Northern California Vehicle Infrastructure Integration Case Study

by

Michael J. Kelly, Ph.D.
Senior Research Scientist

Western Transportation Institute
College of Engineering
Montana State University

Prepared for the

State of California
Department of Transportation
Division of Research and Innovation
1227 O Street
Sacramento, CA 94273

January 17, 2005

1. Introduction

1.1. The Background of this Project

The area comprised of CALTRANS District 1 is the northwestern corner of California and consists of the counties of Humboldt, Del Norte, Mendocino, and Lake. The geography is primarily coastal, coastal hills and low mountains. The largest city is Eureka (pop. 27,000) located on the coast approximately 100 miles south of the Oregon border. 50 miles north of Eureka is the tourism destination of Redwood National Park. The most important highway in this area is US 101, which parallels the Pacific coastline from southern California to near Seattle. US 101 is primarily a four-lane highway with short lengths of two-lane. The remainder of the roads are mostly two-lane rural highways carrying a mixture of local residents, tourists, and fleet traffic. There is a significant component of large trucking, with many trucks carrying logs and lumber in support of the area's lumber industry.

This project builds on two foundations, the California/Oregon Advanced Transportation Systems (COATS) project and the independent development of technologies for vehicle-infrastructure integration (VII) systems. The COATS project investigated travel challenges in the two-state California-Oregon border area and is testing advanced technologies of various kinds to address those challenges, primarily on multiple-lane highways. The development of VII systems is providing technologies for direct communication of hazards and potential responses between the roadway infrastructure and the vehicle. These two foundations will be described in more detail in the following sections.

1.1.1 The COATS Project

The transportation corridor connecting northern California with central Oregon provides significant challenges to the transportation engineer and the traveling public. The terrain is mountainous, a large percentage of the roadways are narrow, rural two-lanes. Even the major roadways (US 101 and I-5) can provide challenging conditions for travelers.

Weather and geography are the sources of many of the transportation challenges. Travelers throughout the corridor must contend with diverse and rapidly changing weather conditions including snow, high winds, fog and heavy rain. The combination of varied driving conditions and abundant off-road, commercial and recreational traffic produces an immediate and expanding need for increased traffic safety measures and information dissemination techniques.

The two-state area contains transportation links vital to the region’s economy and commercial industry. Numerous primary and secondary routes serve commercial vehicles destined for urban centers throughout the West.

The overarching goal of the COATS project was to provide a showcase for advanced technologies in order to address these problems. The goals of COATS were as follows:

- Identify the transportation and information needs within the study area;
- Determine ITS solutions that are beneficial, cost-effective, and implemental for deployment within the study area on the basis of the identified needs;
- Identify, design and deploy initial, small-scale “early winner” projects with existing funds on a multi-year basis to test the feasibility of rural ITS;
- Develop a Strategic Deployment Plan that describes a strategic approach for implementing rural ITS strategies on a larger scale, with an emphasis on integration and expansion of future ITS components within the study area based on evaluation results; and
- Prepare proposals and secure Federal funds to implement Rural Model Deployment Initiative projects.

Another way of describing the COATS project is that it is a combination of ITS planning, through the creation of the Strategic Deployment Plan, and ITS demonstration, through projects like the “early winners.” The demonstration aspect of the COATS project continues after COATS project funding is exhausted, with the COATS Showcase program. This effort provides funding for demonstration and evaluation of identified technologies, consistent with COATS goals and objectives, in the COATS study area.

1.1.2. Vehicle-Infrastructure Integration Systems

For the purpose of this project, five specific functions were initially selected for primary consideration. These were:

- Longitudinal Warning: Functions related to sensing and maintaining a safe following distance between vehicles in the same lane.
- Lateral Warning: Functions related to sensing and correcting unsafe deviations from the selected driving lane.
- Intersection Collision Warning: Functions related to sensing on-coming vehicles on an intersecting crossroad and alerting the driver when it is safe/unsafe to enter the intersection.
- Vision/Visibility Enhancement: Functions related to supporting the vision of the driver during conditions of degraded visibility resulting from darkness, weather, glare, or other factors.
- Safety Readiness: Functions related to alerting the driver concerning potential safety problems including obstacles, infrastructure problems, or issues of driver fitness.

1.1.3. Project Summary

Vehicle Infrastructure Integration Systems are Intelligent Transportation Systems (ITS) that integrate infrastructure, such as traffic and traveler information technologies, with in-vehicle advanced vehicle display, control and safety systems. These cooperative solutions are intended to address short-term safety and operational challenges, as well as the more long-term complex transportation challenges - as in the areas of safety, congestion, pollution, and land use - that conventional ITS or traditional transportation cannot address.

Vehicle Infrastructure Integration Systems are intended to bridge the gap between advanced vehicle control systems and infrastructure communications and information systems. These systems require both conventional transportation planning and the planning needed to integrate new technologies into the existing system.

The Vehicle Infrastructure Integration Systems are the next generation of Intelligent Transportation Systems. The goal of the VII Case Study is to recommend applications and consider implications of Vehicle Infrastructure Integration Systems in a rural environment. The research is focused on developing applicable advanced technology solutions that will assist fleet operations and would ultimately increase safety and improve operations of the transportation system in northern California. The research will examine principally the two-lane rural highway (non-interstate) system. While many emerging VII systems provide some degree of automated vehicle control and the ability of a computer to take over control of the vehicle from the driver when indicated, this technology is beyond the scope of this project. The scope of this analysis was limited to systems that provide supplemental information to the vehicle driver.

This project is conducting research and development that will lead to testing and deployment of Vehicle Infrastructure Integration Systems concepts that solve rural transportation challenges. As it is difficult to initiate or influence the deployment of technologies on light duty passengers vehicles, the opportunities for research, development, testing and potential deployment lie in partnering with a fleet owner/operator or in developing infrastructure systems that complement emerging in-vehicle technologies. Examples of fleets include trucking, transit, law enforcement, and emergency vehicles as well as vehicles that operate and maintain utilities like power, communications, or transportation facilities. Emerging technologies that this project may interact with include in-vehicle traveler information, where one challenge will be the ability to provide reliable, real-time highway related information such as local weather or roadway surface conditions.

1.2. Description of the problem

Initial activities by the National Automated Highway System Consortium (NAHSC) were focused on urbanized areas. However, a need exists to investigate the applicability of advanced transportation technology in rural settings. Technology applications have primarily focused on problems associated with urban traffic congestion; with secondary considerations related to safety, air quality and energy conservation. These areas are also of concern to the rural transportation provider; however, the primary focus of the rural transportation provider is to improve safety.

There are many safety benefits potentially realized through the application of Vehicle Infrastructure Integration Systems to the existing transportation infrastructure, such as through advanced driver warnings. It is estimated that if a driver were warned of an impending collision one half second earlier, 50 percent of rear-end and intersection crashes and 30 percent of head-on crashes could be avoided. If an additional second is provided to the driver, 90 percent of all crashes could be avoided. Experts estimate that advanced transportation technologies will potentially save 11,500 lives, 442,000 injuries, and $22 billion in property damage nationally by 2010.

1.3 Vision

The vision for this VII Case Study will be a Vehicle Infrastructure Integration System that can evolve as the roadside and vehicle safety systems are implemented, communication coverage increases, fleet technology improvements migrate to a rural environment, and fleet managers understand the application of technology to their specific needs. It is envisioned that the Vehicle Infrastructure Integration System that may be used in this project would evolve from spot application to information assistance.

It is expected that this project will focus on technologies that exchange information between the vehicle and roadside infrastructure and may provide, at most, some very minimal level of assisted vehicle control based on this exchanged information. This project reviewed technologies that can be implemented in the near term, are beneficial in the rural environment, and can be implemented in a fleet of vehicles. An example would be the use of remote weather information systems and dynamic message signs. While the general public may use this information for safety at this time, the information is not transmitted to in-vehicle systems but directly to the vehicle drivers via their eyes .

The Rural Fleet Application Case Study would utilize targeted fleets to demonstrate the benefits of Vehicle Infrastructure Integration System. The Vehicle Infrastructure Integration System would provide for increased benefits over roadside infrastructure (e.g., signs) that can only provide information to the driver and not to the vehicle. The VII Case Study might utilize roadside infrastructure to transmit a signal to the vehicle (for example, through a smart license plate) that would automatically provide hazard information to the driver. Partially automated communication of travel information between vehicles may also be included.

1.4 Why California District 1?

This project is focused on the California portion of the California Oregon Advanced Transportation System (COATS) region and will build upon findings from that research. Because of the project's rural focus Caltrans Division of Research and Innovation (DRI) and WTI chose to emphasize deployment on non-interstate highways. COATS was a study that focused on rural intelligent transportation systems in the Northern California and Southern

Oregon regions. For the present project, Caltrans and WTI wished to narrow the geographic area to northern California and focus on one district to minimize logistical challenges to help minimize overhead costs, reduce the size of the advisory committee, and reduce travel costs.

WTI chose to concentrate on District 1 for the VII project. District 1 appeared to be better suited for VII deployment than District 2 in three of the four focus areas:

- District 1 has a higher density of safety challenges per mile of roadway
- District 1 has a higher density of existing or short-term planned ITS elements
- District 1 has a higher frequency of road closures per mile of roadway
- District 2 has a lower population density

The larger and denser population of District 1 would favor District 2 as the choice for a rural environment in that category. But both districts are considered rural in comparison to areas such as San Francisco and Los Angeles, which have population densities ranging from 1,000 to 3,000 people per square mile.

Nine categories of safety challenges were identified by the COATS project, with six of them selected as relating to this project. The Intersection Safety challenge was tabulated as a count of intersections and the remaining were tabulated based on mileage of roadway where those types of dangers were prevalent. A logical way was needed to compare the number of challenges in each district because of the difference in size. This was done by comparing the total miles of hazards to the total miles of rural highways for each district, excluding Interstate 5. A larger number would show a higher number of hazards per mile of roadway in the district. Table 1 shows the number and miles of challenges identified in the COATS project for each district. Based on this comparison District 1 has a higher density of safety challenges than District 2.

Table 1: Challenges for Northern California VII Project

Challenge	District 1	District 2
Intersection Safety (number)	1	0
Narrow Roads (mi.)	487.3	124.3
Inclement Weather-Road Surfaces (mi.)	0	87.2
Inclement Weather-Poor Visibility (mi.)	102.5	0
Animal Collsion (mi.)	0	67.8
Driver Fell Asleep (mi.)	174	91
Total Challenges Road Miles	***764.8***	***370.3***
Road Miles Per District	***620***	***1258***
Mile Challenges per mile of road in district	***1.23***	***0.29***

The ITS elements that will be in place at the time of deployment of the *NCVIIS* possibly can be used in conjunction with *NCVIIS* elements to increase the effectiveness. Therefore, the count and density of existing elements and these planned for short-term deployment is a factor in choosing the district for *NCVIIS* deployment. Figure 1 shows the locations of short-term planned and existing ITS in the region, excluding Interstate 5. A summary of ITS in the region shows District 1 to have 36 locations and District 2 to have 13.

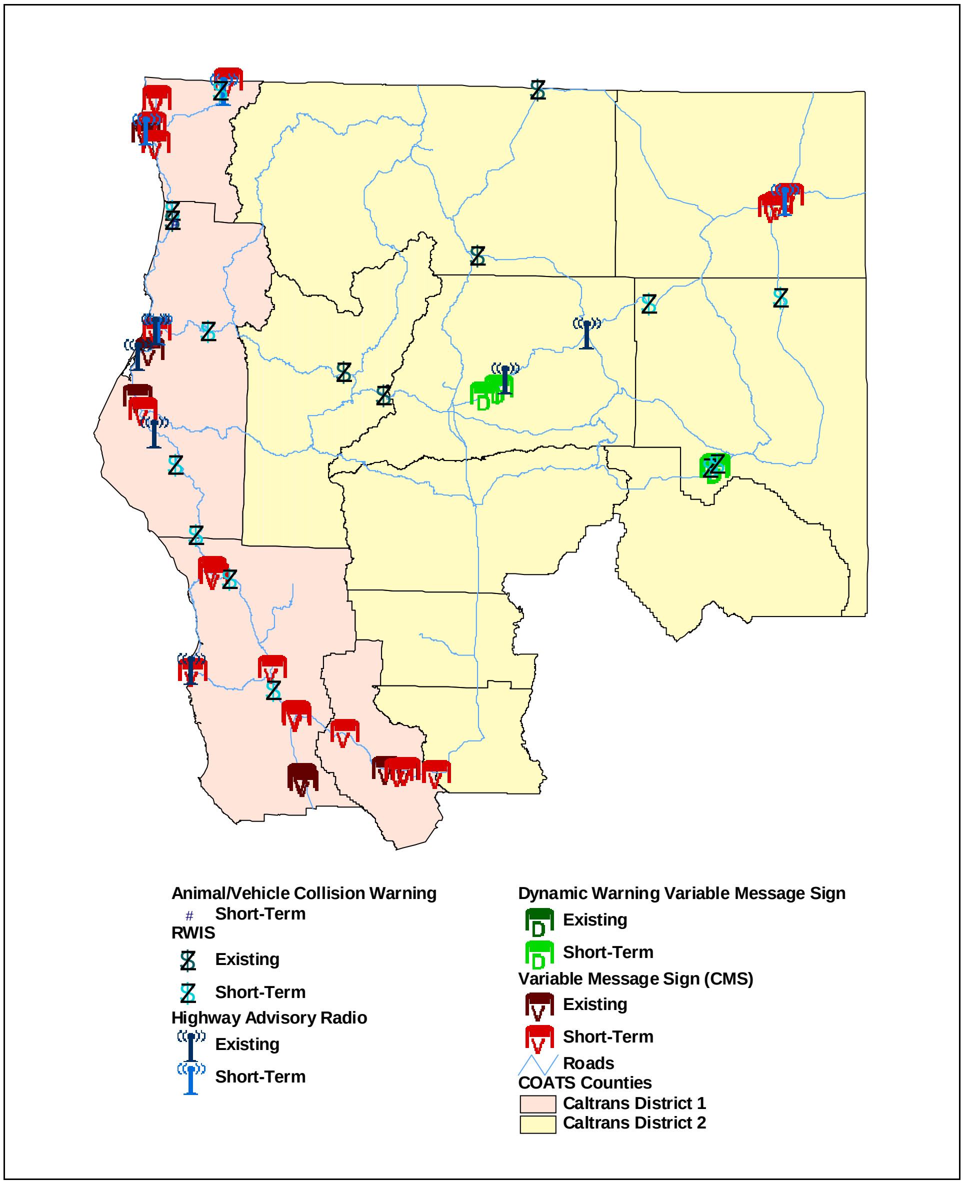

Figure 1: ITS in the Northern California Region

Numerous accidents and accidental delays could be avoided or minimized by providing information to travelers about closures and alternate routes. Table 2 shows data collected by the COATS project over different time periods. The information for District 1 was collected from February 1995 through December 1997, a 34 month period. The information for District 2 was collected from January 1998 through September 1998, a nine month period. Because the time periods of data collection differed, the totals were normalized to get a per year average for each type of closure along with totals. The number of closures could be partial or full, and the length was for the total duration of the closure. Per mile comparison was needed between the districts because of differentiation in size. The higher the number of closures or days, the greater amount of reduced traffic flow per mile of roadway per year.

Table 2: Road Closures for Northern California VII Project Area

	District 1				District 2			
Reason for Closure	Number of Closures (34 mo.)	Number of Closures per year (closures*12/34)	Days of Closure per year (34 mo.)	Days of Closure per year (days*12/34)	Number of Closures (9 mo.)	Number of Closures per year (closures*12/9)	Days of Closure per year (9 mo.)	Days of Closure per year (days*12/9)
Flood	62	21.9	217.7	76.8	6	8.0	0.8	1.0
Object on Road	45	15.9	40.0	14.1	8	10.7	0.0	0.0
Slide	181	63.9	1718.7	606.6	18	24.0	70.9	94.6
Vehicle Crash	78	27.5	107.8	38.0	89	118.7	258.1	344.1
Weather (Snow)	0	0.0	0.0	0.0	18	24.0	11.6	15.5
Construction	48	16.9	22.4	7.9	6	8.0	170.7	227.5
Fire	7	2.5	1.2	0.4	0	0.0	0.0	0.0
Maintenance	28	9.9	169.3	59.7	0	0.0	0.0	0.0
Other	15	5.3	9.3	3.3	0	0.0	0.0	0.0
Total		***163.8***		***806.9***		***193.3***		***682.8***
Road Miles	***620***				***1258***			
Totals (closures or days/mile/year)		***0.264***		***1.302***		***0.154***		***0.543***