Caltrans TMC Coordination

The William and Barbara Leonard
University Transportation Center

California State University San Bernardino

Prime Award No. 65A0244, Subaward No. GT 70771
Awarding Agency: California Department of Transportation

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September 2009

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ACKNOWLEDGMENTS

The authors wish to acknowledge and thank the agencies and associated TMC management staff that have provided information and / or contributed to this report:

- Mike Jenkinson, Caltrans Headquarters, TMC Operations
- Markus Heiman, Caltrans District 3 TMC
- Ramin Bolourchian, Caltrans District 4 TMC
- Jacques Van Zeventer, Caltrans District 5 TMC
- Sergio Venegas, Caltrans District 6 TMC
- David Lau, Caltrans District 7 TMC
- Alan Kirst, Caltrans District 8 TMC
- Lima Kopitch, Caltrans District 11 TMC
- Paul King, Caltrans District 12 TMC

ABSTRACT

Caltrans Transportation Management Centers (TMCs) are tasked with the management of the statewide transportation system to reduce congestion and provide for the safe movement of people, goods, and information. They must work with neighboring TMCs to ensure the continued efficient operation of that system, and coordinate to manage larger-scale incidents and regional emergencies. This report focuses on coordination in metropolitan areas of California and summarizes the methods utilized for coordination statewide through interviews with operations managers from eight Caltrans TMCs. It identifies the major tools utilized in TMC traffic management, specific examples of TMC coordination, and potential areas for improvement in coordination including methods of sharing collected data between districts.

EXECUTIVE SUMMARY

The first Traffic Management Center in California was constructed in 1971 in Los Angeles, providing management of the Santa Monica, San Diego, and Harbor freeways. TMCs today operate under a mandate to aggressively manage the statewide transportation system to reduce congestion and provide for the safe and efficient movement of people, goods, and information. They must respond to unique and dynamic traffic conditions and incidents, which can arise without warning, change rapidly and unpredictably, and create both congestion and potentially dangerous conditions for travelers.

California is divided into 12 Caltrans districts, covering a wide geographical area and having varied traffic management and coordination requirements. These districts are comprised of more than 50,000 miles of highway and freeway lanes, supporting in excess of 150 billion vehicle miles traveled per year. Caltrans TMCs use a variety of tools to manage this traffic, with significant traffic management tool commonality between districts. The telephone is the primary means of coordination between Caltrans TMCs. CHP Computer Aided Dispatch (CHP CAD) and maintenance radios are also sometimes utilized to assist in coordination. Changeable message signs are commonly used to organize coordinated traffic diversions. Surveillance video and field equipment are sometimes also shared during the process of coordination. Additionally, some inter-district coordination occurs through statewide TMC manager meetings and the development of standard operating procedures to aid in coordinating a well thought out response to predictable, yet significant traffic disturbances.

Effective coordination between four Caltrans districts was demonstrated during a large oil tanker fire in Southern California in 2002. The telephone was used to create CMS-based diversions, which were central to the management of the incident. This incident affected traffic over a wide geographical area. Southern California TMCs have also demonstrated effective coordination for closures of Interstate 5 on the Grapevine during winter storms; well thought out standard operating standard operating procedures help TMC operators and Caltrans personnel in the field respond methodically and properly to the predictable closures of this stretch of freeway, minimizing delays and dangerous conditions for motorists. Other incidents in Central California illustrated the need for better preparation and more eyes in the field. California TMC training has been modified to help TMCs be better prepared to manage large incidents.

Traffic management capabilities can be leveraged through coordination. Quick and reliable inter-district communications, even if it is simply a telephone conversation, can assist in reducing the effects of an incident in one district on conditions in a neighboring district through the use of CMSs to reduce or mitigate the effects of upstream traffic upon an incident. The concept of interoperable equipment should be fully explored to determine feasibility. Data and video sharing between jurisdictions, regardless of government level, e.g. city, county, or state, should be seamlessly integrated into future ATMS implementations.

Inter-district collaboration and preparation develops the skills and capabilities required to effectively handle large incidents. The development of standard operating procedures provide an excellent opportunity to both explore methods of handling incidents and for district personnel to establish working relationships which can be called upon during the handling of major incidents. CHP CAD is an unsung hero of traffic management due to its reliability and consistency of use throughout the state. CHP CAD demonstrates many attributes which are desirable in traffic management systems; it is trusted, comprehensive, timely, and ubiquitous within California. The design of future transportation management tools should consider these key characteristics of CHP CAD which have contributed to its success.

COMMONLY USED TERMS AND ACRONYMS

ATMS	Advanced Traffic Management System
Caltrans	California Department of Transportation
CCTV	Closed-circuit television. Used by TMC operators to monitor traffic flow, and respond to incidents.
CHIN	Caltrans Highway Information Network. A system to provide the public with current highway condition information.
CHP CAD	California Highway Patrol Computer-Aided Dispatch.
CMS	Changeable Message Sign. An electronic traffic sign used to convey travel advisories and other information or warnings to motorists.
D[x]	Caltrans District number (e.g. D5). Highway operation and maintenance responsibilities throughout California are broken up into districts. A district map included in this document, and can also be found online at http://www.dot.ca.gov/districtmap.htm.
DHS	Department of Homeland Security
EOC	Emergency Operation Center. Central command and control facility to perform strategic level management in the event of an emergency situation.
FHWA	Federal Highway Administration
HAR	Highway Advisory Radio. Low-powered radio stations that provide traffic hazard and travel advisory information.
ICS	Incident Command System. A system utilized by CHP to manage incidents.
MAIT	Multidisciplinary Accident Investigation Team or Major Accident Investigation Team. Responsible for intensive incident investigations in order to determine all of the causative factors leading up to the collision and any injuries or fatalities.
MPO	Metropolitan Planning Organization. Policy-making organization comprised of representatives from local government and transportation authorities.
NIMS	National Incident Command System. Consists a set of principles, doctrines, and terminology to provide a systematic and proactive approach to preventing, responding to, and mitigating the effects of incidents.

PeMS	Freeway Performance Measurement System. Collects real-time and historical freeway data to compute freeway performance measures.
SOP	Standard Operating Procedure
TMC	Transportation Management Center
TMCAD	Traffic Management Center Activity Database
TMCAL	Traffic Management Center Activity Log
TMT	Traffic Management Team

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1. INTRODUCTION

The National Interstate and Defense Highways Act, or Federal-Aid Highway Act of 1956 initiated one of the largest public works projects in American history – to construct approximately 41,000 miles of interstate highway. While a primary goal of this effort was one of national defense, a direct result was the subsidy of roadway infrastructure that permitted easy travel of both personal and commercial traffic between urban centers, contributing to the suburbanization of the nation.

By the early 1990's, the focus on managing highway congestion, both nationally and within the state of California, was shifting from that of continued highway build-out to an approach of improving the efficiency of existing roadways. The first major direction at the federal level came in the form of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) which pushed an intermodal approach to highway funding, promoting the intelligent management of infrastructure. ISTEA spawned the concept of Intelligent Vehicle Highway Systems (IVHS), which grew into Intelligent Transportation Systems (ITS), which is defined as "the application of computers, communications, and sensor technology to surface transportation".

The first Traffic Management Center in California was constructed in 1971 in Los Angeles, providing management of the Santa Monica, San Diego, and Harbor freeways through the use of technologies such as loop detectors and ramp metering. Today, TMCs have become an accepted tool for managing traffic incidents and congestion at the state and local levels, both within and outside of California. They must respond to unique and dynamic traffic conditions and incidents, which can arise without warning, change rapidly and unpredictably, and create both congestion and potentially dangerous conditions for travelers.

This report provides an overview of TMC coordination within the state of California and is based on interviews with TMC managers from the Southern, Central, and Northern regions. Due to the modest nature of this project not all TMC managers were interviewed, rather a subset from major urban areas of California were queried for information to paint a representative picture of the whole. As such, this report will focus on traffic coordination in metropolitan areas of California. Although this report focuses on TMC coordination, the general concepts related to traffic and incident management tools and techniques utilized in California are explored, as their use is directly applicable to coordination of traffic management, both at a state-to-state and a state-to-local level.

2. CALTRANS TRAFFIC MANAGEMENT

2.1 Caltrans Districts

California is divided into 12 Caltrans districts, covering a wide geographical area and having varied traffic management and coordination requirements. These districts include both major metropolitan and rural areas. Figure 1 below shows the different Caltrans districts within California. Major metropolitan areas in California include the San Francisco Bay Area, Los Angeles, the Inland Empire, San Diego, and the Stockton/Sacramento area. Caltrans manages more than 50,000 miles of highway and freeway lanes across these districts, in both rural and metropolitan areas, supporting in excess of 150 billion vehicle miles traveled per year.

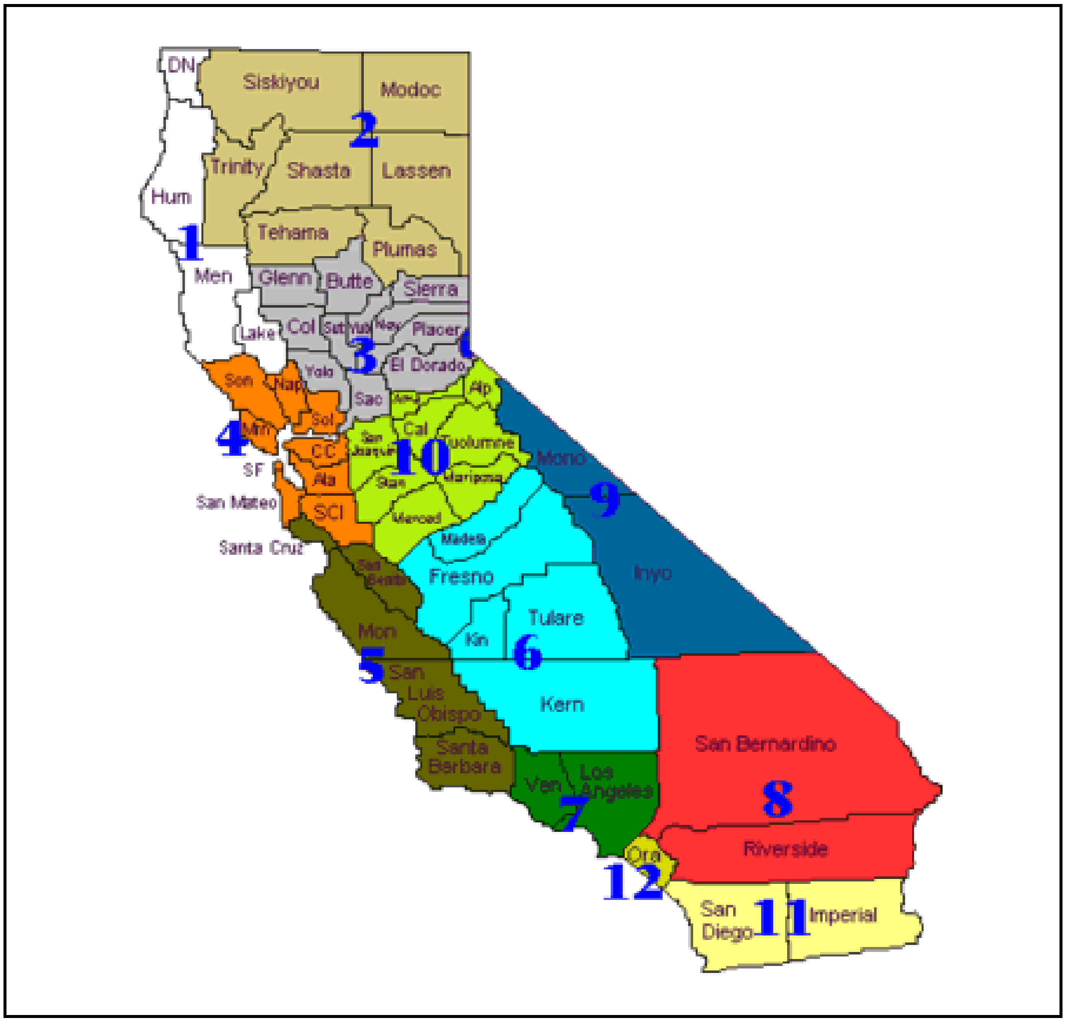

Figure 1: California Department of Transportation District Map

2.2 California Traffic Management Tools

The mission of a Caltrans TMC is to “efficiently manage the region’s transportation system to reduce congestion and provide the safe and efficient movement of people, goods, services, and information”. Key TMC tools, which are used to support both normal TMC and coordinated TMC operations, are discussed in the following sections.

2.2.1 Advanced Transportation Management System (ATMS)

The Advanced Transportation Management System provides a high level management interface to real-time data sources to monitor highway traffic flow. With it, operators are able to utilize technologies such as vehicle detector stations (VDS), ramp-metering stations (RMS), closed-circuit television cameras (CCTV), and changeable message signs (CMS) to improve highway safety, swiftly react to highway and regional incidents, and reduce congestion. Examples of vehicle detector stations include in-roadway inductive loops, camera-based video detectors, and microwave wireless stations. These stations provide vehicle counts, speed information, and lane occupancy.

The most commonly used ATMS system in California is the Delcan ATMS, currently installed in the Southern California and Inland Empire districts (D7, D8, D11, and D12) and installed or being implemented in northern California (D3, D4). Roadway speed information is readily viewable on the ATMS display as green, yellow, or red icons depicting flow conditions. Operators can click on these icons to learn more information about a particular segment of roadway. If an incident occurs it is often visible as a series of red icons on the roadway where traffic has begun to significantly slow or stop. Operators can quickly assess the situation using integrated CCTV access and respond appropriately. The public can be advised using integrated CMS messaging tools within the ATMS.

While the Delcan ATMS is the dominant traffic management system in California, it is not without its flaws. Despite similar architectures, ATMS software installations in each Caltrans district require extensive customization, configuration, and modification efforts to function within the installation device network. This results in a highly specialized installed system that cannot easily be linked to display data from outside of the host district nor readily permit replication for transplant installation in another district. There is desire within the Caltrans ranks for a next-generation ATMS implementation that would allow easy extension and modification in a non-proprietary implementation, but as of this writing no significant progress has been made towards this approach.

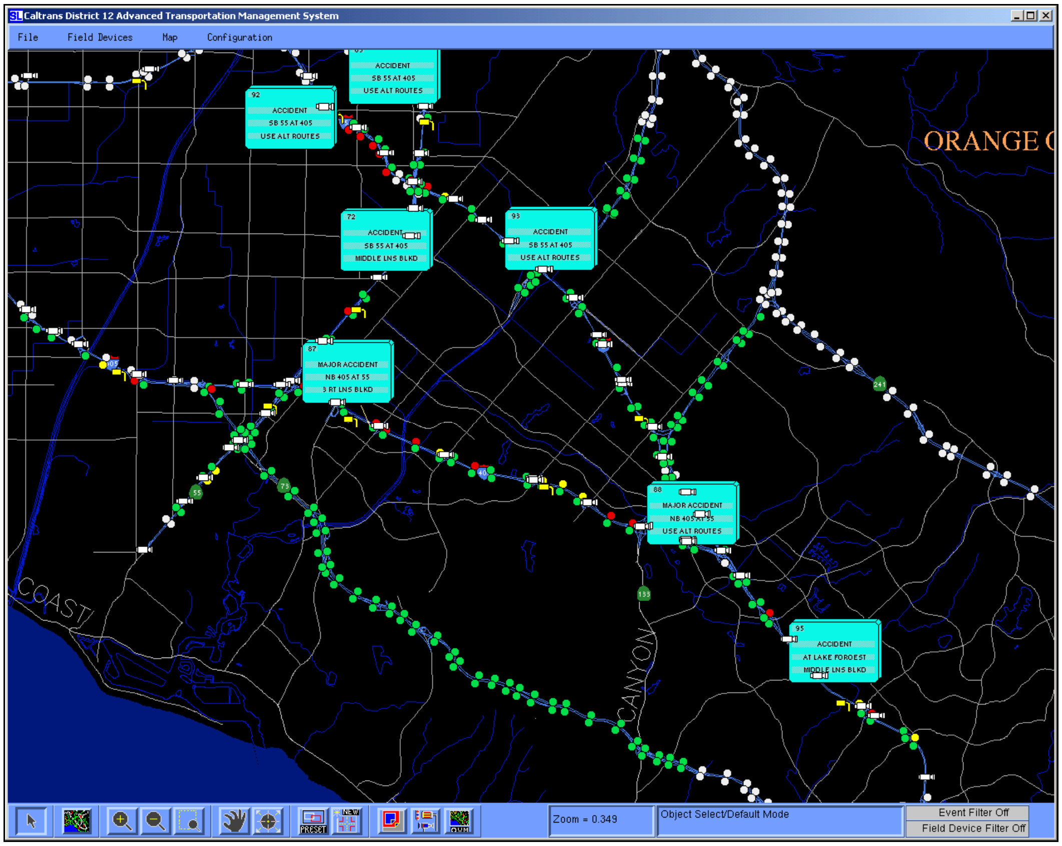

Figure 2: Delcan Advanced Traffic Management System

2.2.2 Video Surveillance

Closed-circuit television systems have been a consistent mainstay of traffic management. While it is not a new technology, in terms of usage CCTV is an extremely useful tool available to TMC operators. The capability to view real-time or near real-time roadway traffic conditions gives operators the ability to analyze traffic and assist in providing effective incident and emergency response through visual assessment of an incident scene. Innovative methods of CCTV implementation have emerged in recent years, enabling the installation of cameras in locations where it previously would have been too costly or otherwise technically impractical. At the time of this writing, Caltrans has approximately 1,300 cameras monitoring freeways, highways, and related infrastructure in the state of California. Some of these cameras have pan, tilt, and zoom capabilities allowing the operator to better focus on objects within range of the device, and gain a better understanding of unfolding events.

In many districts video feeds are also made available for use outside of the TMC. Of these feeds, only a subset are typically made available to the public and to the media via the Internet. More than half of Caltrans districts have their own individual Web pages that list cameras available for viewing on their district web site. Caltrans also maintains a consolidated set of links to public video feeds at http://video.dot.ca.gov. Additional non-public video feeds are available to TMC personnel via the Caltrans intranet.

While these public video feeds provide a valuable service to many interested parties such as news aggregators, media outlets, and the motoring public, Caltrans must balance the desire for openness with the concern for privacy. Organizations such as the ACLU have voiced civil-liberty concerns regarding the increasing use of CCTV cameras on highways, and the potential for their use in law-enforcement roles. To alleviate such concerns, Caltrans does not routinely record or archive video data as part of normal operations. Additionally, cameras are only used in law-enforcement roles when installed in toll-based locations such as bridges for the ticketing of non-paying vehicles. Districts also have the ability to disable any or all of their public video feeds to prevent the viewing of sensitive or disturbing imagery by the public on an as-needed basis.

2.2.3 California Highway Patrol Computer-Aided Dispatch (CHP CAD)

The CHP CAD is a secure system used by the CHP to support dispatch and response functions. It links all dispatcher workstations, provides reliable and accurate incident information, and both standardizes operational procedures and decreases incident response times through elimination previously used manual processes. Although not a Caltrans system nor originally intended for Caltrans use, CHP CAD is today one of the primary methods for the dissemination of incident information within TMCs. TMC operators in many districts now rely on this system as it is often the point of first notification for an incident, and provides regular updates as the situation progresses.

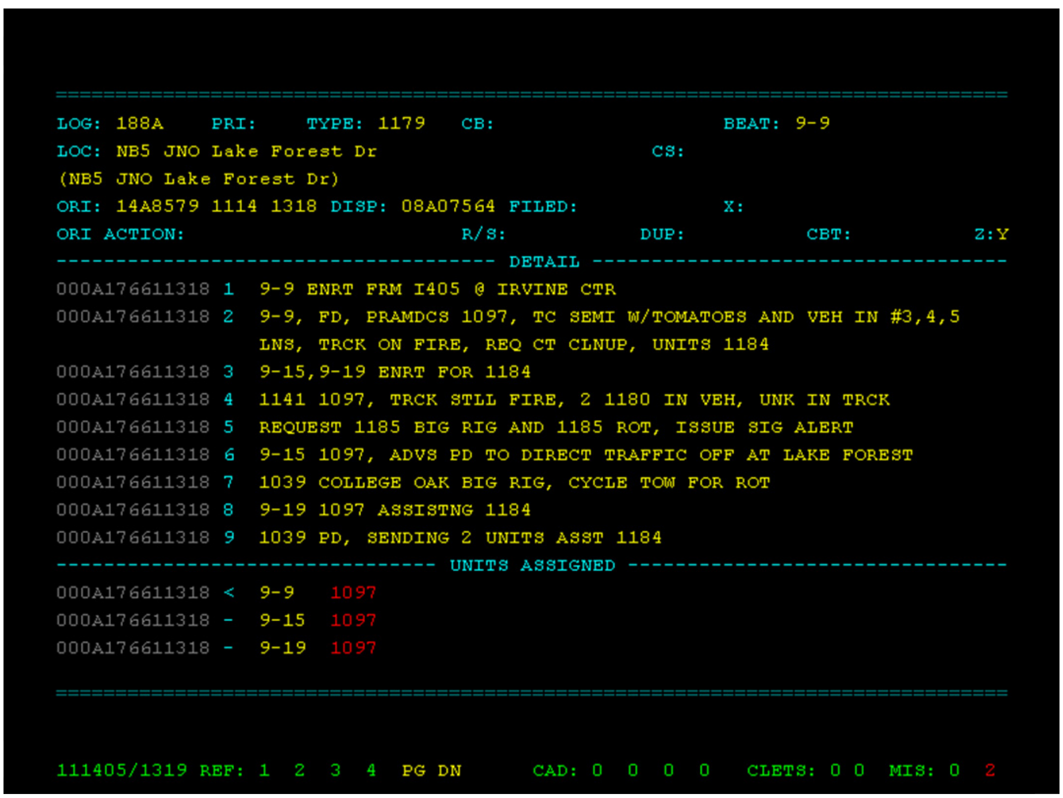

Figure 3: CHP Computer-Aided Dispatch

The CHP CAD is now considered a legacy system due to its specialized dedicated hardware requirements, and a project is currently underway to develop its replacement.

2.2.4 Incident Logging

The Federal Highway Administration (FHWA) defines a traffic incident as "any non-recurring event that causes a reduction of roadway capacity or an abnormal increase in demand" or "an emergency road user occurrence, a natural disaster, or other nonrecurring or unplanned event that affects or impedes the normal flow of traffic". Traffic Management Centers handle a significant number of traffic incidents daily, up to several hundred per day in urban areas. Maintaining a record of the management of incidents facilitates the handling and clearing of incidents and provides a record of activities undertaken. Such a record can be crucial in providing accurate incident reporting both during an incident for the purposes of intra and inter-agency notifications, and for after-action analysis and accounting to both state and federal agencies.

While standardization is desired, currently no statewide standard system exists in California for the provision of incident logging. As a result many districts have created their own implementation for recording incident management activities. For example, District 12 in Orange County, has implemented an Internet browser-based system that easily enables operators to create new incident logs and update them as needed with simple click-lists that walk them through adding an entry. Incident and notification reports such as Sigalerts are easily generated from within this interface.

Another incident logging system utilized by Caltrans is TMCAD, developed and implemented by the District 6 TMC in Fresno. TMCAD is a Microsoft Windows-based application that provides linkages for the management of field devices, and can provide ready access to contact information and standard operating procedures. Two other districts (D5 and D10) are currently also using the Fresno TMCAD logging system.

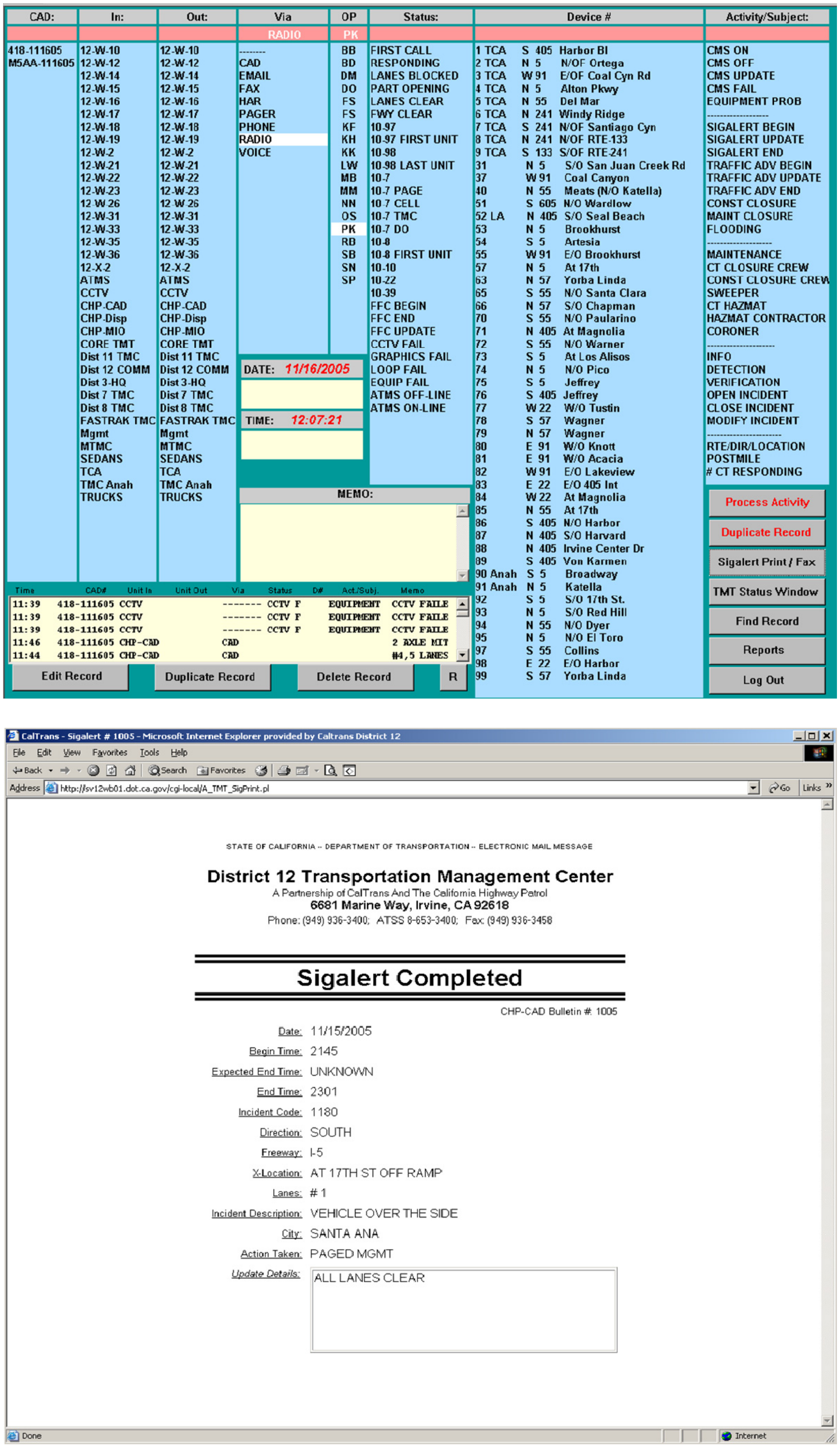

Figure 4: District 12 Activity Log and Sigalert notification

2.2.5 TMCAL

Due to the lack of a standardized statewide logging system, Caltrans is currently investigating options for developing such a system. The designation for this new logging system is the Traffic Management Center Activity Log, or TMCAL. TMCAL will incorporate many of the features found in the custom logging systems installed throughout the state, and provide a centralized source of incident information with a uniform interface and standardized operation for use throughout California.

In addition to the provision of centralized logging, it is envisioned that TMCAL will provide post incident reports and performance measurement and reporting for Traffic Management Center operations, and simplify data archiving and retrieval. It will include linkages to the Satellite Operation Center Command System (SOCCS) and Advance Transportation Management System (ATMS) in each district, as well as updates to the California Integrated Information Network (Calnet II). In addition, the creation of a standardized statewide system would provide for automatic notification of incidents and closures to both the California 511 webpage servers and to the Caltrans Headquarters Communication Center, which operates the California Highway Information Network (CHIN) and provides the department's notification and reporting of incidents to the Governor's office.

A core requirement of TMCAL is the provision of a centralized interface to the CHP's Computer Added Dispatch (CAD) System. As the CHP moves towards implementation of their next-generation computer-aided dispatch system, the capability for direct communication between the two systems to synchronize incident logging is a high priority. Such a communications capability will enable both Caltrans and CHP to be aware of the activities undertaken by each other and eliminate redundant log entries on either side. The integration of TMCAL as the primary information bridge between the two organizations would also likely result in the elimination of direct CHP CAD terminal access for TMC personnel, thus eliminating a long-time security issue for both CHP and Caltrans alike due to the U.S. Department of Justice security clearance certifications required to use and view CHP CAD.

The stated objectives for the TMCAL project as defined by Caltrans are:

- Reduce twelve (12) independent systems to one statewide system to perform incident response logging.
- Improve capture, archive and reporting of incident data and activities performed by TMC operations.
- Generate performance measurement reports.
- Provide an interface to the CHP CAD system.
- Increase the efficiency and timely reporting of the Calnet II data.
- Replace the existing process of notification by telephone and fax between TMCs and the executive branch; to a single data file provided through a statewide system of

information used for the Department's Executive Notification and reporting of incidents.

– Replace the existing system using telephones for coordination between TMCs with a centralized database.

2.2.6 Ramp Meter Control

Freeway on-ramp metering is one of the primary dynamic methods available to Caltrans to aid in maintaining efficient travel on the highway system. By managing the rate at which vehicles enter the freeway system, overall travel and highway speed is maintained and provides greater efficiency over the length of a corridor. Safety is also improved as the numbers of incidents are reduced in the area of the metered onramp. Ramp-metering is a relatively inexpensive tool which provides visible improvement in traffic flow. Caltrans is committed to ramp-metering systems, and considers them an integral part of their Traffic Operations Program Strategic Plan.

While much of the control for these systems are automated and run at scheduled times of peak traffic flow, some districts utilize dynamic ramp metering systems. Dynamic metering systems adjust metering rates based on real-time traffic flow data from Caltrans vehicle detection stations. For example, District 7 in Los Angeles implemented a Delcan System Wide Adaptive Ramp Metering (SWARM) system, which in addition to providing TMC operators with a centralized platform for control of the ramp-metering is also capable of forecasting traffic conditions, and adapting metering rates system-wide to compensate for anticipated traffic flow issues.

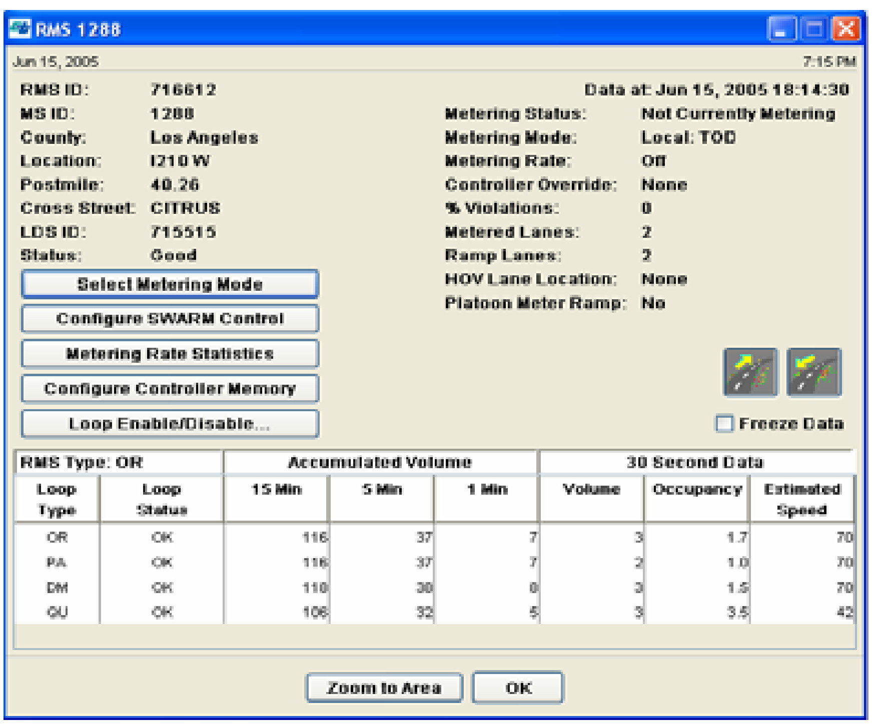

Figure 5: Delcan System Wide Adaptive Ramp Metering system

2.2.7 Changeable Message Signs and Highway Advisory Radio

Changeable Message Signs and Highway Advisory Radio are two of the primary tools utilized by TMC operators to advise and inform the motoring public to traffic advisories, delays, and emergency conditions. For districts with ATMS installations, CMS control is typically performed through the ATMS application, allowing the operator to use a map-based display to view which signs have been activated within their district and what messages are displayed. Additionally, automated CMS systems are utilized on various routes in both northern and southern California to provide estimated travel times to commuters.

Highway Advisory Radio systems broadcast a prerecorded loop of information on a low-power radio stations. These radio bulletins are usually announced via activation of CMSs to notify motorists to tune to the broadcast. While some districts HAR installations still require voiceover of the recorded message to be broadcast by a practiced TMC operator, these systems have largely been replaced in favor of text-to-speech voice synthesis systems. Text-to-speech voice systems provide message uniformity throughout the HAR network and permit the ready-activation of pre-formed messages that are vetted against both Caltrans district and Headquarters communications policies.

Figure 6: Changeable message sign displaying estimated travel times

2.2.8 Lane Closure System (LCS)

The Lane Closure System (LCS) provides reporting capabilities which allow traffic managers to track lane, ramp, and road closures due to incidents, construction, and maintenance. Caltrans currently maintains a statewide LCS that tracks active closures as well as all planned closures for the next seven days from any given day. District TMCs can utilize this information to monitor both their own closures as well as those planned on highways in adjacent districts, and also coordinate closures with their neighbors. This system is utilized by all districts save District 7 in Los Angeles, which employs its own implementation and provides notification of planned closures via its Web site.

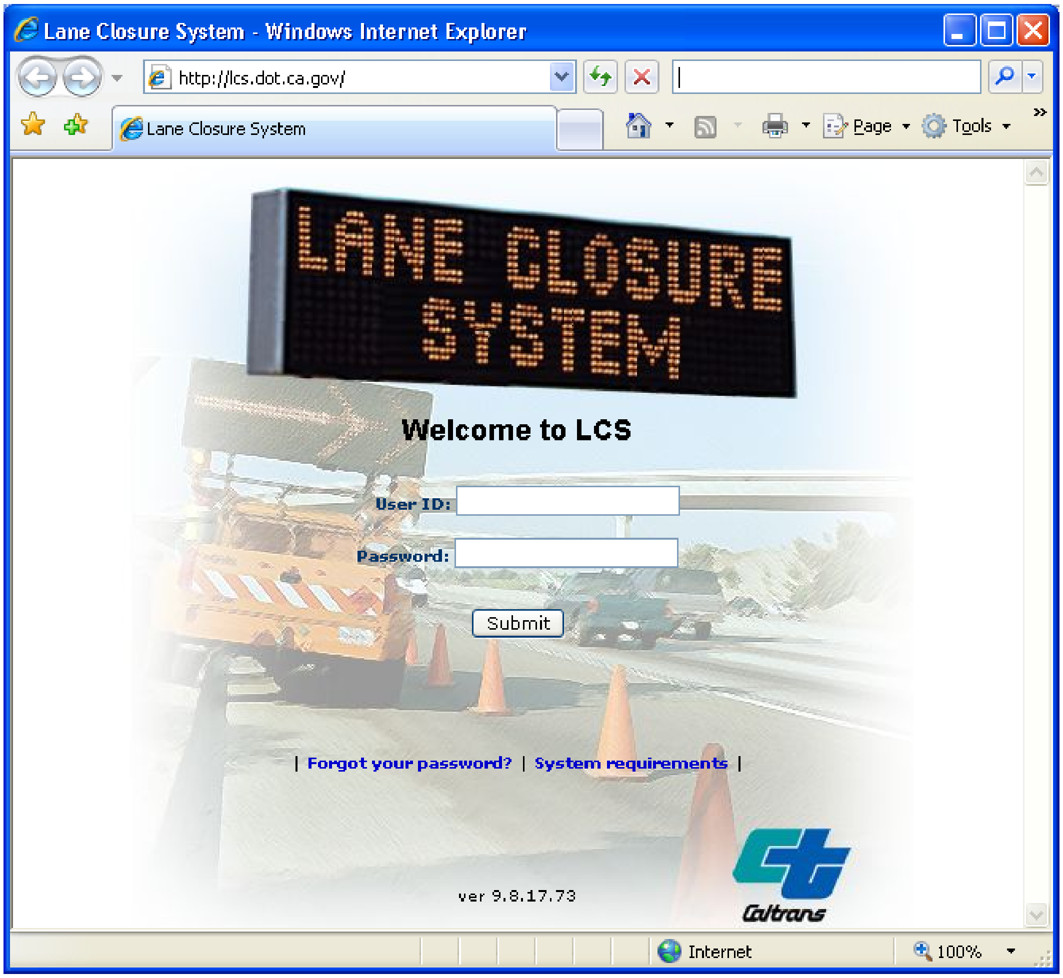

Figure 7: Caltrans Lane Closure System

2.2.9 Freeway Performance Management System (PeMS)

The Freeway Performance Measurement System is a cooperative project between Caltrans and the U.C. Berkeley Partners for Advanced Transit and Highways (PATH) to collect real-time highway data and provide both live and historical perspectives on freeway performance. While PeMS is more actively utilized in some districts than others, it is one of the only means of inter-district traffic data sharing. Real time roadway information and charting is available to the public via the PeMS web site (https://pems.eecs.berkeley.edu), and historical data is accessible via login.

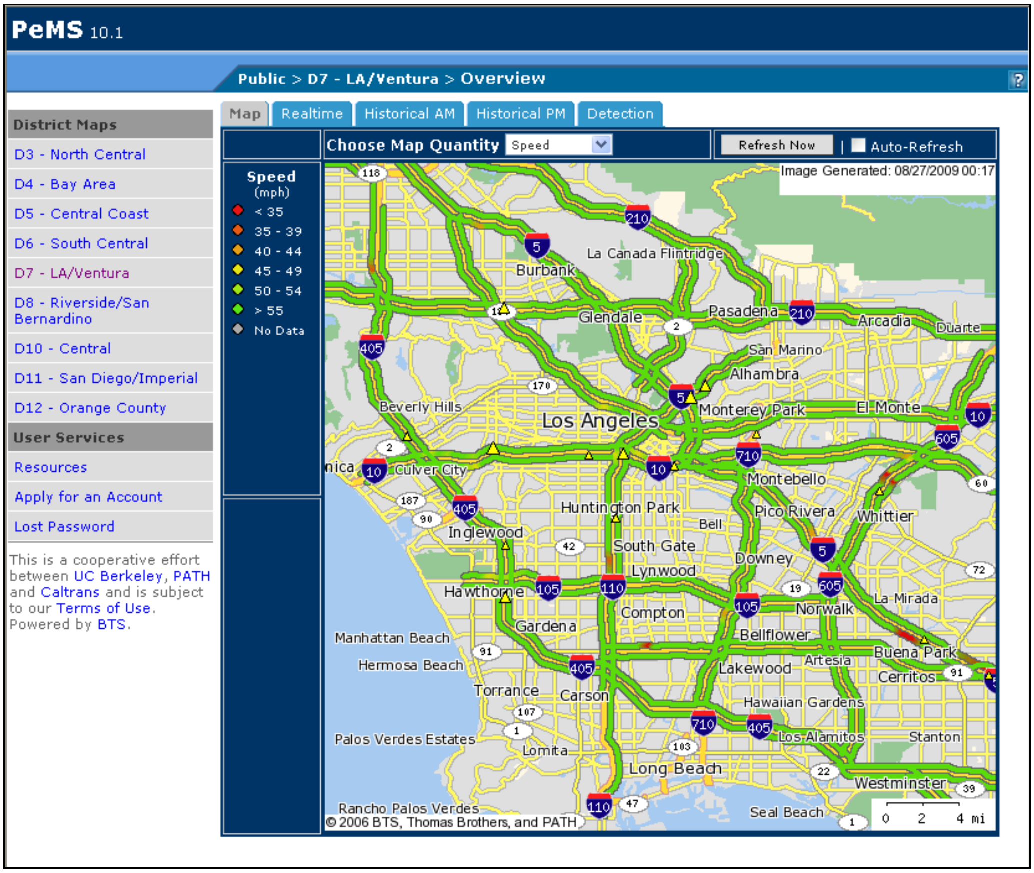

Figure 8: Freeway Performance Measurement System web site

3. EXISTING TMC COORDINATION IN CALIFORNIA

Coordination between Caltrans TMCs in California is extremely varied, ranging from electronic sharing of data for control of ramp metering rates in some districts to using the telephone to coordinate activities in others. This section first provides an overview of tools which are used to support TMC coordination and then provides examples of TMC coordination in California.

3.1 Coordination Methods

3.1.1 Telephone

The telephone is the cornerstone of TMC coordination; TMCs routinely call each other to work out how to handle non-recurring congestion which is crossing district boundaries. Every district interviewed utilizes the telephone for coordination with entities outside their boundaries. For example, Caltrans District 7 (Los Angeles and Ventura Counties) indicated that TMC-to-TMC lines of communication are always open and that one district can always call another to solve a problem. District 7 also indicated that they coordinate via telephone with local cities regarding signal timing on arterials.

Figure 9: Telephone Coordination

Although it might seem obvious that telephone is central to inter-district communications, its importance should not be understated due to its prevalent use – the telephone provides a critical link between Caltrans TMCs.

3.1.2 CHP CAD

CHP CAD is a workhorse of traffic management and is often used to support coordination between districts. CHP Divisions and Caltrans Districts do not follow the same boundary lines, as shown in Figure 9. These overlapping district/division boundaries provide TMC traffic managers with the opportunity to peer into a neighboring district when the CHP division which includes their district also includes part of a neighboring district. TMC managers can use the information gained in this process to better understand the details and implications of an incident in a neighboring district, hence helping to understand the potential impact on traffic in their own district. Additionally, Caltrans TMCs may request CHP CAD logs for neighboring districts to better aid in their understanding of traffic conditions in specific areas of interest.

For example, the CHP Border Division in Southern California encompasses all of Caltrans District 11 (San Diego and Imperial Counties), Caltrans District 12 (Orange County), and most of Riverside County, which is in Caltrans District 8. TMC personnel in any of these areas may use the CHP CAD to gain information regarding incidents in neighboring TMC districts which are within the CHP Border Division. Caltrans District 6 and District 10 also utilize their overlap within the CHP Central Division to aid in understanding conditions in each other's districts. Additionally, Caltrans District 5 utilizes CHP CAD Coastal Division CAD to better understand conditions within Ventura County, which is part of Caltrans District 7.

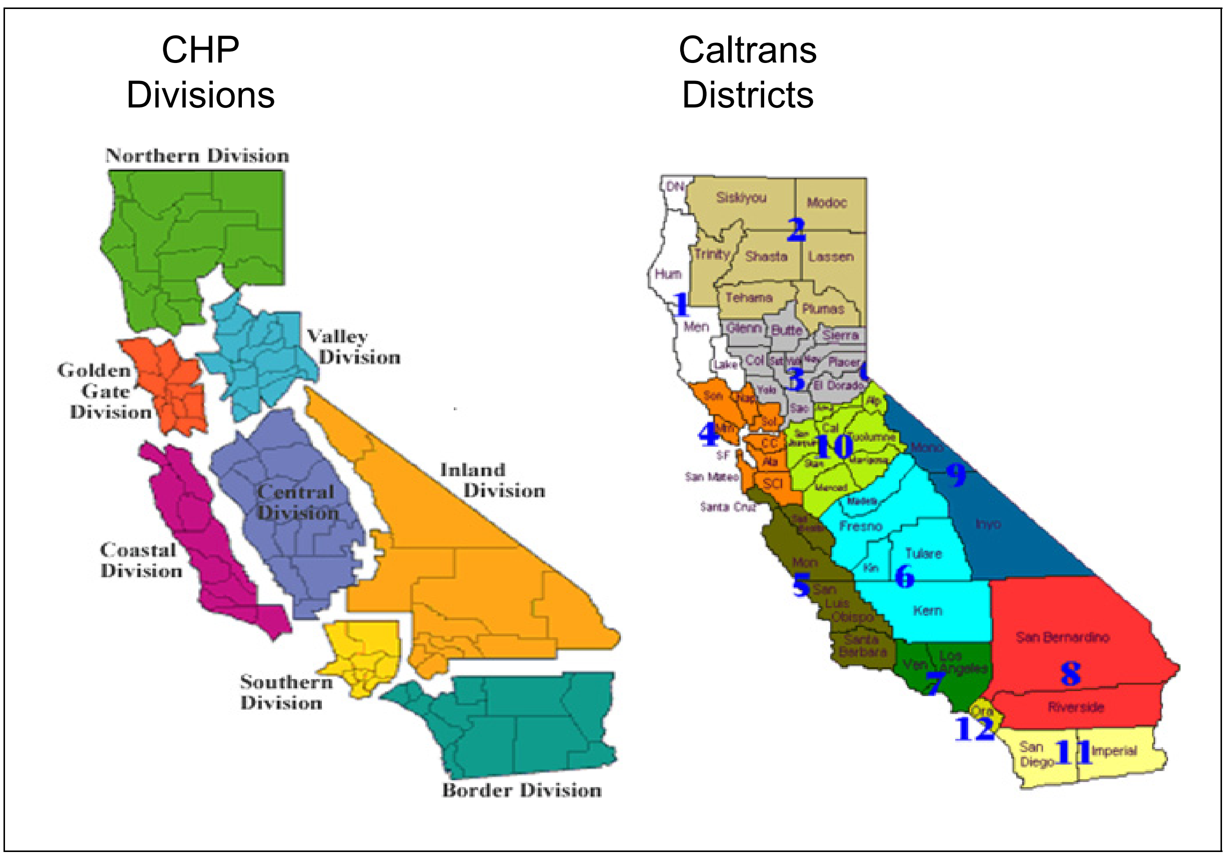

Figure 10: CHP Division and Caltrans District overlap in Southern California

Caltrans Districts 8 and 11 are linked by Interstate 15, which traverses an extended section of sparsely inhabited terrain. There is a large gap in roadway sensor data between San Diego and San Bernardino, roughly between the cities of Murrieta and Escondido along Interstate 15, as shown in Figure 11 below. Note that significant parts of Caltrans Districts 8, 11, and 12 are contained within the CHP Border Division. CHP CAD helps to bridge this information gap. San Bernardino typically utilizes CHP Border Division media CAD to attain incident information for the Interstate 215/15 link between Highway 79 and Highway 74, which assists in coordinating with District 11. District 8 TMC staff utilizes this with a variety of other data sources to provide themselves with a complete and accurate view of traffic conditions along this corridor.

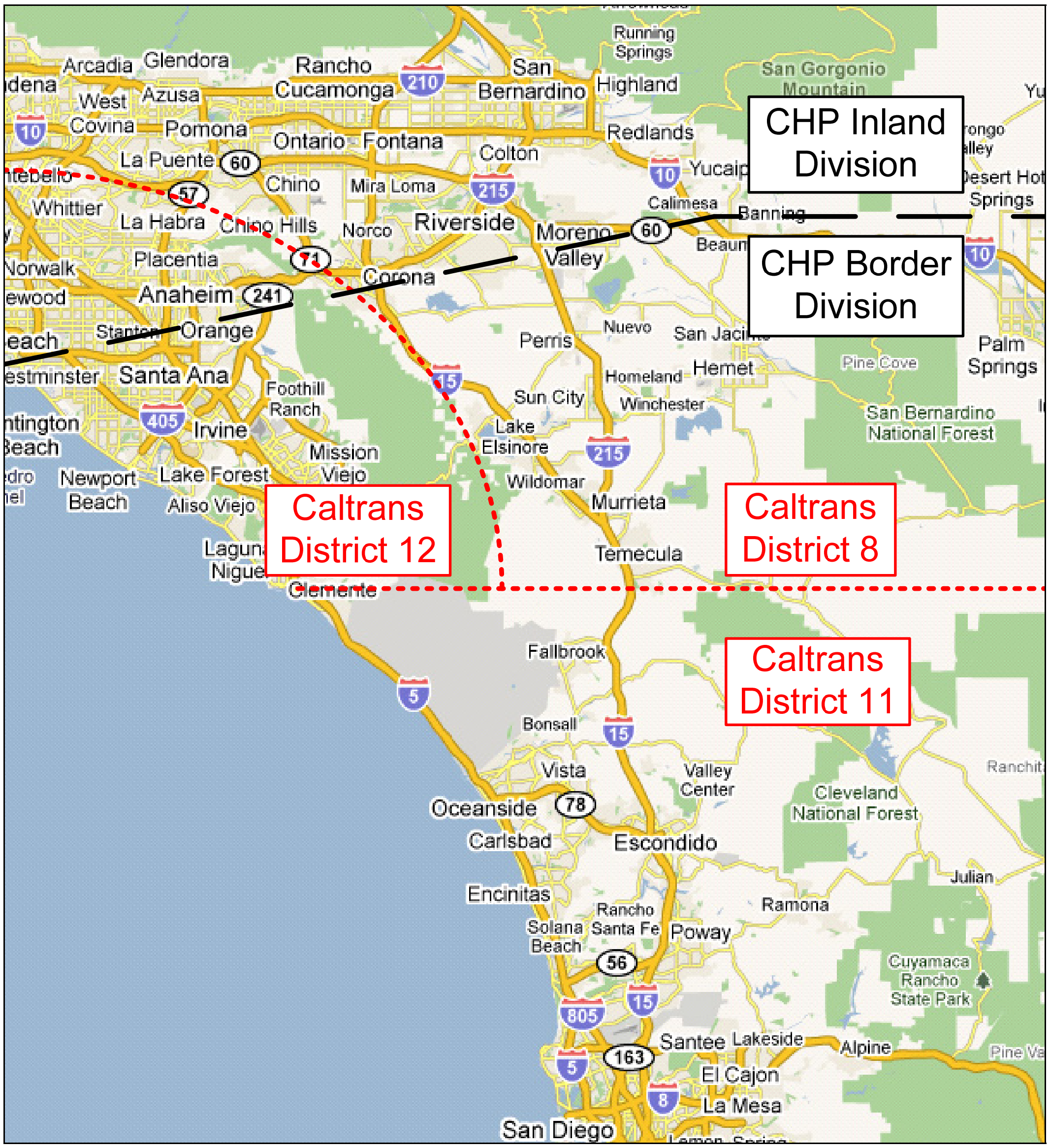

Figure 11: D8 and D11 I-15 / I-215 Corridor with Caltrans District & CHP Division boundaries

3.1.3 Changeable Message Signs & Coordinated Diversions

Districts often arrange for CMS messages to be posted in neighboring districts when they have an incident in their own district which will cause traffic to queue into the neighboring district. An example scenario would be an accident on Interstate 10 West in Los Angeles inside District 7, causing traffic to back up into District 8 (San Bernardino and Riverside Counties). District 7 TMC operators would place a telephone call to the District 8 TMC to apprise them of the situation, allowing them to deploy traffic management strategies as they see fit. A similar telephone call would be made in the event of an accident deeper in District 7 which still has the potential to affect District 8 roadways. Please see section 3.2 below for additional examples of coordinated diversions using CMS messages.

3.1.4 Shared Surveillance Video

Surveillance video and imagery are typically shared among Caltrans districts through the Caltrans public Web interface; a district will determine which cameras it is willing to share and then make the video feed available for Headquarters to link to on the Caltrans web site. Any district or member of the public may then view the data. Some districts also post their own links to this shared video.

District 7 (Los Angeles and Ventura Counties) sends a preselected set of video feeds to Caltrans headquarters for posting to the Web. District 11 (San Diego and Imperial Counties) has approximately 60% of their freeway surveillance video available on the Web. District 11 staff takes steps to ensure that cameras are always kept to a zoom level which is suitable for traffic management functions and not zoomed to a level which can potentially reduce privacy. District 6 (Counties in the Southern San Joaquin Valley) does not currently share video on the Web, but is planning to put video on the Internet via the Caltrans Web site. District 6 traffic managers indicated that they would like the ability to display relevant video feeds from neighboring districts during major incidents and Department of Homeland Security (DHS) events at some point in the future. District 12 (Orange County) utilizes District 8 imagery from the Caltrans public website during operations which involve both districts. District 3 (Sacramento and surrounding counties) also provides various video links for viewing on the Web.

3.1.5 Field Units and Equipment

TMTs, maintenance equipment, and portable devices such as CMSs are sometime shared across district boundaries during large incidents. For example, District 11 (Orange County) crews can work and communicate with crews from other districts. While they can work independently, responses are generally prompted by their managing TMC with arrangements for their use made between TMCs via telephone. District 5 (Central Coast) will coordinate its TMT crews to travel to other districts when assistance is requested for major incidents, but generally they remain within District 5 boundaries for most incidents. Neighboring districts do not always have compatible radio channels, so communications must be made through some other medium such as cell phones. District 5 would like to improve coordination with neighboring districts on Highways 9, 17, 101, and 152, and would like to see improved interoperability for TMS units on these shared corridors to aid in coordination efforts.

District 6 field crews often work in coordination with District 10 due to the fuzzy borders in outlying rural areas between these two districts. The crews and offices in both Districts 6 and 10 have a cooperative relationship and hence share information and coordinate responsibilities. In contrast, District 3 field crews generally don't fall under the management of other districts but rather are given short-term transfers to the district where they are needed.

Lastly, District 7 does not find incidents at district boundaries which require sharing of crews to be a common occurrence, and thus does not see much of a requirement for being able to share field crews.

3.1.6 Inter-District TMC Management Meetings

TMC managers from various districts and associated CHP personnel periodically meet to discuss traffic issues affecting their districts and divisions. These meetings range from highly focused meetings between neighboring districts and CHP from a specific geographic area to more generalized statewide TMC manager meetings.

For example, District 6 TMC management meet with Districts 3 and 10 quarterly at a CHP facility to discuss operations, coordination strategies, and the handling of large incidents to determine what went right and what went wrong, and how to do better next time. Biannual statewide TMC meetings allow TMC managers from throughout California to meet on various topics, including discussion of new or modified operation policies and their implementation, and planning for statewide emergency preparedness events such as Golden Guardian.

3.1.7 Standard Operating Procedure (SOP)

Standard Operating Procedures are utilized to articulate traffic management strategies for areas and situations where non-recurring traffic congestion is expected or predictable to some extent. SOPs are generally written for traffic conditions which can result from a variety of factors, including weather, maintenance, and accidents. For example Districts 5, 6, and 7 utilize an SOP titled "Operation Snowflake" as a detailed operational plan for winter highway closures on Interstate 5 and Highways 58, 166, and 101, which when combined together will isolate Southern California from much of the rest of the state.

3.1.8 Freeway Performance Management System (PeMS)

While PeMS is used in many districts to understand both real-time and historical traffic data, PeMS is does not seem to be used too much in a coordination role for districts seeking to look outside of their boundaries. Various districts interviewed indicated that they would rather have experts from a neighboring district interpret that district's traffic data rather than use PeMS and attempt to understand the traffic data from the other district themselves.

3.1.9 Regional ITS Element Integration

Regional integration of ITS elements is advancing in various parts of California, allowing various municipalities and governmental entities at different levels to coordinate. District 6 is currently creating a fiber hub, sharing the cost with the city of Fresno. This hub will be utilized for video transport and controlling of CMSs and other field elements. District 3 in Sacramento coordinates with the city of Elk Grove regarding signal timing on three main arterials which travel between Interstate 5 and Highway 99. D3 has been working with local governments in the Sacramento area to implement STARNET, which allows the sharing and use of video system controls and incident logs. STARNET has been in planning and development for over 10 years and began operation in 2008.

District 7 coordinates with the city of Los Angeles via telephone, and would like to be able to coordinate more effectively with both the city and other local agencies regarding diverting traffic to local streets during lane closures and other freeway incidents. While District 7 and the city of Los Angeles do not share any camera or data feeds, they are working together on a 511 system that will be driven by the Regional Integration of ITS Elements (RITS) system, an information portal for sharing traffic speed data and other information. RITS is expected to help D7 coordinate with the City of Los Angeles, Los Angeles Metro, and several other local agencies.

District 11 is working with their Metropolitan Planning Organization (MPO) and the San Diego Association of Governments (SANDAG) to implement a Regional Transit Management System (RTMS), which will allow the local cities and Caltrans to share transportation data and video. District 11 staff looks forward to being able to view video of arterials near freeway ramps within their TMC, which will aid in coordination with city traffic operations.

3.2 TMC Coordination Examples

3.2.1 Tanker Fire on Interstate 5 in Southern California

Interstate 5 is a critical link between Northern, Central, and Southern California, and is part of the Strategic Highway Network. An oil tanker truck fire on Interstate 5 near Camp Pendleton/Oceanside in 2002 blocked all southbound lanes for over 8 hours due to the intense heat resulting from the blaze, forcing large traffic diversions in Districts 7, 8, and 12. Initially District 11 TMC operators called District 12 operators since both southbound Interstate 5 and Interstate 405 are upstream of the incident and would be most directly affected. District 11 also requested and received TMT assistance from District 12 to manage the incident. Please see Figure 12 for a map showing the location of the incident and roadways affected by traffic diversions.

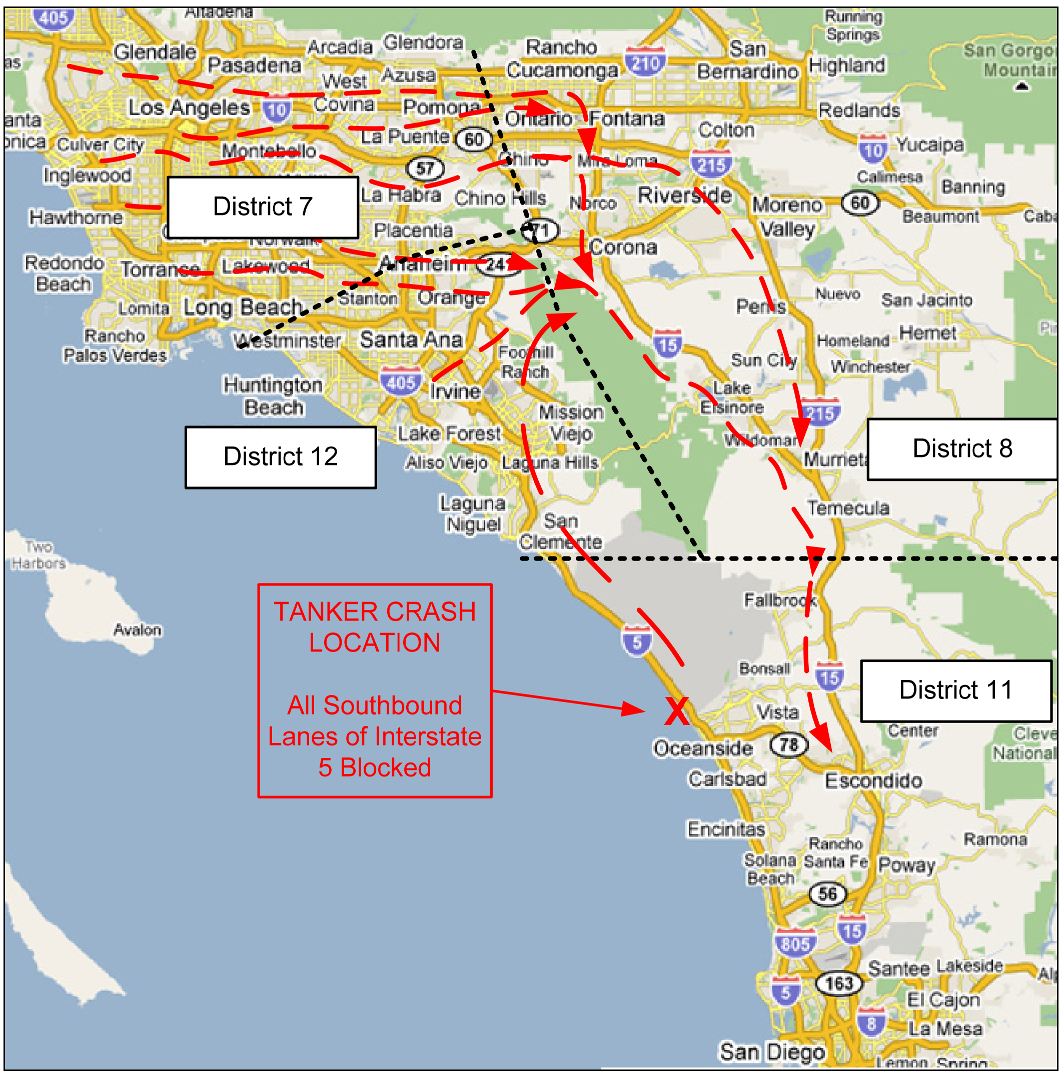

Figure 12: Tanker fire on Interstate 5 in Southern California near Oceanside

TMC staff from Districts 11 and 12 conferred via telephone to determine an appropriate traffic diversion strategy, which included recommending that traffic use Interstate 10 East, State Route 91 East, and Highway 60 East, all of which fed to Interstate 15 South, leading traffic to northern San Diego County, where they could then continue on to their destinations. Once the diversion plan was determined, the District 11 and District 12 TMCs then communicated via telephone with both Districts 7 and 8 to implement the agreed upon diversion strategy. Districts 7, 8, and 12 posted CMS messages to guide traffic towards Interstate 15 South. Figure 13 below shows a screen shot of the District 12 ATMS display, with changeable message signs activated during this incident. Districts 7 and 8 also had compatible CMS message deployments. Additionally, District 12 utilized District 11 traffic data available on the Internet to monitor the queue and traffic conditions close to the site of the incident.

The end result of this four-district extended incident and associated coordination effort was that traffic was successfully diverted over a long-distance detour from as far upstream as possible; truck and automobile traffic were provided with information regarding closure to Interstate 5 at the earliest possible locations.

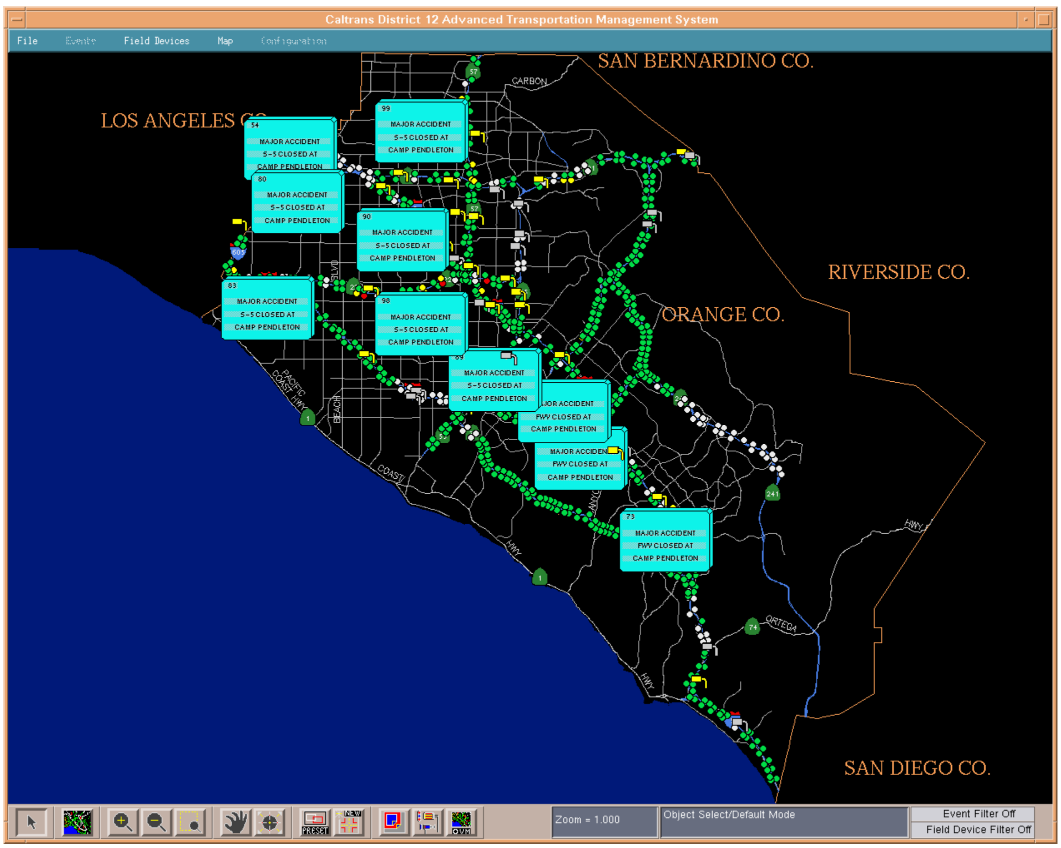

Figure 13: District 12 CMS diversion message deployment for Interstate 5 South closure

3.2.2 Operation Snowflake – Closure of Interstate 5 North of Los Angeles

Higher elevations of Interstate 5 between Bakersfield and Los Angeles (also known as the

Grapevine) are subject to snow closures during the winter months. Please see Figure 14 for a map of this region with areas subject foul weather closures annotated. Closures of Interstate 5 in this area have a dramatic effect on traffic as this roadway is a critical link into and out of Southern California. Traffic is rerouted during these Interstate 5 closures to either Highway 58 or the combination if Highways 101 and 166 if possible.

Districts 5, 6, and 7, and the CHP have collaborated to develop a standard operating procedure (SOP) titled *Operation Snowflake* to handle this situation. Operation Snowflake provides a detailed operational plan for diverting traffic around a closed Interstate 5. Operation Snowflake utilizes a phased approach to understanding roadway conditions and hence determining when to proceed to the next operational phase. Each operational phase describes actions to be taken with resources in the field based on weather conditions on the highway. The phases of Operation Snowflake are shown below in Figure 15, which describes highway conditions in unambiguous terms.

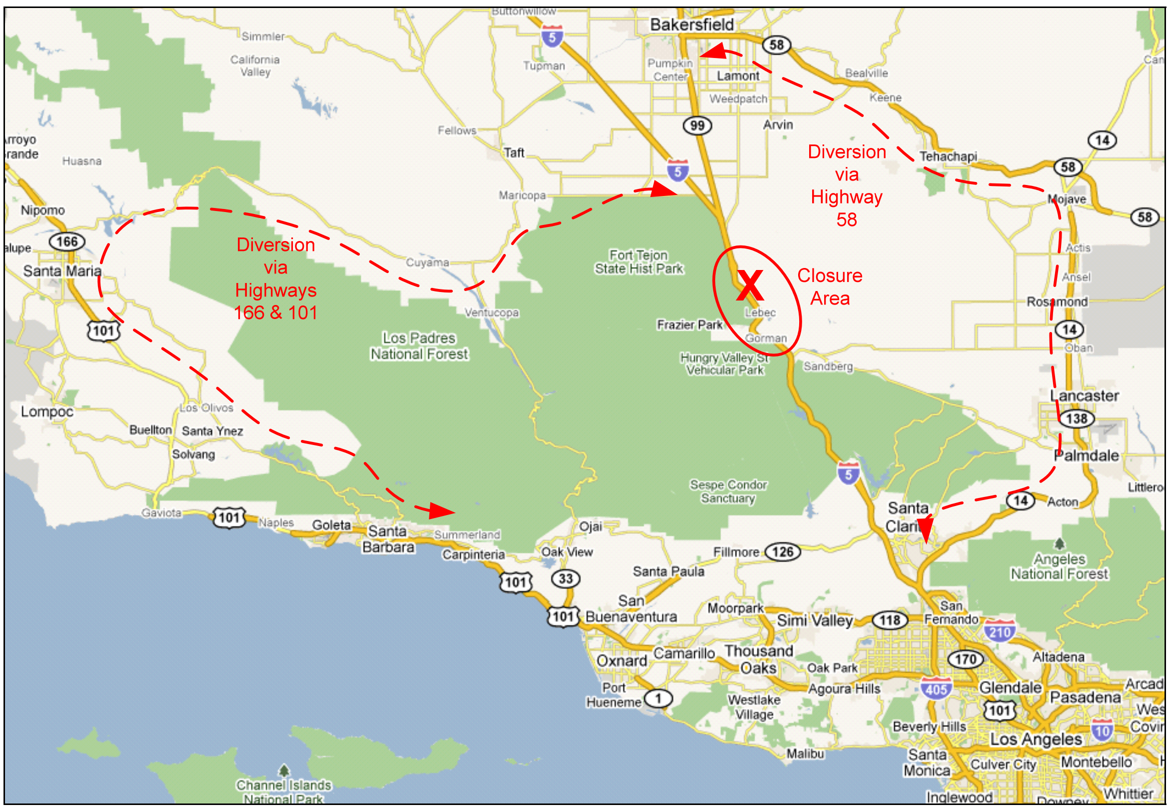

Figure 14: Interstate 5 with snow closure area and diversion routes shown

Each phase of Operation Snowflake is broken into a set of traffic management tasks, which spell out a set of detailed actions in step-by-step format. These tasks include things such as:

- Deploying CMS and HAR messages
- Calling specific TMCs
- Calling the command center

- Calling the CHP
- Sending group pages to relevant traffic managers
- Sending updates to the media via fax
- Logging actions into TMCAD

Operation Snowflake's detailed SOP helps to ensure that the response to this traffic situation is implemented consistently and as it was intended.

Operational Phase	**Summary**	**Notes**
Phase 1	REPORTS OF SNOW FALLING ON THE GRAPEVINE	Snow is actually falling but may not be sticking to the roadway. Caltrans Maintenance is not on the scene. CHP is not pacing or escorting convoys.
Phase 2	COORDINATION CENTER FULLY OPERATIONAL	Snow is falling and sticking to the highway. The CHP is pacing or escorting convoys. The Lebec Coordination Center is fully operational.
Phase 3A	I-5 CLOSED - HWY 58 AND HWY 166 OPEN	The CHP has closed southbound I-5 at the Grapevine interchange. Detours to Southern California are possible using SR 58 and SR 166-except for truck traffic using SR 33 from SR 166 to Ojai.
Phase 3B	I-5 AND HWY 58 CLOSED - HWY 166 OPEN	The CHP has closed southbound I-5 at the Grapevine interchange. Detours to Southern California are possible using SR 166-except for truck traffic at using SR 33 from SR 166 SR 166 to Ojai
Phase 3C	I-5 AND HWY 58 AND HWY 166 CLOSED	The CHP has closed southbound I-5 at the Grapevine interchange. Detours to Southern California are possible using SR 46 and SR 41 to highway 101.
Phase 3D	I-5 AND HWY 58 AND HWY 166 AND HWY 101 CLOSED	The CHP has closed southbound I-5 at the Grapevine interchange. No detours are available to Southern California.

Figure 15: Operation Snowflake operational phases and planned diversions

3.2.3 Lane Closures on Highway 17 South of San Francisco

Highway 17 is a busy and critical link for commuters and weekend travelers between the towns of Santa Cruz and Scotts Valley, which are in District 5, and the San Jose/Silicon Valley area, which is in District 4. Please see Figure 16 for a map of this area.

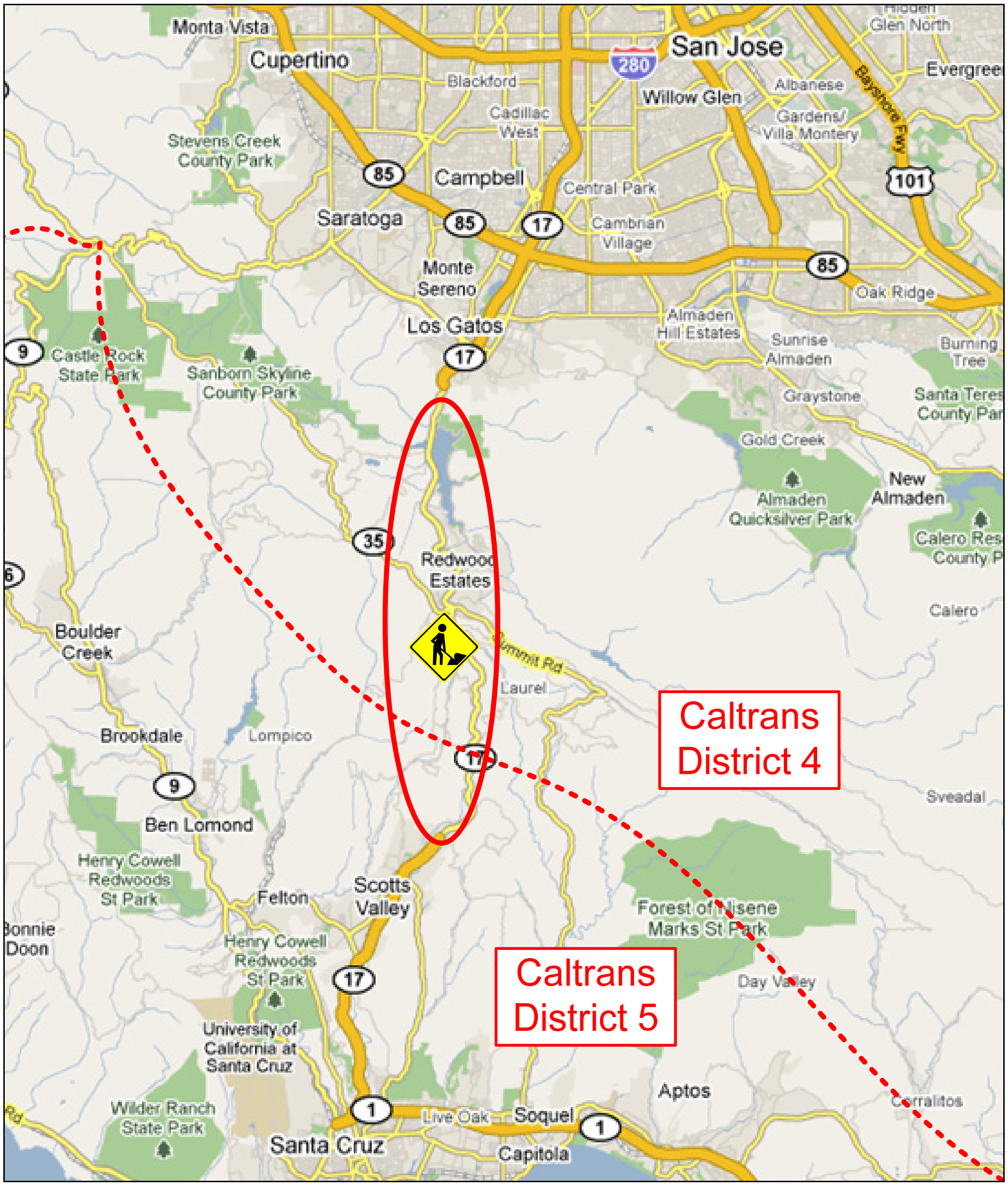

Figure 16: Hwy. 17 maintenance area with approximate Caltrans district boundaries shown

Highway 17 traverses rugged terrain and is subject to fairly frequent maintenance closures, which can greatly affect travelers. The District 4 TMC, which is responsible for the Bay Area, is open 24/7. The District 5 TMC, whose northernmost area of responsibility is Santa Cruz County, is only open on weekdays. Districts 4 and 5 communicate via phone and email, and conduct periodic meetings to coordinate activities on sections of Highway 17 which reside in District 5. District 4 performs traffic management functions for this highway while District 5 performs maintenance. This shared role in the maintenance and operation of Highway 17 requires an effective coordination strategy.

A common situation where coordination is useful is when District 5 maintenance personnel are working on Highway 17 and the District 4 TMC determines that a closure should occur at a different time of the day. In general, the two districts work together to determine the best times to plan closures for maintenance. District 5 will perform the maintenance, and District 4 will perform management functions such as releasing information to the public, controlling CMSs, and working with the CHP on traffic controls.

District 4 will also utilize their TMC CHP officer, who is assigned to the CHP Golden Gate Division, to make enquiries with the CHP Monterey Division regarding roadway conditions on Highway 17 within District 7. Lastly, these two districts also utilize a liaison at Caltrans Headquarters in their coordination efforts.

3.2.4 Closure of Interstate 5 in Central California with Diversions to Local Arterials

A tanker trailer crashed on Interstate 5, near Shields, California. As the location of this incident was near the intersection of Merced and Madera counties, it was near the boundary between Districts 6 and 10. This incident completely closed Interstate 5 and required detours onto local arterials. This incident lasted for over a day, requiring personnel from both of the two districts to be in the field for longer than normal periods of time. Keeping critical field operations, such as detour flagging, TMT drivers, and maintenance positions staffed continuously turned out to be difficult due to some district personnel not being accustomed to extended hours in the field. This problem was exacerbated by the fact that work shifts ended during the middle of the incident.

Caltrans District 6 TMC staff discovered that they had some incorrect contact information for other agencies which they needed to work with during this incident. The TMC also had some difficulty selecting appropriate detours due to a lack of "eyes" in the field to help choose appropriate detour paths. Caltrans TMC operators also had limitations in their knowledge of the Incident Command System (ICS), hindering their ability to coordinate with CHP.

Communications between D6 and D10 were handled via telephone and radio. A typical inter-district message between Caltrans field personnel could require several "hops" as it traveled from Caltrans maintenance in one district to Caltrans maintenance in the other district, as shown in Figure 17.

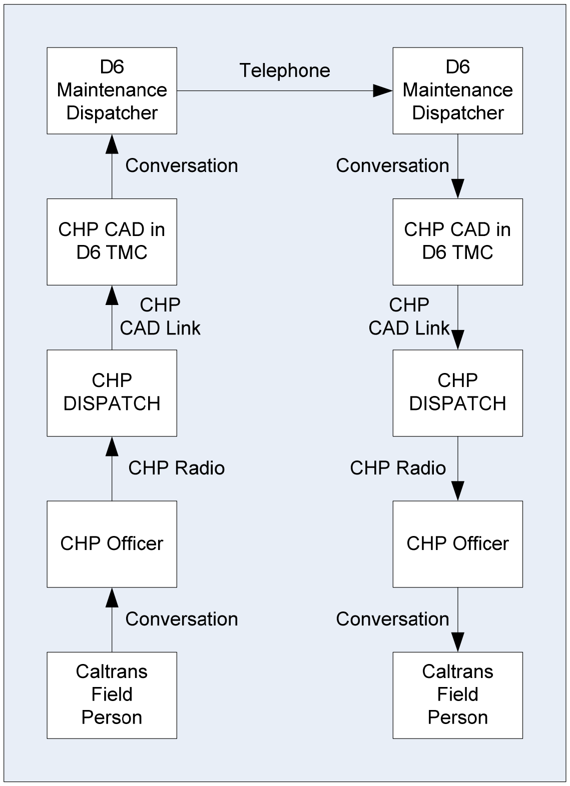

Figure 17: Typical inter-district information path between maintenance personnel

4. DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

4.1 Coordination Fundamentals

4.1.1 Leverage Local Traffic Management Capabilities with Coordination

Managing incidents and reducing their impact, whether they are contained within a district or cross district boundaries, is best accomplished by influencing and controlling the flow of traffic upstream of the incident and providing the motoring public with sufficient warning to navigate around the incident if they so desire. This is accomplished by implementing two critical actions upstream of the incident: modifying ramp metering parameters to make them more restrictive, and rapid deployment of CMSs to advise motorists to seek out alternate routes. CMSs are a tried and true tool for diverting traffic in various recurring and nonrecurring traffic conditions.

The benefits from these systems can be leveraged through coordination. Quick and reliable inter-district communications, even if it is simply a telephone conversation, can assist in reducing the effects of an incident in one district on traffic in a neighboring district. Having one district post CMS messages within their own district regarding incidents at district boundaries or in another district can be useful to TMCs and the general management of traffic. This is because the messages are based on the local knowledge from within that specific district rather than being posted by a person from a different TMC who may only possess limited knowledge of the other district, and hence could be making decisions on an incomplete set of data or with incorrect assumptions. Local knowledge of traffic operations and available information sources is vital to traffic management decision making.

Various districts could coordinate more effectively if they were to have interoperable field equipment. The concept of interoperable equipment should be fully explored to determine feasibility. Use of shared interoperable equipment on common routes between districts enhances coordinated management activities, and has the potential to permit personnel and equipment to be maximally utilized in boundary areas.

4.1.2 Share Video Comprehensively to Support Public and Private Use

Although making video from districts easily available to other districts sound would seem like a “no brainer” due to the relative technical ease with which it can be accomplished, it should be noted that many TMC managers find limited used for this video access. Most traffic managers interviewed preferred to have a reliable and accurate assessment of traffic conditions in another district made by experts from that district, rather than attempt to interpret traffic conditions from various video and data information sources. Despite this, having video from other districts might be considered a “bonus” feature and has utility in permitting TMC operators to corroborate and or supplement other sources of information.

Data and video sharing between jurisdictions, regardless of government level, e.g. city, county, or state, should be seamlessly integrated into future ATMS implementations. Data and video should be made available to the public to the maximum extent possible to facilitate independent decision making by drivers to reroute around incidents and enhance travel plans. Existing broadband Internet connectivity and advanced hand-held devices, e.g. smartphones such as the Blackberry and iPhone, can provide the opportunity for shared data to be well utilized. Making traffic data and video seamlessly available to the public can enhance incident management, both within a jurisdiction and across jurisdictional boundaries, as drivers will use this information to avoid incidents, hence reducing congestion. Also, making traffic data and video ubiquitous to the public may lead to future unforeseen private sector inventions and products which aid drivers in making good driving decisions, regardless of jurisdiction.

Sharing of video with the public is seen as a generally good thing among interviewed TMC managers as it allows the public and the media to use this information independently. A percentage of Caltrans traffic surveillance video is available on the Internet. One district posts 60% of their video in this manner. Another district posts all of their video on the Internet, which provides a simple mechanism for managers from one district to see into another district.

When traffic video is made available on the Internet, traffic managers must be cautious to ensure that detailed information, especially graphic accident footage, is not placed in the public domain. Several districts have detailed policies regarding camera usage to avoid potential distribution and associated liability of accidentally releasing sensitive information. Care should be taken to ensure that the zoom level of surveillance video made available to the public does not reveal too much detail, hence protecting motorist privacy. It may be desirable to implement controls which allow video to be blocked on a case by case basis as dictated by the status of an in incident. Controls which allow cameras to be selectively deactivated from public access should be available for all video made public, allowing Caltrans and other traffic managers the ability to fully utilize the zoom levels of Traffic surveillance video posted on the Web.

4.1.3 Different Districts Use Different Methods

TMC managers within their own district are best at interpreting their own traffic data and determining a best course of action in response to an incident. The existing network of TMCs defined by County boundaries appears to be a good fit to some extent for traffic management operations. It seems that the most important aspect of TMCs working together is not detailed sharing of data with each other, but rather TMCs collaborating to coordinate a response based on each interpreting their own traffic data. TMC managers have a variety of opinions and approaches, as would be expected given the variation of management styles and policies amongst Caltrans districts as well as the traffic conditions within them.

This is borne out in the application of ramp metering. Different districts have different ramp metering policies, and this can pose some difficulty if a district with limited metering control is upstream of an incident and hence can’t use metering to assist in reducing demand at the incident. One district may find it challenging if it is in the practice of modifying ramp metering policies to control traffic and a neighboring district won't do the same due to more restrictive ramp metering policies. Situations such as this are inevitable in California, where there are twelve districts, each with their own management style and policies. These districts must compromise in situations such as this and hence agree to disagree.

4.1.4 Telephone and Incident Logging

The power of a one-on-one conversation via the telephone should not be underestimated and is often preferred over other forms of communication by TMC operators and managers. The telephone is universally regarded as one of the best tools for TMC coordination. If traffic logging is done with accuracy and regularity, it will become an accepted and trusted source of information to support coordinated traffic management. Both the telephone and incident logging are valuable coordination tools and hence both should be utilized to support coordination as situations dictate. These two tools can leverage each other, with the end result being improved coordination of traffic management.

4.1.5 Deploy New Systems to Retain Existing Capabilities

Due to the significant diversity of transportation management systems and capabilities in California, deployment of future systems, such as TMCAL, must be accomplished in a fashion that does not reduce or hinder existing capabilities or operations.

4.2 Prepare to Manage Traffic

4.2.1 Inter-District Collaboration and Preparation Develops Coordination Muscle

TMC managers expressed genuine interest in working with their peers in neighboring districts. The current system for training TMC operators in California allows TMC operators from neighboring districts to get to know each other and hence potentially be ready and be more open to inter-district traffic operations; TMC training as done in California leads to cooperation, thus providing the opportunity to facilitate coordination. TMC coordination has the potential to be enhanced through the development of multi-district incidents within the TMC simulator and supporting curriculum taught in the California TMC Academy.

Caltrans TMC managers meet periodically to discuss a variety of issues, including major incidents, planning for anticipated traffic congestion, and other agenda items. TMC managers find that these meetings are both productive and useful as they present a forum to confer on policy initiatives, review recent incidents and events, share and discuss differences in management techniques and their local application within each district, and collaborate on inter-district coordination efforts where necessary.

Additionally, Caltrans TMCs are now also tasked with an Emergency Operations Center (EOC) role, increasing their need and their ability to coordinate. Participation in Golden Guardian exercises requires that Caltrans districts meet with each other and take the opportunity to discuss large incidents and "disasters of national significance", helping to consider regional operations and their impact at all agency levels. This type of preemptive coordination can aid in the handling of any incident, large of small, which requires different agencies and entities to work together to cooperatively solve a problem. Caltrans TMC participation in Golden Guardian exercises should be continued to help ensure maximum opportunities for coordination at all levels. In preparation for these exercises, Caltrans TMC personnel should continue receive NIMS training as part of the TMC Academy or through other opportunities which may arise. Additionally TMCs should take the opportunity afforded during Golden Guardian preparations to ensure that their contact lists for allied agencies are maintained and up to date, eliminating needless coordination difficulties.

4.2.2 Standard Operating Procedures – Thought Provoking and Extremely Useful

The development and use of the Operation Snowflake SOP demonstrated coordination at many levels, which include collaborative meetings, development of the SOP document itself, TMC to TMC and TMC to CHP communications during weather incidents, and coordinated deployment of CMS and HAR messages. Operation Snowflake might be considered to be a model for coordination between Caltrans districts.

Operation Snowflake, which is used to handle weather closures of Interstate 5, provides a concise and unambiguous set of guidelines to aid in a coordinated multi-jurisdictional traffic management effort. Operation Snowflake is well thought out and is based on the consensus of various parties, making it an effective tool. The development, ongoing modifications, and use of this SOP has provided and continues to provide an opportunity for various districts and agencies to work together to develop an optimal traffic management solution.

Agencies should capitalize on the development and use of SOPs to facilitate good working relationships with each other and first rate solutions to traffic management problems. Traffic management scenarios suitable for application of an SOP need not be as extensive as the Operation Snowflake example described in this report, but may be a simple, yet predictable situation where a well thought out solution will provide the best possible utilization of transportation resources to the motoring public and commercial vehicle operators. Documents such as the Federal Highways Handbook for Developing a TMC Operations Manual can be useful in approaching, creating, and implementing Standard Operating Procedures.

4.2.3 Ensure Coordination Ability by Covering the Basics

The problems encountered during the Interstate 5 incident near the D6/D10 boundary were largely caused by a few issues: (1) Incorrect contact information for allied agencies, (2) Limitations in TMC knowledge of the Incident Command System (ICS), and (3) Field staff not being prepared to work past the end of their shift during unusual circumstances. The end result of this reduced ability to coordinate resulted in a reduced effectiveness of resource utilization and hence less than optimum handling of the incident. The extended nature of this incident further exacerbated the impact of coordination limitations, adding to difficulties keeping critical roles in the field filled for the duration of the incident. Caltrans is addressing limitations in staff knowledge of ICS through the addition of NIMS training to the California TMC Academy.

4.3 CHP CAD Achievements & Lessons

4.3.1 Trusted, Comprehensive, Timely, and Ubiquitous

California Highway Patrol CAD data is a significant aid for traffic managers to understand traffic conditions. After over 15 years in traffic operations, one manager has found that CHP CAD is one of the best tools available to him. During the interviews it was observed by the researchers that CHP CAD is universally well-liked and well-used by TMC managers. Attributes of CHP CAD include:

1) It is well trusted – its content is credible as it is based on first-hand observations by reliable and well-trained personnel (CHP officers).

2) It is comprehensive in nature – nearly all incidents which occur within a district results in a 911 call which then triggers an emergency response and hence data collection in the form of field reports which are recorded and displayed in the CHP CAD record.

3) It is timely – data shows up as soon as a 911 call is reported and is updated and verified upon the arrival of an officer at an incident scene.

4) It is ubiquitous - CHP CAD is the same throughout the state, hence it is universally understood by transportation managers, making it a common point of point of understanding across district boundaries

4.3.2 A Traffic Management Success Story and a Role Model for Future Systems

It is interesting to note that CHP CAD was designed to support law enforcement operations, not traffic management from a high-level, or traffic system perspective. The fact that CHP CAD has inadvertently become a crucial traffic management tool speaks to the fact that a good tool is not necessarily planned but results from a synthesis of the correct attributes. It is important to ensure that reasons for the success of CHP CAD as a traffic management tool are observed and considered in the development of future tools. Future traffic management tools, including any future ATMS considered for California, should subscribe to these ideals.

A light and capable "ATMS" console with features which allow incident information from a variety of sources to be shared and which could be used at a variety of state and local agencies has the potential to aid TMC coordination and hence reduce the impacts of recurring congestion in California. Such a console should allow the sharing and display of information including:

- Video
- Incident log data
- Traffic flow
- Allied agency data
- Field elements status and control
- Messaging between agencies

This light ATMS console would allow per-agency policy editing control of information and device control. The user of such a console would have a complete amalgamation of relevant data at their fingertips to facilitate traffic management at a local, state, and inter-jurisdictional level.

4.3.3 Lessons in Sharing Data Across Jurisdictional Boundaries

An unexpected benefit of CHP division boundaries being different from Caltrans district boundaries is that inter-district knowledge of conditions in certain areas is easier to obtain than with existing Caltrans traffic management tools. Any future ATMS or coordination tool being considered for deployment in California should have the capability to allow one district to seamlessly observe traffic conditions in neighboring districts. This further emphasizes the importance of having seamless data across various jurisdictional boundaries.

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