California Center for
Innovative Transportation

DEPLOYING MOBILITY SOLUTIONS

2006 ANNUAL REPORT

California Center for Innovative Transportation

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OUR MISSION

CCIT's primary mission is to facilitate and implement the operational deployment of transportation research and innovation. Working with researchers, practitioners, and industry partners, we focus on practical applications and direct improvements to the safety, mobility and security of California's transportation system.

WHAT WE DO

Established at UC Berkeley's Institute of Transportation Studies, CCIT is a bridge between the academic world, transportation public agencies and private industry. We are particularly strong in the area of Intelligent Transportation Systems (ITS). What is truly unique about CCIT's activities is our focus on transforming research results into deployable products and services that can directly benefit practitioners. Located in downtown Berkeley, CCIT staff is made up of engineers, post-doctoral researchers, and UC Berkeley graduate students with additional support from a network of consultants to deliver projects in four areas:

- Research Deployment
- ITS Implementation
- Technology Assessments
- Support to Research and Innovation

PARTNERS AND CONNECTIONS

One of CCIT's strengths is to leverage its network of partners in academia, research, government and the private sector. Ever since the Center's inception, our facilities have been a focal point of exchange between our partners. As part of UC Berkeley's Institute of Transportation Studies, CCIT collaborates with leading academics in the field of transportation and with the Institute's research centers, particularly the Partners for Advanced Transit and Highways (PATH) and the Technology Transfer program. CCIT is also connected to the Institutes of Transportation Studies at UC Irvine and UC Davis through, respectively, the Advanced Transportation Management and Information System (ATMIS) testbed and the new Mobility Center. Over the past few years, CCIT has worked with many other programs in the University of California and California State University systems.

CCIT's main sponsorship comes the California Department of Transportation (Caltrans). There, CCIT works with Headquarters staff in Sacramento as well as with local district practitioners. We also have strong ties with the principal Metropolitan Planning Organizations in California, such as the Metropolitan Transportation Commission of the San Francisco Bay Area (MTC), and the San Diego Association of Governments (SANDAG). CCIT regularly acts as an industry forum, inviting practitioners and policymakers to meet with field experts, researchers and technology providers. CCIT entertains contacts with a wealth of ITS companies, transportation consultants and professional organizations, both locally and at the national and international levels.

JOIN US

Join us at CCIT for opportunities to partner and network with state and local government and with other private members. Go to **www.calccit.org**
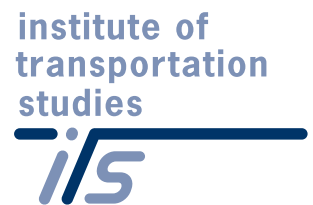
DIRECTOR'S FOREWORD

Dear Friends and Colleagues,

The past year has been a very exciting one for all of us who strive to improve transportation in California and beyond, and I am proud to say that CCIT has fully contributed to the thrill.

My first thought goes to the 12th World Congress on Intelligent Transportation Systems (ITS) that took place last November in San Francisco. All of you fortunate enough to have attended this event will undoubtedly join me in calling it an unprecedented success. This was one of the largest-ever gathering of ITS professionals, bringing just over 7,000 attendees from 57 countries. The University of California, and CCIT quite prominently, played a crucial role in the organization of the event. Being the current chair of ITS California, I also want to commend all of its members for their outstanding participation.

One trend I noticed this year that brings me great satisfaction is that everyone seems to be finally talking about system management, particularly in the wake of the Governor's *GoCalifornia* initiative. The idea that transportation networks are systems processing the public's demand for mobility with a variable throughput, while abstract, is a rather natural one. Yet, it has taken us decades to finally consider the problem in those terms. CCIT has been involved on that front in several meaningful ways. Our Corridor Management Demonstration project, which employs objective performance measures to simulate the impact of operational improvements on corridor mobility, has received a great deal of attention at all levels of state and local government in California. We are also rolling out a statewide training program on PeMS, a traffic detector data archive with extraordinary online analysis capabilities. I believe that PeMS, which was initially developed at the University, is bound to quickly become a central element of freeway system management, and CCIT will continue to promote it accordingly.

As a young organization, CCIT is still changing rapidly. I am immensely grateful of the progress accomplished by the staff and of the contributions of our Graduate Student Researchers. We were able to deliver significant projects in the areas of traveler information systems, freeway operations and ITS best practices. Other projects are underway in these areas and on hot topics like infrastructure security and public-private partnerships. This report features project descriptions that I hope will help you understand how CCIT is deploying mobility in California.

As the icing on the cake, I am glad to report that I have solicited participations from valued individuals at public agencies, private industry and public universities to sit on the first CCIT advisory board. I have confidence that our board members will lead us to do even better at partnering with their respective organizations, and to improve the relevance and quality of our work.

While we've had a fantastic year, the year ahead promises to be no less interesting. CCIT having now attained a substantial size, our association with PATH as well as the Technology Transfer program make Berkeley's Institute of Transportation Studies uniquely positioned to deliver innovations from start to finish. An event to highlight this year is the 20th anniversary of the California Partners for Advanced Transit and Highways. Since its inception, PATH has been a leading force in the development of ITS, and I am delighted to see an organization with which I have had so many ties over the years reach this milestone. Also on the radar scope is a series of bi-partisan infrastructure bonds for California, including nearly $20 billion for transportation, which will be on the ballot this fall. Passage of these bonds would provide an unprecedented opportunity to deploy technology to improve California's transportation system. Lastly, I am making it one of my priorities in the upcoming year to further institutionalize CCIT's mission and to encourage more participation from our private partners. While one needs to be realistic about the scope and nature of public-private partnerships, it is still evident to me that there are countless opportunities to realize. I look forward to welcoming private industry to join us at CCIT and collaborate with our state and local public partners.

I sincerely thank you for taking the time to read our 2006 annual report, and I look forward to our cooperation in the next year.

Dr. Hamed Benouar
CCIT Director

TESTIMONIES

Increasingly, governments are being held accountable for how they spend taxpayers' money and improve services to their constituents. The Division of Research and Innovation at Caltrans ought to be in the front line of this transformation toward more sensible business practices. Under my lead, the Division has started to become a more result-oriented organization that delivers products to customers. Our customers include all Caltrans practitioners, transportation planning and operating agencies statewide and, ultimately, the traveling public. In this new perspective, CCIT plays a crucial role by making our outstanding research walk the last mile needed to reach customers. They do it in large part by leveraging their growing network of private industry partners. Intensified public-private collaboration is going to be a key to our success in years to come, and I am confident that CCIT has the right team to take us there.

Larry Orcutt
Chief, Division of Research and Innovation
California Department of Transportation

The 2005 ITS World Congress in San Francisco was a stellar gathering and presentation of innovative, cutting-edge transportation technology. CCIT was instrumental in enabling a hearing on Intelligent Transportation Systems for the California Senate Transportation Committee, which offered an insightful examination of current and potential applications of technology to transportation challenges in California. The Committee was fortunate to receive the experience and perspective of some of the world's most recognized experts in transportation innovation and development. The demonstrations of developing vehicle and infrastructure technologies that followed the Senate hearing constituted the most exciting proof a policymaker could hope for.

Steve Schnaidt
President, Schnaidt & Associates
Former Staff Director Senate Transportation
and Housing Committee

CCIT is an invaluable resource to small technology start-ups looking to serve the transportation industry. From the early introductions to Caltrans practitioners, to the participation in the product requirements definition, to the rigorous and impartial performance evaluation of the product, we have found the team at CCIT to be extremely helpful at every stage of our company's development.

Amine Haoui
President & CEO, Sensys Networks Inc.

Being in charge of research and general studies in the field of people and goods transportation for the French Ministry of Transport, I know all too well that making the link between research results and operational needs is not something straightforward. Some crucial interrogations from the users can't find any answer in the academic world while researchers sometimes have difficulties being listened to by policymakers. CCIT is one of the rare places where those two worlds can talk to one another. In collaborating with CCIT, I have witnessed first-hand how not only researchers and decision makers, but also private industry, practitioners and even overseas professionals like me can sit at the same table to turn research projects into an operational reality.

No organization like CCIT exists in France but I believe that creating one should be seriously considered. CCIT's method, based on broadmindedness, dialogue, and the continuous improvement of research until it becomes a standard at-large, seems to hold much promise for developing sustainable transportation solutions.

Marie Villette
Chief, General Studies and Research
Sea and Land Transportation Directorate
French Ministry of Transport

CCIT plays a unique role in SANDAG's overall effort to enhance mobility in the San Diego region. The organization's focus on transitioning innovations into practice provides us with an important tool to address transportation issues. The complementarities between PATH and CCIT are particularly helpful to SANDAG when it comes to foreseeing and implementing new applications of Intelligent Transportation Systems in our region. CCIT is currently assisting us with the deployment of PeMS, training practitioners and adding functionalities to track arterial, transit and vehicle classification data. This will allow PeMS to be used for comprehensive performance monitoring and evaluation of our surface transportation network.

Jack Boda
Director of Mobility Management
Sand Diego Association of Government

CCIT PROGRAMS AND PROJECTS

Like last year, this annual report is comprised of a series of short descriptions of CCIT's most significant projects and achievements. It is organized into four sections corresponding to CCIT program areas.

Bringing about new products or promoting best practices from transportation research is by no means a linear and definite business. Our four program areas reflect the overall scope of our activity and structure our efforts. Individual projects usually span more than one area.

Research Deployment: This area consists in developing research results into available products and services. It is central to CCIT's mission and objectives. Read about it on page 5.

ITS Implementation: CCIT specializes in ITS technologies and this often means making direct contributions to existing systems or developing new ones. Projects in this area are described starting on page 8.

Technology Assessments: CCIT helps practitioners identify and select technological innovations and promising products. Such assessments entail both technical and business evaluations. Read more on page 11.

Support to Research and Innovation: In order to deploy innovations, facilitation and networking activities are just as important if not more as implementation and analytical capabilities. Discover CCIT's activities in this area on page 15.

In total, 18 projects and initiatives are described in this year's annual report.

Project	Page	Research Deployment	ITS Implementation	Technology Assessments	Support to Research
PeMS Deployment	5	primary			
ITS Decision Website	6	primary	additional		
Corridor Management Plan Demo	7	primary	additional	additional	additional
Systems Engineering Diffusion	7	primary			
Data from Probe Vehicles	8		primary	additional	
Displaying Travel Times on CMS	9	additional	primary	additional	
Statewide ITS Architecture	10	additional	primary		
Wireless Sensors Evaluation	11	additional		primary	
Innovative Corridors Initiative	11	additional	additional	primary	
Wi-Fi on Trains	12	additional		primary	
Communication Infrastructure	13			primary	
Hybrids on HOV Lanes	13			primary	
Homeland Security	14	additional		primary	
Travel Time Forum	15	additional			primary
Berkeley Highway Lab	16		additional	additional	primary
REDS	17				primary
ITS World Congress '05	17				primary
Partnerships and Networking	18	additional			primary

■ primary program area   ▨ additional program area

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RESEARCH DEPLOYMENT

This project area is quintessential to CCIT's mission. With sponsorship from Caltrans for the most part, we identify research projects that have a high potential for operational and/or commercial deployment. We then work with the researchers and industry partners to extract a finished product from the research results. Along the way, we clear intellectual property rights issues, examine the economic viability and the business models to enable it, identify commercial partners to develop products. Promoting and facilitating the adoption of such products by transportation practitioners is also part of this process.

PERFORMANCE MEASUREMENT SYSTEM (PEMS) PROMOTION

Since being launched over five years ago, the Freeway Performance Measurement System (PeMS) has evolved into a powerful freeway performance measurement tool for the California Department of Transportation (Caltrans), its partner agencies and the research community. PeMS is a web-based tool designed at UC Berkeley to host, process, retrieve and analyze road traffic condition information. PeMS receives data from California freeway traffic detectors, as well as incident-related data from the California Highway Patrol (CHP) and Caltrans accident data. The system has the ability to extract various performance measures from real-time and historic freeway detector data, including vehicle miles traveled, average daily traffic, level of service, and delay among others.

CCIT is currently leading two major initiatives towards a full operational deployment of PeMS. The first is the installation of computer and networking hardware allowing Caltrans to host its own copy of the software, which is nearly complete. The second is developing and implementing a focused training initiative to boost both the breadth and depth of PeMS usage among operations and planning personnel. An analysis of PeMS training needs was conducted among Caltrans planning and operations staff statewide in order to develop courses best suited to the Department's needs. The result has been twofold: first, the implementation of a variety of outreach methods to build awareness of PeMS from Executive Management to the staff level; second, delivery of a range of training courses to build PeMS expertise among Caltrans and partner agency staff. Information sessions and training courses are being held through the end of year, at which point an assessment will be made on how best to fulfill additional PeMS training needs.

The PeMS training being provided is introductory and practical, and is being presented in a perspective of continuity to augment existing methods. Adopting PeMS has already immensely improved the performance measurement capabilities of Caltrans. This will be increasingly important as Caltrans has committed itself to a system management approach to the highway system that has system monitoring and evaluation as its foundation. This will also bring additional focus on performance measurement to justify investment decisions. CCIT is supported in this effort by System Metrics Group, Berkeley Transportation Systems and CQ Consultants.
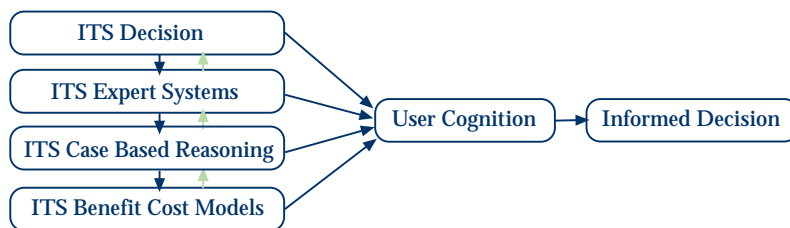
ITS DECISION WEBSITE
www.calccit.org/itsdecision/

The ITS Decision Website is a gateway to ITS. It offers a wealth of information, reports, and case studies that constitute a reference source for ITS technologies and services. This website was designed for a wide audience, and includes engineers, professionals, researchers, planners, decision makers, and the general public.

To facilitate professionals and decision makers to determine whether ITS technology is suitable to meet their specific transportation needs, a three-step decision tool has been developed. The decision process contains Expert Systems (ES) Modules, Case Based Reasoning (CBR) Modules, and Benefit-Cost Analysis Modules. ES extracts rules from published documents and domain expert interviews to develop knowledge bases for specific ITS applications. It is a high-level analysis on a given ITS technology's suitability for solving a particular transportation problem. CBR archives existing ITS implementations across the United States. It presents examples of previous implementations of the given ITS technology with a carefully calculated similarity score to the users' proposed application. CBR can help the users of the website to adapt old solutions to meet their new demands. The users can finally conduct a Benefit-Cost Analysis to assess whether the given technology is cost-effective.

Between 2005 and 2006, CCIT has developed a new standalone ES module for ramp metering installation. The project team is now working on integrating the system to the ITS Decision Website, and expanding the ES module to multiple ITS applications. The new design of the ES module utilizes a powerful ES inference engine, JESS, and will provide enhanced information to decision makers. Five CBR modules are currently available in the ITS Decision Website, and the project team is working on the extension to include five new applications. During the last year, the ITS Decision Website's searchable database has been extended, resulting in more than 1,000 records. The project team will continue to update contents of the website, including the searchable database and summary reports of ITS technologies.

The ITS Decision Website has attracted and will continue to attract world-wide attention, indicated by international Internet visitors and email inquiries from throughout the globe, including Europe, Asia, Australia, South America, and the United States. CCIT is excited about its role in managing and updating this valuable decision-making tool. CCIT plans to proactively continue updating and publicizing the website by making presentations and promptly responding to email inquiries.

CORRIDOR MANAGEMENT PLAN DEMONSTRATION

CCIT leads a project team that is developing a template for corridor system management in California. Its goals are to better define how the system is performing, as well as explore how to conduct more detailed evaluations of a wide variety of operational strategies. By combining more detailed multi-modal performance measurement and operational analysis into traditional corridor planning efforts, this project seeks to demonstrate new methods for corridor analysis. Infrastructure expansion, although still an important strategy, should not be the only strategy for addressing the mobility needs of Californians. System management is needed to get the most out of the current system and must be an important consideration.

The study will result in a template for the California Department of Transportation (Caltrans) to use in corridor planning efforts that will integrate both long-range planning activities and operational analysis. This will help to address the problem of lost system productivity during congestion, pointing the way toward improving mobility in the most cost-effective manner.

There are the three corridors being studied in this demonstration project. The first is the I-880 freeway corridor which is located east of San Francisco. It is a 37-mile long freeway corridor that serves the San Francisco-Oakland Bay Bridge, the Port of Oakland and Silicon Valley; included in its simulation are 163 actuated signals, 20 fixed-time signals, and 149 traffic-responsive ramp meters. The second is the SR-41 corridor network through the City of Fresno in California's Central Valley. This simulation study aims to reproduce real-world peak AM and PM congestion patterns in microscopic simulations, as well as evaluate short or medium term operational improvements based on the calibrated network. The third corridor is the I-5 corridor in Orange County, which is among the most congested in Southern California. Each of these studies use Paramics as the microsimulation model, which will be used to evaluate packages of improvement scenarios. All three studies are well underway.

Partners involved in this project include State, regional, local agencies with congestion management responsibilities within the three demonstration corridors. Researchers from the University of California (Berkeley and Irvine) are supported by System Metrics Group, Cambridge Systematics, Braidwood Associates, and the University of Minnesota.

SYSTEMS ENGINEERING DIFFUSION

The California Department of Transportation (Caltrans) is incorporating development of Intelligent Transportation Systems (ITS) into its planning, project development, and overall business policy. Federal rules that require that all federally funded ITS projects use a process of Systems Engineering analysis. While Caltrans has guidelines for a Systems Engineering approach to implementing both traditional and technology projects, such an approach is not uniformly understood across Caltrans and local transportation agencies. CCIT coordinated an evaluation of Caltrans' Systems Engineering approach, recommended refinements in its Systems Engineering guidance, and developed a Systems Engineering training course for Caltrans and local public agency staff. CCIT was supported in this undertaking by ASE Consulting and Ice Associates. The project has been completed and its recommendations under review by Caltrans' Executive Management. These recommendations include integration with Regional and Statewide ITS Architecture requirements, as well as coordination with UC Berkeley's Technology Transfer program to continue dissemination of this knowledge through additional training courses.

ITS IMPLEMENTATION

CCIT hires talented engineers and transportation researchers, who together combine outstanding knowledge of Intelligent Transportation Systems (ITS), as well as design and development capabilities. We can help our sponsors make the best use of their existing ITS infrastructure and recommend new investments. We also develop and deliver turn-key systems, leveraging our unique relationship with Caltrans to directly impact its daily operations.

COLLECTING DATA FROM PROBE VEHICLES

Caltrans' Highway Congestion Monitoring Program (HICOMP) is an on-going effort to measure freeway congestion. For this purpose, data is collected from almost 2,300 miles of California's most heavily traveled urban freeways. There are two methodologies for collecting HICOMP data. The most frequently used method utilizes floating cars, or probe vehicles, to sample traffic conditions. The other method is to collect traffic measurements directly from fixed traffic detectors. In 2001, Caltrans Districts 3, 4, 5, 6, 10, and 12 only used probe vehicles, District 7 only used loop detectors, and Districts 8 and 11 used a combination of both methods.

While it is generally agreed that the way of the future is to completely automate the data collection process through more comprehensive traffic detector coverage, this will take several years to complete under the best-case scenario. Therefore, despite obvious statistical shortcomings, the probe vehicle method will likely remain the prevalent means of data collection for HICOMP purposes in years to come.

Starting in the fall of 2004, CCIT was charged by Caltrans to investigate and deploy alternative technologies to improve HICOMP data collection and processing. Two main objectives of this Next-Generation HICOMP project were identified as follows:

- To replace relatively cumbersome and inflexible tachometer readers with a better-performing and cost-effective technology to collect speed profiles on board probe vehicles. To that end, GPS was immediately identified as the primary candidate.
- To streamline and standardize the post-processing of the data collected during probe runs, in particular by establishing a database as a common repository. The common repository could ultimately be outfitted with a set of on-line analysis tools.

The first year provided a comprehensive benchmark of GPS technologies and allowed the CCIT team to touch on the key issues that needed to be resolved in order to complete the project. After narrowing down data collection options to 7 GPS-based units, the team conducted a field test to finally retain 2 systems that are recommended for deployment. One of these systems is built upon an upgrade of the CONGEST data collection software which was implemented by the Translab team at Caltrans' Division of Engineering Services. This resulted in Caltrans Division of Traffic Operations purchasing 40 GPS receivers for early deployment in the districts.

The past year was geared towards the implementation of an end-to-end system, the main part of which is a database that can serve as a common repository and features a web-based user interface. This implementation work followed a system engineering process. As such, it consisted of the development of an operations document, the establishment of a list of system requirements, and the implementation of a prototype system.

The next step in this project is to field the prototype system to gather operational feedback. In parallel, an industry partner would be brought to the project to develop a full-fledged version of the system. Ideally, the front end of the data repository will be integrated to the PeMS user interface, so as to provide a one-stop shop for archived traffic data.

DISPLAYING TRAVEL TIMES ON CHANGEABLE MESSAGE SIGNS (CMS)

Real time traffic information on Changeable Message Signs (CMS) has gained popularity in urban areas where congestion and incidents frequently affect vehicle travel. CMS have been used to broadcast information about corridor downstream delays, traffic incidents and estimated travel times. Displaying accurate travel times on CMS helps commuters assess traffic, alleviates driver's stress, and allows drivers to make better route decisions. Knowing the driving times to popular destinations, travelers may be able to map their driving to the less congested route or chose a different form of transportation. Moreover, signs are the most effective means to communicate real-time, relevant information to motorists. Unlike a radio broadcast, signs target drivers passing a given location. Hence, the message is highly likely to be of interest to those drivers.

For the past two years, CCIT has helped Caltrans implement and deploy an automated system nicknamed MITTENS to display travel times on CMS. From May to October 2005, a pilot deployment on Interstate 80 in Emeryville and Berkeley tested the system on two signs. For this project, CCIT partnered with Caltrans District 4, Caltrans' Division of Research and Innovation, and the San Francisco Bay Area 511, which is operated by the Metropolitan Transportation Commission (MTC). Trials were conducted with either two or three destinations on each sign and led to a comprehensive evaluation of the system. The evaluation was broken down into the following three pieces:

- A pre-pilot evaluation found that MITTENS, based on 511 data, produced available, reliable information of satisfactory accuracy.

- A traffic impact study found that the continuous use of CMS to display travel information may have had a limited impact on driving speed. The study showed a possible speed reduction of three mph for one sign, and no significant slowdowns for the other sign. Anecdotal evidence suggests that slowdowns, if any, wear out over time, although this could not be established by the study.

- A survey of 953 Bay Area commuters determined that the public responded very positively to the system. Only 10% of the respondents rated it negatively with respect to usefulness and information accuracy.

Concurrently with the evaluation, the project was expanded to include a total of 19 signs. This expansion was completed days before the start of the 12th World Congress on Intelligent Transportation Systems, which took place in San Francisco in early November, 2005. The system has been operating in this configuration since then.

MITTENS relies on MTC's 511 for travel time predictions. These predictions are based on real-time traffic data collected by toll tag readers (FasTrak program), by Caltrans' embedded loop traffic detectors, and by speed radar data purchased from Speedinfo, Inc. Predictions are updated every minute and are reported on the signs accordingly. MITTENS also applies filters to the estimated travel time estimates, so that inaccurate data doesn't get reported on the signs. In the near future, CCIT is developing Graphical User Interfaces to enhance system interaction for Caltrans District staff. In time, Caltrans will autonomously operate and administer MITTENS. This will enable them to deploy MITTENS to the remainder of their CMS, which currently number about one hundred in the whole Bay Area. MITTENS will also be upgraded to allow deployment in other Caltrans districts, and to test alternative technologies and processing techniques to calculate travel times.

In parallel, CCIT is working with PATH on outlining requirements and best practices to display travel times on CMS. This work addresses several questions of importance to practitioners. One of the questions is to determine whether or not the amount and quality of traffic data collected on a freeway corridor is adequate to produce acceptable travel time estimates. Another fundamental issue is how commuters respond to the messages. Depending on how commuters change or don't change their travel behavior should influence the signs' location and their displayed information.

ITS ARCHITECTURE PLANNING

How to adopt transportation technology in a more coordinated fashion has been a central question in planning for Intelligent Transportation Systems (ITS) technologies. ITS technologies incorporate computing and communications technologies to improve transportation systems. When integrated into the transportation system's infrastructure, and in vehicles themselves, these technologies provide additional congestion relief, traveler safety and economic productivity.

The Statewide ITS Architecture and System Plan for California provides a blueprint for the development and application of ITS projects to systematically improve the operations of the state's surface transportation networks. However, many state and regional agencies do not yet incorporate ITS into project planning and coordination. A key focus area of this project is development of guidance for the California Department of Transportation (Caltrans) that clearly outlines how ITS fits into traditional transportation planning processes. The result will be a more recognized and uniform approach to planning for ITS within Caltrans and its partner agencies.

Another focus area of this effort is the identification of regional ITS projects with potential for added value when implemented in conjunction with adjacent regions and/or state-level projects. CCIT has identified these projects in order to demonstrate to regional agencies how to apply the California Statewide ITS Architecture and System Plan. One of the projects where CCIT will demonstrate this process of ITS architecture integration is through an effort in rural Northern California to improve center-to-center exchange of traffic management information among neighboring jurisdictions in Oregon, Nevada and the Central Valley. A second demonstration integration project will be assisting jurisdictions in and around the Ports of Los Angeles and Long Beach with high-level ITS planning as they develop a framework for the integration of ITS projects. The emphasis is on partnerships among public agencies for inter-regional project planning and coordination.

This effort directly supports the Caltrans Director's Policy on ITS, as well as a key Caltrans goal of partnering to achieve mobility goals. Stakeholders who will benefit from this project include multiple divisions and districts of Caltrans and several regional and local agencies. CCIT manages the overall project, working with the support of Kimley-Horn and Associates, Inc. and Caltrans Planning staff. CCIT is also making recommendations, analyzing data, and facilitating communication. In addition, CCIT is identifying potential industry partners to participate in ITS integration projects and providing forums for additional partnership opportunities.

PROJECTS

ITS Implementation

TECHNOLOGY ASSESSMENTS

Over the past five years, the ITS industry has been rife with new products and innovations. Keeping up with the multitude of opportunities and options available can stretch the Department of Transportation's resources beyond what is desirable. By cultivating industry relationships and constantly scrutinizing the market, CCIT can identify the most promising technologies and independently evaluate their performance. We act as a point of contact for many companies that wish to do business with Caltrans and our research partners, and we also develop our own prototypes to get first-hand experience with the latest technology trends.

WIRELESS SENSORS EVALUATION

CCIT has just completed the evaluation of a new generation of wireless traffic sensors that use micro-scale components (referred to as MEMS, or Micro Electro-Mechanical Systems). The vast majority of California's traffic sensors are inductive loops. Even though the technology is reliable and well-accepted by practitioners, it suffers several drawbacks. Loops are notoriously hard to install and fix, because doing so requires extensive lane closures and construction work. Loops can break in the pavement, generating either bad data or no data. In addition, erroneous data can be caused by errors in wire splicing.

The wireless sensors are manufactured by Sensys Networks of Berkeley. CCIT and Caltrans have installed twelve sensors across five freeway lanes at the Berkeley Highway Lab (BHL), a freeway testbed on Interstate-80 in Emeryville (see corresponding paragraph in this report). The evaluation was focused on the timeliness and reliability of the traffic data produced by the wireless sensors. The results showed that these sensors are comparable to loops in terms of data quality, and meet the requirements of traditional freeway applications such as counting and classifying vehicles, estimating congestion, and controlling ramp metering algorithms. The wireless sensors, because of their smaller footprints and their chip-based design, are a lot easier to install and maintain. The expectation is a significantly reduced life-cycle cost, which would enable more extensive traffic detection across the California freeway system.

For this evaluation, CCIT worked in coordination with Caltrans' Division of Traffic Operations as well as the new product group, and received strong and dedicated support from Caltrans District 4. By receiving an independent evaluation from CCIT, Caltrans can accelerate its product approval process without straining its internal resources. Thus, CCIT is enabling the adoption of new technology that can improve data collection and traffic control while saving the department millions.

As part of this study, CCIT also developed systematic metrics for measuring traffic sensor data quality with respect to accuracy, completeness, validity, and timeliness. Such metrics have been drafted in compliance with Federal Highway Administration guidelines on traffic data quality. Leveraging the BHL infrastructure, CCIT implemented an automated process to generate the data quality metrics irrespective of sensor type. The objective is to establish performance standards that can be used uniformly to further benchmark sensing technologies.

INNOVATIVE CORRIDORS INITIATIVE (ICI)

California's Innovative Corridors Initiative (ICI) is a multi-year project that seeks to accelerate the deployment of Intelligent Transportation Systems (ITS) technologies, products, and services through partnerships between public agencies and private industry. In 2003, CCIT and California Partners for Advanced Transit and Highways (PATH) assisted Caltrans and the San Francisco Bay Area Metropolitan Transportation Commission (MTC) to issue a Call for Submissions (CFS) to industry inviting proposals to test and illustrate traveler services that facilitate mobility, convenience, and traveler safety.

As a result of the CFS, Caltrans and MTC entered into the following public-private partnerships that provide access to data and/or rights-of-way in return for data and/or products designed to help the traveling public and transportation managers:

- Circumnav Networks Inc. and Caltrans for a Dynamic Route Advisory Navigation System.
- ENCOM Wireless Data Solutions and Caltrans for Seamless Wireless Integration for Traffic Applications.
- InfoTek Associates and Caltrans for Intelligent Loop Detector.
- NAVTEQ and Caltrans for Vehicle Infrastructure Cooperation Demonstration.
- NAVTEQ and MTC for a 511 Level Two Demonstration.
- Outreach and MTC for Bay Area Web Congestion Mapping and Traffic Forecasting.
- SpeedInfo and Caltrans for Speed Sensor Demonstration.
- Tele Atlas North America and MTC for TV511 Demonstration.

In 2005, each of these demonstration projects was deployed in conjunction with their agency partners. In addition, the Intelligent Transportation Society of America provided an opportunity for the participating industry partners to showcase their technology as part of the 2005 ITS World Congress in San Francisco, either as part of the Innovative Mobility Showcase or in the Exhibition Hall.

WI-FI ON TRAINS

Wireless Fidelity, commonly known as Wi-Fi, allows portable devices, like laptops, to connect to the Internet wirelessly. Wi-Fi on trains can improve train safety, security, and efficiency in addition to creating a more productive and pleasurable traveling environment. CCIT researched and analyzed potentially broad applications for improving train operations and security. This project is also supported by a grant from the department of Homeland Security to design a decision framework for train security, such as grade crossing and infrastructure security.

CCIT provided operation support for ongoing research and field operation tests of Wi-Fi on inter-city rail. CCIT looked at existing Wi-Fi deployments, both nationally and internationally, and based on those formulated business model plans. The technological development and solution options were assessed and researched for developing a decision framework for selecting wireless Internet access vendors on behalf of customers riding the three California State sponsored Intercity Rail services. In addition, CCIT held an expert panel to validate and improve the decision framework. Based on the input from the panel experts, CCIT is supporting the Capitol Corridor Joint Power Authority (CCJPA) to conduct a Request for Information (RFI) to enlist industry solution partners to conduct technical trials.
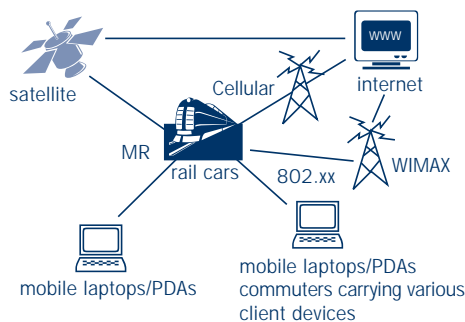
As shown in the diagram, laptops and Personal Digital Assistants (PDAs) work by accessing cell phone towers or satellites, WiFi access points and WiMAX trackside infrastructure.

Wi-Fi on trains will attract new rail riders, reduce congestion and pollution in the region, enhance regional rail system security, and increase productivity and efficiency.
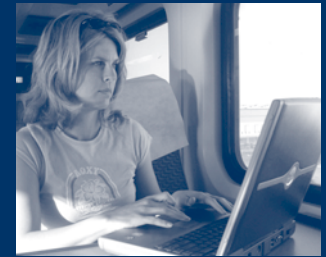
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EMERGING COMMUNICATION INFRASTRUCTURE

Caltrans invests significant resources in technology to help manage the State transportation system. These investments include ITS technology: ramp metering systems, loop detectors, closed circuit television cameras, weather stations, changeable message signs, etc. These devices must communicate with the Transportation Management Center (TMC) in their local areas. Each TMC needs to communicate with other TMCs as well and send data to a central repository. In addition, a communication network is also needed to control ITS tools and transmit data to the TMC and the archived database.

Currently, Caltrans relies on a communication system that is becoming outdated. CCIT is helping Caltrans create a long-term cohesive and efficient communications infrastructure. This planning and analysis will reduce costs and support new applications. To create a workable plan, CCIT performed these tasks: analyzed Caltrans' technological investments for their advantages and disadvantages; identified the requirement of Transportation Management System (TMS) such as business goals, applications, supported field elements and related requirements, operation environments and communication technology trends; identified the TMS communication requirements such as functional, performance and operational requirements; and formulated a cohesive communication network architecture including an urban and rural network architecture and network alternatives.

In the spring of 2006, CCIT held a statewide stakeholder meeting to refine the communication plan. It aimed to analyze existing as well as emerging technologies to find the best fit between costs, user functional requirements and reliability. CCIT is supported by Accelero Systems Inc. to perform this project.

IMPACT OF HYBRIDS ON HOV LANES

A recent state policy allows electric-hybrid vehicle drivers to apply for a permit to use High-Occupancy Vehicle (HOV) lanes, also known as carpool lanes. With hybrid vehicles being so popular, there is a risk that the HOV lanes will become too crowded, degrading their performance and limiting the incentive to carpool. In fact, the Federal Highway Administration is mandating that hybrids should not clutter HOV lanes past a set level. The mandate requires monitoring the speed and flow of traffic in HOV lanes. Such monitoring is typically performed by traffic sensors, usually inductive loop detectors. However, there are long stretches of HOV lanes on California freeways that are either not instrumented or instrumented with deficient loop detectors.

CCIT, with sponsorship from Caltrans, is assessing the current impact of hybrid vehicles on HOV lanes and devising optimal ways to fill the gaps in HOV lane monitoring. Emerging sensor technology is making it cheaper and faster to deploy traffic detectors than was possible with inductive loops. This project aims to demonstrate the use of such detectors for equipping HOV lanes statewide. As part of this effort, CCIT has recommended a pilot deployment of wireless sensors (see corresponding section in this report) in the Sacramento area. This pilot deployment complements our data quality assessment of the sensors with an investigation of their practicality and robustness in an operational context.

HOMELAND SECURITY PREPAREDNESS

Keep abreast of the latest transportation security technologies and best practices

California Center for Innovative Transportation (CCIT) of University of California, Berkeley, is helping the California Department of Transportation (Caltrans), to secure Caltrans transportation systems and improve Caltrans' preparedness and response to terrorist attacks.

A multi-pronged methodology is being used to keep Caltrans and other agencies abreast of the latest ITS technologies and best practices. We are combining a top-down approach (e.g., assessing Caltrans' unique security needs) with a bottom-up approach (e.g., surveying states' and institutions' state-of-the-art technologies) to help recommend security solutions tailored for Caltrans. In addition, we are establishing forums on transportation security technologies and best practices. These forums will allow participants to better share information, discuss the latest technologies, and refine best practices.

The following project tasks are aimed to address and improve Caltrans' security needs:

- Researching and assessing transportation security technologies and best practices.
- Setting up secured forums for transportation security officers to share their experiences with security technologies and to refine best practices.
- Assessing Caltrans' specific transportation security needs and synthesizing related security reports.

The knowledge gained from these tasks will be used to compliment each other, as shown in the below relationship-depicted diagram:

- The survey of security technology and best practices is used for developing the knowledge base.
- The knowledge base is used for interactive discussion in the security forums and can be used for assessing the vulnerability in the transportation systems.
- The knowledge gained in the security forums, and potentially in the vulnerability assessment, can be used to formulate mitigation plans and programs.
- The interactive security forums are used to improve Caltrans' security technology and best practices knowledge base.
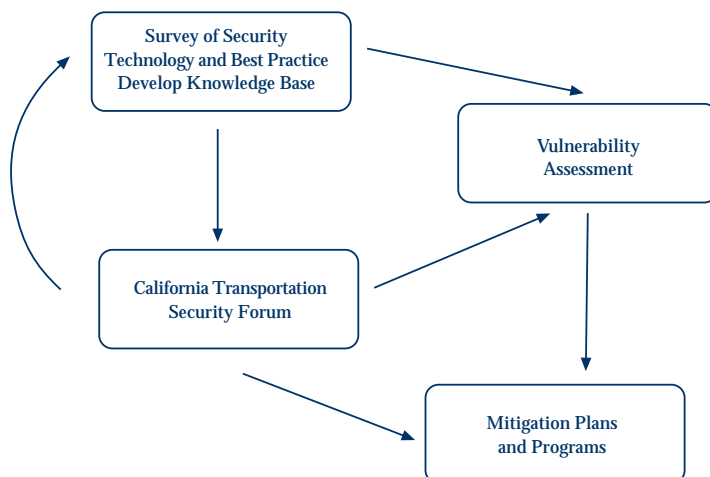
PROJECTS

Technology Assessments

SUPPORT TO RESEARCH AND INNOVATION

Although CCIT acts only in a supporting role in the early stages of research, we strive to facilitate the emergence of innovation in transportation. One way to do this is to promote exchanges between otherwise isolated communities working towards the same goals. Another key activity is the management of a traffic technology testbed made available to transportation researchers, where we offer state of the art monitoring and analysis tools.

STATEWIDE TRAVEL TIME FORUM

CCIT prepared and held an industry forum for public and private organizations to discuss the needs and the availability of ubiquitous, accurate travel time information. Travel times constitute an effective metric to describe level of service on roadways. It is an adequate indicator of congestion and is well understood by the traveling public.

Traditionally, traffic data is collected by sensors installed at fixed locations. While this yields good results to estimate traffic volume, travel time information based on this data can only be accurate if the sensor coverage is very dense. Traffic sensors are also expensive to install and maintain. Over the past few years, a number of private industry vendors have approached Caltrans with solutions to collect travel time data on highways and city arterials. Cell-phone based technology has been presented as a promising avenue, although research and field tests have not yet been conclusive.

Although travel times alone may not cover the full extent of the department's traffic data needs, accurate and reliable travel times could be used for both planning and operations purposes. Additionally, as the state's Department of Transportation, Caltrans is looking after the interests of the traveling public, the transportation industry, and the economy as a whole in California. Therefore, Caltrans will be instrumental in facilitating the collection and diffusion of travel time data if it is determined that there is significant demand from consumers and private business.

A larger market for traffic data has been envisioned by many, but has yet to materialize. Historically, traffic radio broadcasts have been delivered free to the public and paid for by advertising. For the most part, traffic information on the Internet is delivered following the same model, even though it provides users with better targeted information. Attempts to charge for even more personalized content have not met widespread commercial success. The emergence of new mediums to diffuse traffic information, such as in-vehicle telematics displays and GPS-equipped cell phones could bring about a shift in how travelers perceive and consume traffic information in years to come. In any case, new plausible business models for the commercialization of travel time information need to be spelled out.

In order to advance the questions posed by the availability of new technologies for both collection and diffusion of travel times, Caltrans mandated CCIT to set up an industry forum. The forum was a chance for state and local practitioners, transportation professionals and solution providers to collaboratively explore and shape opportunities.

The forum took place in San Diego on December 14, 2005. The event brought around 80 participants and was considered by all to be a great success, not only in addressing the topic, but also in bringing together such a diverse mix of practitioners. Issues that ran high at the forum included the ever-enduring question of data quality, the use of cell phones as probes, and discussions around preferred channels for distribution. Each of these subjects generated lively debates between the panelists and the audience, providing a sense of recent achievements and challenges ahead for the industry. However, what was truly remarkable and new about the event was the willingness shown by Caltrans and SANDAG to partner with the private sector to do more and better. This, we hope, can be materialized in the near future by maintaining an open dialogue.

MANAGEMENT OF THE BERKELEY HIGHWAY LABORATORY

The Berkeley Highway Laboratory (BHL) is a 2.7-mile section of Interstate 80 in Berkeley and Emeryville, California. It features 168 loop detectors providing 60Hz data, 8 birds-eye view video cameras perched 300 ft. above the ground, and 2 Changeable Message Signs. BHL equipment is funded by Caltrans and operated by CCIT.

BHL, together with the UC Irvine's Advanced Transportation Management Systems (ATMS) testbed, form the integrated California Testbed. Testbed facilities provide transportation researchers with the necessary infrastructure to conduct investigations in a real-traffic environment. Applications of BHL include micro-traffic studies, simulation calibration and validation, and field-testing of detection equipment or other hardware. Because of the amount of traffic information it makes available, BHL is also a good site for a variety of pilot projects.

CCIT's mission in managing BHL is to operate and maintain the equipment, facilitate and promote the use of the testbed by the transportation community, and make regular improvements by modernizing the equipment, developing traffic detection capabilities, and expanding the range of available applications.

Between 2005 and 2006, BHL hosted significant Caltrans projects as well as academic research. Some of the more practical applications included:

- A pilot project to display travel times on Changeable Message Signs. The Changeable Message Signs project is also featured in this Annual Report.
- The evaluation of a new traffic detector product based on MEMS technology and wireless networking, which was manufactured by Sensys Networks Inc. of Berkeley, California. CCIT's evaluation of the new wireless sensors is also featured in this Annual Report.

The following research made extensive use of BHL data:

- UC Berkeley student Ki Tae Jang used BHL video data to analyze the effect of a High-Occupancy Vehicle Lane on overall traffic conditions.
- PhD candidate Juan-Carlos Herrera, under supervision from UC Professor and ITS Director Samer Madanat, used extensive video footage from BHL to calibrate an Origin-Destination Matrix.

Additionally, data processed at BHL is requested on a more casual basis. Last year, a federally-funded project enabled the extraction of individual vehicles' digitized space-time coordinates from BHL video. The resulting data set has been downloaded by research units at General Motors and Toyota. Loop data is also used on a regular basis by worldwide researchers and industry partners.

Current improvements to BHL include an upgrade of the video capabilities and an overhauled website (http://bhl.its.berkeley.edu:9006/bhl/index.html). The new website integrates key information about BHL in addition to downloadable data sets. It also features real-time webcam views generated by BHL cameras.

The latest development effort at BHL is the setup of a WiMax network to backhaul field elements data. WiMax is a promising wireless communication standard for urban areas. WiMax, or a close cousin, may soon become attractive options for transportation public agencies to use to backhaul their ITS field elements data. CCIT is evaluating and deploying WiMax technology, with a double objective to demonstrate the potential to practitioners and to improve BHL operations.

PROJECTS

Support to Research and Innovation

RESEARCH EVALUATION DATABASE SYSTEM (REDS)

The Research Evaluation Database System (REDS) fulfills a critical need for Caltrans' Division of Research and Innovation (DRI). It is a simple user-friendly decision support system tool that allows Project Managers and researchers to identify the current state-of-research projects funded by the Department. By offering comprehensive data on projects, REDS helps DRI determine where its limited resources should be spent, thereby maximizing the state's return on investments.

The main modules of REDS include the following:

- Research Programs: This module contains individual topic hierarchy and information, such as Advanced Vehicle Control & Safety Systems, Testing & Demonstrations, Highway Infrastructure Systems, Transportation Management, Systems Planning & Engineering, and Highway Pavement Research.
- Project Search: This module keeps track of research projects and provides mapping from each project to its topic information, principal investigator and project managers. It also details project objectives, deliverables, and a technology transfer brief.
- Queries: Project information can be easily obtained by setting a sort criteria based on budget years, campuses, principal investigators and project managers.
- Global Search Option: This allows system-wide searches across subjects.

12TH WORLD CONGRESS ON INTELLIGENT TRANSPORTATION SYSTEMS, SAN FRANCISCO 2005

This past year, California was given the privilege to host the 12th World Congress on Intelligent Transportation Systems (ITS). Organized by the Intelligent Transportation Society of America (ITSA), the event took place in San Francisco, November 7-10, 2005.

The ITS World Congress brings practitioners from all continents to share progress and perspectives in the application of technologies to better manage and operate roadways and public transit. This year, the traditional format, which comprises an exhibition floor and hundreds of technical and executive sessions, received two notable additions to which CCIT staff significantly contributed. The first one was the Innovative Mobility Showcase (IMS), undoubtedly the largest assembly of ITS demonstrations ever produced. The second one was a special hearing session of the California Senate Transportation Committee to shed light on how ITS can save lives and relieve congestion in California, both in the near and distant future.

PARTNERSHIPS AND NETWORKING

A key role of CCIT is to facilitate the exchange of information within the transportation community, thus enabling the diffusion of innovations between laboratories, practitioners, private industry and policy makers. In this capacity, CCIT hosts multiple meetings every year, and our network extends beyond California, both nationally and internationally.
In the year 2005-2006 alone, CCIT welcomed delegations from the Korean Institute of Construction Technology, from Beijing University and the Chinese Ministry of Transports, and from Vietnamese officials. Executives from the Japan Central Railway company were invited to share results of a year-long exchange during which Mr. Kazuhiro Yamada, a company engineer, worked as part of the CCIT staff. Several meetings with Finnish researchers and technology transfer experts took place at CCIT.

These international visits are in addition to regular meetings with California-based public agencies and private companies, as well as federal officials. In the past year, CCIT received Dr. Kaveeshwar, who was recently appointed the first administrator of the Research and Innovative Technology Administration (RITA), a newly created agency within the U.S. Department of Transportation (DOT). Staffers from the Transportation Research Board also came to appreciate the unique mission of CCIT as a deployment-focused organization.

Undoubtedly the most successful partnership of the past few years is an offshoot of the long-standing relationship between UC Berkeley transportation researchers and French researchers at INRETS and other organizations. Recently, the so-called CalFrance collaboration was carried on by CCIT and ARIEL (Association for Research with Industrial and Educational Links), with grants from the French and California DOTs. That collaboration comprised two components:

- Yearly seminars for DOT officials and researchers from both countries, with alternate hosts.
- A joint project was selected from an initial short list. That project involved both the Capital Corridor Joint Project Authority and French rail operator SNCF, and consisted in the assessment and initial deployment of internet service to passengers.

Two seminars were organized in the past year, the first one in France in September, 2005, and the second one in California in July, 2006. Both seminars were week-long visits during which perspectives and on-going initiatives were presented extensively in meetings with researchers, DOT practitioners and local companies. Following the latest visit, CCIT is working with both Caltrans and the French DOT to perpetuate the CalFrance partnership and set a mechanism for additional joint projects in areas ranging from traffic operations and ITS to infrastructure security and public policy.

PROJECTS

Support to Research and Innovation

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