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Research Planning for Caltrans Emergency Maintenance Response

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DISCLAIMER/DISCLOSURE

The research reported herein was performed as part of the Advanced Highway Maintenance and Construction Technology (AHMCT) Research Center, within the Department of Mechanical and Aerospace Engineering at the University of California – Davis, and the Division of Research and Innovation at the California Department of Transportation. It is evolutionary and voluntary. It is a cooperative venture of local, State and Federal governments and universities.

The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the State of California, the Federal Highway Administration, or the University of California. This report does not constitute a standard, specification, or regulation.

LIST OF ACRONYMS AND ABBREVIATIONS

AHMCT	Advanced Highway Maintenance and Construction Technology Research Center
API	Application Programming Interface
ATMS	Advanced Traffic Management System
AVL	Automatic Vehicle Location
Caltrans	California Department of Transportation
COTS	Commercial Off–The-Shelf
DB	Database
DOE	Caltrans Division of Equipment
DOT	Department of Transportation
DRI	Caltrans Division of Research and Innovation
EMR	Emergency Maintenance Response
ESC	Caltrans Equipment Service Center
FIDAS	Fleet In-vehicle Data Acquisition Systems
GPRS	General Packet Radio Service
GSM	Global System for Mobile communications
IRIS	Intelligent Roadway Information System
LED	Light Emitting Diode
LEO	Low Earth Orbit
MRM	Mobile Resource Management
OEM	Original Equipment Manufacturer
OFDM	Orthogonal Frequency Division Multiplexing
OSS	One-Stop-Shop
PM	Post Mile
R&D	Research & Development
RFP	Request for Proposals
SAE	Society of Automotive Engineers
TAG	Technical Advisory Group
TSI	Transportation System Information
UI	User Interface
WTI	Western Transportation Institute

ACKNOWLEDGMENTS

CHAPTER 1:
INTRODUCTION

Background and Motivation

Caltrans has always provided key resources for Emergency Response (ER) in California. With the implementation of AB 38, and the combining of the Governor's Office of Emergency Services (OES) and the Governor's Office of Homeland Security (OHS) into the new cabinet-level California Emergency Management Agency (Cal EMA), Caltrans' role will be more important than ever. Cal EMA will use a matrix-based approach, where each State Agency's capabilities are known, and the Governor, through Cal EMA, can call upon any agency with needed capabilities, regardless of the Agency's routine jurisdiction. Hence, Caltrans can be called upon in any situation that can benefit from their capabilities, and their role will now extend in such situations beyond the transportation system. As Caltrans has most capabilities in the California Emergency Functions (CA-EF) matrix (see State Agency Responsibilities Matrix, SCEP, exhibit 13-2, pg. 90) with few exceptions (e.g. emergency medical services and life-saving), this is a significant responsibility, and Caltrans will need to take advantage of all available and emerging communications technologies to effectively marshal and manage its rapid response resources and maintain the safety of its personnel, equipment, and the public. In addition, supporting Mutual Aid Regions (pp. 52-53 of State of California Emergency Plan, herein SCEP) introduces further responsibilities and complexities, as the six mutual aid regions do not clearly map to Caltrans regions, districts, or sets of districts.

Cal EMA, and all State agencies, will need to provide coordinated responses for severe weather, natural disasters (e.g. earthquake, flood, fire), as well as man-made disasters, such as terrorist acts. While the agencies have their capabilities identified in the matrix, each agency is generally accustomed to operating in its normal jurisdiction. In novel emergency situations, communications will be even more important than normal in order to provide a tight, well-coordinated response within and across agencies.

Problem

Severe incidents and emergencies often lead to degraded communications, just at the time when communications are most important. Cellular voice networks are often overwhelmed, and many forms of communications typically fail during the early and critical stages of an emergency. The State will need to leverage all modes of communications, in particular digital data communications, in order to effectively respond to novel and life-threatening situations.

On a day-to-day basis, Emergency Maintenance Response (EMR) is most relevant in winter maintenance areas, particularly those subject to frequent avalanches. These areas are often communications-challenged even in good conditions, and more so in harsh winter conditions. Snow fighting, for all but routine storms, is an emergency situation, in the sense that it is an unplanned incident requiring careful resource management and clear communications to effectively respond. As such, winter maintenance will provide a scenario for the current development, as well as the testbed for future prototype field testing and eventual deployment.

Background

Available Technologies and Systems

Emerging technologies, systems, and trends will provide important components for an effective Emergency Maintenance Response (EMR) communications system. These technologies include:

• Data over cellular networks (e.g. Short Message Service, or SMS, a.k.a. "texting", Twitter[1], instant messaging), which is generally still available even when the cellular voice channel is not.

• GPS-enabled commodity smartphones and similar mobile devices, and advanced operating systems that can support communications and user interfaces customized specifically for Caltrans needs for EMR.

• Data over other existing Caltrans communications channels, e.g. 800 MHz voice radio, microwave radio systems (often the last working system in an emergency), Cal EMA OASIS, etc. Other systems of particular importance will include those noted in the SCEP, pp. 47-48, under the Communications, Alert and Warning Systems subsection.

• Emerging commodity communication technologies such as WiFi, 4.9 GHz communication components, and other systems that may provide enhanced low-cost EMR communication.

• Available or near-term deployable rural research technologies, such as the WTI Redding Responder system, WeatherShare, First Responder, and Caltrans Earth.

• Commodity open-source software and collaboration methodologies, enabling development of resource management systems (freeway management, traffic management, fleet management, etc.) that leverages existing software capabilities, increases customization, and lowers initial and ongoing costs by reducing or eliminating vendor lock-in. This can lead to zero recurring licensing costs.

• General integrated asset tracking, communications, and resource management systems that provide robust capabilities and redundancies for maximum availability in challenging conditions and scenarios.

Research Approach

The research methodology, as discussed in detail in this report, included:

- Formation of a technical advisory group (TAG)

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[1] E.g. as used in the Bay Bridge closure and repair of October, 2009, at: http://twitter.com/baybridgeinfo

- A brief literature review

- A scan of previous research products

- A review of commercial systems

- A review of Caltrans systems, policies, plans, and infrastructure

- Development of requirements for a prototype system

The key deliverable of this project is:

- Requirements for a research prototype system for emergency maintenance response.

CHAPTER 2:
LITERATURE REVIEW

Numerous vehicle-based technologies, including automatic vehicle location (AVL), surface temperature measuring devices, freezing point and ice-presence detection sensors, salinity measuring devices, visual and multi-spectral sensors, and millimeter wavelength radar sensors have been developed in recent years to improve winter maintenance efficiency and safety. A key consideration in implementing these technologies is communications, especially in rural areas [9]. Many of these technologies are candidates for integration with the proposed research prototype.

Watkins provides an overview of the Operational Area Satellite Information System (OASIS) satellite-based communications system [11]. Caltrans currently has three trailers and several urban sites equipped with OASIS. Compatibility with OASIS may be an important component of the prototype system, depending on customer need.

The National Traffic Incident Management Coalition's goals include interoperability between responders to incidents. They present strategies to achieve their goals, including: Strategy 16 - Broadband Emergency Communications Systems [7]. This work, as it proceeds, will benefit the proposed system.

Thomas and Piekarski's work on through-walls collaboration allows users in the field to work in real time with users indoors who have access to reference materials, a global picture, and advanced technology [10]. The concept leverages ubiquitous workspaces, augmented reality, and wearable computers. A portion of this work is relevant to the proposed system.

Amann and Quirchmayr present a framework for knowledge management in context-aware and pervasive computing [1]. The focus is to enable adaptive, two-way interaction between context-aware systems and users in mobile settings.

CHAPTER 3:
RELATED RESEARCH

There are several research projects or products that can be leveraged to benefit the prototype system. The key projects and products are reviewed here, including the context for their use with the prototype.

<u>One-Stop-Shop</u>

The One-Stop-Shop[2] (OSS) web application provides travelers in California with comprehensive, real-time data. This information consists of both traditional information (routing, imagery, weather, wind speed, etc.), as well as points of interest and other route-specific information (elevations, rest areas, etc.). Specifically for weather, WeatherShare[3] presents weather data for California in a map-based format (see Figure 3.1).
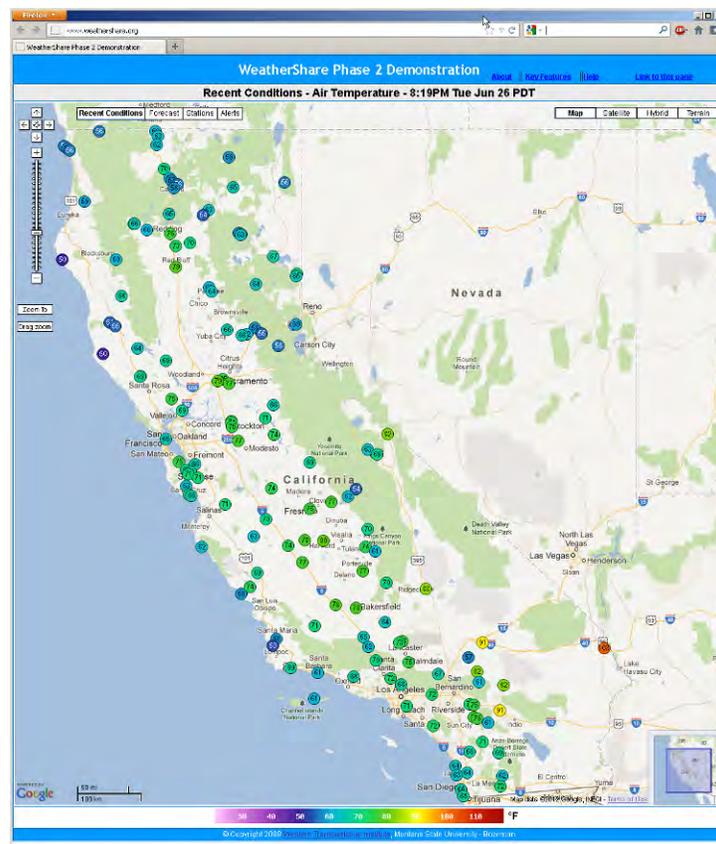
Figure 3.1 Weathershare.org website screenshot

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[2] http://www.westernstates.org/Projects/OSS/ and http://oss.weathershare.org/

[3] http://www.weathershare.org/

OSS and WeatherShare, both developed by the Western Transportation Institute (WTI) at Montana State University, can serve as information feeds to the proposed prototype, fulfilling a key information need for the system.

WTI's Redding Responder[4] system facilitates communication and documentation of incidents in rural areas [8]. Incident responders use the Redding Responder system to describe an incident and convey details back to a traffic management center. The Responder system consists of a tablet PC, an optional communications briefcase, and purpose built software. The briefcase houses cellular and satellite communication equipment for more rural areas, or the tablet PC can use a built in cellular radio.

Responder Communications Briefcase

The Responder communications briefcase may serve as a component of the prototype system. This would depend on a number of factors, particularly the state of related commercial technologies at the time of prototype implementation. The Responder cellular/satellite hybrid communication components may be used for the other emergency maintenance response applications. The future Responder system will switch from laptop to tablet. Considerations should be made so that the emergency maintenance should be able to share and run on the same platform to facilitate deployment of both systems and reduce duplication of hardware and services cost.

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[4] http://www.westernstates.org/Projects/Responder/

Figure 3.2 Responder Communications Briefcase

Light and Heavy Vehicle Fleet Tracking

Recently, Caltrans Division of Equipment and Division of Maintenance have started exploring the use of vehicle tracking systems to improve overall fleet management. The Division of Equipment (DOE) is assessing the availability of cost-effective fleet in-vehicle data acquisition systems (FIDAS) for fleet management. DOE has initiated the first phase of this assessment which targets light fleet vehicles (less than 3/4 ton) that typically allow more uniform installations, require less customization, and have reduced per vehicle costs. In conjunction, the Division of Maintenance will evaluate FIDAS for heavy duty vehicles. The objective is to improve fleet management, reduce fuel use, and produce accurate fuel use reporting. Improvements will be accomplished by automating trip-related data collection and report generation, and improving communications to equipment managers. Commercial off-the-shelf (COTS) components (hardware and software) will be procured, tested, and evaluated for both light and heavy fleet vehicles. The results will provides vehicle asset location data that can greatly enhance resource allocation decisions in an emergency. The research result will be available in 2013.

IRIS (Intelligent Roadway Information System)

The enhanced IRIS system is in the deployment stage and is being actively used in Caltrans District 10. A Feasibility Study Report (FSR) was completed for full deployment of IRIS in Districts 1, 2, and 5. AHMCT will deploy, maintain, and enhance of IRIS for Districts 1, 2, 5, and 10. IRIS (Intelligent Roadway Information System) is an Advanced Traffic Management

System (ATMS) that was developed and released as open-source by the Minnesota Department of Transportation (Mn/DOT) in 2007. Caltrans is the first agency to adopt and enhance IRIS, contributing numerous improvements back to the public project. The system provides significant capabilities, improved safety, lower personnel maintenance needs, and higher reliability. For example, IRIS provides changeable message sign libraries and fonts, as well as system logging, error checking, and configuration flexibility. The system provides traffic flow data from traffic detectors in the district, video from traffic cam, traffic incident data, and changeable message sign status as well as data from weather stations. These data are crucial for emergency management.
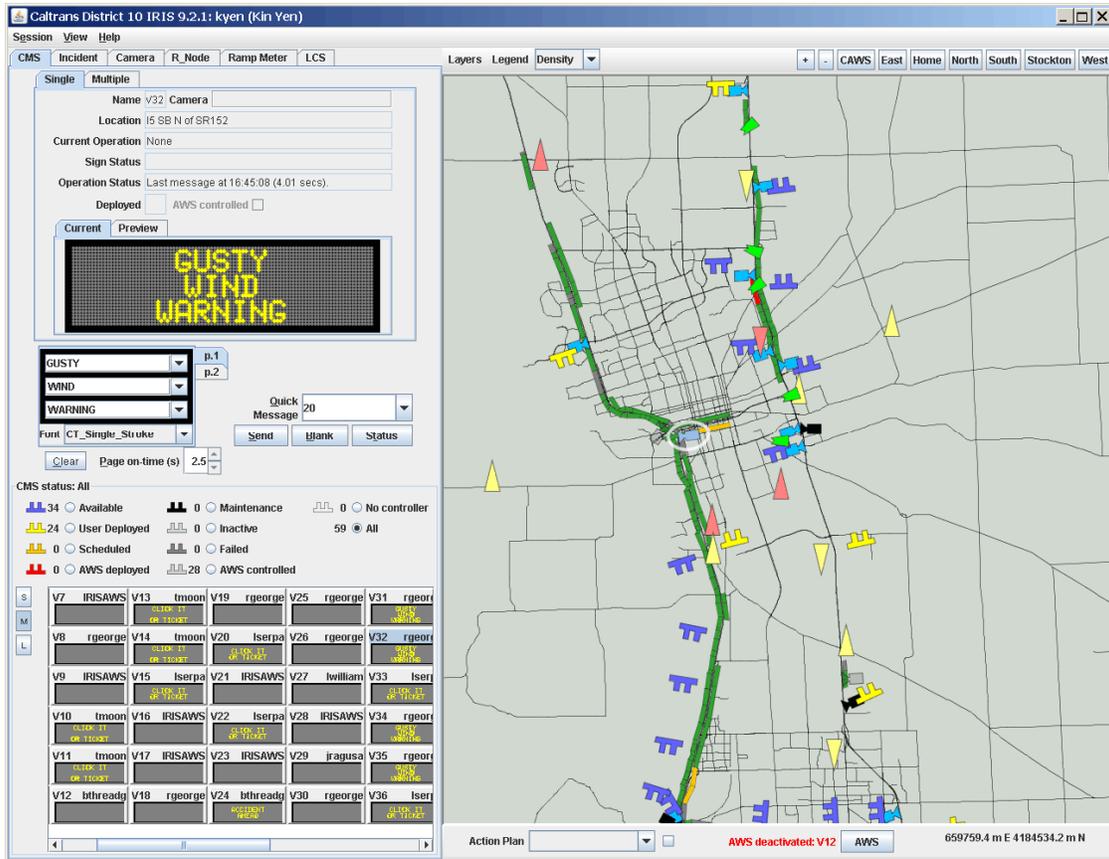

Figure 3.3 IRIS ATMS screenshot

CHAPTER 4:
COMMERCIAL SYSTEMS

There are two main types of commercial systems that are suitable for use in emergency maintenance response applications: wireless communication systems/components, and mobile information display systems. Example COTS wireless communication components and systems includes cellular communications, 802.11abgn, satellite communications (one-way or both ways), 802.11s mesh network, 4.9 GHz frequency and 5.9 GHz DSRC communication components and systems. Examples of mobile information display systems are light-weight rugged laptops, tablets (IOS, Android, Windows), and smartphones.

COTS Communication Components and Systems

Cellular wireless data communication

Mobile Cellular wireless data communication is one of the most widely available and economical high-speed communications. AT&T and Verizon are the two major service providers with large coverage area in California. However, cellular services are usually very limited in rural areas despite effort by all carriers to set up cellular communication towers along the major highways. Highway 88 near Caples Lake, SR108 Sonora Pass, and Highway 299 near Burney are example areas of very limited cellular services. Users often have to drive more than an hour to get a location with cellular services. Thus, sole commercial cellular communication link would not be viable for data communication in rural area.

OpenBTS – open source 2G GSM implementation

OpenBTS, a Linux application, uses a software radio to provide a 2G GSM air interface to 2G GSM compatible handsets to make voice phone calls or send SMS massages. It can provide a low-cost private GSM cellular base station in remote areas where commercial GSM service is not available, and highway workers can communicate with each other via voice or SMS using low-cost GSM phone or smartphones. An OpenBTS development kit is available for under $5,000 (http://www.rangenetworks.com/store/development-kit). OpenBTS base station hardware, as shown in Figure 4.1, is compact and low power. AHMCT has set up an OpenBTS base station and evaluated it. It works well, providing voice and SMS communication for a radius of 1 km.
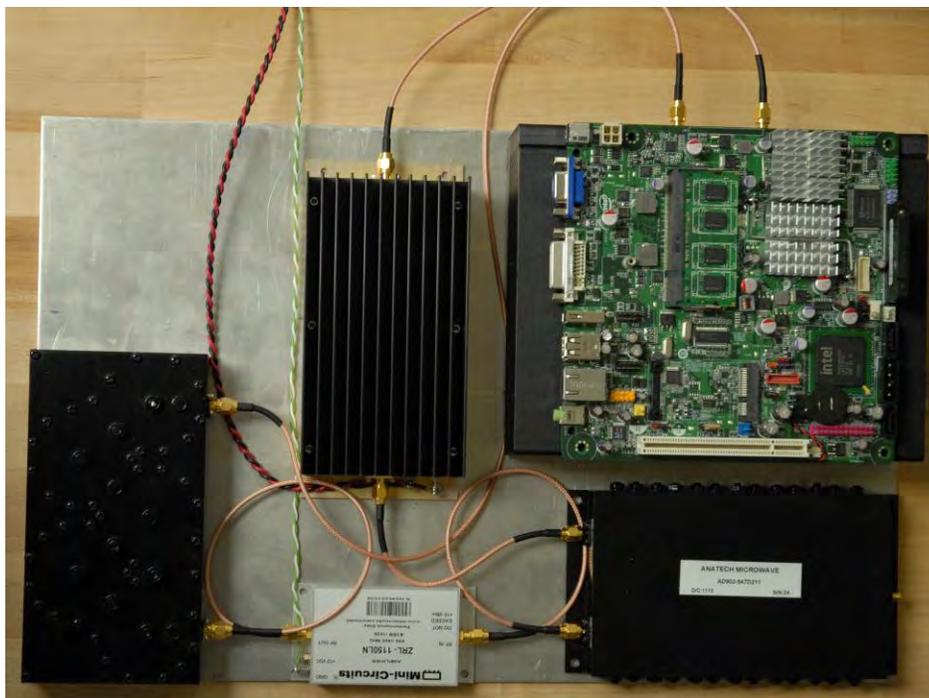
Figure 4.1 OpenBTS base station hardware implementation at AHMCT

Satellite Communication

All satellite communication provides coverage for the entirety of California. There may be some localized dead zones caused by signal blockage by local mountainous terrain or building in urban canyon. Popular two-way satellite communication providers are Inmarsat and Iridium. Inmarsat employs 11 satellites flying geosynchronous orbit. The Iridium constellation is composed of 66 cross-linked Low Earth Orbit (LEO) satellites. User's line of sight to geosynchronous satellite can sometimes be blocked permanently by local terrain or buildings. In addition, geosynchronous satellite communication has higher latency. On the other hand, the blockage to user's line of sight to LEO satellites caused by local terrain is often only temporary as the LEO satellites position move over time away from the terrain blockage.

Recently, low-cost one-way satellite simplex uplink-only connection (one-way data transmission) has become available. This service allows users at remote location to send short text message in rural area reliably. These messages can be geo-location of mobile asset, sensors readings, or SOS messages. SPOT LLC (http://www.findmespot.com/en/index.php) provides products and services for one-way satellite simplex uplink-only connection. SPOT Satellite GPS Messenger is a small portable unit that allows a user to send its geo-location periodically, SOS, or pre-formed custom messages in remote area within 20 minutes. The SPOT Connect enables smartphone user to send custom email or text messages out via satellite through a Bluetooth connection between the SPOT Connect and the smartphone. It enables a worker to send critical emergency messages out within delay for $99 a year plus 10 to 50 cents per message. With the reduction of work force, highway workers are often working along rural highways with no other means communication. SPOT products would allow them to call for help in emergency such as avalanche or vehicle breakdown. Hackers (http://natrium42.com/projects/spot/) were able to

reverse engineer the internal data communication protocol of the SPOT Satellite GPS Messenger so that an external microcontroller may send message out directly via the SPOT Messenger satellite modem. Thus, remote sensors can send simple data such as snow depth and avalanche alert back via satellite.

Figure 4.2 SPOT Satellite GPS Messenger

Figure 4.3 SPOT Connect

Terrestrial wireless components

The commercial success of the IEEE 802.11abgn standard and its components has led to development of low-cost OFDM (Orthogonal Frequency Division Multiplexing) wireless radio in other radio frequencies (700 MHz, 900 MHz, 4.9 GHz, and 5.9 GHz) based on 802.11 technology. These radios use Qualcomm Atheros AR91xx chipset or AR54xx chipset originally developed for 802.11abgn. AHMCT researchers have experimented with these low-cost radios in 5.8 GHz and 900 MHz frequencies for point-to-point communication. Using the 5.8 GHz radio, a high-speed reliable point-to-point connection was achievable over 5 km using COTS sector antenna mounted on a vehicle at about 12 feet off the ground. Longer range can be achieved using higher antenna height and optimizing radio operational parameters such as bandwidth and timeout timing. The 4.9 GHz radio should achieve similar performance.

Figure 4.4 AHMCT 5.8 GHz point-to-point communication experimental setup

In 2002, the Federal Communication Commission FCC designated the 4.9 GHz band for use in support of public safety. The FCC has allocated 50 megahertz (MHz) of spectrum in the 4940-4990 MHz band (4.9 GHz band) for fixed and mobile wireless services and designating the band for use in support of public safety. This allocation and designation will provide public safety users with additional spectrum to support new broadband applications such as high-speed digital technologies and wireless local area networks for incident scene management. The spectrum also can support dispatch operations and vehicular or personal communications. Specific FCC rules are covered in Subpart Y in 47CFR part 90. Caltrans is eligible to use the allocated 4.9 GHz spectrum. Currently, Caltrans District 2 is using the 4.9 GHz frequency for point-to-point data link in a few locations. The expanded used of the allocated 4.9 GHz frequency by Caltrans and other DOTs would ensure that FCC would not reallocate the 4.9 GHz spectrum to other applications or commercial uses. 4.9 GHz is currently underutilized and thus it is not subjected to interference issue that often happen when using 2.4 GHz and 5.8 GHz frequencies. 4.9 GHz provides a prime opportunity for Caltrans to build a wireless data network similar to the 800 MHz voice network.

Figure 4.5 shows an example of a 4.9 GHz mini-PCI card based on the Atheros 802.11 chipset made by Doodle Labs. It is well-supported by the open source MadWiFi Linux kernel driver (http://madwifi-project.org/) and open-source router software OpenWrt (https://openwrt.org/). The open-source nature of the driver and software provide maximum flexibility for user to configure the radio parameters to optimize for range and bandwidth. In conjunction with open 802.11s (http://open80211s.org/open80211s/), an open-source implementation of the recently ratified IEEE 802.11s wireless mesh standard, a 4.9 GHz mesh data network can be implemented with COTS components and open-source software at low cost. AHMCT researchers have set up a 5.8 GHz mesh network using open-source software and evaluated it used for network backhaul application. Figure 4.6 shows a group of small mesh node and single mesh node hardware with two 5.8 GHz 802.11 radios. The 5.8 GHz 802.11 radio cards can be easily changed to 4.9 GHz radio. Since these radio share the same software driver, the reconfiguration is minimal. The open-source firmware allows users to make changes to best suit their applications. AHMCT researchers envision a 4.9 GHz data network backbone can be built using mesh network technology and installing 4.9 GHz mesh network nodes on light poles along the highway. However, further development and experimentation is required to evaluate the envision mesh network performance in mountainous terrain found typical in many snow routes.
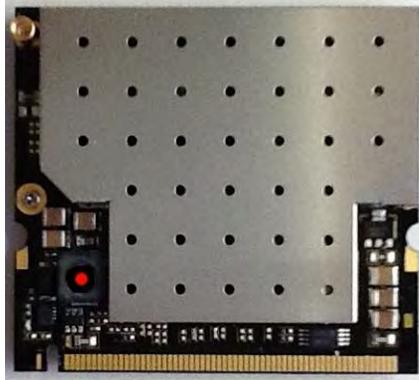
Figure 4.5 4.9 GHz wireless radio (www.doodlelabs.com)
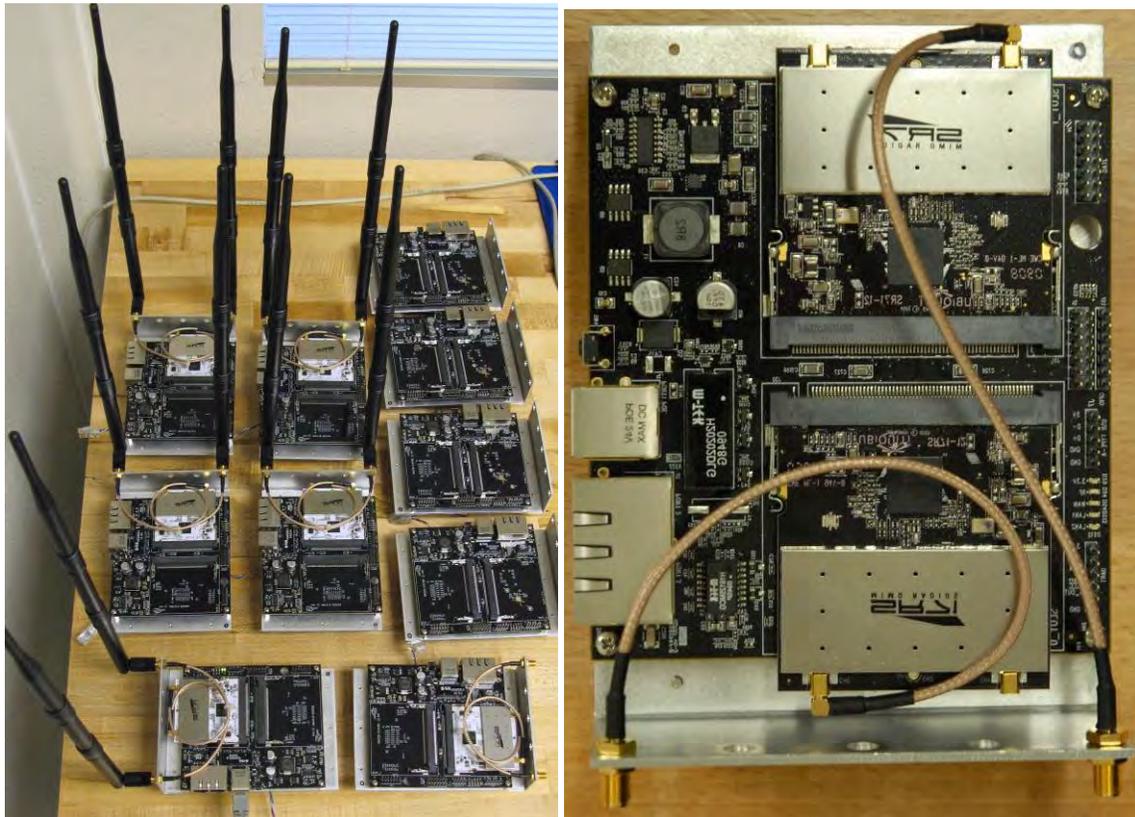
Figure 4.6 AHMCT 5.8 GHz mesh network experiment setup

Information display and input devices

In addition to data communication backbone, information display and input devices is vital to display critical data for decision making and data input from the field remote location. In the past, rugged laptops with high-resolution display and processing power were the only viable choice. However, they were large and bulky with short battery life. Recently, powerful light-weight smartphones and tablets with high-resolution display and long battery life have been developed and are well-accepted by consumers. These devices are a viable alternative to laptop. The envisioned application for snow operation and emergency maintenance in the fields does not

require extensive use of keyboard. On the other hand, the majority of existing research projects and Caltrans software were design to run on PC or laptop. Nevertheless, a new generation ultra-light notebook remains a viable choice. Head-mounted display remains in its infancy and is not ready for field deployment for at least several years.

Apple IOS, Google Android, and Windows Mobile are three major platforms of smartphone and tablet. Apple IOS and Google Android are the most popular platforms and have larger community of software developer support and third party software available as well as accessories such as rugged protective cases. The open-source nature of the Android platform is well-supported by the open-source community. There are many software library developed and compatible the Android operating system. Android devices are produced by several manufacturers. Apple IOS devices are only produced by Apple. As a result, the choice of IOS devices is very limited. On the other hand, software testing and validation on IOS devices are simpler since the number of devices required for testing are much less compared to Android devices. For example, in the testing of AHMCT GPS-ATD app, the app was tested over fifteen different models of smartphone with different versions of Android operating system and manufacturers' custom user interface.

Tablet is better-suited for information intensive application and viewing website that was originally designed for desktop computers because of its larger and higher resolution screen. The majority of the available tablets have either a 7" or 10" display. Two different models of 7" and 10" tablets were evaluated for it usability by AHMCT researchers. The 7" tablet can be held securely in one hand while inputting data with the virtual keyboard. It is difficult to hold a 10" tablet securely with one hand without having a thumb on the display area which interferes with the touch screen interface. The preliminary conclusion is that the 7" tablet has a large enough screen for information display and input. In addition, 7" tablet has advantage in portability and usability category. There are too many Android and Windows Mobile devices to review as a list. The following Table 4.1 lists some of the suitable devices for snow operation and emergency maintenance.

Apple	iPad	10" tablet on IOS platform http://www.apple.com/
Apple	iPhone	Smartphone on IOS platform http://www.apple.com/
Samsung	Galaxy Tab	7" and 10" tablets on Android platform http://www.samsung.com/us/mobile/galaxy-tab/
TerreStar	GENUS Smartphone	Window mobile smartphone with both GSM (AT&T) and satellite communication. (~$800) http://www.terrestar.com/
Winmate	Rugged PDA and Tablet	Winmate makes various Rugged PDA and tablet that run either Android or Window Mobile operating system thttp://www.winmate.com.tw/
Google	Galaxy Nexus	Android smartphone with high resolution display http://www.google.com/nexus/#/galaxy
Google	Nexus 7	7" Android Tablet http://www.google.com/nexus/#/7
Panasonic	Toughpad B1	http://www.panasonic.com/business/toughpad/US/secure-tablet-specs.asp#
Panasonic	Toughpad A1	10" rugged Android Tablet http://www.panasonic.com/business/toughpad/US/secure-tablet-specs.asp
Trimble	Yuma	Rugged Window 7 tablet computer with Intel processor http://www.trimble.com/
Trimble	Juno	Rugged Window Mobile PDA with build in GPS and cellular voice and data. http://www.trimble.com/
Delorme	Earthmate PN-60W	GPS (u-blox) plus text messaging via SPOT satellite Communicator (GPS World 8/2010), http://www.delorme.com
EMS Global Tracking	Osprey Personal Tracker	GPS (u-blox) plus Inmarsat communications of up to 450 predefined messages (GPS World 8/2010), http://www.emsglobaltracking.com
GeoPro Solutions	GeoPro Messenger	Satellite text-messaging and integrated GPS, coupled to secure hosted web application for workplace safety in disaster zones (GPS World 8/2010), http://www.geoprosolutions.com/geopro-messenger
Javad GNSS	Triumph-V.S.	High-precision 216-channel GPS/GLONASS/Galileo receiver, UHF, GSM/GPRS, WiFi, Bluetooth, and Ethernet, with widescreen touch-screen. Size of a professional camera. Also includes forward and downward looking cameras, recording microphone, two speakers, compass, and inclinometers. Depending on config, $12k - $34k fully-loaded (8/2010 pricing from Javad web site), http://www.javad.com/jgnss/products/receivers/triumph-vs.html

Table 4.1 Suitable information display and input devices

CHAPTER 5:
CALTRANS SYSTEMS, POLICIES, PLANS, AND INFRASTRUCTURE

Caltrans Systems

Caltrans Earth

Caltrans Transportation System Information (TSI) has deployed Caltrans Earth (http://earth.dot.ca.gov/), based on Google Earth technology. However, all the GIS data and aerial images are gathered from either internal Caltrans sources or publicly available data. Thus, the use of the Caltrans Earth data are free from Google Earth restriction. Thus, all or part of Caltrans Earth data can be stored locally on a laptop. When the data are cached locally, the user can look up the data quickly even when there is no internet link or if the data link has low bandwidth with high latency or is unreliable. Currently, Caltrans Earth is available on Microsoft Windows Platform. The availability of Caltrans Earth on other platform such as Android and Apple IOS is unclear. The Caltrans Earth web interface requires Google Earth plugin. Currently, there is no Google Earth plugin for mobile browsers (Android, IOS, and Windows Mobile). However, the Google Earth app is available on Android and IOS platform.

Figure 5.1 show Caltrans Earth web interface. In addition to high-resolution aerial imagery, it provide GIS data for highway, travel information, Caltrans facilities, bridges, boundaries, planned projects (CIB), weigh stations, ports, rail, and airports. In addition, it provides a Post Mile (PM) lookup tool, as shown in Figure 5.2. User can pick a location on the map or by typing in a Latitude and Longitude coordinates to determine the PM location on State highways. Since Caltrans maintenance operation and assets are tied to PM location reference system, PM to Latitude and Longitude conversion tool is extremely important and useful in coordinating an emergency response. Caltrans TSI is actively collecting and making GIS data available on Caltrans Earth. It is a valuable tool for emergency response.
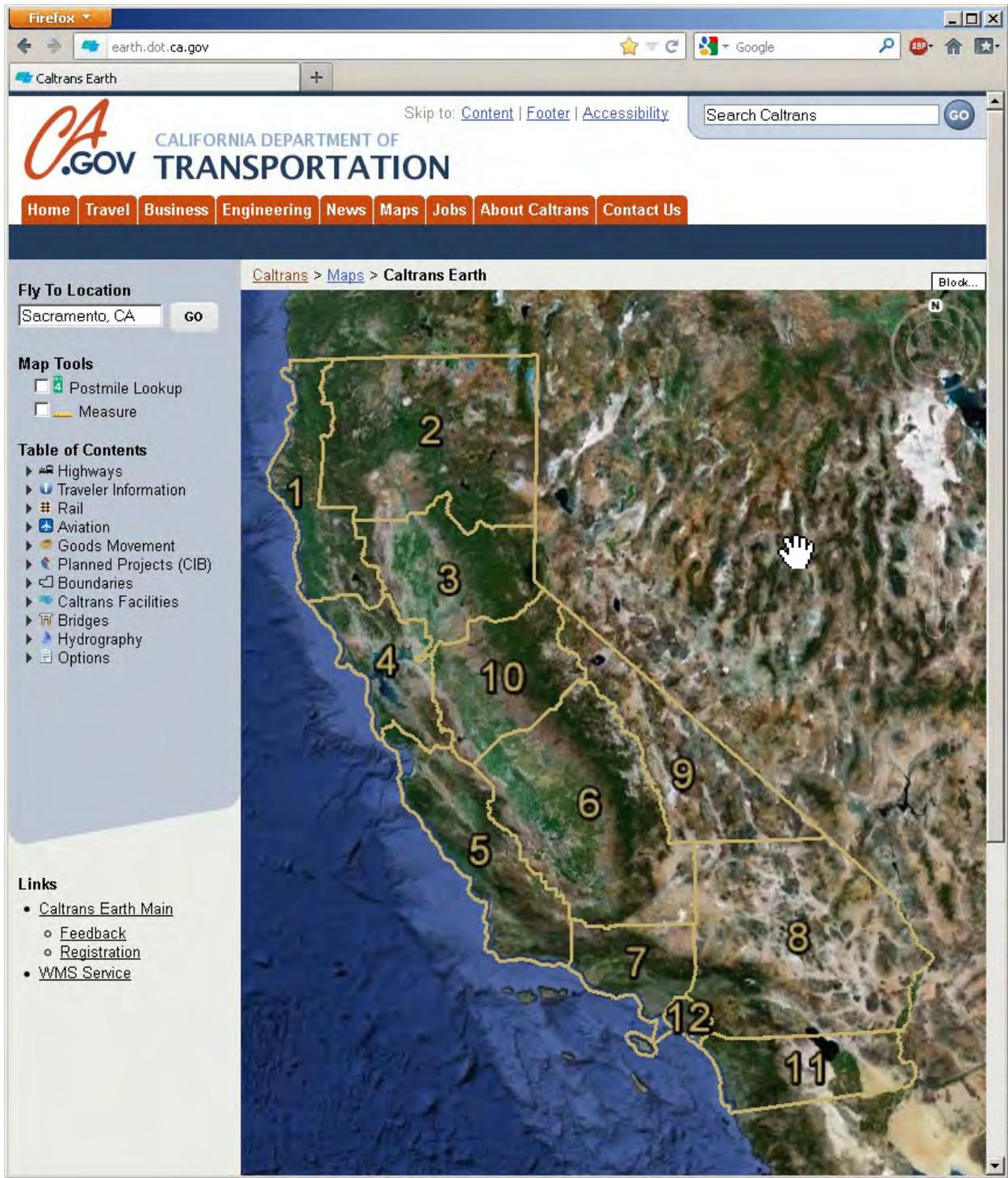
Figure 5.1 Caltrans Earth Screen Shot
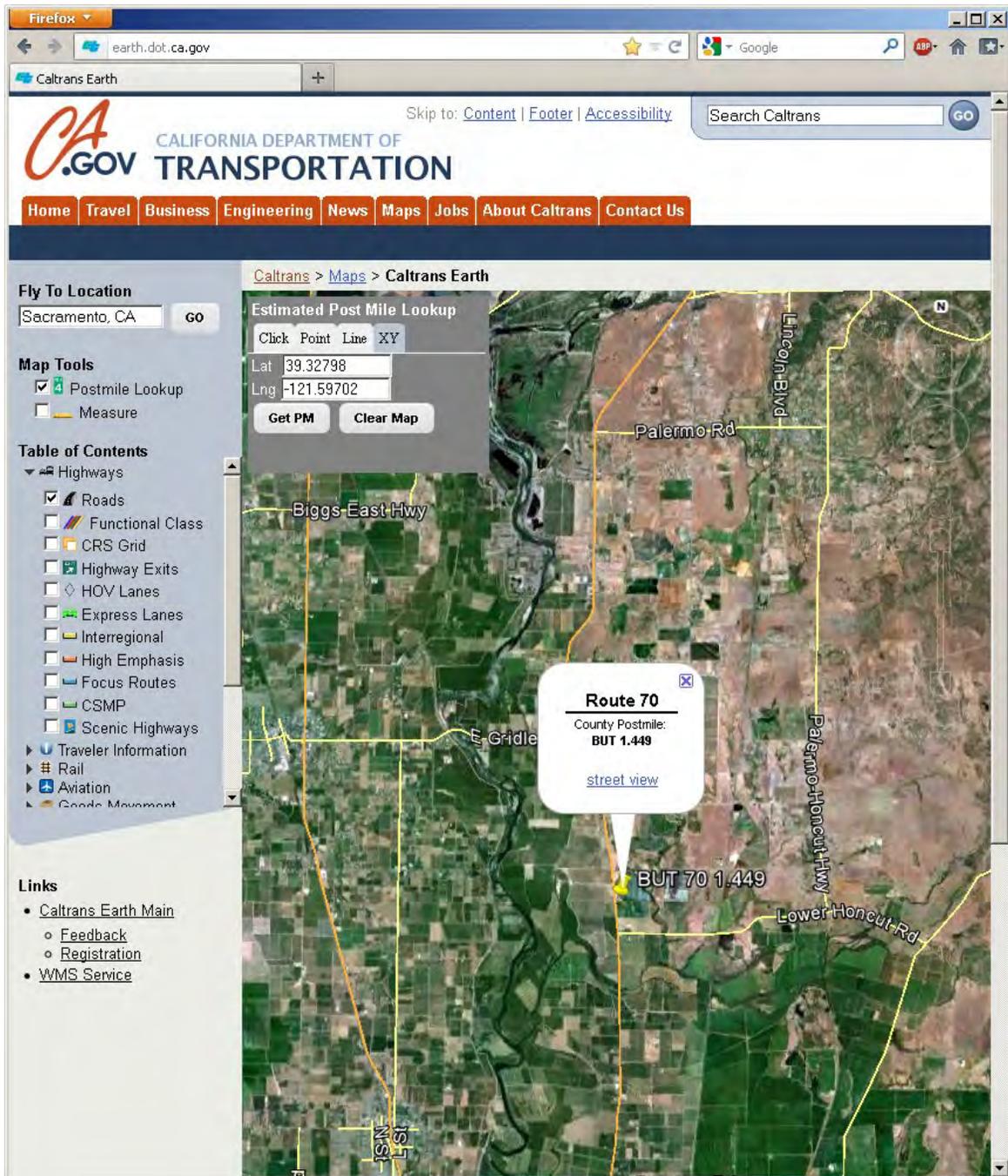
Figure 5.2 Caltrans Earth Post Mile Lookup Tool Screen Shoot

Culvert Asset Management

Caltrans Districts and Headquarter have been collecting detailed culvert condition and location information and converting to Keyhole Markup Language (KML) files for visualization on Google Earth. Example data is shown on Figure 5.2. Culvert GIS data may be useful in an emergency response. The Culvert Asset data should be added to Caltrans Earth so that users only have to go to a single source for GIS data.
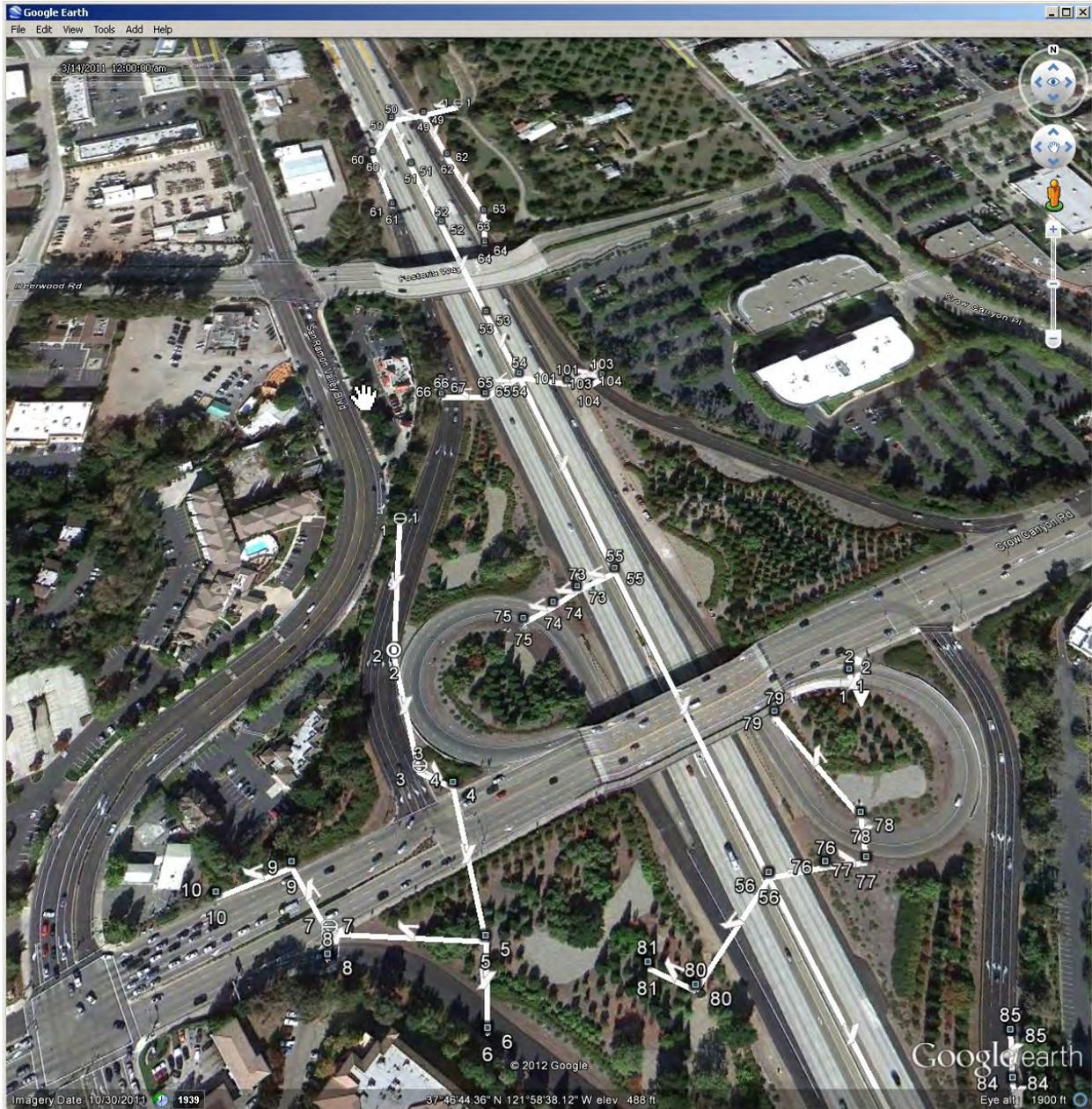
Figure 5.3 Caltrans District 4 Culvert Displayed on Google Earth

<u>**Caltrans Policies and Plans**</u>

800 MHz Voice Communication Expansion

Caltrans has a compressive plan to expand and build out the 800 MHz voice radio network throughout California [6]. For example, plans and work have been performed to add 800 MHz repeaters along some of the District 10 Highway 88 to improve coverage. However, it will take time to complete due to budgetary constraints. The 800 MHz voice radio coverage will improve over time throughout the State.

Governor Brown policy on reducing cellular usage

In January 2011, Governor Brown of the State of California issued an executive order (B-1-11) to review and reduce cell phone and smartphone procurement and related phone, data, Internet and other usage plans for and by their employees. The goal is to meet or exceed a 50 percent reduction in the number of cell phones and smartphones for which the State is currently responsible and achieve at least $20 million in savings.

Numerous Caltrans field elements, such as traffic detector, CCTV, Changeable Message Sign (CMS), Highway Advisory Radio (HAR) station, and weather station, rely on the commercial Cellular network and services to transmit the data back to the Transportation Management Center (TMC) or data customers. Building and using dedicated wireless data network system, similar to the 800 MHz voice radio network, could reduce overall lifecycle cost for Internet and wireless data services cost. The FCC has allocated 4.9 GHz and 700 MHz for wireless broadband application for public safety agency. In July 2007, the FCC revised the 700 MHz band plan and service rules to promote the creation of a nationwide interoperable broadband network for public safety and to facilitate the availability of new and innovative wireless broadband services for consumers. The Commission designated the lower half of the 700 MHz Public Safety Band (763-768/793-798 MHz) for broadband communications. In 2003 the FCC assigned the 4940-4990 MHz frequency band for use by public safety agencies for public safety use. Caltrans currently has no plan on large scale deployment of equipment using the 4.9 GHz band. District 2 deployed some 4.9 GHz for point-to-point communications in the field. Research and plans should be made to better utilize the 4.9 GHz band for wireless data communication.

[6]	Gartner, "Capscom Analysis for Caltrans (Agency Roadmap - Strategic Objectives & Tactical Plan Issued by Caltrans Division of Maintenance)," California Department of Transportation, 2010	Focus is on radio communications, 800 MHz transition, and mobile wireless data requirements.
[4]	California State Department of Transportation, "Caltrans Strategic Plan 2007-2012," Caltrans, Sacramento, December 2007	Identifies a strategy for achieving Objective 2.2 by 2012 – Increase reliability by 10% throughout the transportation system: Improve incident management. Follow up for this in [5]

[3]	California Emergency Management Agency, "State of California Emergency Plan," Cal EMA, July 2009	Cal EMA will use a matrix-based approach, where each State Agency's capabilities are known, and the Governor, through Cal EMA, can call upon any agency with needed capabilities, regardless of the Agency's routine jurisdiction
[2]	California Emergency Management Agency, "California Emergency Services Act," Cal EMA,2009	Cal EMA will use a matrix-based approach, where each State Agency's capabilities are known, and the Governor, through Cal EMA, can call upon any agency with needed capabilities, regardless of the Agency's routine jurisdiction

Table 5.1 Additional State policies and plans

CHAPTER 6:
PROTOTYPE REQUIREMENTS

Based on meeting with Caples Lake personnel in November, 2010, and Technical Advisory Group (TAG) discussion of February 16, 2011.

General scope: Provide pertinent Winter Maintenance information to field personnel to improve winter maintenance capabilities.

Focus for Current Phase: Develop the requirements and specifications for a system to provide information to snow supervisor personnel in the field. Target is information to supervisor, sander truck, and lead plow operator. Use Caples Lake needs to provide focus for current effort.

Primary project customer: Caltrans District 10, SR 88, Caples Lake Maintenance Yard

Additional customers: Caltrans Districts 1, 3, 9

Guiding principles:
- Use Commercial Off-the-Shelf (COTS) or other research project prototype systems where available.
- Leverage and harmonize with other research and deployment efforts, including Redding Responder, WeatherShare, One Stop Shop, and CT-Earth.
- For deployed research products, we will need to consider their current evolution, availability, and the evolving commercial landscape (e.g. emerging smartphone and similar communications capabilities).
- Use open standards and interfaces to enhance capability to obtain data from and feed data to existing or future systems, e.g. MDSS, and similar fleet and material management systems.

Main information:
- Weather data (temperature, precipitation, wind, pressure, etc.)
- Avalanche information in support of prediction, control, and monitoring. E.g. if instrumentation were available to confirm snow movement in the chute, this would greatly facilitate control and operator safety.
- Similar information for winter landslides, where instrumentation is available
- Chain control
- CMS status
- Incident status

Additional features: These may be of interest for HQ and some districts. Note that most of these are available in existing COTS systems or emerging MDSS prototypes. Also, some of these capabilities may need to be user-configurable at the appropriate level within Caltrans (district or yard, for example).

- Automated logging for spreading of materials (sand, salt)
- Automated logging of plow locations

- Road temperature logging

Constraints:
- Communications-challenged environment
- Restricted bandwidth, when available
- Limited cellular signal availability, strength
- Limited range for radio communications, and line-of-sight issues
- Cost (often fixed, annual) for alternative communications channels, e.g. satellite
- Some availability issues even for satellite-based options, depending on service provider or type of satellite

CHAPTER 7:
CONCLUSIONS

Key contributions of this research project included:

- Identification of existing commercial systems, research systems, and services that can be leveraged for emergency maintenance response.

- Development of requirements for a research prototype system for emergency maintenance response.

Recommendations

The researchers recommend a full field test of a prototype system meeting the specification developed in the current research. Winter maintenance provides a worst-case test scenario, as mountainous terrain and reliably severe winter storm conditions would allow season-long testing of Emergency Maintenance Response communications in the most severe conditions encountered on a routine basis. The test should occur in a communications-challenged environment, with snow and avalanches, as these are the most reliable emergency situations. SR88 near Caples Lake in District 10 is an excellent choice. This field test should include:

- Two supervisor vehicles equipped with the prototype for bi-directional voice and data communications.

- Two snowplow vehicles equipped with the prototype for bi-directional voice and uni-directional data communications from the plow to the server. The plows should be equipped with GPS and a road temperature sensor.

The field test should occur over two winter seasons. Existing systems such as WeatherShare,, Redding Responder, and One Stop Shop should be leveraged as data feeds to the prototypes, where possible.

Upon successful completion of the field test, the next stage would be field operational testing and support for transition to enterprise-wide deployment. This would include any updates to the prototype system based on its field test results. A large number (~ 10) of supervisor vehicles and snowplows (~20) would be equipped, and tested over two winter seasons.

If each of these phases is successful, the system could be deployed at that point, to the full fleet. With the existing FOT systems, emerging technologies, and core technical competencies already in place, reaching this broad level of implementation and deployment may be feasible in a relatively short term, if all the relevant stakeholders are involved and committed along the way.

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