char	32	Yes
ROUTES	DESTINATION_CONNECTION_ID	char	32	Yes
ROUTES	ROUTE_NAME	varchar	100	Yes
SCHEDULE	SCHEDULE_ID	char	32	No
SCHEDULE	NAME	varchar	60	No
SCHEDULE	DESCRIPTION	varchar	255	Yes
SCHEDULE	RECEIVING_CENTER_ID	char	32	No
SCHEDULE	ENABLED	numeric	5	No
SCHEDULE	LAST_USE_TIME	datetime2	6	Yes
SCHEDULE	SUPPRESS_NEXT_ACTIVATION_TIME	datetime2	6	Yes
SCHEDULE	SCHEDULE_TYPE	numeric	5	No
SCHEDULE	BEGIN_DATE	datetime2	6	Yes
SCHEDULE	END_DATE	datetime2	6	Yes
SCHEDULE	SUNDAY	numeric	5	Yes
SCHEDULE	MONDAY	numeric	5	Yes
SCHEDULE	TUESDAY	numeric	5	Yes
SCHEDULE	WEDNESDAY	numeric	5	Yes
SCHEDULE	THURSDAY	numeric	5	Yes
SCHEDULE	FRIDAY	numeric	5	Yes
SCHEDULE	SATURDAY	numeric	5	Yes
SCHEDULE	DB_CODE	varchar	1	Yes
SCHEDULE_DOW_OCCURRENCE	SC_SCHEDULE_ID	char	32	No
SCHEDULE_DOW_OCCURRENCE	CHART_HOUR	numeric	5	No
SCHEDULE_DOW_OCCURRENCE	CHART_MINUTE	numeric	5	No
SCHEDULE_DOW_OCCURRENCE	DB_CODE	varchar	1	Yes

Table_Name	Column_Name	Type	Size	Nullable
SCHEDULE_MULTIDATE	SC_SCHEDULE_ID	char	32	No
SCHEDULE_MULTIDATE	OCCURRENCE_TIME	datetime2	6	No
SCHEDULE_MULTIDATE	DB_CODE	varchar	1	Yes
SHAZAM	DEVICE_ID	char	32	No
SHAZAM	SHAZAM_MODEL_ID	numeric	5	No
SHAZAM	ORG_ORGANIZATION_ID	char	32	No
SHAZAM	DB_CODE	varchar	1	Yes
SHAZAM	DEVICE_NAME	varchar	15	No
SHAZAM	DEVICE_LOCATION	varchar	60	Yes
SHAZAM	HAR_DEVICE_ID	char	32	Yes
SHAZAM	SHAZAM_ACCESS_PIN	varchar	3	Yes
SHAZAM	DEFAULT_PHONE_NUMBER	varchar	25	Yes
SHAZAM	SHAZAM_DIRECTIONAL_CODE	numeric	5	Yes
SHAZAM	REFRESH_INTERVAL	numeric	5	Yes
SHAZAM	REFRESH_ENABLED	numeric	5	No
SHAZAM	PORT_TYPE	numeric	5	Yes
SHAZAM	PORT_MANAGER_TIMEOUT	numeric	9	Yes
SHAZAM	CREATED_TIMESTAMP	datetime2	6	Yes
SHAZAM	UPDATED_TIMESTAMP	datetime2	6	Yes
SHAZAM	MESSAGE	varchar	256	Yes
SHAZAM	MAINT_ORGANIZATION_ID	char	32	Yes
SHAZAM	TCP_HOST	varchar	16	Yes
SHAZAM	TCP_PORT	numeric	5	Yes
SHAZAM	RELAY_NUMBER	numeric	5	Yes
SHAZAM	COMMISSIONED_DATE	date	3	Yes
SHAZAM	MANAGED_EXPORT	bit	1	Yes
SHAZAM_PHONE_NUMBER	SHAZAM_DEVICE_ID	char	32	No
SHAZAM_PHONE_NUMBER	PORT_MANAGER_NAME	varchar	30	No
SHAZAM_PHONE_NUMBER	PHONE_NUMBER	varchar	25	No

Table_Name	Column_Name	Type	Size	Nullable
SHAZAM_PHONE_NUMBER	SORT_ORDER_NUMBER	numeric	5	No
SHAZAM_PHONE_NUMBER	DB_CODE	varchar	1	Yes
SHAZAM_STATUS	SHAZAM_DEVICE_ID	char	32	No
SHAZAM_STATUS	CEN_CENTER_ID	char	32	Yes
SHAZAM_STATUS	DEVICE_STATE_CODE	numeric	5	No
SHAZAM_STATUS	BEACON_STATE	numeric	5	Yes
SHAZAM_STATUS	COMM_STATUS	numeric	5	No
SHAZAM_STATUS	STATUS_CHANGE_TIME	datetime2	6	Yes
SHAZAM_STATUS	LAST_ATTEMPTED_REFRESH_TIME	datetime2	6	Yes
SHAZAM_STATUS	LAST_CONTACT_TIME	datetime2	6	Yes
SHAZAM_STATUS	BEACON_STATE_ACTUAL	numeric	5	Yes
SOCIAL_MEDIA_MESSAGES	EVENT_EVENT_ID	char	32	No
SOCIAL_MEDIA_MESSAGES	MESSAGE_TIME	datetime2	6	No
SOCIAL_MEDIA_MESSAGES	MESSAGE_TYPE	numeric	3	No
SOCIAL_MEDIA_MESSAGES	MESSAGE_TEXT	varchar	3000	No
SOCIAL_MEDIA_MESSAGES	MESSAGE_KEY	varchar	32	No
SOP_DOCUMENT	SOPD_ID	char	32	No
SOP_DOCUMENT	NAME	varchar	100	No
SOP_DOCUMENT	HEADER	varchar	1000	No
SOP_DOCUMENT	DESCRIPTION	varchar	300	Yes
SOP_DOCUMENT	URL	varchar	200	Yes
SOP_DOCUMENT	MAJOR_DIST_INDICATOR	bit	1	Yes
SOP_DOCUMENT	ALL_CENTERS_INDICATOR	bit	1	Yes
SOP_DOCUMENT	CREATED_TIMESTAMP	datetime2	6	No
SOP_DOCUMENT	UPDATED_TIMESTAMP	datetime2	6	No
SOP_EVENT_TRIGGERS	SOPET_ID	char	32	No
SOP_EVENT_TRIGGERS	SOPD_ID	char	32	No
SOP_EVENT_TRIGGERS	EVT_TRIG_TYPE	tinyint	1	No
SOP_EVENT_TRIGGERS	CREATED_TIMESTAMP	datetime2	6	No

Table_Name	Column_Name	Type	Size	Nullable
SOP_EVENT_TRIGGERS	UPDATED_TIMESTAMP	datetime2	6	No
SOP_OP_CENTERS	SOPOPC_ID	char	32	No
SOP_OP_CENTERS	SOPD_ID	char	32	No
SOP_OP_CENTERS	CEN_CENTER_ID	char	32	No
SOP_OP_CENTERS	CREATED_TIMESTAMP	datetime2	6	No
SOP_OP_CENTERS	UPDATED_TIMESTAMP	datetime2	6	No
STANDARD_LANE	CONFIG_NAME	varchar	80	No
STANDARD_LANE	LANE_NUMBER	numeric	5	No
STANDARD_LANE	DB_CODE	varchar	1	Yes
STANDARD_LANE	LANE_CODE	numeric	5	No
STANDARD_LANE	LANE_DESCRIPTION	varchar	10	No
STANDARD_LANE	LANE_REFERENCE_DIRECTION	numeric	5	Yes
STANDARD_LANE	LANE_ORIENTATION	numeric	5	Yes
STORED_MESSAGE	MSG_ID	char	32	No
STORED_MESSAGE	ML_ML_ID	char	32	No
STORED_MESSAGE	HM_HAR_MSG_PK	char	32	Yes
STORED_MESSAGE	MSG_TYPE_CODE	numeric	5	No
STORED_MESSAGE	CATEGORY	varchar	32	Yes
STORED_MESSAGE	DB_CODE	varchar	1	Yes
STORED_MESSAGE	IS_MESSAGE_TEXT_MULTI	numeric	5	Yes
STORED_MESSAGE	MESSAGE_BEACON	numeric	5	Yes
STORED_MESSAGE	LAST_MODIFIED_BY	varchar	32	Yes
STORED_MESSAGE	MSG_DESCRIPTION	varchar	255	Yes
STORED_MESSAGE	MESSAGE_TEXT	varchar	1024	Yes
STREAMING_SERVER_CONFIG	ID	char	32	No
STREAMING_SERVER_CONFIG	INTERNAL_SFS_HOST	varchar	50	Yes
STREAMING_SERVER_CONFIG	LOGIN_NAME	varchar	50	Yes
STREAMING_SERVER_CONFIG	LOGIN_PASSWORD	varchar	32	Yes
STREAMING_SERVER_CONFIG	CMD_PORT	numeric	5	Yes

Table_Name	Column_Name	Type	Size	Nullable
STREAMING_SERVER_CONFIG	EXTERNAL_SFS_HOST	varchar	50	Yes
STREAMING_SERVER_CONFIG	ALT_STREAM_ID	varchar	128	Yes
STREAMING_SERVER_CONFIG	IS_PUBLIC	numeric	5	Yes
STREAMING_SERVER_CONFIG	NAME	varchar	255	Yes
STREAMING_SERVER_CONFIG	URL_PATTERN	varchar	255	Yes
STREAMING_SERVER_CONFIG	LAST_UPDATE_TIME	datetime2	8	No
STREAMING_SERVER_CONFIG	ZONE_TYPE	numeric	5	No
sysdiagrams	name	sysname	256	No
sysdiagrams	principal_id	int	4	No
sysdiagrams	diagram_id	int	4	No
sysdiagrams	version	int	4	Yes
sysdiagrams	definition	varbinary	-1	Yes
SYSTEM_BINARY_PROFILE	CHART_KEY	varchar	128	No
SYSTEM_BINARY_PROFILE	CHART_VALUE	varbinary	-1	Yes
SYSTEM_BINARY_PROFILE	DB_CODE	varchar	1	Yes
SYSTEM_PROFILE	CHART_KEY	varchar	128	No
SYSTEM_PROFILE	CHART_VALUE	varchar	2048	No
SYSTEM_PROFILE	DB_CODE	varchar	1	Yes
SYSTEM_PROFILE	SYSTEM_TIMESTAMP	datetime2	6	Yes
TOLL_DATA_IMPORT	IMPORT_ID	numeric	9	No
TOLL_DATA_IMPORT	SYSTEM_TIMESTAMP	datetime2	6	No
TOLL_DATA_IMPORT	EXT_SYS_NAME	varchar	35	No
toll_data_import_seq	toll_data_import_seq_id	int	4	No
TOLL_RATE_ROUTES	TOLL_RATE_EXT_SYS_NAME	varchar	35	No
TOLL_RATE_ROUTES	TOLL_RATE_EXT_START_ID	varchar	35	No
TOLL_RATE_ROUTES	TOLL_RATE_EXT_END_ID	varchar	35	No
TOLL_RATE_ROUTES	TOLL_RATE_EXT_DESC	varchar	127	No
TOLL_RATE_ROUTES	LAST_RECEIVED_TIME	datetime2	6	No
TOLL_RAW_DATA	TOLL_DATA_IMPORT_ID	numeric	9	No

Table_Name	Column_Name	Type	Size	Nullable
TOLL_RAW_DATA	EXT_SYS_START_ID	varchar	35	No
TOLL_RAW_DATA	EXT_SYS_END_ID	varchar	35	No
TOLL_RAW_DATA	EXT_SYS_ROUTE_DESC	varchar	127	No
TOLL_RAW_DATA	TOLL_RATE_EFF_TIME	datetime2	6	No
TOLL_RAW_DATA	TOLL_RATE_EXP_TIME	datetime2	6	Yes
TOLL_RAW_DATA	TOLL_RATE_CENTS	numeric	5	No
TOUR	TOUR_ID	char	32	No
TOUR	TOUR_CONFIG_ID	char	32	No
TOUR	TOUR_NAME	varchar	50	No
TOUR	DWELL_TIME	numeric	5	No
TOUR	CREATED_TIMESTAMP	datetime2	6	Yes
TOUR	DELETED_TIMESTAMP	datetime2	6	Yes
TOUR	DB_CODE	varchar	2	Yes
TOUR	CATEGORY	varchar	50	Yes
TOUR_ENTRY	TOUR_CONFIG_ID	char	32	No
TOUR_ENTRY	CAMERA_DEVICE_ID	char	32	No
TOUR_ENTRY	PRESET	numeric	5	Yes
TOUR_ENTRY	SEQ_NUM	numeric	5	No
TOUR_ENTRY	CREATED_TIMESTAMP	datetime2	6	Yes
TOUR_ENTRY	DELETED_TIMESTAMP	datetime2	6	Yes
TOUR_ENTRY	DB_CODE	varchar	2	Yes
TOUR_STATUS	TOUR_TOUR_ID	char	32	No
TOUR_STATUS	MON_DEVICE_ID	char	32	No
TRADER_INCARNATION	HIGH	numeric	9	No
TRADER_INCARNATION	LOW	numeric	9	No
TRADER_OFFER	ID	varchar	300	No
TRADER_OFFER	TRADER_SERVICE_TYPE_NAME	varchar	256	No
TRADER_OFFER	IOR	varchar	1024	No
TRADER_OFFER_ID_SEQ	trader_offer_id_seq_id	int	4	No

Table_Name	Column_Name	Type	Size	Nullable
TRADER_OFFER_PROPERTY	TRADER_OFFER_ID	varchar	300	No
TRADER_OFFER_PROPERTY	NAME	varchar	256	No
TRADER_OFFER_PROPERTY	VAL_TYPE	numeric	9	No
TRADER_OFFER_PROPERTY	VAL_STRING	varchar	1024	Yes
TRADER_SERVICE_TYPE	NAME	varchar	256	No
TRADER_SERVICE_TYPE	INTERFACE_NAME	varchar	256	No
TRADER_SERVICE_TYPE	IS_MASKED	numeric	5	No
TRADER_SERVICE_TYPE	INCARNATION_HIGH	numeric	9	No
TRADER_SERVICE_TYPE	INCARNATION_LOW	numeric	9	No
TRADER_SERVICE_TYPE_PROPERTY	TRADER_SERVICE_TYPE_NAME	varchar	256	No
TRADER_SERVICE_TYPE_PROPERTY	NAME	varchar	256	No
TRADER_SERVICE_TYPE_PROPERTY	PROP_KIND	numeric	9	No
TRADER_SERVICE_TYPE_PROPERTY	IS_SEQUENCE	numeric	5	No
TRADER_SERVICE_TYPE_PROPERTY	PROP_MODE	numeric	9	No
TRADER_SERVICE_TYPE_SUPER_TYPE	TRADER_SERVICE_TYPE_NAME	varchar	256	No
TRADER_SERVICE_TYPE_SUPER_TYPE	SUPER_TYPE_NAME	varchar	256	No
TRAVEL_ROUTE	ROUTE_ID	char	32	No
TRAVEL_ROUTE	NAME	varchar	50	No
TRAVEL_ROUTE	MILLI_MILES	numeric	5	Yes
TRAVEL_ROUTE	USER_LOCATION_IND	numeric	5	No
TRAVEL_ROUTE	PRIMARY_DEST_TEXT	varchar	30	Yes
TRAVEL_ROUTE	TRAVEL_TIME_ENABLED_IND	numeric	5	Yes
TRAVEL_ROUTE	MIN_TRAVEL_TIME_MINS	numeric	5	Yes
TRAVEL_ROUTE	MAX_TRAVEL_TIME_MINS	numeric	5	Yes
TRAVEL_ROUTE	MAX_BAD_LINKS	numeric	5	Yes
TRAVEL_ROUTE	ALERT_TRAVEL_TIME_MINS	numeric	5	Yes
TRAVEL_ROUTE	TRAV_TIME_ALERTS_ENABLED_IND	numeric	5	Yes
TRAVEL_ROUTE	TRAV_TIME_NOTIFS_ENABLED_IND	numeric	5	Yes
TRAVEL_ROUTE	TOLL_RATE_ENABLED_IND	numeric	5	Yes

Table_Name	Column_Name	Type	Size	Nullable
TRAVEL_ROUTE	TOLL_RATE_EXT_SYS_NAME	varchar	35	Yes
TRAVEL_ROUTE	TOLL_RATE_EXT_START_ID	varchar	35	Yes
TRAVEL_ROUTE	TOLL_RATE_EXT_END_ID	varchar	35	Yes
TRAVEL_ROUTE	TOLL_RATE_EXT_DESC	varchar	127	Yes
TRAVEL_ROUTE	TOLL_RATE_ALERTS_ENABLED_IND	numeric	5	Yes
TRAVEL_ROUTE	TOLL_RATE_NOTIFS_ENABLED_IND	numeric	5	Yes
TRAVEL_ROUTE_CONSUMER	TR_ROUTE_ID	char	32	No
TRAVEL_ROUTE_CONSUMER	SORT_ORDER_NUMBER	numeric	5	No
TRAVEL_ROUTE_CONSUMER	CONSUMER_ID	char	32	No
TRAVEL_ROUTE_CONSUMER	PROXY_CONSUMER_ID	char	32	Yes
TRAVEL_ROUTE_DEST	TR_ROUTE_ID	char	32	No
TRAVEL_ROUTE_DEST	SORT_ORDER_NUMBER	numeric	5	No
TRAVEL_ROUTE_DEST	ALT_DEST_TEXT	varchar	30	Yes
TRAVEL_ROUTE_LINK	TR_ROUTE_ID	char	32	No
TRAVEL_ROUTE_LINK	SORT_ORDER_NUMBER	numeric	5	No
TRAVEL_ROUTE_LINK	RL_LINK_ID	char	32	No
TRAVEL_ROUTE_LINK	CHART_PERCENT	numeric	5	No
TRAVEL_ROUTE_LINK	MIN_ALLOWED_QUALITY	numeric	5	No
TRAVEL_ROUTE_LOCATION	TR_ROUTE_ID	varchar	32	No
TRAVEL_ROUTE_LOCATION	SORT_ORDER_NUMBER	numeric	5	No
TRAVEL_ROUTE_LOCATION	COUNTY_NAME	varchar	50	Yes
TRAVEL_ROUTE_LOCATION	COUNTY_FIPS_CODE	char	3	Yes
TRAVEL_ROUTE_LOCATION	COUNTY_CODE	numeric	5	Yes
TRAVEL_ROUTE_LOCATION	DIRECTION_CODE	numeric	5	Yes
TRAVEL_ROUTE_LOCATION	USPS_STATE_CODE	char	2	Yes
TRAVEL_ROUTE_LOCATION	STATE_FULL_NAME	varchar	32	Yes
TRAVEL_ROUTE_LOCATION	STATE_FIPS_CODE	char	2	Yes
TRAVEL_ROUTE_LOCATION	ROUTE_SPEC_TYPE	numeric	5	Yes
TRAVEL_ROUTE_LOCATION	ROUTE_FREE_FORM_TEXT	varchar	60	Yes

Table_Name	Column_Name	Type	Size	Nullable
TRAVEL_ROUTE_LOCATION	ROUTE_TYPE	numeric	5	Yes
TRAVEL_ROUTE_LOCATION	ROUTE_PREFIX	varchar	10	Yes
TRAVEL_ROUTE_LOCATION	ROUTE_NUMBER	varchar	10	Yes
TRAVEL_ROUTE_LOCATION	ROUTE_SUFFIX	varchar	10	Yes
TRAVEL_ROUTE_LOCATION	ROAD_NAME	varchar	50	Yes
TRAVEL_ROUTE_LOCATION	DB_CODE	char	1	Yes
TRIGGER_CONDITION	TRIGGER_COND_ID	char	32	No
TRIGGER_CONDITION	TRIG_TRIGGER_ID	char	32	No
TRIGGER_CONDITION	CONDITION_ENABLED	bit	1	No
TRIGGER_CONDITION	PROVIDER_NAME	varchar	60	No
TRIGGER_CONDITION	SOURCE_ID	varchar	32	No
TRIGGER_CONDITION	SOURCE_NAME	varchar	60	No
TRIGGER_CONDITION	ELEMENT_ID	varchar	32	No
TRIGGER_CONDITION	ELEMENT_NAME	varchar	60	No
TRIGGER_CONDITION	DATA_TYPE	tinyint	1	No
TRIGGER_CONDITION	COMPARATOR	int	4	No
TRIGGER_CONDITION	COMPARE_VALUE	varchar	40	No
TRIGGER_CONDITION	VALUE_UNITS	varchar	20	No
TRIGGER_CONDITION	TRIGGER_COND_LAST_TRUE	datetime2	6	Yes
TRIGGER_CONDITION	CURRENT_VALUE	varchar	40	No
TRIGGER_CONDITION	CURRENT_VALUE_TIMESTAMP	datetime2	6	Yes
TRIGGER_CONDITION	CREATED_TIMESTAMP	datetime2	6	No
TRIGGER_CONDITION	UPDATED_TIMESTAMP	datetime2	6	No
TRIGGER_CONDS_STATUS_LOG	SYSTEM_TIMESTAMP	datetime2	6	No
TRIGGER_CONDS_STATUS_LOG	COND_LOG_SEQUENCE	int	4	No
TRIGGER_CONDS_STATUS_LOG	TRIGGER_ID	char	32	No
TRIGGER_CONDS_STATUS_LOG	TRIGGER_COND_ID	char	32	No
TRIGGER_CONDS_STATUS_LOG	TRIGGER_COND_LAST_TRUE	datetime2	6	Yes
TRIGGER_CONDS_STATUS_LOG	CURRENT_VALUE	varchar	40	No

Table_Name	Column_Name	Type	Size	Nullable
TRIGGER_CONDS_STATUS_LOG	CURRENT_VALUE_TIMESTAMP	datetime2	6	Yes
TRIGGER_CONDS_STATUS_LOG	ACTIVE	bit	1	No
TRIGGER_CONDS_STATUS_LOG	ENABLED	bit	1	No
TRIGGER_CONDS_STATUS_LOG	COND_TRUE	bit	1	No
TRIGGER_CONDS_STATUS_LOG	STALE	bit	1	No
TRIGGER_CONFIG_CONDS_LOG	SYSTEM_TIMESTAMP	datetime2	6	No
TRIGGER_CONFIG_CONDS_LOG	TRIG_CONFIG_LOG_SEQUENCE	int	4	No
TRIGGER_CONFIG_CONDS_LOG	TRIGGER_ID	varchar	32	No
TRIGGER_CONFIG_CONDS_LOG	TRIGGER_COND_ID	char	32	No
TRIGGER_CONFIG_CONDS_LOG	CONDITION_ENABLED	bit	1	No
TRIGGER_CONFIG_CONDS_LOG	PROVIDER_NAME	varchar	60	No
TRIGGER_CONFIG_CONDS_LOG	SOURCE_ID	varchar	32	No
TRIGGER_CONFIG_CONDS_LOG	SOURCE_NAME	varchar	60	No
TRIGGER_CONFIG_CONDS_LOG	ELEMENT_ID	varchar	32	No
TRIGGER_CONFIG_CONDS_LOG	ELEMENT_NAME	varchar	60	No
TRIGGER_CONFIG_CONDS_LOG	DATA_TYPE	tinyint	1	No
TRIGGER_CONFIG_CONDS_LOG	COMPARATOR	int	4	No
TRIGGER_CONFIG_CONDS_LOG	COMPARE_VALUE	varchar	40	No
TRIGGER_CONFIG_CONDS_LOG	VALUE_UNITS	varchar	10	No
TRIGGER_CONFIG_LOG	SYSTEM_TIMESTAMP	datetime2	6	No
TRIGGER_CONFIG_LOG	TRIGGER_ID	varchar	32	No
TRIGGER_CONFIG_LOG	TRIGGER_NAME	varchar	100	No
TRIGGER_CONFIG_LOG	ENABLED	bit	1	No
TRIGGER_STATUS_LOG	SYSTEM_TIMESTAMP	datetime2	6	No
TRIGGER_STATUS_LOG	STAT_LOG_SEQUENCE	int	4	No
TRIGGER_STATUS_LOG	TRIGGER_ID	char	32	No
TRIGGER_STATUS_LOG	TRIGGER_NAME	varchar	100	No
TRIGGER_STATUS_LOG	TRIGGER_ENABLED	bit	1	No
TRIGGER_STATUS_LOG	TRIGGER_ACTIVE	bit	1	No

Table_Name	Column_Name	Type	Size	Nullable
TRIGGER_STATUS_LOG	TRIGGER_LAST_ACTIVE	datetime2	6	Yes
TSS	DEVICE_ID	char	32	No
TSS	TSS_MODEL_ID	numeric	5	No
TSS	ORG_ORGANIZATION_ID	char	32	No
TSS	DB_CODE	varchar	1	Yes
TSS	DEVICE_NAME	varchar	15	No
TSS	DEVICE_LOCATION	varchar	60	Yes
TSS	DROP_ADDRESS	numeric	5	No
TSS	DEFAULT_PHONE_NUMBER	varchar	25	Yes
TSS	POLL_INTERVAL_SECS	numeric	5	No
TSS	PORT_TYPE	numeric	5	Yes
TSS	PORT_MANAGER_TIMEOUT	numeric	9	Yes
TSS	BAUD_RATE	numeric	5	Yes
TSS	DATA_BITS	numeric	5	Yes
TSS	FLOW_CONTROL	numeric	5	Yes
TSS	PARITY	numeric	5	Yes
TSS	STOP_BITS	numeric	5	Yes
TSS	ENABLE_DEVICE_LOG	numeric	5	No
TSS	CREATED_TIMESTAMP	datetime2	6	Yes
TSS	UPDATED_TIMESTAMP	datetime2	6	Yes
TSS	CEN_ALERT_CENTER_ID	char	32	Yes
TSS	EXT_ID_SYSTEM_ID	varchar	35	Yes
TSS	EXT_ID_AGENCY_ID	varchar	35	Yes
TSS	EXT_ID_TSS_ID	varchar	256	Yes
TSS	TCP_HOST	varchar	16	Yes
TSS	TCP_PORT	numeric	5	Yes
TSS	MAINT_ORGANIZATION_ID	char	32	Yes
TSS	DISPLAY_BEARING	numeric	5	No
TSS	TSS_PROTOCOL_ID	numeric	5	Yes

Table_Name	Column_Name	Type	Size	Nullable
TSS	ENABLE_SCHEDULED_BIT	numeric	5	Yes
TSS	COMMISSIONED_DATE	date	3	Yes
TSS	MANAGED_EXPORT	bit	1	Yes
TSS_DEVICE_SEQ	TSS_DEVICE_seq_id	int	4	No
TSS_PHONE_NUMBER	TSS_DEVICE_ID	char	32	No
TSS_PHONE_NUMBER	PORT_MANAGER_NAME	varchar	30	No
TSS_PHONE_NUMBER	PHONE_NUMBER	varchar	25	No
TSS_PHONE_NUMBER	SORT_ORDER_NUMBER	numeric	5	No
TSS_PHONE_NUMBER	DB_CODE	varchar	1	Yes
TSS_RAW_DATA	TSS_DEVICE_ID	char	32	No
TSS_RAW_DATA	SYSTEM_TIMESTAMP	datetime2	6	No
TSS_RAW_DATA	ZONE_NUMBER	numeric	5	No
TSS_RAW_DATA	DIRECTION	numeric	5	No
TSS_RAW_DATA	SPEED	numeric	5	No
TSS_RAW_DATA	VOLUME	numeric	5	No
TSS_RAW_DATA	OCCUPANCY	numeric	5	No
TSS_STATUS	TSS_DEVICE_ID	char	32	No
TSS_STATUS	DEVICE_STATE_CODE	numeric	5	No
TSS_STATUS	COMM_STATUS	numeric	5	No
TSS_STATUS	LAST_CONTACT_TIME	datetime2	6	Yes
TSS_STATUS	TSS_HARDWARE_STATUS	numeric	5	Yes
TSS_STATUS	HARDWARE_STATUS_TIMESTAMP	datetime2	6	Yes
TSS_STATUS	HARDWARE_FAILURE_TIMESTAMP	datetime2	6	Yes
TSS_ZONE	TSSZG_TSS_DEVICE_ID	char	32	No
TSS_ZONE	TSSZG_GROUP_NUMBER	numeric	9	No
TSS_ZONE	ZONE_NUMBER	numeric	5	No
TSS_ZONE	DB_CODE	varchar	1	Yes
TSS_ZONE_GROUP	TSS_DEVICE_ID	char	32	No
TSS_ZONE_GROUP	GROUP_NUMBER	numeric	9	No

Table_Name	Column_Name	Type	Size	Nullable
TSS_ZONE_GROUP	DIRECTION_CODE	numeric	5	No
TSS_ZONE_GROUP	DEFAULT_SPEED	numeric	5	No
TSS_ZONE_GROUP	DB_CODE	varchar	1	Yes
TSS_ZONE_GROUP	DESCRIPTION	varchar	60	No
TSS_ZONE_GROUP	DISPLAY_TYPE	numeric	5	No
TSS_ZONE_GROUP	DISPLAY_ORDER	numeric	9	No
TSS_ZONE_GROUP	OVERRIDE_DESCRIPTION	numeric	5	Yes
USER_FAILED_LOGIN	UI_USER_NAME	varchar	32	No
USER_FAILED_LOGIN	CREATED_TIMESTAMP	datetime2	6	No
USER_ID	USER_NAME	varchar	32	No
USER_ID	DB_CODE	varchar	1	Yes
USER_ID	DEFAULT_CEN_CENTER_ID	char	32	No
USER_ID	OTHER_CENTER_CAPABILITY	int	4	No
USER_ID	LAST_LOGIN_TIMESTAMP	datetime2	8	Yes
USER_ID	LAST_LOGIN_CEN_CENTER_ID	char	32	Yes
USER_ID	CREATED_TIMESTAMP	datetime2	6	Yes
USER_ID	LAST_LOGOUT_TIMESTAMP	datetime2	6	Yes
USER_ID	DISABLED_INDICATOR	numeric	5	No
USER_ID	UNLOCK_TIMESTAMP	datetime2	6	Yes
USER_ID_OTHER_CENTER	UI_USER_NAME	varchar	32	No
USER_ID_OTHER_CENTER	CEN_CENTER_ID	char	32	No
USER_LOCKED_NON_ACCT	USER_NAME	varchar	32	No
USER_LOCKED_NON_ACCT	UNLOCK_TIMESTAMP	datetime2	6	No
USER_PASSWORD	UI_USER_NAME	varchar	32	No
USER_PASSWORD	CREATED_TIMESTAMP	datetime2	6	No
USER_PASSWORD	PASSWORD	varchar	32	No
USER_PASSWORD	ADMINISTRATIVELY_SET_INDICATOR	numeric	5	No
VIDEO_FABRIC	DEVICE_ID	char	32	No
VIDEO_FABRIC	ORG_ORGANIZATION_ID	char	32	No

Table_Name	Column_Name	Type	Size	Nullable
VIDEO_FABRIC	DEVICE_NAME	varchar	32	Yes
VIDEO_SESSION	SESSION_ID	char	32	No
VIDEO_SESSION	USER_NAME	varchar	32	No
VIDEO_SESSION	CENTER_ID	char	32	No
VIDEO_SESSION	CENTER_NAME	varchar	16	No
VIDEO_SESSION	CREATED_TIMESTAMP	date	3	No
VIDEO_SESSION	UPDATED_TIMESTAMP	date	3	No
VIDEO_SESSION	USER_HOST	varchar	50	No
VIDEO_SESSION	USER_IP	varchar	15	No
VIDEO_SESSION	CLIENT_APP_HOST	varchar	50	No
VIDEO_SESSION	CLIENT_INSTANCE_ID	char	32	No
VIDEO_SESSION	SUBJECT_DESC	varchar	512	No
VIDEO_SESSION	SUBJECT_ID	char	32	No
VIDEO_SESSION	SUBJECT_TYPE	numeric	5	No
VIDEO_SWITCH_CONNECTION_DROPPED_ROWS	CONNECTION_ID	char	32	No
VIDEO_SWITCH_CONNECTION_DROPPED_ROWS	VS_DEVICE_ID	char	32	No
VIDEO_SWITCH_CONNECTION_DROPPED_ROWS	VIDEO_SWITCH_PORT	numeric	5	No
WEATHER	EVENT_EVENT_ID	char	32	No
WEATHER	WEATHER_CODE	numeric	5	No
WEATHER	CREATED_TIMESTAMP	datetime2	6	Yes
WEATHER	DB_CODE	varchar	1	Yes

D RELEASE HISTORY

The CHART system has been evolving over a long period of time. Release 1 provided the foundation on which future releases are based and was the first operational release. Subsequent releases have added additional functions prioritized by CHART operations needs. Hardware resources have been deployed in a phased manner to support each system release. A detailed schedule for each release broken down by release and build was provided in the original CHART System Development Schedule. A summary description of the system capabilities for each of the CHART releases is presented in the following sections.

D.1 CHART ATMS Release 1

Release 1 of the CHART ATMS consisted of four separate "builds" (R1B1, R1B2, R1B3, and R1B4). The final build, R1B4, was deployed June 13, 2003. Release 1 provided system administration, DMS, HAR, and basic traffic management support. The Release 1 software capabilities as they existed after the final build of Release 1 are listed in Table D-1. Release 1 was deployed with a dual server system in a local SAN located at the SOC. The text-to-speech conversion software was hosted on the backup server at the SOC and on an interim system located at the Greenbelt site. Multiple remote client systems (the "fat" Java GUI) were deployed as needed. Release 1 also included the deployment of a redesigned FMS server system. Figure D-1 shows the server configuration as it existed at the Hanover, Greenbelt, and Brooklandville sites at the end of Release 1. Since CCTV video distribution had not yet been integrated with the CHART system, the existing video distribution system (AVCM) servers remained as separate components. This diagram is a high level view of the system and is meant to impart the architecture concepts. In the interest of keeping the diagram readable, not every system component is shown. Release R1B2 was deployed approximately December 4, 2000. Release R1B3 (R1B3.08) was deployed January 20, 2002 and an update (R1B3.11) was deployed March 6, 2003. Release R1B4 was deployed June 13, 2003.

Table D-1. CHART ATMS Release 1 Functions

CI	Subsystem	Function
Core Services	Audio Management	TTS conversion, audio management
	Communications Log Management	Communication Log
	Device Management	Device online/offline/maintenance mode, maintenance commands
	Dictionary Management	Approved words and banned words for DMS and HAR
	DMS Control	8 models of DMS including NTCIP
	HAR Control	ISS AP55 HAR
	HAR Notification	EIS RTMS SHAZAM
	Message Library Management	Libraries
	Plan Management	Plans

CI	Subsystem	Function
	Resource Management	User login, resource tracking
	System Monitor	Logging system actions
	Traffic Event Management	Manual incident data entry Operator selection of incident response actions EORS (initial interface) (EORS is now LCP)
	Traffic Sensor System Management	RTMS Support
	User Management	Roles and functional rights
	Utility	CHART Chat
GUI Services	GUI Management	Navigator GUI
FMS Services	Port Manager	ISDN, POTS, Telephony
	Protocol Handlers	DMS, HAR, SHAZAM, TSS
Database Instance	Operational DB	
Database Archive	Archive DB	Interim storage for archive data
	Query	Querying capability
	Report Generation	Reporting

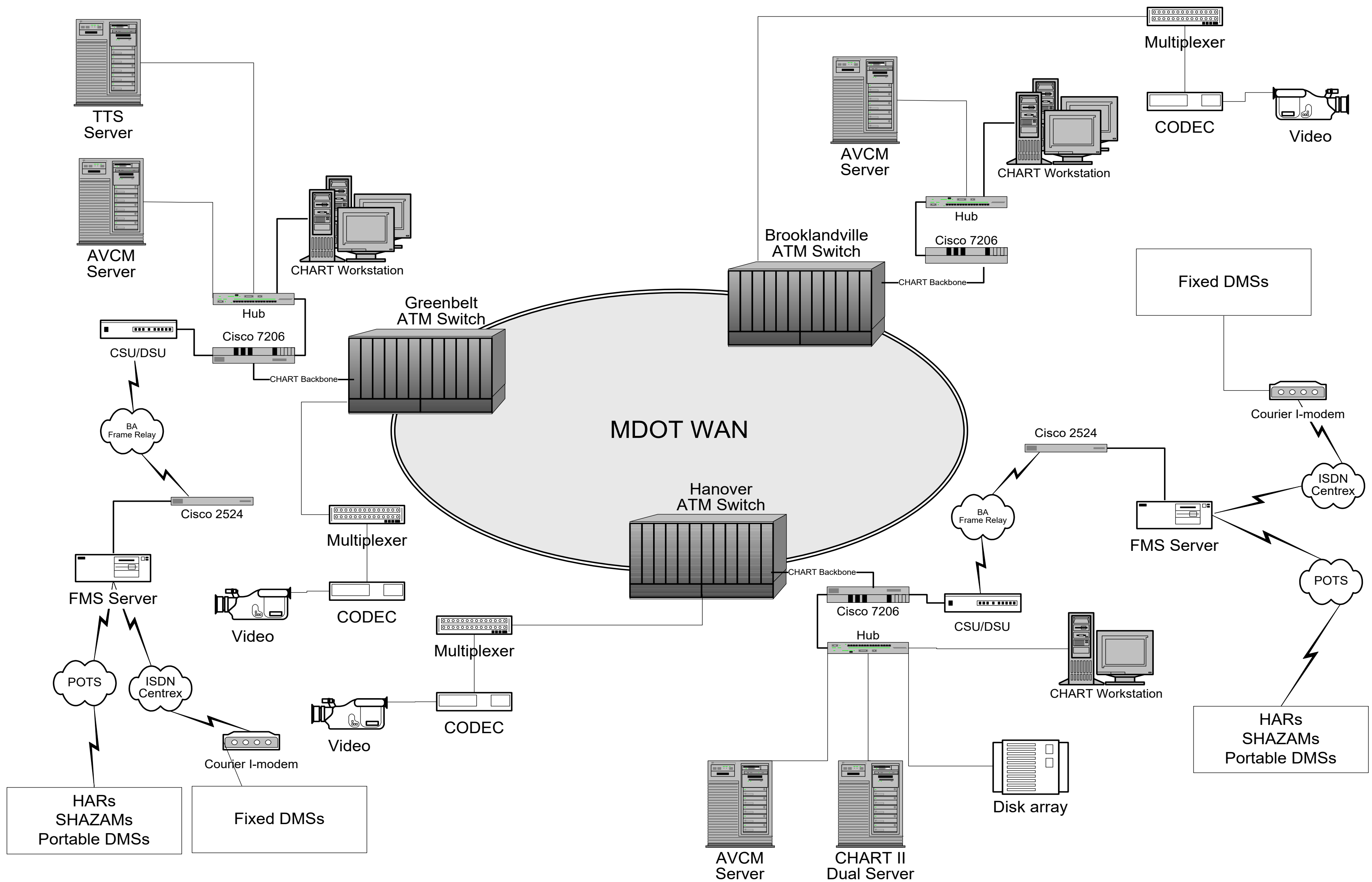

Figure D-1. CHART ATMS Release 1 Server Installations

D.2 CHART ATMS Release 2

Release 2 release consisted of three builds (R2B1, R2B2, and R2B3). The final build, R2B3, was deployed April 27, 2007. Release 2 provided video integration into CHART, un-federation of the CHART servers, disabling the "fat" Java-based CHART GUI, the addition of direct connect communications ports for low speed data communications, and support for a new CORBA ORB (JacORB). These changes are summarized in Table D-2. This release worked exclusively with the CHARTLite browser-based GUI. This release provided upgraded MDTA integration capabilities. Additionally, this release provided support for additional models of HARs for the CHART HAR subsystem. An updated CHART Reporting capability was released during this time period, however it was considered independent of CHART ATMS Release 2. Figure D-2 is a high level view of the system and is meant to impart the architecture concepts of this release. In the interest of keeping the diagram readable, every system component is not shown. Release R2B1 was deployed approximately January 1, 2006. Release R2B2 was deployed September 21-23, 2006. Release R2B3 was deployed April 27, 2007.

Table D-2. CHART ATMS Release 2 Functions

CI	Subsystem	Function
Core Services	Video Management	New Video Management subsystem added to support Camera Control; Camera Display on Monitors, including V1500 control and Video Router
	HAR Control	HIS DR 1500 HAR, synchronized HARs
GUI Services	GUI Management	Web based GUI replaces fat Java based "Navigator" GUI
FMS Services	Port Manager	Direct Port Communications
	Port Configuration Utility	
Database Instance	Operational DB	CHART operational data Detector data
Database Archive	Archive DB	
	Report Generation	Operational reports

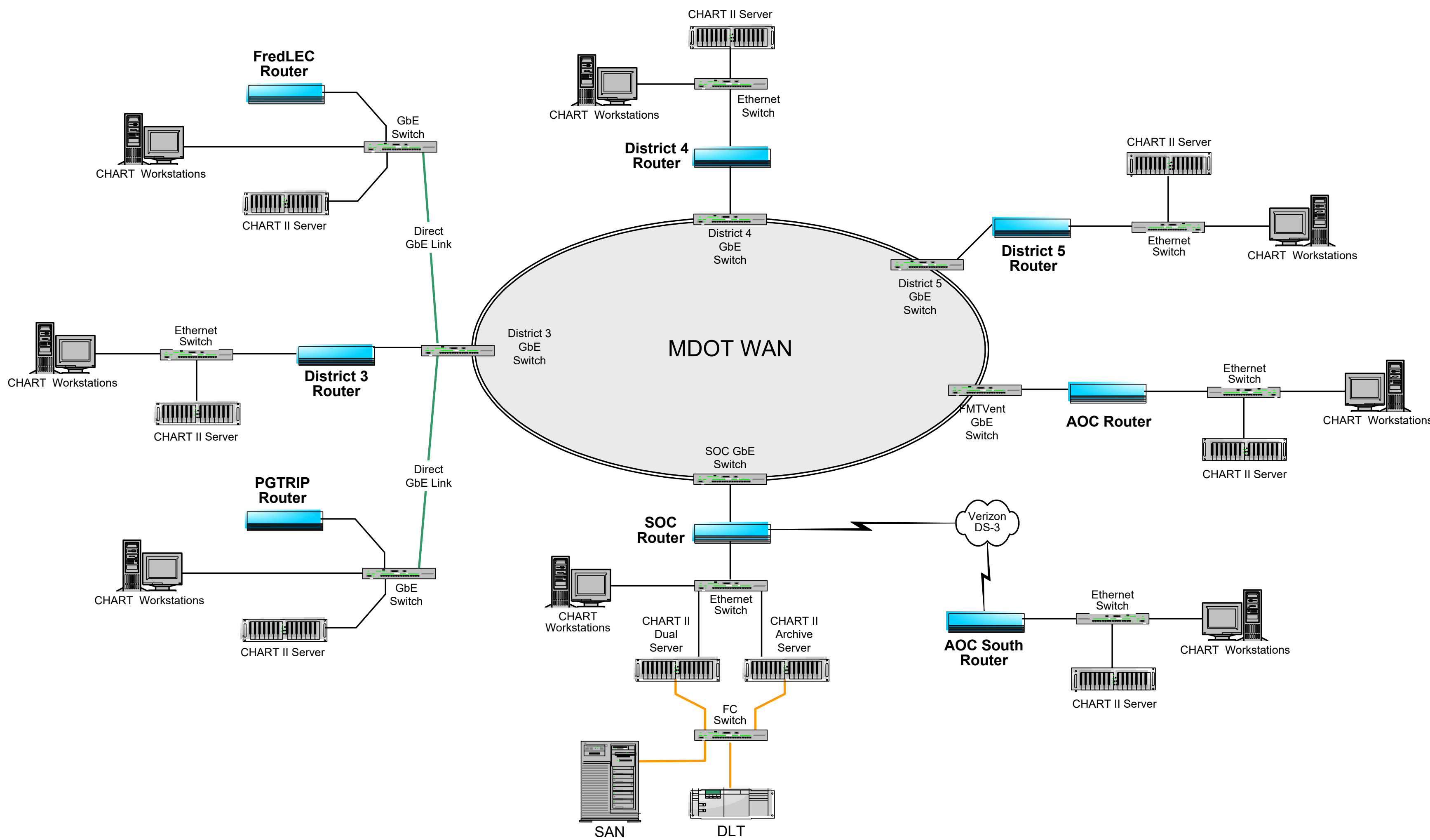

Figure D-2. CHART ATMS Release 2 Server Installations

D.3 CHART ATMS Release 3

Release 3 consisted of three builds (R3B1, R3B2, and R3B3) and was the last CHART ATMS release to be released in multiple builds. The final build, R3B3, was deployed December 8, 2009. Release 3 added a newly designed CHART GUI, alert support, schedule support, notification support, additional incident management capabilities, operational reports, data import capabilities from external systems, and support for automated Travel Times and Toll Rates on DMSs. It also provided support for a new type of HAR, the synchronized DR1500 HAR, and geo-location capabilities for all types of devices and for traffic events. It also continued to enhance the traffic management capabilities. This release updated the CHART Archive interface with general reporting and predefined query capabilities. These changes are summarized in Table D-3. Server installations are illustrated in Figure D-3. Release R3B1 was deployed February 27, 2008. Release R3B2 was deployed September 23, 2008. Release R3B3 was deployed December 8, 2009.

Table D-3. CHART ATMS Release 3 Functions

CI	Subsystem	Function
Core Services	Alert Management	New Alert Management subsystem to create and process alerts, manage escalation rules
	Data Import Management	New Data Import Management subsystem to import data from RITIS, INRIX, Vector
	DMS Control	TCP/IP communications, automated Travel Times and Toll Rates
	HAR Control	HIS DR 1500 HAR
	Message Template Management	New Message Template Management subsystem to manage templates for travel time and toll rate messages
	Notification Management	New Notification Management subsystem to support email, texting via email, and paging via email
	Traffic Event Management	Advanced management Improved Lane graphic control Geo-location
	Traveler Information Management	Travel times and toll rates for display in GUI and on DMSs
	Traffic Sensor System Management	TCP/IP communications support
	User Management	Operations
	Utility	CHART Chat Map import Equipment inventory

CI	Subsystem	Function
	DMS Control, HAR Control, HAR Notification, Traffic Sensor System Management, Video Management	Geo-location of CHART devices

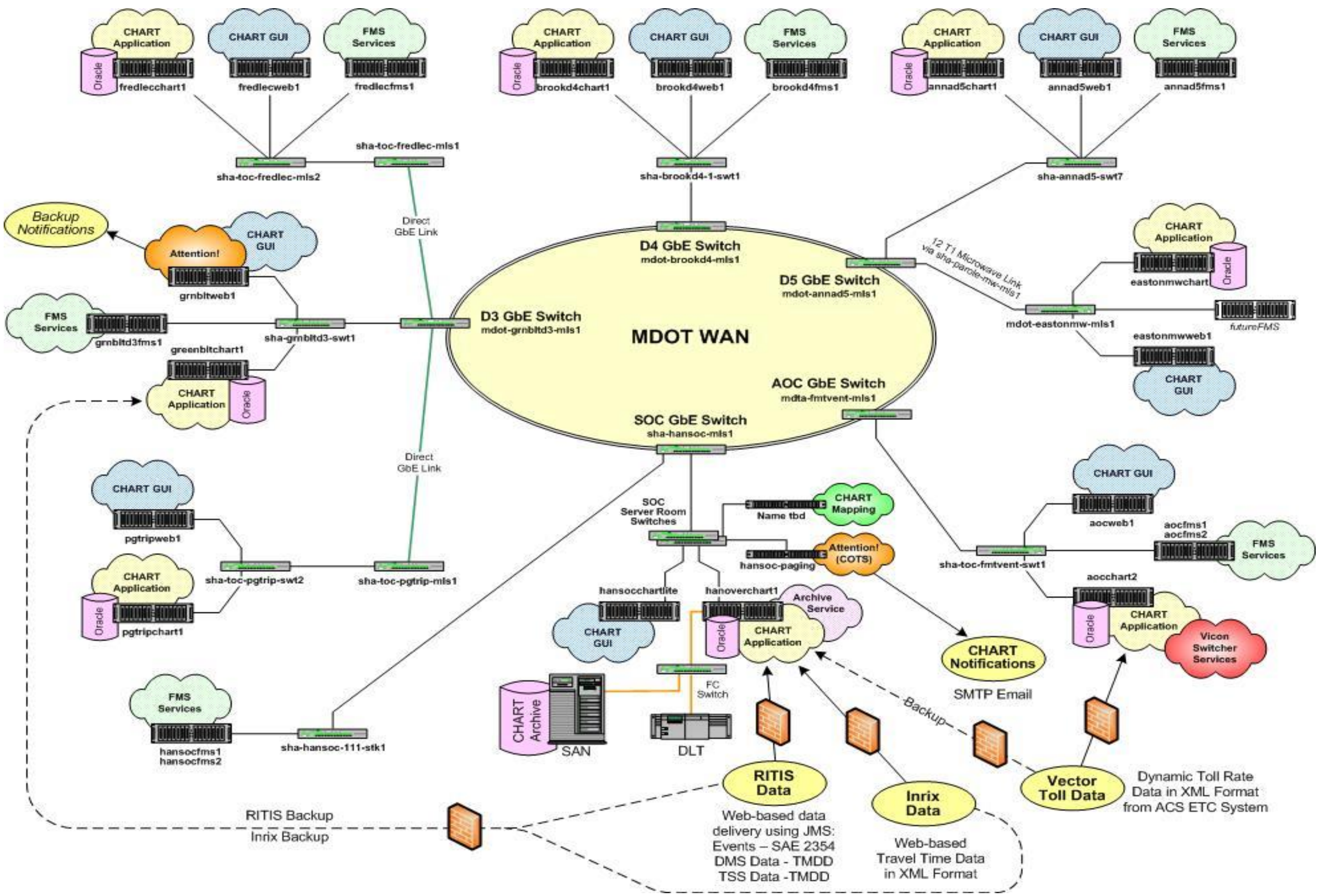

Figure D-3. CHART ATMS Release 3 Server Installations

D.4 CHART ATMS Release 4

Release 4, deployed April 12, 2010, added the System Monitor subsystem, via a new service known as the Watchdog. This new service was (and still is) installed on every CHART ATMS server and FMS server and monitors the availability of each CHART ATMS service on the server where it is installed. A second Watchdog service on each server allows monitoring of the Watchdog services. The Watchdog provides the ability for alerts and notifications to be sent automatically when a service is detected to be failed, and provides for the ability to auto-restart services when failures are detected. Release 4 also added a new GUI portal known as the maintenance GUI, which provides a simplified view of the system tailored to device maintenance personnel for use via laptops, tablets, and smartphones in the field. Release 4 included updates to the NTCIP DMS model to support version 2 of the protocol and to add several status fields and features. Lastly, Release 4 added an updated version of the middleware used by all CHART ATMS services to address stability issues. These changes are summarized in Table D-4. There were no changes to the Server Installations for Release 4, so no illustration is provided. See CHART ATMS Release 3 Server Installations above. Release 4 was deployed April 12, 2010.

Table D-4. CHART ATMS Release 4 Functions

CI	Subsystem	Function
Core Services	Alert Management	System Alert added.
	DMS Control	Updates to NTCIP DMS model to support version 2 and add functionality.
	System Monitor	Watchdog services added.
GUI Services	GUI Management	Device Maintenance Portal added.

D.5 CHART ATMS Release 5

Release 5, deployed October 19, 2010, added an integrated map, through which users are able to set and view the locations of CHART devices and traffic events on a map. Release 5 also added a Data Exporter feature – an interface into the CHART ATMS to allow external systems to receive DMS, TSS, Traffic Event, HAR, and SHAZAM configuration and status information from the CHART ATMS. Finally, CHART ATMS Release 5 provided some enhancements to video so that a camera can be configured with multiple video sending devices. These changes are summarized in Table D-5. Server installations are illustrated in Figure D-4. Release 5 was deployed October 19, 2010.

Table D-5. CHART ATMS Release 5 Functions

CI	Subsystem	Function
Core Services	Data Export Management	New Data Export Management subsystem to export CHART data
	Video Management	Enhancements to Camera Display

CI	Subsystem	Function
	DMS Control, HAR Control, HAR Notification, Traffic Sensor System Management, Traffic Event Management	New Map Management subsystem and Core Services updates to support map integrated into the CHART ATMS
GUI Services	Map Management	

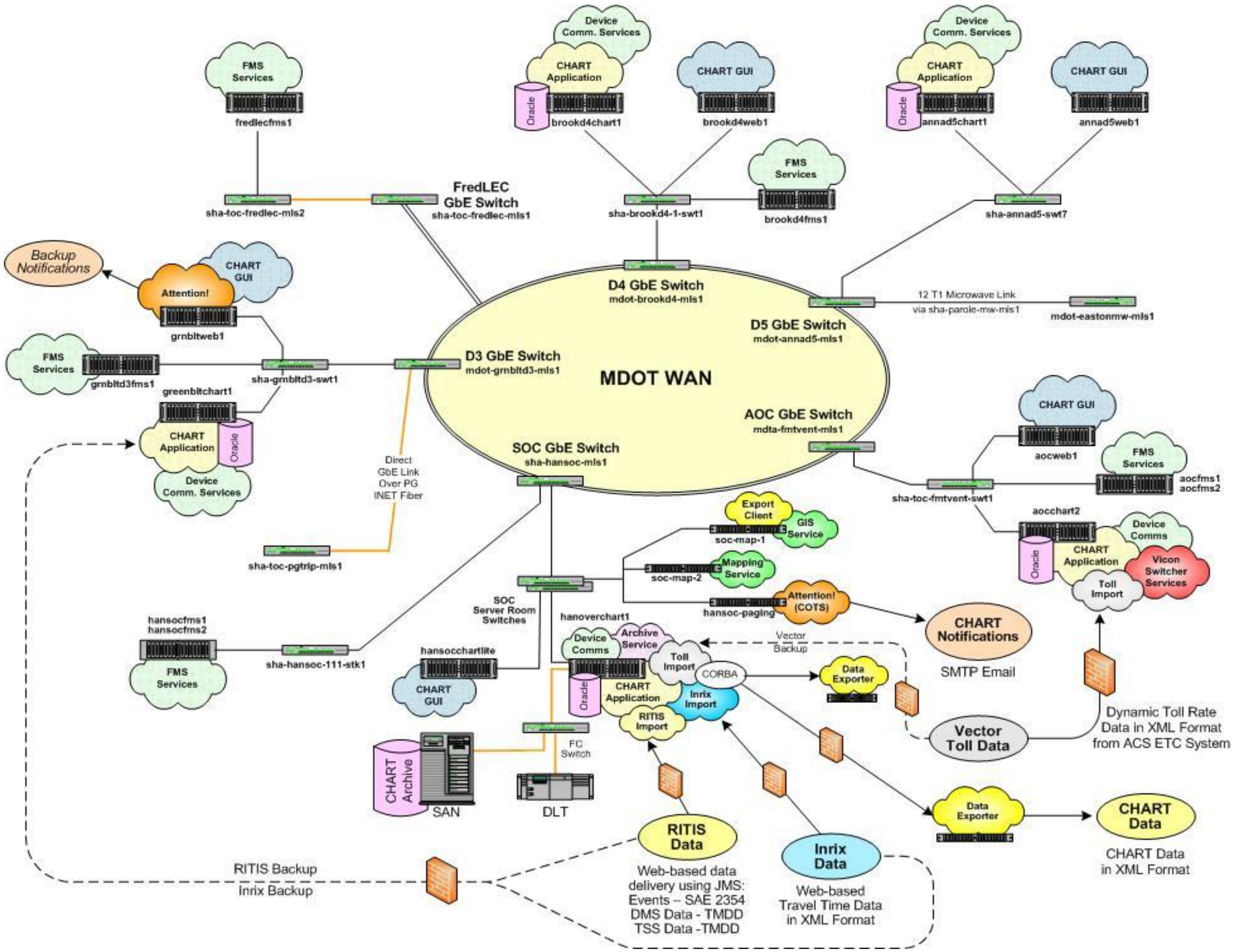

Figure D-4. CHART ATMS Release 5 Server Installations

D.6 CHART ATMS Release 6

Release 6, deployed February 24, 2011, added enhanced lane configuration capability, including suggested lane configurations based on the location of a traffic event and the ability for the user to edit and create lane configurations. Release 6 also added the ability to specify event locations as being between two features or spanning a length of roadway from one location to another location. Another enhancement made it easier for users to associate CHART planned closure events with a lane closure permit. External detectors (received via RITIS rather than native to the CHART ATMS) are exported from the CHART ATMS and can be displayed on the CHART Mapping maps. As of Release 6, camera configuration data is now centralized in the CHART ATMS (rather than requiring additional configuration within CHART Mapping). These changes are summarized in Table D-6. Server installations are illustrated in Figure D-5. Release 6 was deployed February 24, 2011.

Table D-6. CHART ATMS Release 6 Functions

CI	Subsystem	Function
Core Services	Data Export Management	Updated to export event “between” and “from/to” locations, CCTV configuration information, and “external” TSS status and configuration information..
	Data Import Management	Import of NavTeq detectors
	Device Management	Import of NavTeq detectors, centralized camera configuration data.
	Traffic Event Management	Enhanced lane configuration
	User Management	New user manager web service to allow CHART Map to authenticate CHART users for access to NavTeq data.
GUI Services	GUI Management	Enhanced lane configuration, event “between” and “from/to” locations, enhanced planned closure event to EORS (now LCP) permit association, centralized camera configuration data.

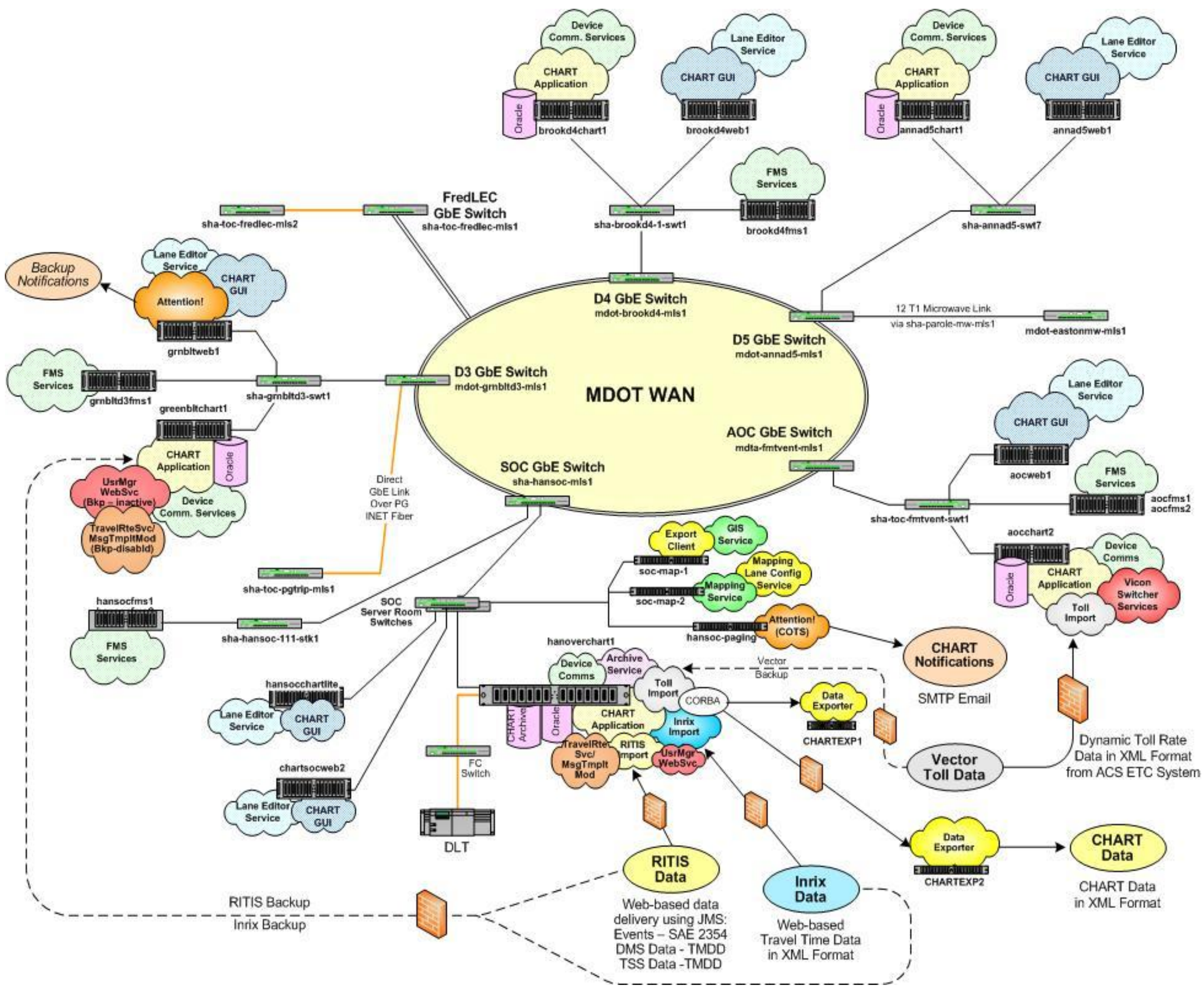

Figure D-5. CHART ATMS Release 6 Server Installations

D.7 CHART ATMS Release 7

Release 7, deployed August 17, 2011, added camera control based on the National Transportation Communications for ITS Protocol (NTCIP) for CCTV cameras, importation of SCAN weather data into CHART, an enhancement to CHART Mapping to display TSS icons showing the directional orientation of the detectors, and a redesigned method for generating the Shift Hand-Off Reports utilizing WordPress. These changes are summarized in Table D-7. Server installations are illustrated in Figure D-6. Release 7 was deployed August 17, 2011.

Table D-7. CHART ATMS Release 7 Functions

CI	Subsystem	Function
Core Services	Device Management	Added NTCIP-compliant CCTV camera control
	Traffic Event Management	Import of SCAN weather data into Traffic Events
	Utility	Shift Hand-Off Report generation re-hosted to WordPress
	Data Export Management	Added directionally-orientated TSS icons on the CHART Map and exports the orientation data
GUI Services	Map Management	

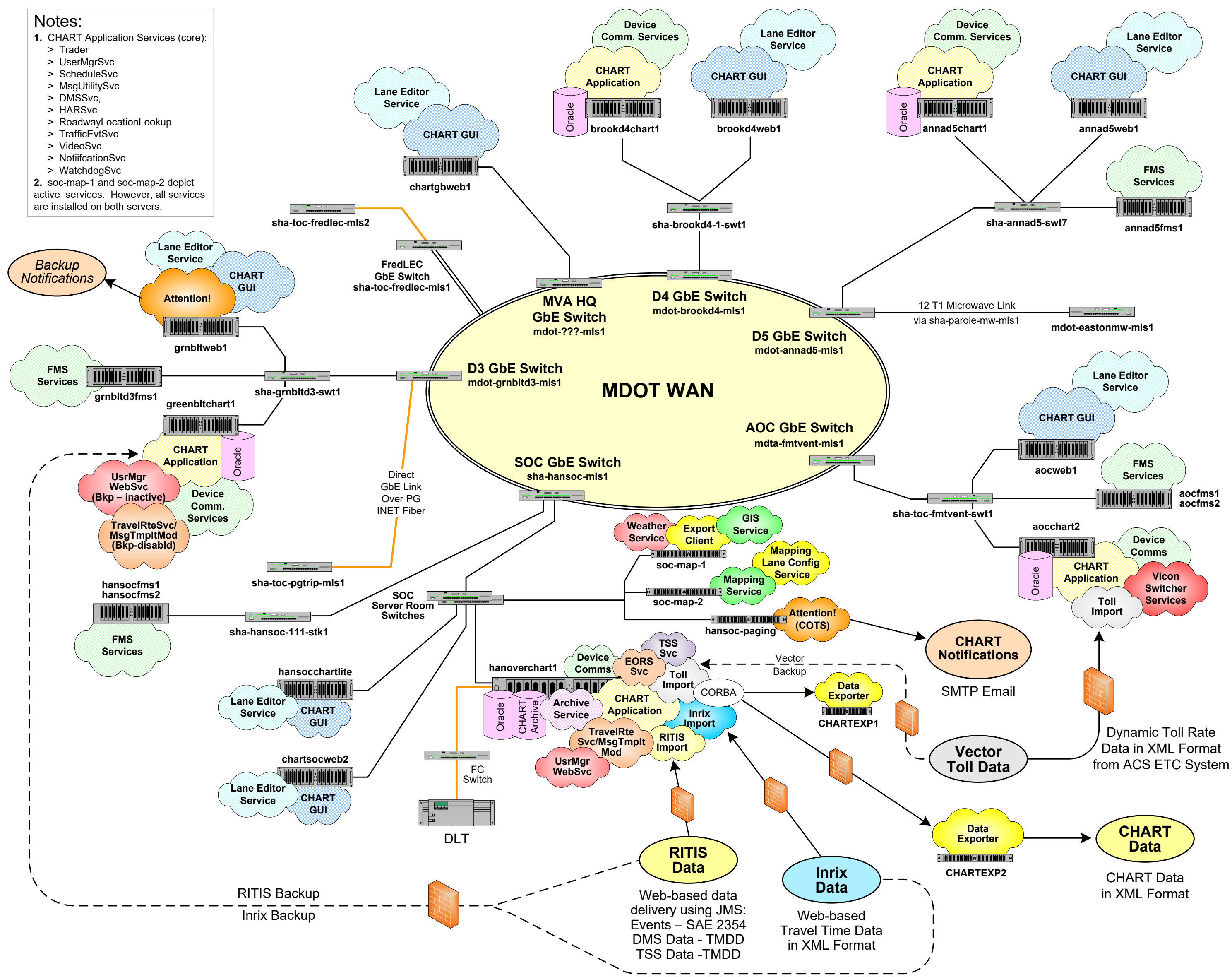

Figure D-6. CHART ATMS Release 7 Server Installations

D.8 CHART ATMS Release 8

Release 8, deployed November 1, 2011, and added TCP/IP-based control for the HIS DR1500 HAR and TCP/IP-based control for SHAZAM signs using HWG-ER02a IP relay switches. Additionally, while originally planned for incorporation in Release 9, Release 8 also included the protocol handler for the new EIS G4 speed sensors. These changes are summarized in Table D-8. CHART's server environment had been recently virtualized, and Release 8 was deployed into this new virtualized server environment (summer of 2011) as illustrated in Figure D-7. Release 8 was deployed November 1, 2011.

Table D-8. CHART ATMS Release 8 Functions

CI	Subsystem	Function
Core Services	HARControl	Support for TCP/IP HAR
	HAR Notification	Support for TCP/IP relay switch to control SHAZAMs
	TSS Control	Support for EIS G4 RTMS, multi-drop communications

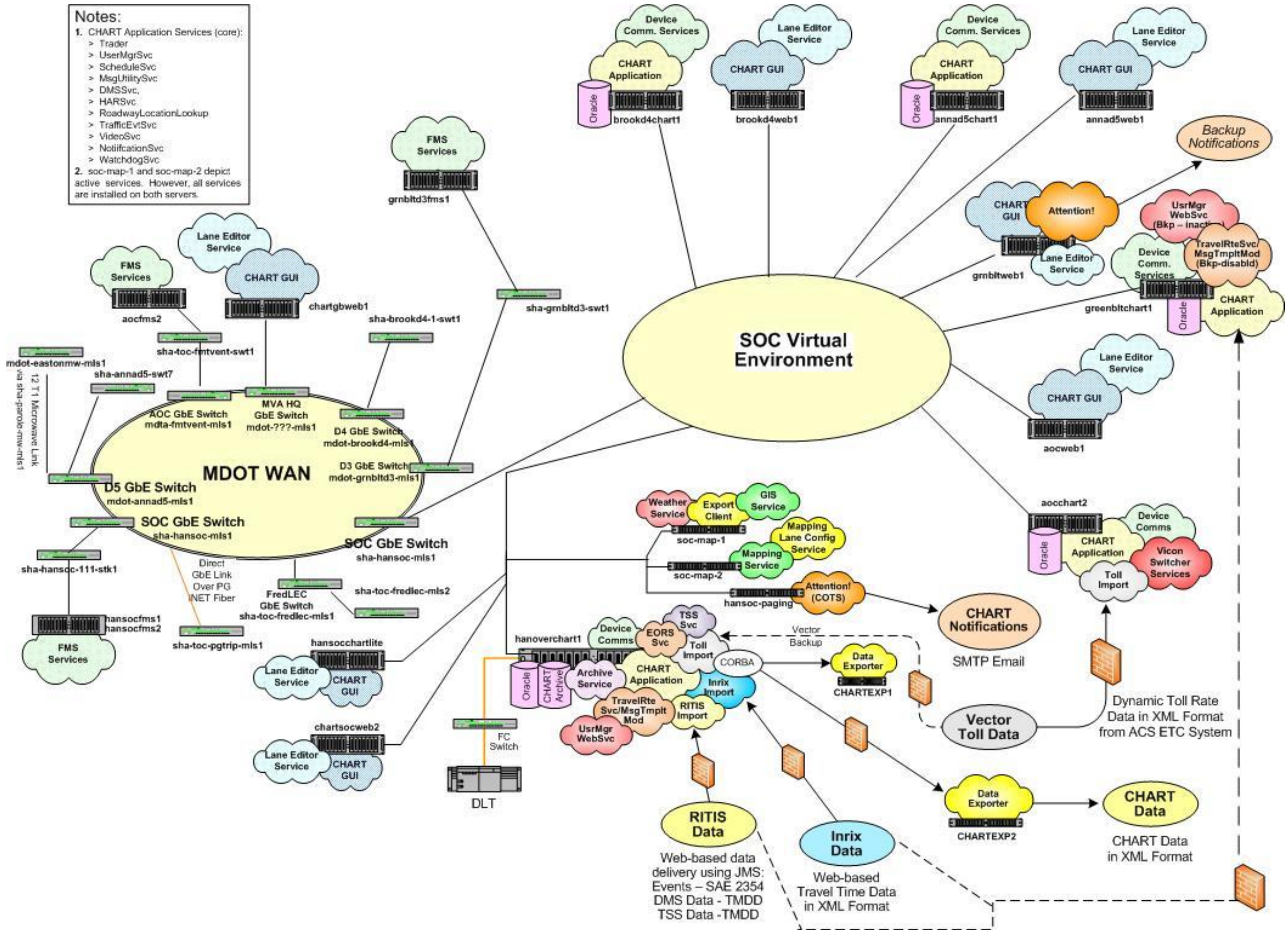

Figure D-7. CHART ATMS Release 8 Server Installations

D.9 CHART ATMS Release 9

Release 9, deployed March 13, 2012, and added decision support capabilities to suggest device messages and appropriate DMS based on conditions in a traffic event. Additional decision support capabilities include suggesting appropriate cameras for display within the context of a traffic event. Release 9 also added the capability to display video within the CHART GUI. Release 9 also extended the capability to block flash video at the source (the Streaming Flash Server (SFS)), to block video at any SFS rather than at just the public SFS. These enhancements are summarized in Table D-9. There were no significant hardware/interface changes for Release 9. The Release 9 CHART virtualized server environment is illustrated in Figure D-8. Release 9 was deployed March 13, 2012.

Table D-9. CHART ATMS Release 9 Functions

CI	Subsystem	Function
Core Services	DMS Control, Traffic Event Management	Decision support: suggest DMS usage and messages for traffic event
	Video Management, Traffic Event Management	Decision support: suggest cameras in the context of a traffic event
	Video Management	Flash video on desktop

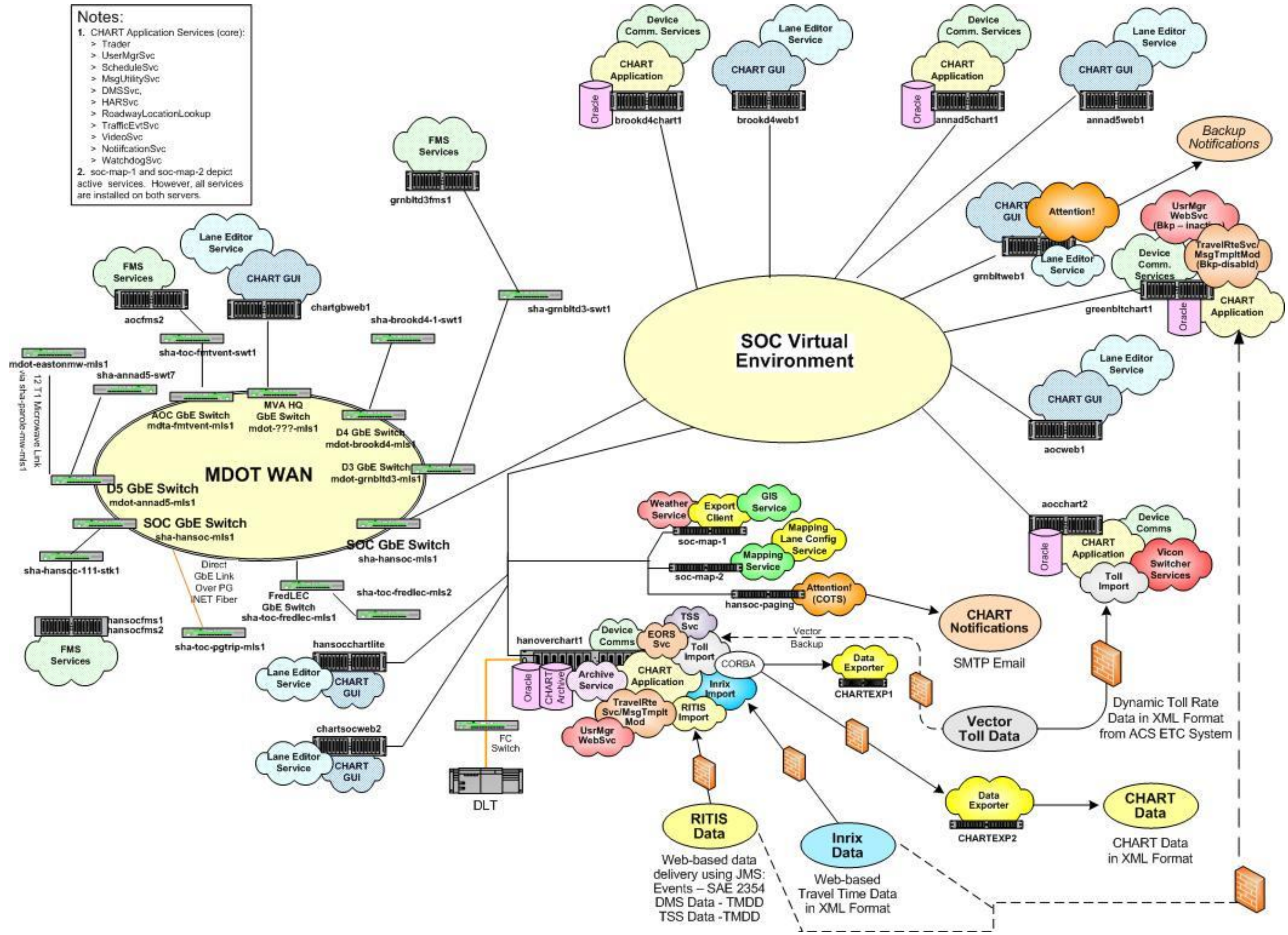

Figure D-8. CHART ATMS Release 9 Server Installations

D.10 CHART ATMS Release 9S

Release 9S, deployed September 19, 2012, consolidated CHART to a single node and included a database conversion. The node consolidation element reduced the amount of CHART server nodes from five to one, which will facilitate lower hardware, software, and network costs. The database element converted Oracle databases to Microsoft SQL Server in accordance with the strategic plan for CHART databases to realize reduced software licensing costs and to ensure vendor support for the database software. The databases were moved off of the application server and onto a separate database server. These changes are summarized in Table D-10. The corresponding application changes required for the database conversion were included in the conversion work. The Release 9S server environment is illustrated in Figure D-9. Release 9S was deployed September 19, 2012.

Table D-10. CHART ATMS Release 9S Functions

CI	Subsystem	Function
Core Services	Device Management	Moved arbitration queue to database
CHART Database	Operational DB	Live database converted to MS SQL Server
CHART Archive	Archive DB Query, (Support for) Report Generation, Replication	Archive database converted to MS SQL Server Live and archive databases replicated to UMD for query and report generation

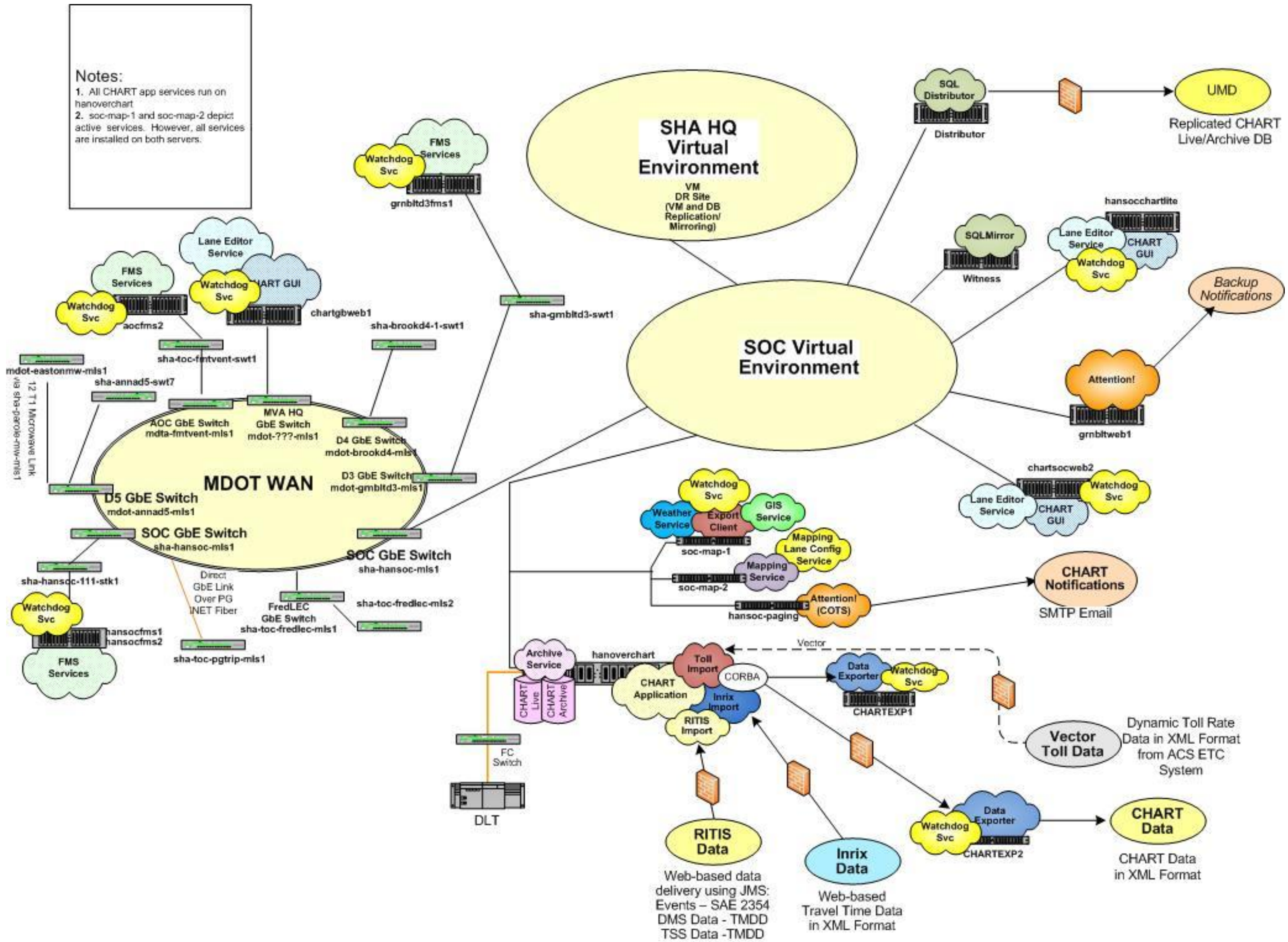

Figure D-9. CHART ATMS Release 9S Server Installations

D.11 CHART ATMS Release 10

Release 10 added additional decision support capabilities, to include adding cameras to a response plan item, which, when executed, cycle in a tour on monitors associated with the location of the traffic event. Release 10 provided control of NTCIP DMS fonts, including the ability to upload and download (but not design) custom fonts, and display DMS messages in the DMS's font in true WYSIWYG style. Release 10 also reprogrammed the notification system to manage notification recipients (individuals/agencies and groups) internally within CHART itself, and to send emails directly from CHART (eliminating the Attention!NS COTS notification management system). Also, cameras were modified to reject tour-directed moves to preset faster than a minimum dwell time, in order to conserve PTZ motors. These enhancements are summarized in Table D-11. The only hardware/interface change for Release 10 is the elimination of the paging servers hansoc-paging and grnbltweb1. The Release 10 CHART virtualized server environment is illustrated in Figure D-10. Release 10 was deployed November 5, 2012.

Table D-11. CHART ATMS Release 10 Functions

CI	Subsystem	Function
Core Services	Traffic Event Management, Camera Control, Video Monitor Management	Decision support: include suggested cameras in traffic event response plan; Cameras form temporary tour for traffic event, auto-mode monitors in area of responsibility show temporary traffic event video tour
	DMS Control	Upload/Download fonts in DMSs; Display true WYSIWYG DMS Messages
	Notification Management	Manage contacts and groups directly within CHART

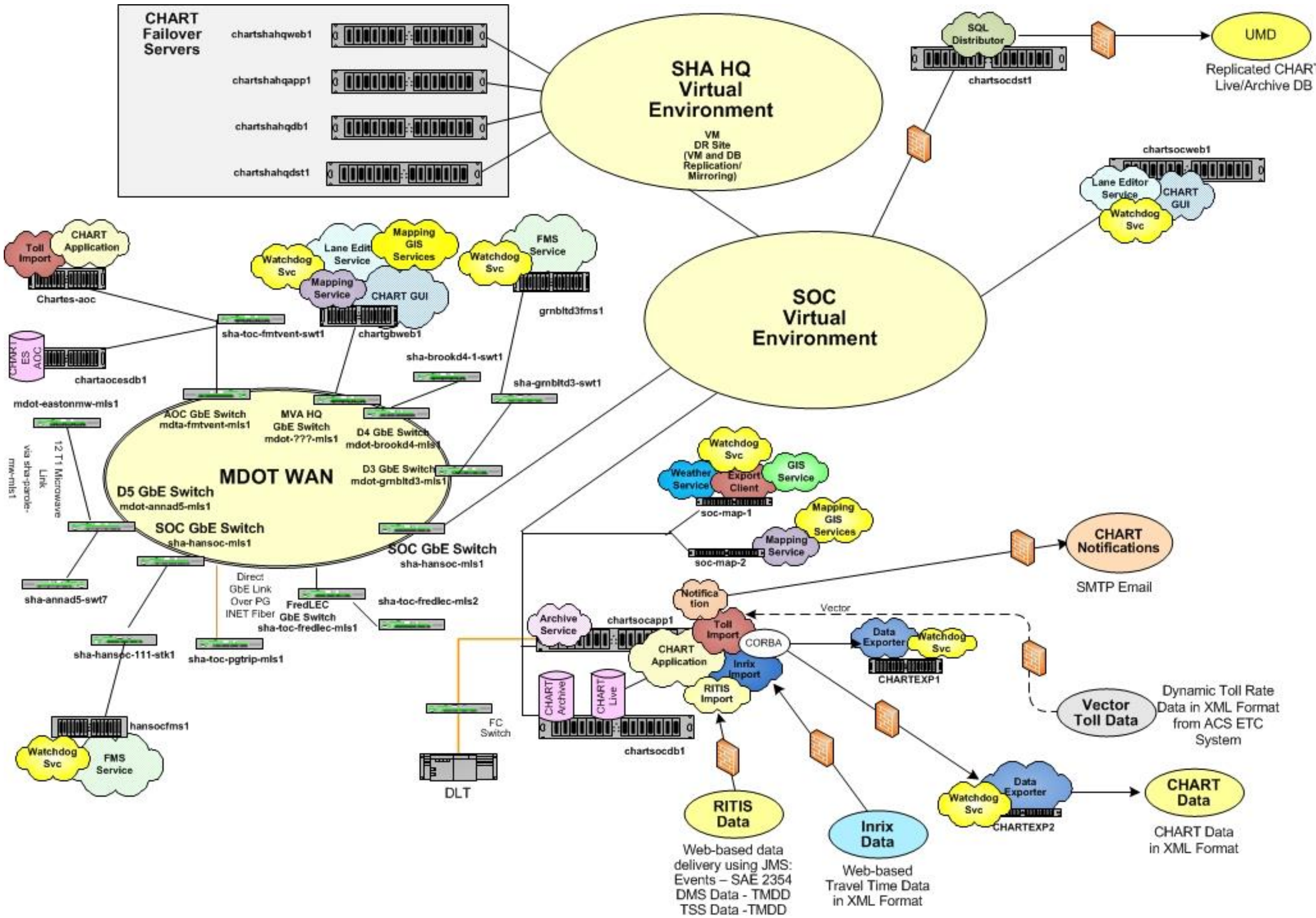

Figure D-10. CHART ATMS Release 10 Server Installations

D.12 CHART ATMS Release 10C

Release 10C upgraded some of the COTS used by the CHART ATMS. There was no new functionality provided with CHART R10C, it was strictly an architecture refresh. The COTS upgrade included an upgrade from Windows 2003 Server to the Windows 2008 Server operating system and compiler upgrades. The Release 10C server environment is illustrated in Figure D-11. Release 10C was deployed January 22, 2013.

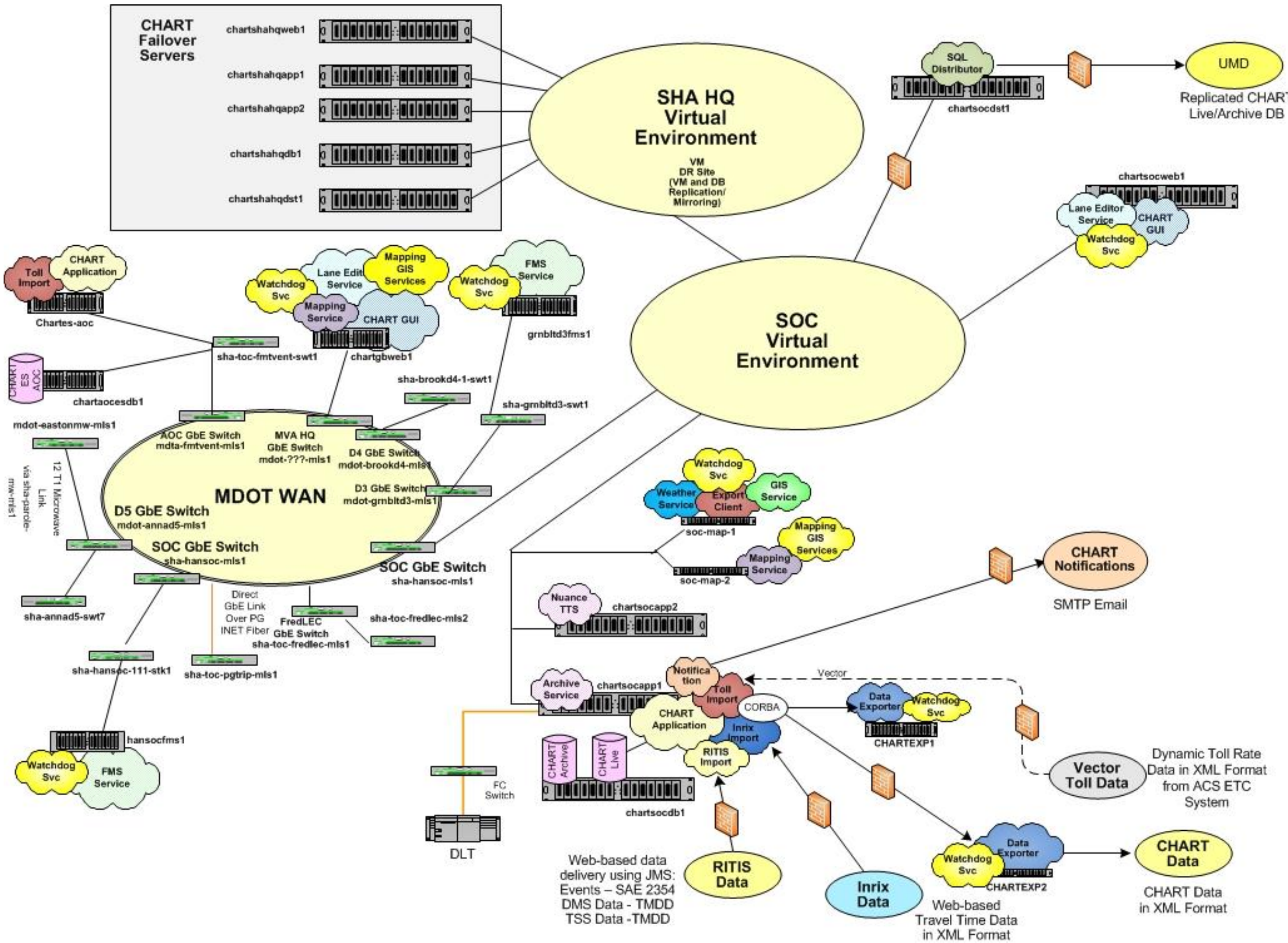

Figure D-11. CHART ATMS Release 10C Server Installations

D.13 CHART ATMS Release 11

Release 11 added several improvements related to traffic event processing in the CHART ATMS. Release 11 brought decision support capabilities to HARs, so the CHART ATMS now suggests HARs and messages for HARs in response to traffic events. Release 11 also added AVL processing to the CHART ATMS directly, which aids in marking participant involvement in traffic events, including automatic marking of arrival times and departure times. With Release 11 the CHART ATMS now has direct access to the "Signal Book" database of traffic signals in the state, allowing users to select and associate traffic signals to action events. Finally, Release 11 also brought improvements in notification text automatically generated from traffic events. These enhancements are summarized in Table D-13. The Release 11 CHART virtualized server environment is illustrated in Figure D-13. Release 11 was deployed June 18, 2013.

Table D-13. CHART ATMS Release 11 Functions

CI	Subsystem	Function
Core Services	Decision Support, Traffic Event Management	Decision support: suggest HARs and HAR messages for use in traffic events
	AVL Management, Traffic Event Management	New AVL Management subsystem added to facilitate use of participants in traffic events
	Signals Management, Traffic Event Management	New Signals Management subsystem added to allow association of traffic signals to action events
	Notification Management	Enhancements to notification text generated from traffic event details

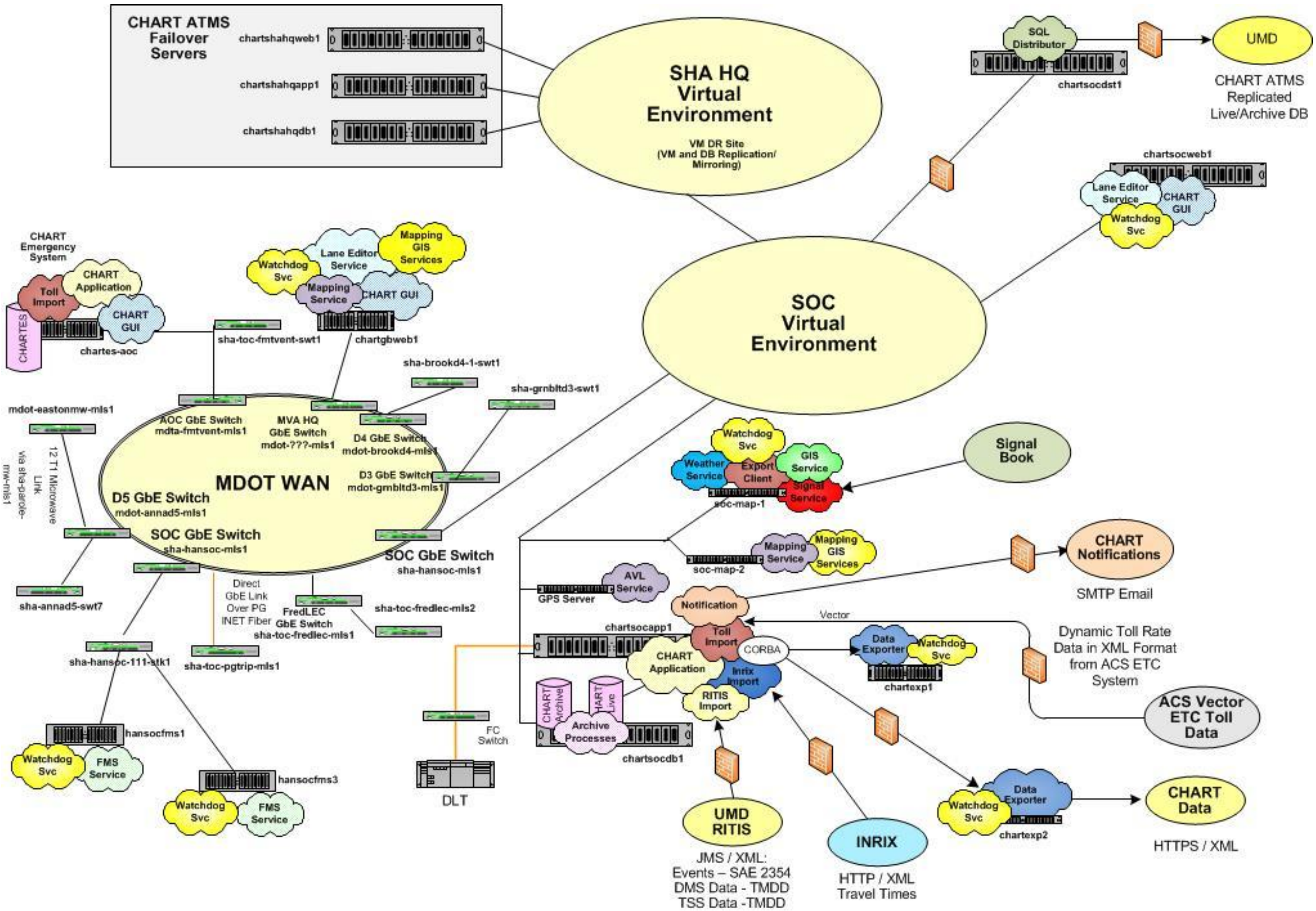

Figure D-13. CHART ATMS Release 11 Server Installations

D.14 CHART ATMS Release 12

Release 12 added several travel time improvements, including the ability to designate travel time specific traveler information messages as pertaining to certain days of the week,and/or holidays or non-holidays and the ability to enable multiple travel time messages simultaneously (the system selecting the most appropriate message to enable based on day of week, holiday/non-holiday status, and priority). Release 12 also brought the ability to enable or disable travel time messages system-wide, on a per-organization basis, and added support for collecting travel time data from a second provider, specifically an MDTA-sponsored provider (conforming to the INRIX interface) for soon-to-be opened HOT lanes north of Baltimore. One more travel time improvement was a travel time summary page providing details on all DMSs with at least one travel time message configured. CHART ATMS R12 also provides better RITIS integration to make better use of traffic events from CAD / 911 call centers, allowing ATMS operators to "link" a CHART event to an external event, with the linked CHART event selectively updating automatically based on changes to the external event. CHART ATMS R12 integrated better with MD511, allowing CHART operators to define event public alert categories and to configure "floodgate" messages for MD511, with separate texts for textual display and for text-to-speech audio for telephone callers. Decision Support was enhanced to use network routing ("driving directions") to help locate roadside devices (DMSs, HARs, cameras) upstream from a traffic event but not necessarily on the same primary route as the event. Finally R12 provided support for new H.264-capable video CODECs developed by Impath, allowing for a new H.264 video fabric. These enhancements are summarized in Table D-14. The Release 12 CHART virtualized server environment is illustrated in Figure D-14. Release 12 was deployed April 2, 2014.

Table D-14. CHART ATMS Release 12 Functions

CI	Subsystem	Function
Core Services	Traveler Information Management	Multiple enabled travel time messages per DMS; system-wide control of travel time messages; travel times from MDTA
	Data Import Management, Traffic Event Management	Support for "linked" CHART events that can selectively update automatically based on chances to their linked external event
	Decision Support, Traffic Event Management	Decision support: suggest upstream DMSs, HARs, and cameras not on a traffic event's primary route, based on network routing (driving directions)
	Data Export Management, Traffic Event Management	Support for MD511 "floodgate" messages and event public alert categories
	Camera Control, Video Monitor Management	Support for Impath H.264-capable encoders and decoders

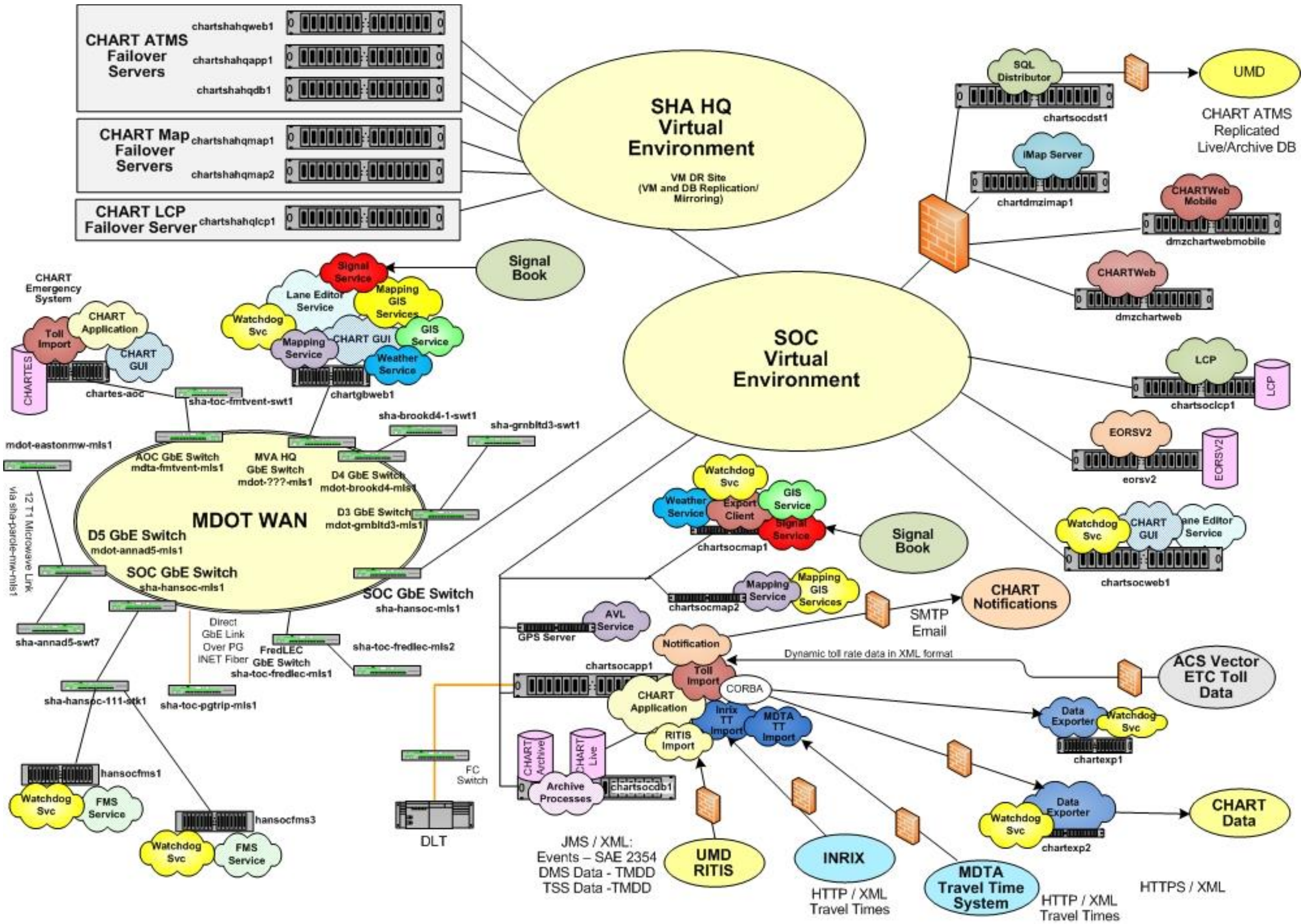

Figure D-13. CHART ATMS Release 12 Server Installations

D.15 CHART ATMS Release 13

Release 13 added the ability to view FITM plans (near a traffic event or outside the context of a traffic event) and provided security enhancements to conform to DoIT and MDOT security requirements for password management. Release 13 also provided behind-the-scenes technology upgrades to several COTS packages used by the ATMS software. These enhancements are summarized in Table D-15. The Release 13 CHART virtualized server environment is illustrated in Figure D-15. Release 13 was deployed June 17, 2014.

Table D-14. CHART ATMS Release 13 Functions

CI	Subsystem	Function
Core Services	Traffic Event Management	View FITM plans (near a traffic event or outside the context of a traffic event)
	User Management	Manage passwords in accordance with DoIT and MDOT policy

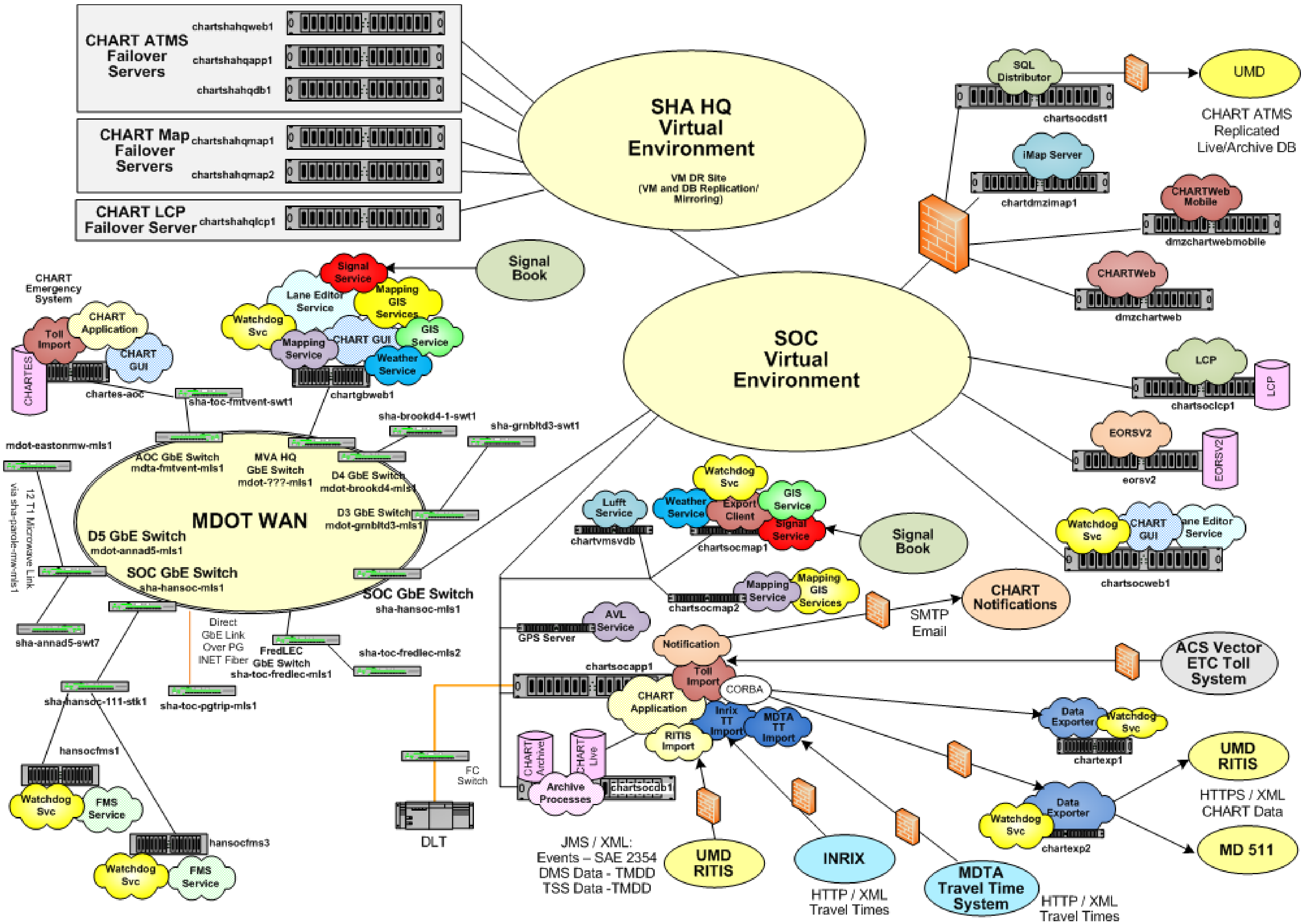

Figure D-15. CHART ATMS Release 13 Server Installations

D.16 CHART ATMS Release 14

Release 14 added the ability to add generic contacts to ATMS. Contacts may be ATMS notification contacts, or non-notification contacts. Those contacts may be associated with call out lists and may be added to traffic events as participants. Release 14 integrated SOPs into ATMS. SOPs are available for viewing or information on specific SOPs will optionally be displayed to users under certain trigger conditions. In addition, a device type: On/Off devices have been added to CHART ATMS. On/Off devices are initially Fog Horns or Fog Beacons controlled by the same HWG-ER02a/b IP relay employed to control IP SHAZAMs. In addition, Release 14 adds the ability to automatically calculate queue lengths for traffic events based the observed versus expected travel time on INRIX links upstream from the event location.

These enhancements are summarized in Table D-16. The Release 14 CHART virtualized server environment is illustrated in Figure D-16. Release 14 was deployed June 17, 2014.

Table D-16. CHART ATMS Release 14 Functions

CI	Subsystem	Function
Core Services	Contact Management	Manage Contacts
	Traffic Event Management	Calculate Queue length View SOPs
	On/Off Device Control	Manage On/Off Devices

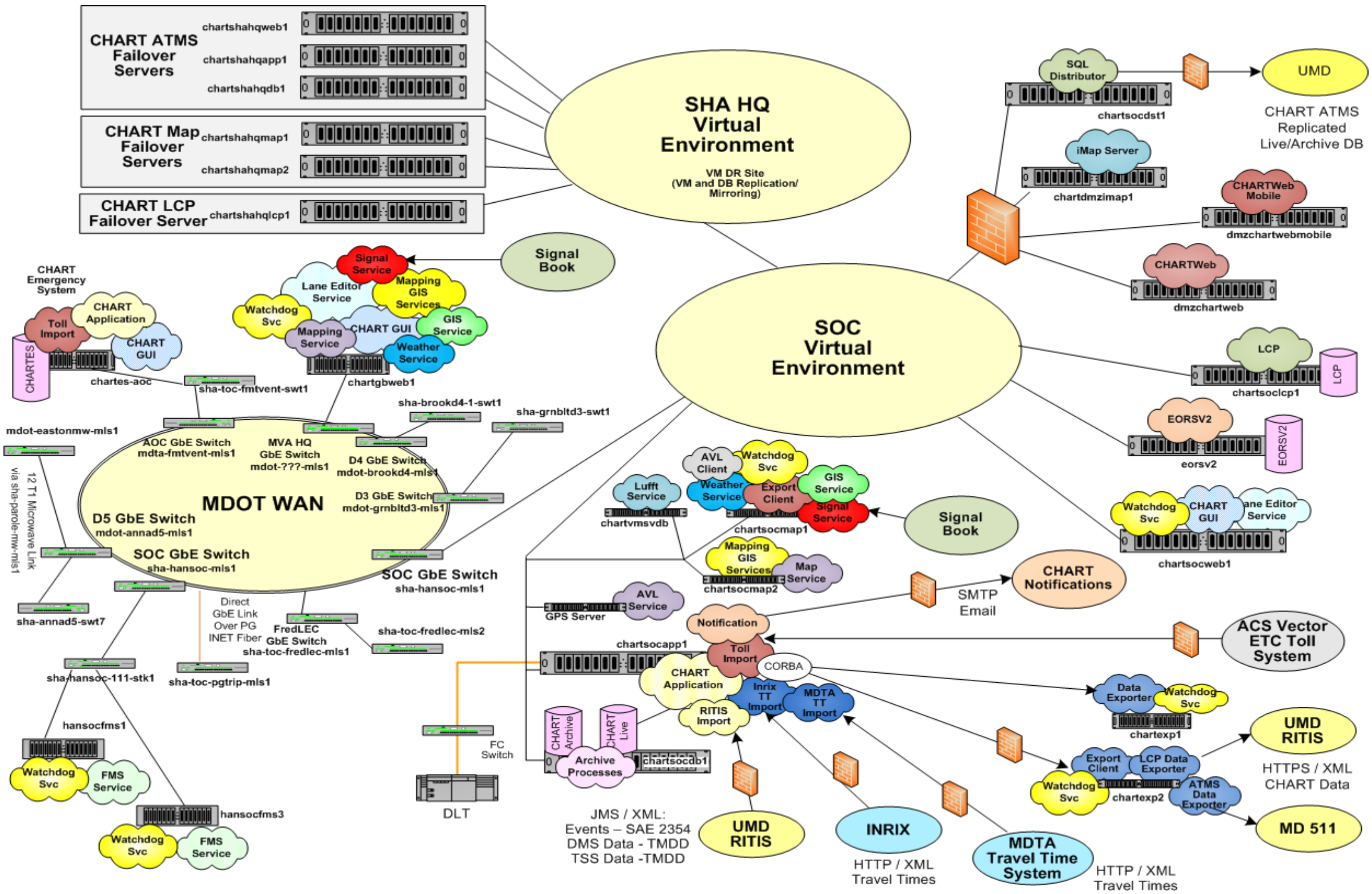

Figure D-16. CHART ATMS Release 14 Server Installations

D.17 CHART ATMS Release 15

Release 15 added an integration between CHART ATMS and the Lane Closure Permit (LCP) system. Permit data is retrieved from LCP and displayed in CHART ATMS and CHART ATMS allows operators to perform actions on LCP permits via this interface. CHART ATMS also sends data to LCP regarding status changes of traffic events that are associated with LCP permits.

Release 15 also added Triggers and Triggered Messages / Activations. Triggers are generic items that can be defined to include one or more weather conditions and criteria that defines when that condition is true. Triggers become active when all of their enabled conditions are true. DMS and HAR devices can then be configured to display/play a message when an associated trigger becomes active, and remove the message when the trigger is no longer active. On/Off devices can be configured to activate and deactivate in lock step with a trigger. This feature was added for the purpose of automated weather messages but is designed generically to allow other types of trigger conditions and associated messages to be added in the future.

Release 15 added a new schedule action to allow safety message events and special events to be opened and activated at a scheduled time or on a recurring basis, and for those events to be automatically closed after a specified duration.

Release 15 replaced the Java Applet voice recorder, used to record audio messages for HAR devices, with an Adobe Flex version.

Release 15 added the ability to define patrol areas and assign them to field units when they are placed in service (or to be changed while the field unit is in service). Likewise, changes were included to allow a contact to be specified for each in-service field unit. Changes were also included in Release 15 to make field units appear on the CHART ATMS Home Page map at all zoom levels, and clustering was added for field units and other types of event resources.

These enhancements are summarized in Table D-17. The Release 15 CHART virtualized server environment is illustrated in Figure D-17. Release 15 was deployed March 15, 2016.

Table D-17. CHART ATMS Release 15 Functions

CI	Subsystem	Function
Core Services	Contact Management	Set field unit assignment eligibility
	DMS Control, HAR Control, On/Off Device Control	Triggered messages / activations (automatic weather messages)
	Permit Management	Integration with the LCP system
	Resource Management	Assignment of patrol areas and contact to in-service field unit
	Schedule Management	New schedule action type to Open and Activate pending safety message event or special event; automatically close event that is automatically opened
	Trigger Management	Management of triggers

CI	Subsystem	Function
GUI Services	GUI Management	New audio recorder to eliminate use of Java Applets. Home Page Map changes for visibility of event resources. Changes associated with changes to Core Services above.

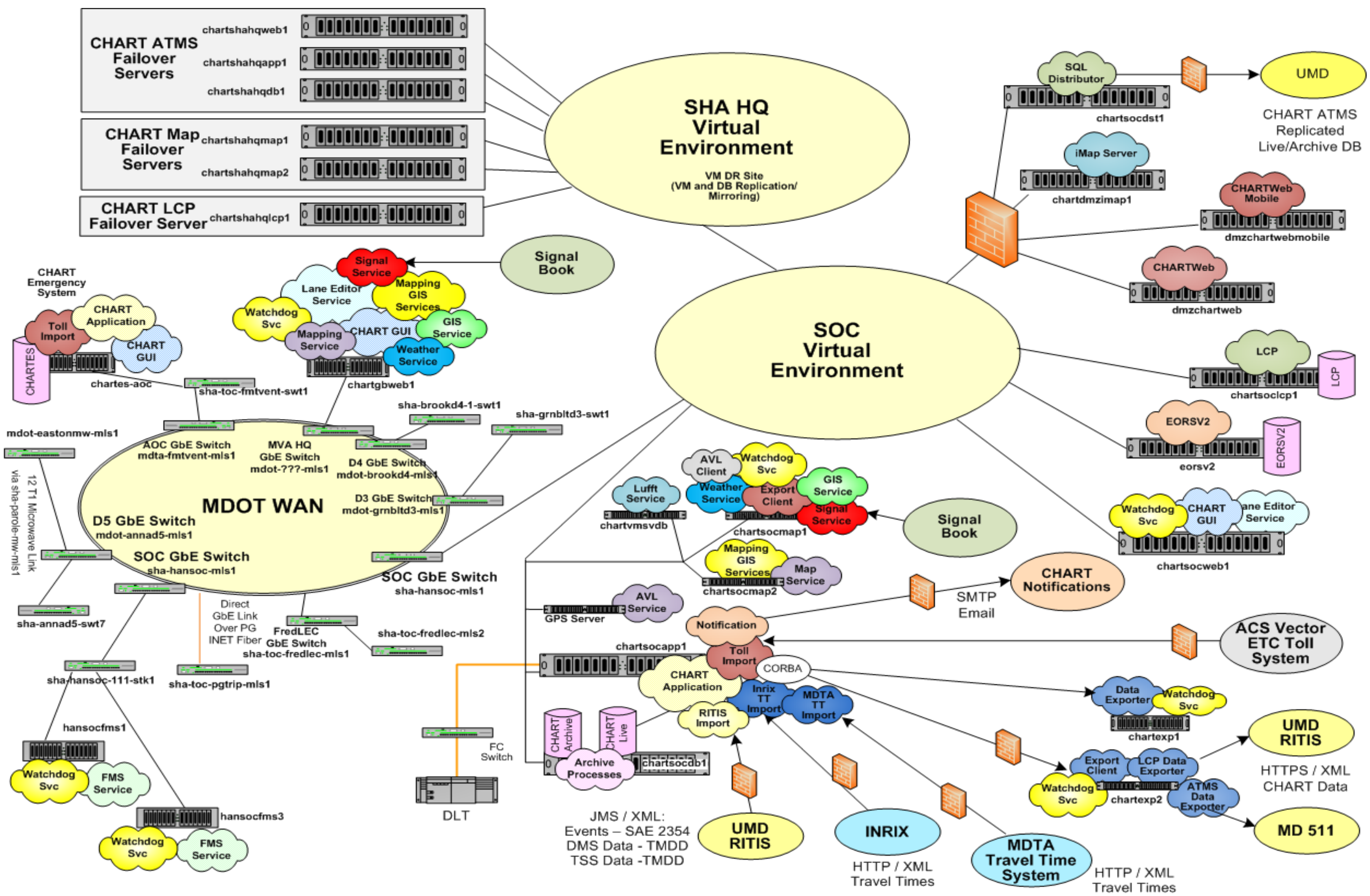

Figure D-17. CHART ATMS Release 15 Server Installations

D.18 CHART ATMS Release 16

Release 16 contained many small enhancements delivered in a short period of time (2-1/2 months). This included:

Added RV as a vehicle type for incidents (including all variations: with trailer, overturned, etc.).

Added Date Commissioned field to all devices types.

Added easier access to contact information from Call Lists.

Added subtypes for Incidents (added to Incident name). This is field is private to the ATMS, and is not exported (but is archived), and is not part of the exported Incident name.

Links that allow the user to easily create a new pending event from a permit or view an existing pending event from a permit are no longer shown, in order to reinforce the proper SOP of activating the permit to create the ATMS event.

Enhanced email address verification.

Added county milepost ranges for editing event locations.

Changed nomenclature of bidirectional "South/North" locations to be labeled as "North/South".

Enhanced the Data Exporter to better handle special characters, such as "squiggly" apostrophes, single quotes, and double quotes, such as might be pasted in from a Word document.

Fixed enforcement of rights relating to association of AORs with monitors.

Enhanced the description of lanes closed when a lane and a shoulder are both closed.

Enhanced contacts to allow multiple email addresses and an optional extension for phone numbers.

Added automatic deletion of Do-Not-Contact schedules after they have expired.

Enhanced logging relating to contacts associated with traffic events.

Improved toll rate external connection notifications to include notifications about both toll rates missing and toll rates expired.

Created a new Training Environment updated nightly from production with all devices simulated, in order to create a more realistic training environment for on-going training. Unlike the existing Training Environment, this new Training Environment will always match the current production version.

Upgraded Java and Tomcat.

Added a new "managed export" flag to devices that are exported, which requires external clients to have a special new right to receive these devices. Display on Intranet Map and Public Map flags are elmininated.

Added a new Category attribute to cameras to allow downstream systems (such as the Intranet Map) to better group the cameras.

Added a zone attribute to Streaming Server Configurations to identify them as Public, Internal, SWGI, or MVIEW. External clients will need a right to receive Streaming Server Configurations for each zone.

Made the CHARTWeb external client make more use of JSON feeds rather than making direct calls to the database.

Made CHART acquire weather sensor data from Lufft via files exported by SmartView rather than by accessing the Lufft database directly.

These enhancements are summarized in Table D-18 (note: for conciseness, minor enhancements listed above are not included). The Release 16 CHART virtualized server environment is illustrated in Figure D-18. Release 16 was deployed June 1, 2016.

Table D-18. CHART ATMS Release 16 Functions

CI	Subsystem	Function
Core Services	Contact Management	Multiple email addresses, phone extensions; do not contact cleanup
	Device Management	Managed Export flag; Date Commissioned field; Camera categories, SFS zones
	Permit Management	Work flow enhancements (fewer links)
	Traffic Event Management	RV vehicle types; Incident subtypes; “North/South” label; better contact logging; better lane closure notifications; county milepost ranges

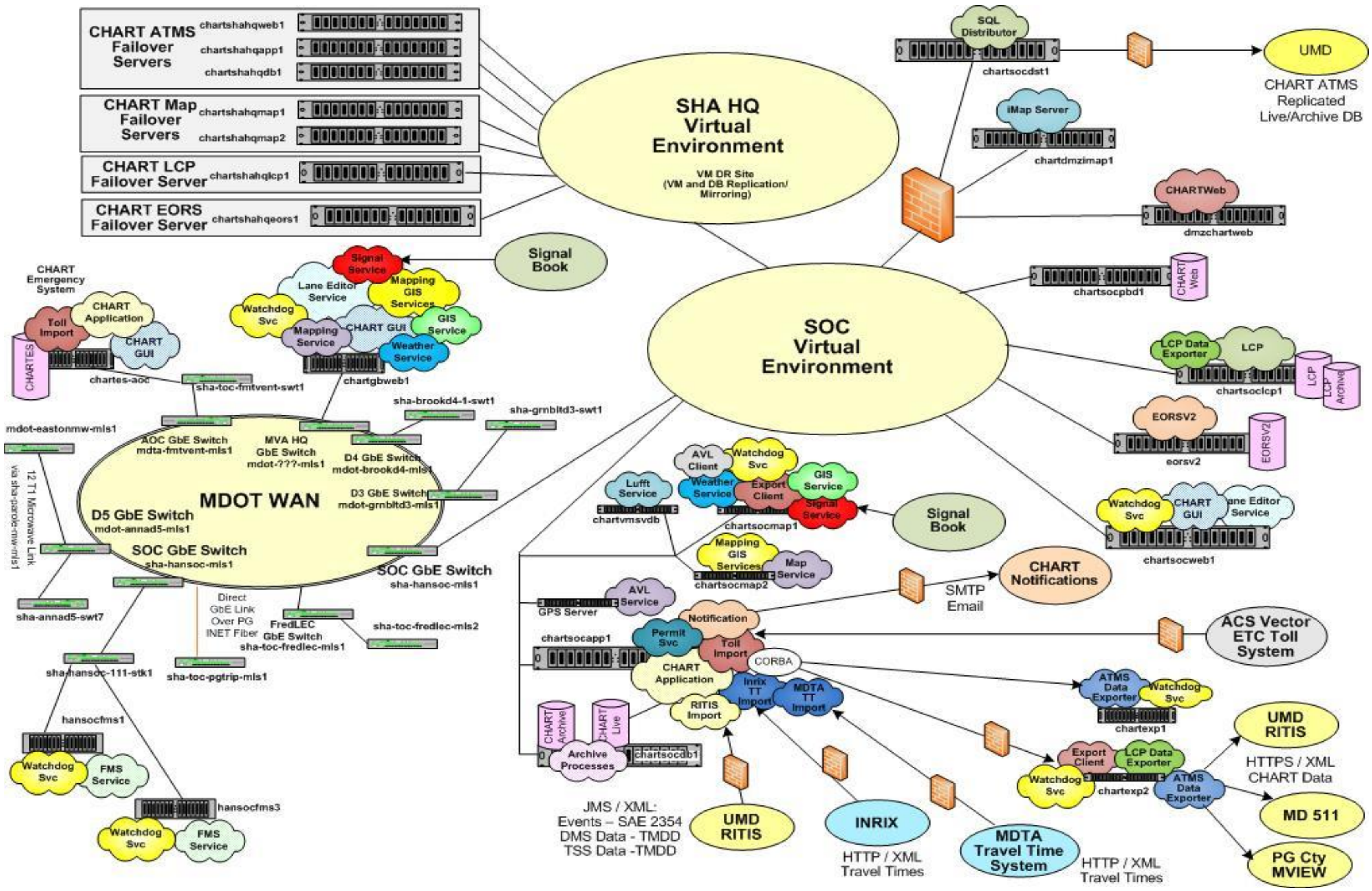

Figure D-18. CHART ATMS Release 16 Server Installations

D.19 CHART ATMS Release 17

Release 17 was a maintenance release that addressed minor enhancements to delete unused code, update various configurations, and perform tasks to make the system more maintainable. This included:

- JavaScript caching issues following deployments: The system was configured such that after future deployments, users' browsers will automatically pick up changes to JavaScript and CSS files (rather than continuing to use the cached old versions of these files).
- DMS_TRAV_ROUTE_MSG_MSGS_LOG: Not deleting the data after 90 days form c2arch3 database: A problem where data was not being deleted from the DMS_TRAV_ROUTE_MSG_MSGS_LOG table in the archive database was fixed.
- TRAVEL_ROUTE_CONSUMER database records not cleaned up: A correction was made to the DMS functionality to persist updates to the Travel Routes Consumer table whenever a DMS indicates to the Travel Route Service that it is no longer a consumer.
- Add Banned Pronunciation Word to Dictionary displays wrong text: An error message will be displayed when adding a banned word to the Manage TTS Pronunciation Page. This message was corrected with the descriptive text of the banned word.
- Inconsistent Date Formats in CHART Log Files: The date format within the CHART log files is inconsistent with others which produces complications when dealing with log messages during production issues. In order to improve issue resolutions, YYYY/MM/DD was used for a more consistent and readable format.
- Create a Capability to set Comm Loss Timeouts for Multiple DMSs: The capability to set the Comm Loss Timeout for multiple DMSs at a time was added to the system.
- GUI-NTCIP Camera Details Page setting: Maximimun to Maximum.: There was a typo error in the current NTCIP Camera Details Page which will be addressed in this issue.
- Trigger conditions units' field not blanked upon editing: When editing a system trigger condition from the ATMS GUI -> General -> Triggers Page, a correction was made to correct the erroneous units field data (Miles, Degrees *F, etc) which is displayed when selecting a different trigger condition with a blank units field.
- Upgrade JW Player version to match CHARTWeb. The version of the ATMS desktop video player was upgraded.
- CHART-ES copy jobs need to be in transaction block: The steps in the CHART ES database copy job was performed in a transaction to avoid partial failures leaving the database in a bad state.
- Lufft deployment script for adding sensors to export job was adding arbitrary characters to the column header: The script that creates the CHART export jobs in

Lufft was updated to not include special characters, such as degree symbol to the column header of the exported weather data files.

- Updated installation profiles and configurations: There were several PRs dealing with updating ATMS build profiles in the lab and production.
- Remove obsolete directories/files from the ATMS codebase: Obsolete files and directories were removed from the ATMS code base. As part of this, unused video functionality will also be removed including: router, video switches, bridge circuits, video routes, and command processors. Video Fabrics will still be used.
- Keep track of stats/report of which GUI actions have been invoked: The ATMS GUI will keep statistics on which request actions have been invoked, how many times they were invoked, and the date/time of last usage. This will allow analysis to find code that may be obsolete.
- Move the C++ build to its own project: The ATMS project baseline was updated to move the native C++ specific projects to pre-compiled library files within the CHART dependencies directory.
- Store GUI dynamic list objects in user session instead of TempObjectStore: Some of the dynamic list pages were changed such that the user's filtering and sorting criteria are preserved as long as they are logged in, the next time the user views the same list by clicking on the link.
- TOLL_DATA_IMPORT in productions CHART_LIVE DB not being cleaned up: A problem where old data in the TOLL_DATA_IMPORT table is not being deleted was fixed.
- Improve Demo ATMS with "minimal" data: Improvements to the CHART ATMS Demo was made to simplify the installation and configuration of the application. The initial database will also be expanded to include specific sample data which may be used to properly demonstrate the capabilities of the CHART ATMS system.
- Create special development only ability to close all alerts and traffic events: Development-only functions was added: Close All Alerts and Close All Open Traffic Events, to clear out the alerts and traffic events that can accumulate during development and testing.
- Clean up obsolete user rights: Obsolete user rights were removed from the ATMS code base. As part of this issue there are 10 unused user rights which are not displayed in the GUI, but still exist in the code base.
- Remove Obsolete DMS Protocols**:** All DMS models and corresponding protocols except for NTCIP and FP9500 was removed, including: Addco, FP1001, FP2002, PCMS, Sylvia, and TS3001.
- Modify the Automatic Weather Messages from ATMS R15 to log the activations and deactivations of devices in a similar fashion to Travel Time messages.

These enhancements are summarized in Table D-19 (note: for conciseness, minor enhancements listed above are not included). The Release 17 CHART virtualized server environment is illustrated in Figure D-19. Release 17 was deployed January 4, 2017.

Table D-19. CHART ATMS Release 17 Functions

CI	Subsystem	Function
Core Services	Alert management	Developer only ability to close all open alerts
	DMS Control	Set Comm Loss Timeout on multiple DMS; Delete obsolete DM protocols
	DMS Management	Delete obsolete DMS protocols
	Traffic Event Management	Developer only ability to close all open traffic events

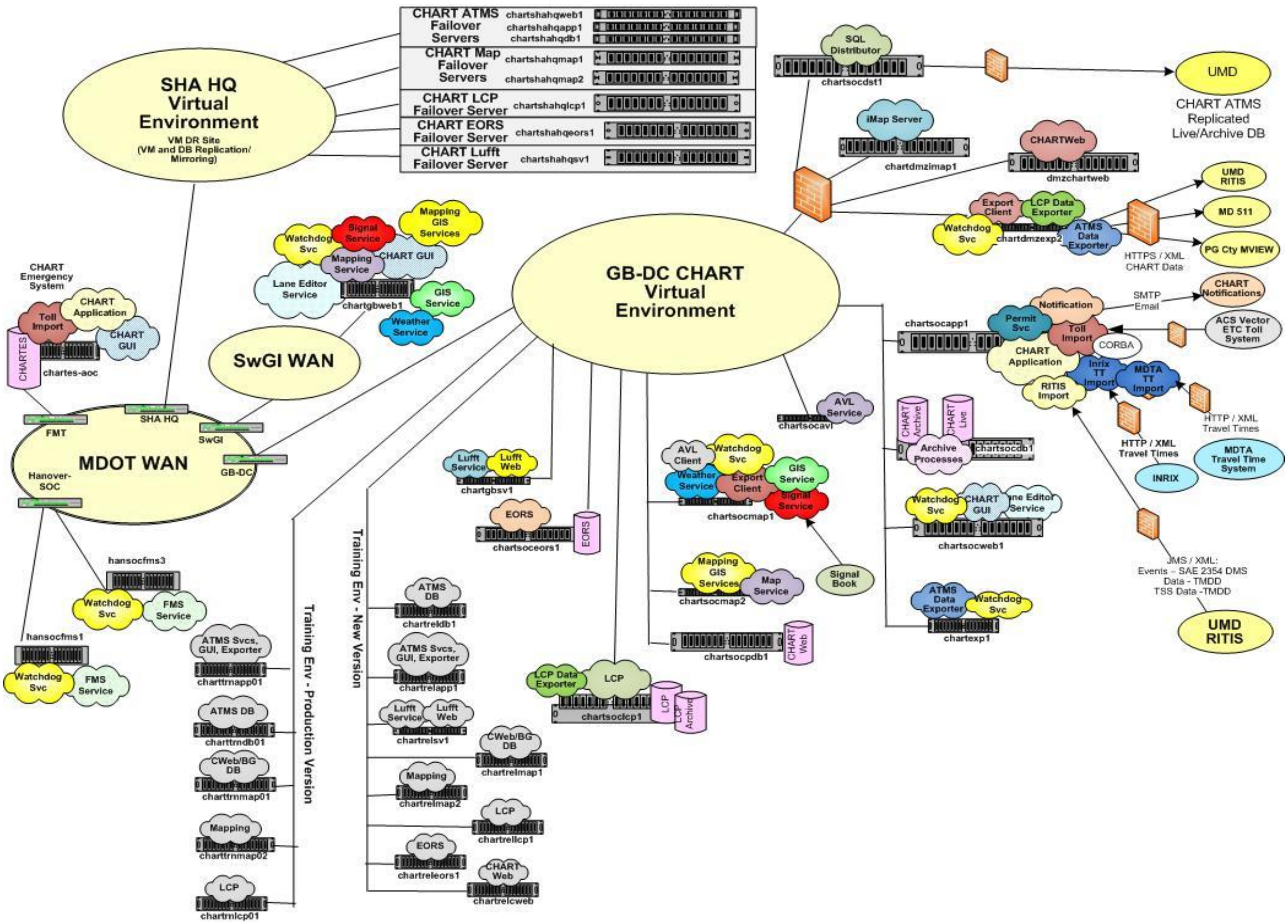

Figure D-19. CHART ATMS Release 17 Server Installations

D.20 CHART ATMS Release 18

Release 18 was a maintenance release that primarily addressed the removal of Adobe Flash / Flex components in favor of HTML 5. Other enhancements included incorporating Skyline/Turnkey Remote Video Display Solution (RVDS) video streaming among others. See full list of enhancements below.

1. **Flash Application Replacement**: Most modern web browsers stopped supporting Flash content and there are some security concerns using Flash. The ATMS GUI application used the Flex framework to develop UI components, which required the Flash browser plug-in at runtime to render and display the application components. Because of above-mentioned concerns, Flex and Flash components in ATMS application were replaced with HTML5 where possible. The GUI components affected are listed below:
    1. Home Page App.
    2. Edit Location App.
    3. Event Launcher App.
    4. Audio Recorder App (which was removed in this release.)
2. **Other PRs:** Several problem reports were addressed in this release. A summary of these is listed below:
    1. The configuration of the DataExporter service was changed to allow up to 64 lanes when exporting lane configurations (previously limited to 32).
    2. A fix made to prevent sending duplicate actions to LCP and which also solved an archiving problem in LCP.
    3. An enhancement was made to take ShortErrorStatus into account when determining Hardware Failure status for NTCIP DMS devices.
    4. A Enhancement was made so that the DMS fontCharSpacing and fontLineSpacing will not be set for a Character Matrix sign, and fontLineSpacing will not be set for a Line Matrix Sign.
    5. An enhancement was made so that DMS will be configurable, as to whether it processes fonts normally, bypasses fontStatus, or bypasses font management entirely.
    6. The Skyline/Turnkey Remote Video Display Solution (RVDS) video streaming was incorporated into the Video Service.
    7. JWPlayer, which is used to display desktop video, was upgraded to version 7.10.2.

These enhancements are summarized in Table D-20 (note: for conciseness, minor enhancements listed above are not included). The Release 18 CHART virtualized server environment is illustrated in Figure D-20. Release 18 was deployed July 11, 2017.

Table D-20. CHART ATMS Release 18 Functions

CI	Subsystem	Function
Core Services	CHART GUI	Remove Flex components in favor of HTML 5.
	DMS Control	Enhancements related to fonts / font management and Hardware Failure status.
	Video Control	Addition of RVDS (support for displaying streaming flash content on physical monitors.)

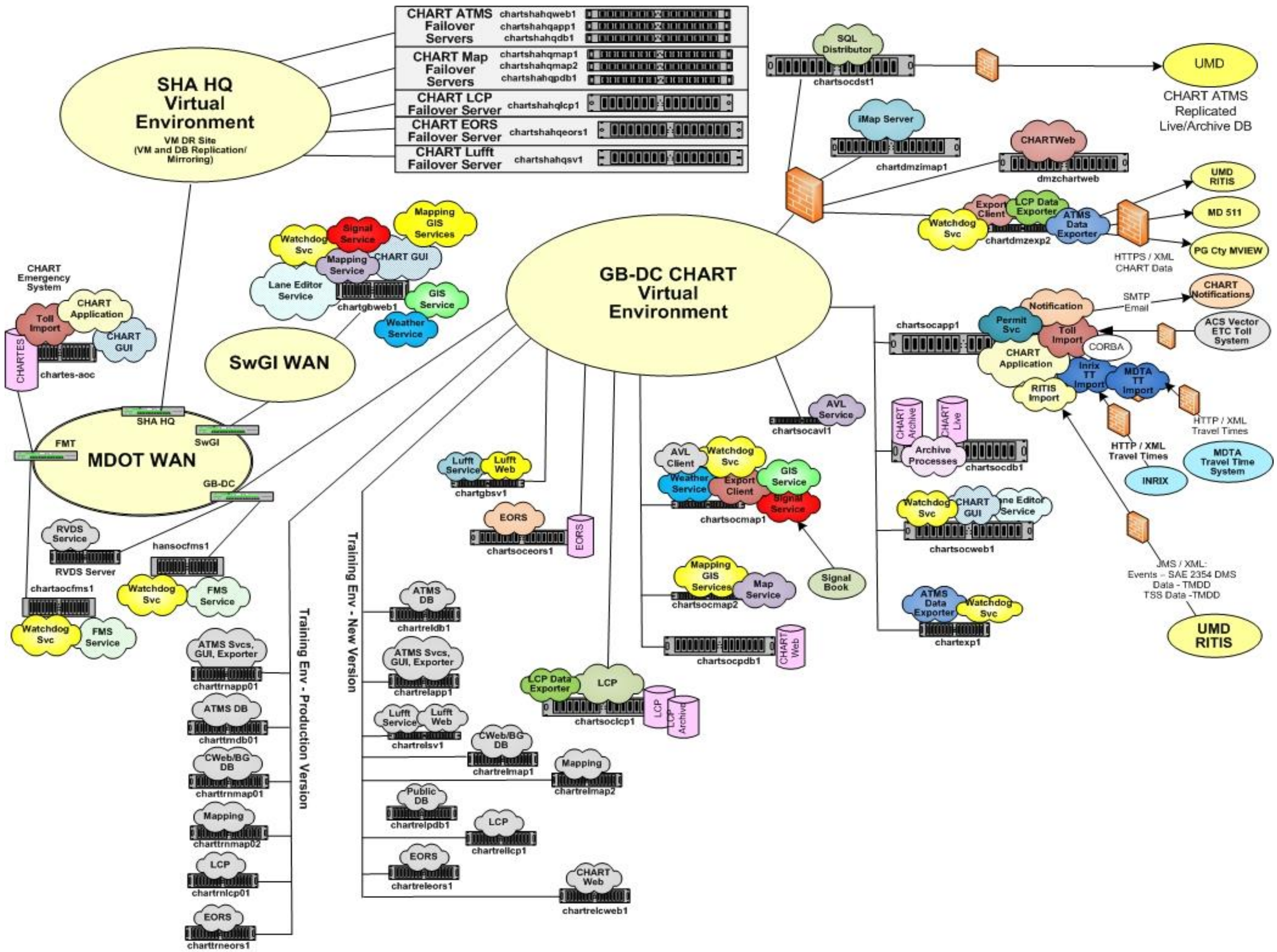

Figure D-20. CHART ATMS Release 18 Server Installation

D.21 CHART ATMS Release 18.1

Release 18.1 was a minor GUI-only release to replace JWPlayer (a commercial video player JavaScript library) with an open source player (VideoJS), as the JWPlayer license was set to expire fairly soon, and licensing was becoming increasingly restrictive and expensive. No other ATMS changes were included in R18.1.

These enhancements are summarized in Table D-21. The Release 18.1 CHART virtualized server environment is illustrated in Figure D-21. Release 18.1 was deployed on August 28, 2017.

Table D-21. CHART ATMS Release 18.1 Functions

CI	Subsystem	Function
Core Services	CHART GUI	Replace JWPlayer library with VideoJS.

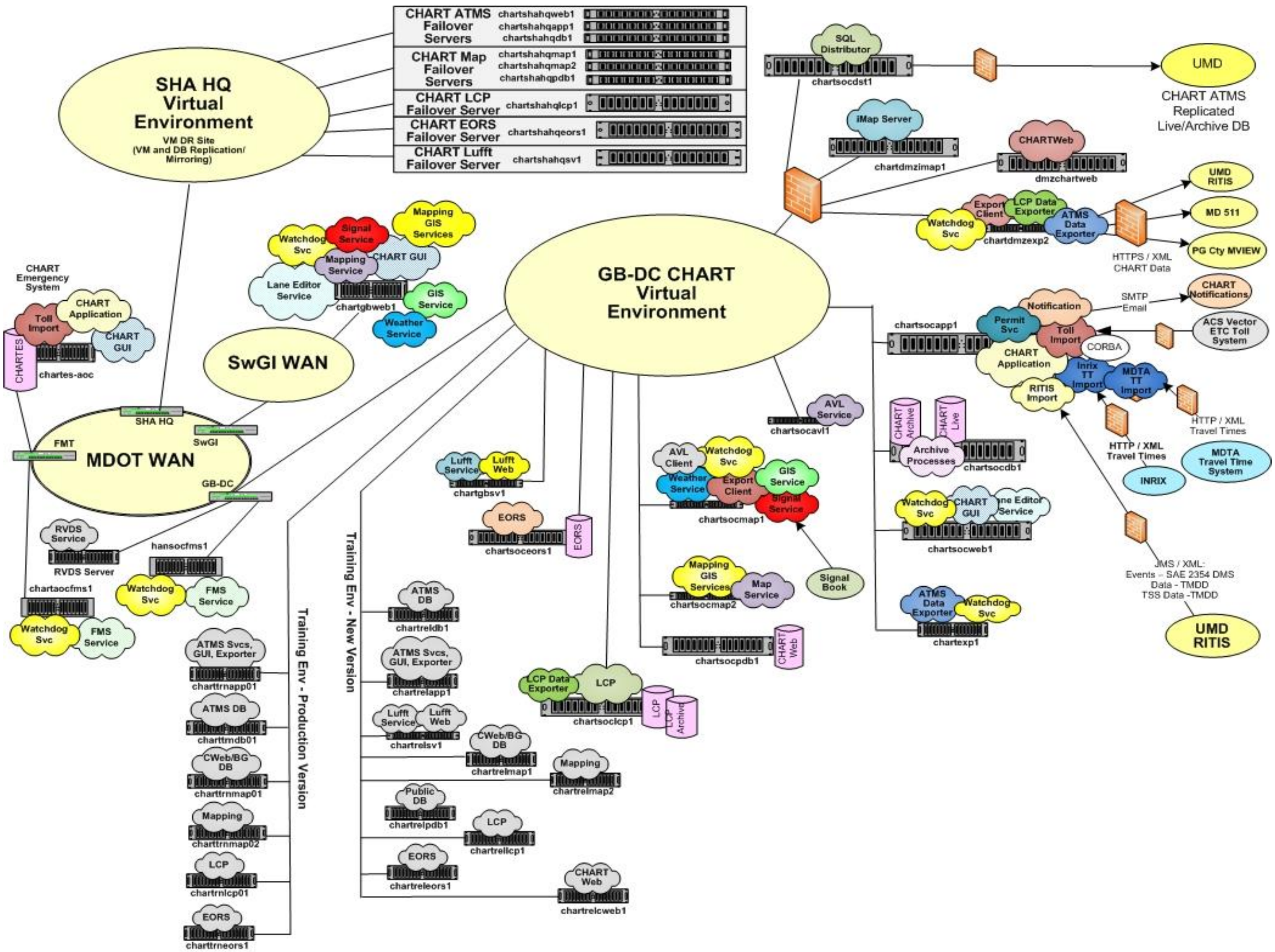

Figure D-21. CHART ATMS Release 18.1 Server Installation

D.22 CHART ATMS Release 18.2

Release 18.2 was a minor release covering Phase 1 of incorporation of Maryland 511 into the ATMS, replacing the standalone MD511 project. The Maryland 511 telephone system was modeled as a new type of HAR, model type “MD511” HAR, because a 511 telephone system essentially mirrors the functionality of a HAR: it accepts audio messages (recorded or text to speech) for broadcast to the public. That is what a HAR does.

These enhancements are summarized in Table D-22. The Release 18.2 CHART virtualized server environment is illustrated in Figure D-22. Release 18.2 was deployed on October 5, 2017.

Table D-22. CHART ATMS Release 18.2 Functions

CI	Subsystem	Function
Core Services	HAR Control	Add MD511 “HAR” to support the Maryland 511 telephone system.

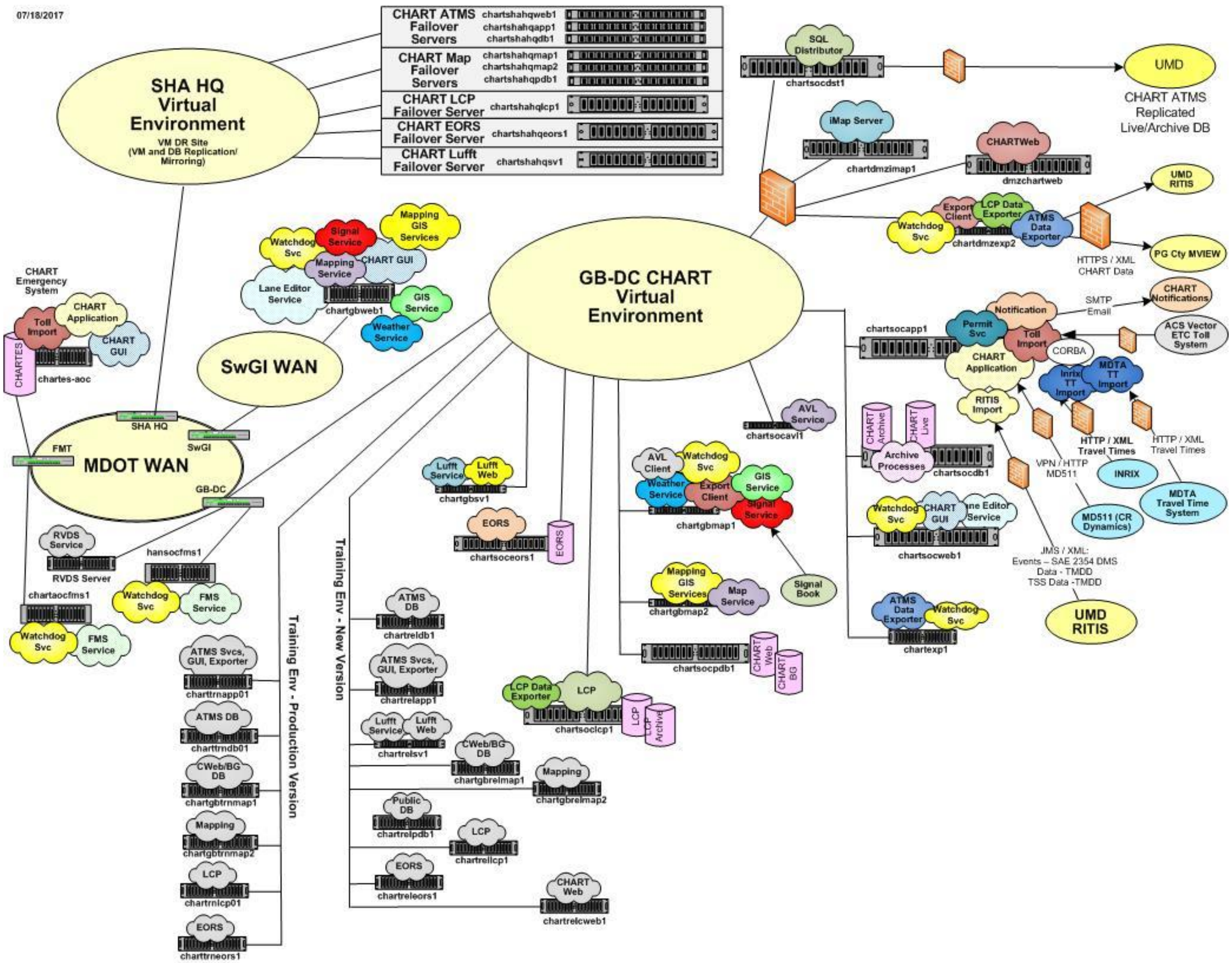

Figure D-22. CHART ATMS Release 18.2 Server Installation

D.23 CHART ATMS Release 18.3

Release 18.3 was a minor release covering Phase 2 of incorporation of Maryland 511 into the ATMS which consists of relocating the functionality of posting to social media. See full list of enhancements below.

3. **Manually Sending Social Media Message**: Initially traffic event users are only able to post traffic-related messages to the Twitter social media application, however in the future it is conceivable the same messages could be posted to other social media websites (Facebook, Instagram, etc.) possibly with graphics and video. Social media messages are only posted from and accessible from traffic events. Features of a social media message are listed below:
    1. Configurable message length below Twitter maximum
    2. Configurable pre-determined word substitutions
    3. Configurable ending message tag included in all messages
    4. Banned-word dictionary checking on manual messages
4. **Preventing Duplicate Social Media Messages**: Social media messages are monitored to ensure an identical message has not been published in the past X minutes by any event (not just this event) beyond the restrictions enforced by external social media application. For Twitter, the current restriction rule for duplicate messages is twenty-four hours.
5. **Pre-populate Message In Traffic Event**: The system defines two message templates: one for while the traffic event is open and one for after it is closed. As Twitter has a strict message length limit and is expected to be the social medium of choice, a Word Substitution list is added to support substitutions in social media messages only.

    While an ATMS operator is creating a traffic event, the system generates a candidate social media message. Traffic event users have the option of editing the message and choosing to send the message or not.
6. **Create Posting Rules**: The system allows the creation of social media posting rules which allow automatic posting for the majority of events however operators can override these rules by switching to "Manual" mode on a per traffic event basis, if necessary. The rules allow for the selection by traffic event type, roadway type, and a minimum % of lanes closed before the event is marked for social media.

    While an ATMS operator is creating a traffic event, the system evaluates the social media rules and generates or updates a social media message. No message is sent until the operator has confirmed the traffic event.
7. **Apply Posting Rules**: The system will apply social media posting rules which are enabled for events which match the rule criteria. Once an event within auto mode has successfully posted to social media, each subsequent update to the traffic event location or to the lane closure percentage for the event will result in an attempt to publish an updated social media message. Automatic publishing of social media messages are still subject to duplicate message checks.

These enhancements are summarized in Table D-23. The Release 18.3 CHART virtualized server environment is illustrated in Figure D-23. Release 18.3 is scheduled for deployment in mid-December, 2017.

Table D-23. CHART ATMS Release 18.3 Functions

CI	Subsystem	Function
Core Services	Traffic Event Control	Add Social Media module to support interactions with external social media applications.
	CHART GUI	Update Traffic Event pages to support automatic and manual posting of social media messages. Add administrator pages to regulate posting rules and settings for social media messages.

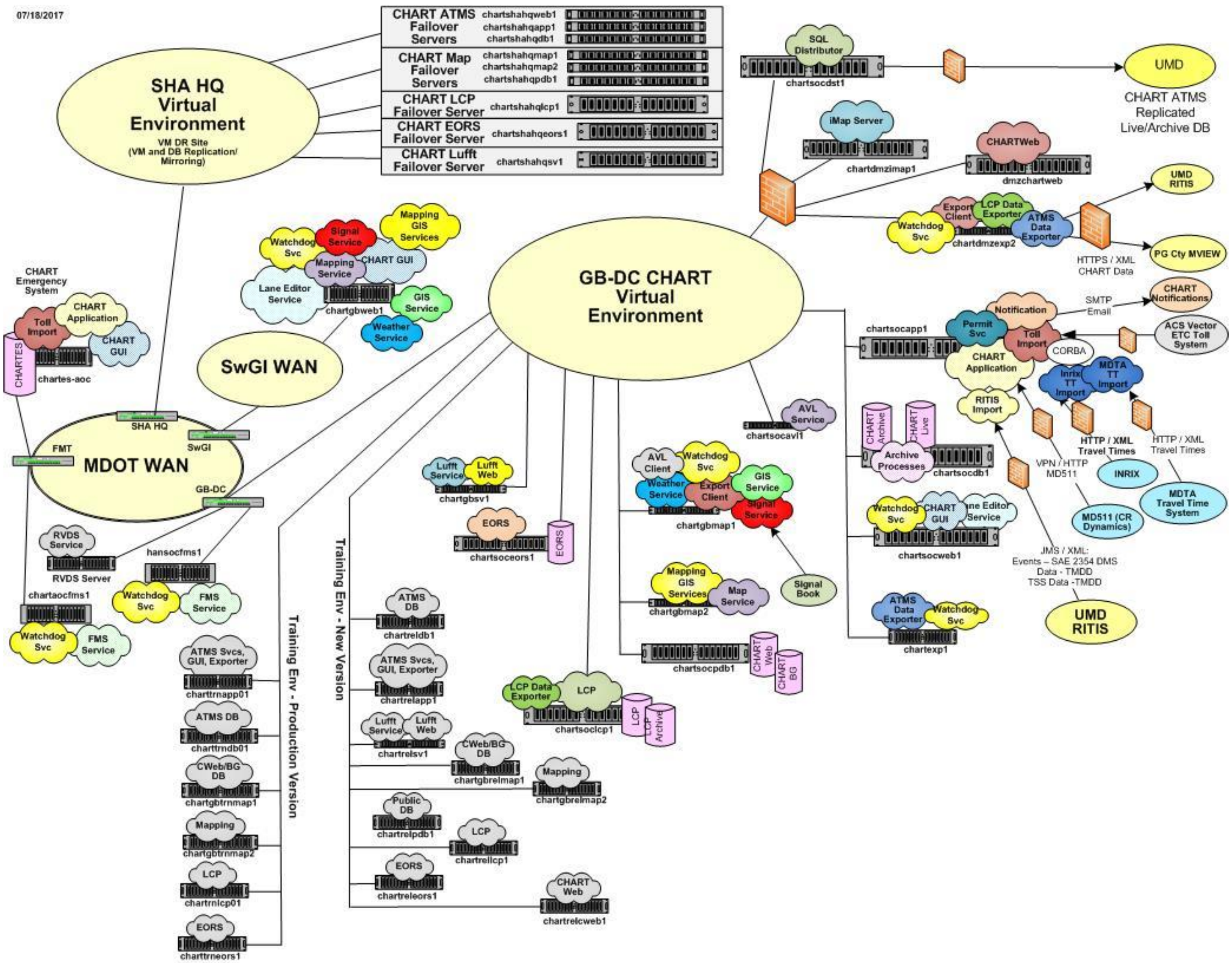

Figure D-23. CHART ATMS Release 18.3 Server Installation

D.24 CHART ATMS Release 18.4

Release 18.4 is Phase 3 of the incorporation of Maryland 511 into the ATMS. It improves the user's ability to post messages to social media and CHARTWeb. Specifically:

- **Manage Social Media Settings**: Management of public messages are moved from the Edit Basic Event Information dialog to a pair of smaller dialogs. The Social Media / Web Settings dialog is available from the event details page and enables the user to choose if the event should be shown to the public, what information should be added to the event on the CHARTWeb website, and what additional information should be added to tweets.
- **Manual Tweeting**: The second new dialog in this release supports the user sending manual tweets. The only user-editable field on this dialog is the message which is initialized with the system-generated message.
- **Allow Duplicates:** This version actively allows duplicate tweets ensuring an event can send a tweet that is the same as a previous (but not-immediately previous) tweet. This circumvents Twitter's duplication suppression period (approximately 24 hours).
- **Update Event Details Page:** The Event Details page is modified as follows:

    1. Rename **Scope of Impact** to **Regional** (Yes / No) - display at all times
    2. Remove **Web Alert Category**
    3. Add **Web / Social Publishing** (By Rule / On / Off)
    4. **Web Alert** - show only if non-Pending and non-external
    5. Rename **Last Web Alert Sent** to **Last Tweet -** show if non-Pending and non-external
    6. Rename **Last Web Alert Time** to **Last Tweet Time** - show when Last Tweet shown
    7. **Social/Web Settings** link displayed for an open, non-external traffic event
    8. **Manual** link displayed for an open, non-external traffic events

- **Revert a Planned Closure to the Pending State**: When an open Planned Roadway Closure reverts to a pending event, if the auto-publishing state is "On" the system will send an event closed tweet for the event. In any case, it will also revert all fields back to their initial state in preparation for the next time the event is opened.
- **Exporter/Export Client Social Media Upgrades:** A summary of changes in the ATMS requiring ATMS Export to be updated:
    - Traffic Event Scope of Impact field replaced with a checkbox for Regional Events.
    - Web Alert Category removed.
    - New Auto Publish Mode (By Rule, On, Off).

    Details of these changes can be found in CHART Traffic Event Export ICD.docx updated for MD511 Phase 3.

These enhancements are summarized in Table D-24. The Release 18.4 CHART virtualized server environment is the same as Release 18.3 as illustrated in Figure D-23. Release 18.4 is scheduled for deployment in February, 2018.

Table D-24. CHART ATMS Release 18.4 Functions

CI	Subsystem	Function
Core Services	Traffic Event Control	Support sending social media message from traffic events. This includes applying rules for when to send a message, generating the message, checking for banned words, and forcing duplicate messages.
	CHART GUI	Update Traffic Event pages to support automatic and manual posting of social media messages.

D.25 CHART ATMS Release 19

Five deployments comprise Release 19. Because each deployment is independent of the others, the releases were able to be deployed as soon as they were available to quickly get the features out to users.

- Deployment 1: Various CRs
    - **[ATMS-2291] - Trigger Data Not Updating After Reboots - ScheduleService Restart Needed**
    - **[ATMS-3230] - SWGI GUI Intermittent Lock Up**
    - **[ATMS-3576] - INRIX data with timestamp N hours in the future causes DMS Travel Times to not be displayed for N hours**
    - **[ATMS-3685] - TSS Import - External TSS Candidates not being created properly**
    - **[ATMS-3757] - Confirming Event From General Information Should Trigger Social Media**
    - **[ATMS-3170] - GUI Home Page - Make Number of Events Sticky w/ Default of 10**
    - **[ATMS-3736] - Update Social Media fields when confirming event from Details page**
    - **[ATMS-3812] - Update INRIX version to 11.4 to match production change**
    - **[ATMS-3844] - Update and Add GUI Link for DMTS and Signals**
    - **[ATMS-3818] - Extra Event Details refreshes when Social Media data didn't change**
- Deployment 2: INRIX Links
    - Update Link Definitions
- Deployment 3: COTS Upgrade

  The following software packages are upgraded:
    - Microsoft Windows Server 2016
    - Microsoft SQL Server 2016
    - Apache Tomcat 9
    - Java JRE 1.8.0.162 (32 & 64 bit)
- Deployment 4: HAR Template & Decision Support Upgrades
    - Improve usability of HAR Template
    - Reduce time users wait for Decision Support recommendations
- Deployment 5: RITIS JMS to RF Migration
    - Migrate RITIS import service from using JMS Queue to use RITIS Filter technology

These enhancements are summarized in Table D-25. The Release 19 CHART virtualized server environment is illustrated in Figure D-25. The final deployment of Release 19 is scheduled for September, 2018.

Table D-25. CHART ATMS Release 19 Functions

CI	Subsystem	Function
Core Services	DMS Service	Travel Time – handle bad INRIX time stamps
	External Interfaces	Migrate RITIS Import from JMS to RITIS Filters and allow TSS' to be imported
	Traffic Event Control	Improve speed of Decision Support & update Social Media fields on details page
	Trigger Module	Restart reliably
GUI Services	GUI Management	HAR Template Editor, add user links, retain number of events on a page, and improve SWGI stability

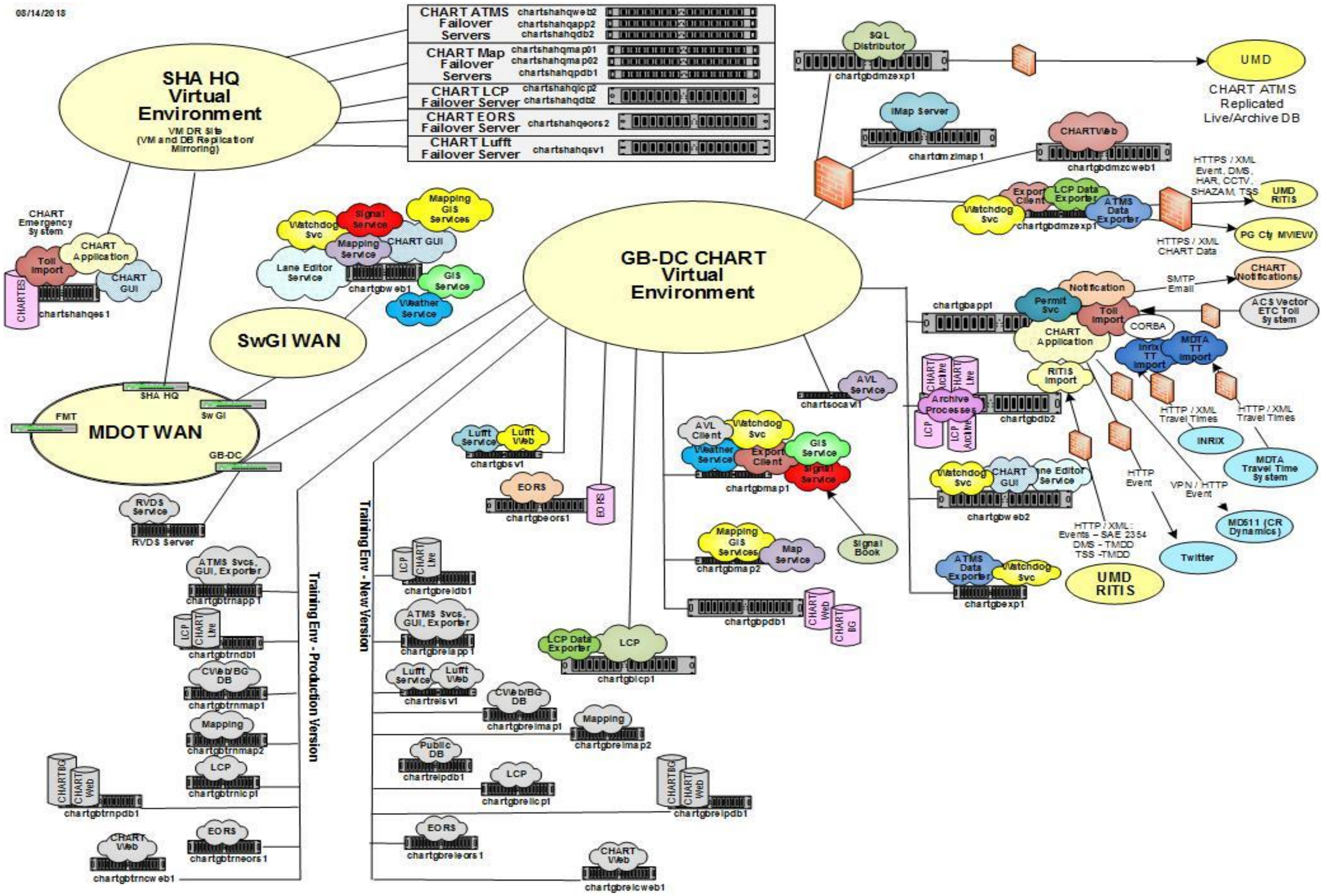

Figure D-25. CHART ATMS Release 19 Server Installation