SPRING 1999

ITS UNIVERSITY OF CALIFORNIA
Institute of Transportation Studies
Technology Transfer Program

Tech Transfer

Technology Transfer for Local Transportation Agencies

Y2K Is Coming Down the Road

California transportation practitioners share some experiences and pass on tips for navigating into the new millennium.

By Phyllis Orrick

When the calendar rolls over to the year 2000 (also known as Y2K), computers may malfunction as they grapple with the first double-zero year of the electronic era. In transportation — as in most other fields — there seem to be as many ideas about how to confront this challenge as there are potential problems. However, a total collapse of major systems is not likely, because most vital functions tend to be carried out on the newest computers, which generally have been built and programmed in such a way that they will not have Y2K problems. Nothing about Y2K, however, is completely guaranteed.

With the turnover to Y2K fast approaching, Y2K experts are emphasizing the need to develop contingency plans, starting with an agency's most vital missions. Interviews conducted with transportation professionals around California provide some insights into how to approach this and other Y2K issues. They are presented here only as a guide. Every system is different, and nothing in this article should be construed as proven advice for any situation. A willingness to try different approaches may be one of the best ways to start.

Some snowplow operators will top off their tanks before Jan. 1, 2000.

For California's larger transportation agencies, such as the California Department of Transportation (Caltrans), Bay Area Rapid Transit (BART) and the public works and traffic departments of the more populous cities and counties, the coming of Y2K has led to extensive inventories of computer software and hardware. Based on the findings, some systems have been "remediated," as Y2K repairs are called, others scrapped

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Technology Transfer Program (TTP) is a unit of the Institute of Transportation Studies at the University of California, Berkeley. Its mission is to support the development and implementation of advanced transportation systems by facilitating exchanges of information between research and practice and by providing a program of professional training and technical assistance in the areas of traffic operation; infrastructure maintenance; transportation planning and management; airport operations, planning and management; and traffic safety. The TechTransfer offices are located at the University of California, Berkeley, Richmond Field Station, 1355 S. 46th St., Richmond, CA 94804-4603. (510) 231-9590. The Web site is located at <www.its.berkeley.edu/techtransfer>.

Linda Howe Ph.D., AICP, *Director, Technology Transfer Program*
Natalie Fay, MA, *Associate Director*

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Catherine Cortelyou, Associate Director
412 McLaughlin Hall, University of California, Berkeley, CA 94720-1720
Tel: (510) 642-3604; Fax: (510) 642-9180
e-mail: itslib@uclink4.berkeley.edu

Tech Transfer is published quarterly and mailed to 11,000 readers in California and the United States with funds from the Local Technical Assistance Program (LTAP). California's LTAP center is part of a nationwide network of centers established by the Federal Highway Administration (FHWA) in cooperation with state transportation agencies. The FHWA LTAP is under the State and Local Programs Branch of the Office of Technology Applications. California's LTAP is funded with support from the California Department of Transportation and is administered by the University of California, Institute of Transportation Studies, Technology Transfer Program. If you reprint one of our articles, please send us a copy.

Donna Reid, *Newsletter Editor*
Phyllis Orrick, *Contributing Editor*
Betsy Wing, *Contributing Editor*

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Central California
Les Jorgensen
2697 W. Dovewood
Fresno, CA 93711
(209) 435-2437
itsltap@aol.com

Far Northern California
Don Raffaelli
3433 Trinity St.
Eureka, CA 95501
(707) 443-5485
DRaffelli@aol.com

Southern California
Dave Royer
23933 Via Aranda
Santa Clarita, CA 91355
(661) 255-6556 (phone)
(661) 255-6156 (fax)
droyerpe@earthlink.net

Asphalt (Statewide)
Larry Santucci
1355 S. 46th St., RFS 452
Richmond, CA 94804-4603
(510) 231-9428 (phone)
(510) 231-9589 (fax)
ohotsky@uclink.berkeley.edu

Letter from the Editor

Nobody knows for sure what will happen to our interdependent computer systems when midnight rolls around on December 31. Meanwhile, transportation agencies around the globe are trying to make sure that our systems will be functioning. We report here on some of these efforts in California and what you can do if you feel more action is necessary. Surf City lists important Web sites to visit for more information. If your agency is still trying to get a firm grasp on the problem, I'd like to recommend our June workshop for local agencies which will provide vendor information and guidance on contingency planning. (See page 8.)

Bill Kane describes automated landslide warning systems, a new technology which is being adopted for the first time, right here in California. The story of how it came to be applied to transportation is a true piece of technology transfer history. Then, David Royer takes us on a guided visual tour of that old familiar highway fixture — the guardrail — but with some exciting new improvements.

Of the many programs that address the problem of teenage drinking and driving, perhaps none has achieved more shock value than "Every 15 Minutes," developed by the Department of Alcoholic Beverage Control of California. This program, which is being implemented by communities around the state, is featured on page 12. And if you are a fan of *The Simpsons*, you'll know that "road rage" is all the rage. Our Bibliography page looks at some recent works on this subject.

While the Y2K problem has us focused on the clock, we pause to note some milestones here at ITS. Though we were saddened to hear that our founder and first Director, Harmer Davis, passed away in December, in January we were delighted that Marty Wachs was officially appointed as Director of ITS Berkeley. You may have heard him speak at our annual symposium and share our certainty that Marty's vision, intelligence and humanitarianism will bring ITS to a new level of scholarship and education.

Finally, as winter melts away, we are happy to include a primer on potholes for decision-makers. Happy pothole hunting!

Y2K Is Coming Down the Road

(Continued from the cover)

or replaced. The Federal Highway Administration (FHWA), which has an extensive Y2K program, is emphasizing the need for smaller and rural agencies, which may not be as well prepared, to take steps to ready themselves.

Under a 1997 Executive Order, the California Department of Information Technology (DOIT) established the California 2000 Project, whose programs include a Web page that acts as an Internet clearinghouse for information about Y2K problem-solving developed by DOIT and others. (DOIT's URL and others referred to in this article appear in "Surf City" on page 9.) DOIT also runs the California 2000 Hot Line (916-445-5900). Among its publications (all downloadable from the Web site) is the *Desktop Systems Program Guide*, which deals specifically with desktop computers and applications (as opposed to mainframe systems or embedded chip systems).

As the *Guide* explains, it may at first appear that only computers that perform date and time functions have the potential to go awry, but in actuality most PCs rely on a date function embedded in the Basic Input/Output System (BIOS), which is part of the operating system and thus controls how the hardware deals with all software applications. To ensure that no glitches will occur, someone must actually read and, if need be, correct all of the thousands of lines of code that tell the computer what to do – a highly detailed and long operation.

The problem is caused by the fact that, in the early days of computer design, programmers decided to save space in computers' memory by eliminating the first two digits of the year — so that instead of showing "1948," for example, they could just use the last two digits ("48" or "YY"). With the start of the year 2000, the first two digits of the year change from 19 to 20, which means computers could be confused. They could interpret the year 2000 as 1900. If the embedded code needs to make reference to the date for sorting, storing, retrieving information or performing operations, which is known as being "date-aware," the computer could send error messages everywhere or even shut down. Generally, one can expect older PCs, including many 386 and 486 models, and even some Pentiums, to interpret the year 2000 as 1900 and possibly respond by shutting down or malfunctioning.

Photographs by Gerald Stone, PATH

A San Francisco police officer directs cars while a traffic signal is out of service; Los Angeles' Y2K contingency plan includes assigning traffic officers to high priority intersections if Y2K glitches at outside power vendors cause the lights to go dark.

Date-aware programs have been found in Transportation Management Centers (TMCs), train control systems, train destination signs, ramp metering software, traffic signal controllers, bridge inspection management programs, traffic control device inventory programs, truck and car onboard diagnostic systems, repair shop diagnostic systems, freeway video monitors and atmospheric monitors. The problem is especially prevalent with custom proprietary software, older (mostly pre-1985) mainframe computers, networked PCs and spreadsheet programs. This is not an exhaustive list by any means, and the date-awareness of these systems may not materially affect their ability to function. For instance, the systems controlling ramp meters, bridge inspections, video monitors and atmospheric sensors are all expected to carry out their primary functions with only minor aberrations, like putting the wrong date into a log or on a screen display. It's hard, however, to be certain.

Interestingly, there may be ways to trick some systems into avoiding the issue, at least for a while. Some computer systems can be told that it is 1972 (a year with the same day-of-the-week, date and leap year configuration — another element of the Year 2000 problem). If the actual date isn't important, the programs will perform their tasks correctly in a virtual time warp.

Telling the computer it is a different date is a trick that can also be used to test a system to see what will happen. However, following this routine can produce surprises. When an agency in New York City ran a test of its trucks using Jan. 1, 2000 as the date, some would not start — presumably because the diagnostic chips embedded in their engines became confused.

Caltrans started a full-fledged Y2K effort in 1996. John McMillan, Caltrans' Year 2000 Project Manager, estimates that remediation will be nearly complete by June 30, 1999. DOIT's *Desktop Systems Program Guide* presents Caltrans' experience in a "Lessons Learned" section.

For example, a Caltrans inventory of its internal systems found 5,636 networked desktop computers using 684 software packages. That added up to 95,197 different hardware and software components to check for Y2K compliance, including desktop ma-

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Automated Landslide Warning Systems

New technology using cable testers shows promise.

By William F. Kane

California Department of Transportation (Caltrans) engineering geologists and geotechnical engineers are employing a new technology, time domain reflectometry (TDR), to monitor unstable slopes next to California's state highways. This technology can also be used to monitor city and county roads. TDR uses a principle much like radar to find and measure locations of ground rupture and movement in a slope or hillside. Because the technology that is employed collects, stores and transmits information digitally, TDR can be used with hard-wired or cellular telephones, or even satellites, to monitor slope movement hundreds of miles away. It is a technology adapted from the mining industry where concern for collapsing mine roofs is an enduring problem. It has also long been used in the communications industry to find faulted cables.

A solar-powered remote monitor on I-15 in Corona

After working as a consultant for the Bureau of Mines in Minnesota, I collaborated with Caltrans engineering geologist Tim Beck on developing the application of TDR for landslide monitoring. Beck realized that TDR could readily be adapted to landslides. We brainstormed the new application in a typical California mode — on our surfboards in the Pacific. We first tested TDR in December of 1994 to learn if, and where, movement was occurring along Last Chance grade in Del Norte County on Highway 101. It worked, marking the first successful geological application of TDR technology in the United States.

Landslides occur when the effects of gravity overcome any resisting strength in a soil or rock slope. They can be induced by saturation from rainfall, which increases the weight of the slope or decreases the strength of the strata. Failure can also occur where supportive material at the slope base has been removed by cutting a road or through natural erosion. Many slopes along California highways have been moving for years and are constant maintenance problems. To repair and stabilize a slide, engineers must know how deeply the movement is rooted.

In TDR, a specialized device, or cable tester, generates an electrical pulse that travels along a coaxial cable embedded vertically in a slope. If the pulse encounters a crimp or break in the cable, some of the electrical energy is reflected back to the cable tester. The tester measures the time it takes for the pulse to travel to the source and reflect back by multiplying the travel time by pulse velocity in the wire (approximately the speed of sound) and calculates the depth where the damage occurred. As movement of the slope continues to deform the cable, the amount of reflected energy increases. In this way, engineers can monitor the rate of movement to determine the stability of the land and estimate when and how the slide will be repaired. Motorists could be alerted to a hazardous condition on the roadway using this technology, although this application has yet to be made.

Remote Monitoring Possible

Because the sensor itself is stationary (and does not require manual movement as in conventional slope maintenance technology), and the data output is digitized, TDR lends itself to remote monitoring. This is particularly important in states like California where major highways cut through remote mountainous areas, and where heavily faulted and broken strata can prove hazardous to explore by vehicle or on foot.

Caltrans geologist Tim Beck checks a site.

Beck has worked with personnel from KANE GeoTech, Inc., Stockton, to set up remote monitoring stations along I-5 on the Grapevine Grade and I-15 near Corona. The remote stations employ a cable tester coupled with a datalogger and cellular phone equipment. The datalogger is a small computer/voltmeter with CPU and memory that can be programmed for a variety of tasks. Power is supplied by a lead/acid marine battery charged by a solar panel. Along I-15, the datalogger was also programmed to turn on and measure the water levels in the slope by reading devices known as vibrating wire piezometers. This was done at 8:00 a.m. every morning. At 8:05 a.m. the machine turned on the cable tester and read the status of two coaxial cables, each embedded 170 ft. (52 m.) deep in the slope. All data were stored in the datalogger memory. At 9:00 a.m. the datalogger turned on a cellular phone. At 9:05 a.m., a computer in Beck's office in Sacramento automatically called the monitoring station and received the data from the datalogger. It was left to Beck to plot the data

and compare it with previous readings to determine if water levels in the slope had increased significantly or if the slope had moved.

The El Niño storms of January and February 1998 caused many slides and road closures all over the state, but particularly in District 5. Highway 25 in San Benito County, for example, was wiped out when Tres Piños Creek surged over its banks and eroded the highway embankment. To make matters worse, this triggered a huge landslide that took out an even larger portion of the highway. Worker safety was a considerable concern during the cleanup and repair phase. Caltrans District 5, San Luis Obispo, under the leadership of geotechnical engineer Ron Richman, embarked on an ambitious program of installing TDR in nearly all its known landslides. District 5 includes the mountainous areas of Monterey, San Benito and San Luis Obispo Counties. As a result, District 5 engineering geologists John Duffy and Wade Hoon helped to develop a portable and reusable alarm system that would use TDR to warn workers of an impending movement during reconstruction.

Highway 1 a War Zone

During January and February 1998, Highway 1 along the Big Sur Coast resembled a war zone more than a stunningly beautiful coastal area. Residents were evacuated by helicopter as landslides either blocked or destroyed the road entirely. Sections of the highway were closed for several months as District 5 engineers and geologists worked with construction crews at a furious pace to repair the damaged highway.

At one location, a system was installed to monitor post-construction movement. It included a datalogger and TDR with a small device known as an electrolytic inclinometer to warn of any slope movement. In this case, a signal from the inclinometer triggered a phone call to Caltrans' pagers. But it could also be relayed to phone, pager or computer at either the local district office, Caltrans headquarters in Sacramento or even

Out of concern for the safety of workers cleaning up landslides after the storms of January and February 1998, Caltrans District 5, San Luis Obispo, installed TDR in nearly all its known landslide sites.

a field technician's pager. Personnel then could go out and read the 200-ft. (61-m.) deep coaxial cable to check for sliding. In June, the first signal that movement may have occurred was sent out. The TDR cable was read and showed a slight movement just below the surface. Fortunately, this event did not result in deep-seated movement, which would be a safety concern.

Conventional practice in slope monitoring uses a probe lowered manually down a borehole into the potential slide area. Establishing a monitor location in a highway using a probe requires lane closures and traffic control. Depending on how deep the hole must be, the process itself may take well more than an hour. With TDR, the cable is run off to the side of the highway, where a technician can take readings from a safe distance. No lane closures are necessary, and personnel do not have to be near moving vehicles or stand on the slope. In addition, reading a TDR cable requires no more than five minutes, no matter how deeply the cable is embedded. It can be installed anywhere, and data can be directed anywhere. The basic application of a remote-monitoring system costs about $20,000 including monitor, cable and CPU.

Tracking Soil Moisture and Scour

TDR technology can also be used to monitor soil moisture content beneath pavements since the electrical properties of soil vary with its moisture content. Caltrans is currently experimenting with TDR to monitor bridge foundation scour. Another possible application is to embed cables in structural members such as reinforced concrete columns to measure their stability. The structural integrity of a column after an earthquake could be immediately examined by using a cable tester to detect if the cable within the column is damaged. This has not yet been tested in California.

The ease and accuracy of TDR technology and the cost savings over conventional inclinometer probe technology make it a good choice for monitoring highway ground movements. The success of TDR is due to its ease of operation, resulting in time savings and the ability to conduct remote sensing through a variety of applications. TDR can help improve both worker safety and traveler convenience.

Dr. William F. Kane has developed a new course on Automated Landslide Warnings for TechTransfer. He received his Ph.D. degree in Civil Engineering from Virginia Tech, and he is President of KANE GeoTech, Inc., in Stockton, CA. He teaches at the University of the Pacific, Stockton.

For more information, contact William F. Kane at KANE GeoTech Inc. in Stockton at (209) 472-1822 , or visit him on the Web at <www.kanegeotech.com>.

For those who want to learn more about this new technology, ITS – TechTransfer is presenting a class taught by William F. Kane:

Automated Landslide Warning Systems
May 12-13, 1999
UC Riverside Campus

Call TechTransfer at (510) 231-9590, or visit our Web site <www.its.berkeley.edu/techtransfer> for more details.

Y2K Is Coming Down the Road

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chines, operating systems, network operating systems, commercial-off-the-shelf software and custom applications. To examine these systems for errors, an automated login script was run on every PC every day. "Some individuals were suspicious ... that 'big brother' was watching ... and may [have been] actually examining more than advertised," the *Guide* notes. Employee complaints were so numerous that the inventory process was repeatedly delayed. Simply executing the script caused under-powered or badly-configured systems to run short of memory, and technicians were forced to make case-by-case fixes. They also had to over-ride the inventory program on occasions when users claimed it was interfering with their work. The DOIT report concluded that personnel issues were as much a factor as purely technical ones.

A Y2K Audit's Unintended Benefits

Despite those difficulties, Caltrans notes, the auditing system proved a powerful, valuable tool, not just in finding Y2K conflicts, but in identifying components of its massive computer inventory. One notable benefit was creating a more rational organization of Caltrans' Novell network.

Once Caltrans started finding Y2K problems in particular software products, it contacted the vendors who had supplied them. DOIT maintains a partial list of major manufacturers who post Y2K information, along with a disclaimer that "what each manufacturer means by Y2K compliance may be inconsistent."

Like many agencies, Caltrans has adopted what is known as "windowing" to work around the year 2000 glitch for systems that are heavily reliant on the old two-digit, YY, format for noting years. To do this, programmers agree on some "pivot year," usually the date of the oldest data in the database. Then a code is written to search for every item whose YY is the same as that year or higher and put a "19" in front of the two YY digits. For example, if the pivot year was 1955 (YY=55), all data in the year "55" and higher would be dated 1955, 1956 and so on. Data created in years whose YYs were lower than 55 would have a 20 put before them. YY 54 would then automatically become 2054 and so on all the way down to 00, which becomes 2000.

"Fortunately, New Year's Day comes on a weekend, so we won't have a rush hour," says Anson Nordby, Los Angeles traffic chief. To prevent immediate shortages of gas and diesel, Nordby plans to stockpile some.

This solution is good only for a century after the pivot year. In this example, the problem would reappear in 2055. However, the pivot year can be changed as needed, so the day of reckoning could be postponed indefinitely. And it's extremely likely that by 2055 the original application would have been replaced.

Backups for Caltrans TMCs

Caltrans' TMCs (Transportation Management Centers) were vulnerable to Y2K malfunctions. However, when the District 7 (Los Angeles) TMC completely upgraded its software in 1998, all suspect programs were replaced with new programs that vendors or staff certified as Y2K-compliant. Caltrans is looking to port this system over to the other Districts' and Regions' TMCs so that they can integrate it and be Y2K compliant, explains Frank Quon, District Division Chief of Operations in Los Angeles, who oversees the management and operation of approximately 1,100 miles of state highway system in Los Angeles and Ventura Counties. The way TMCs are structured, he says, regional centers such as District 7, District 4 (San Francisco) and District 3 (Sacramento/Marysville) would have the potential to serve as a backup to their respective regions. "Overall, we do not anticipate any Y2K problems in our TMC operations," he says.

The City of Los Angeles, with its vast freeway and surface street network, has been analyzing its vulnerability to Y2K for several years. It, too, found problems in the TMC. They are being fixed, according to Anson Nordby, Principal Transportation Engineer in charge of the Bureau of Traffic Operations for the city's Department of Transportation.

Problems in Analog Controllers

For instance, a Y2K survey turned up potential problems in about 600 older, analog models of the conflict monitors used in 4,300 Model 170 traffic signal controllers. The controllers with those conflict monitors might have to be restarted manually from flashing operation if the power is disrupted. Because power blackouts are a possible side effect of the Y2K problem generally, the city stepped up what had been a gradual program to replace its older Model 170 controllers with new Model 170 or 2070 controllers, which can be restarted remotely if necessary.

Nordby has also developed contingency plans for possible loss of phone and radio communications, which could have problems after Jan. 1. (The city has its own radio system, but relies on outside vendors for phone service.) The plan gives staff people locations where they are to gather for work assignments if they can't contact each other. Others can use telephone sets that can be plugged into traffic controller cabinets in the field; these are linked directly to the TMC through the signal system communications network, which has an off-the-grid power supply.

Nordby is installing uninterruptable power sources (batteries and generators) at his communications hubs, so the automated monitoring of the signal system by the Automated Traffic Surveillance And Control (ATSAC) operations center will continue in the event of regional power failures and alert operators of traffic signal failures.

If intersections do go dark, city staff will be sent out to direct traffic according to a prioritized list of locations. "Fortunately, New Year's Day comes on a weekend, so

we won't have a rush hour," Nordby says. He is thinking long-term as well. If gas stations aren't able to process the credit cards many of the fleet drivers use, and if suppliers can't process orders to fill the tanks at the depots, the city may not be able to buy gas and diesel fuel. To prevent immediate shortages, Nordby plans to stockpile some fuel.

Doug Acker, who coordinates traffic signals and software for Los Angeles County, expects the 1,400 traffic signals he's responsible for will function properly. Gary Duncan, chairman of the Technical Oversight Committee of the Traffic Management Systems and Associated Control Devices Section of the National Electrical Manufacturers Association (NEMA) and an executive with Econolite Control Products, Inc. (one of the largest manufacturers of traffic control equipment and systems in the country and a major supplier in California), says NEMA's own informal survey showed most members' products had no major problems.

Traffic Signals Sail Through

At the worst, according to Duncan, the date on a display might be off — but this wouldn't affect traffic at an actual intersection. In one case, Duncan said, an event logged onto a controller on 01/01/00 displayed a date of 01/01 with no year. In another instance, it showed 190 instead of 00. For one of his compliance tests, Acker set some of L.A. County's signals to the potentially problematic dates that Caltrans had suggested could be used to test for Y2K readiness and ran the signals through their cycles.

All signals passed the test, because most don't need to know the actual date. Signals run on a seven-day plan and are programmed to "know" only that Monday follows Sunday, no matter what the numerical date may be — and no matter what the year. Now, however, Acker is worried about Y2K compliance by neighboring jurisdictions with whom he shares the responsibility for some roads. If one agency's equipment malfunctions, disruptions could be felt in another. All of Acker's partners have assured him that they are Y2K-compliant.

BART began preparing for Y2K eight years ago, says Dave Warwick, Group Manager of Systems Engineering. At that time it launched a complete changeover from one programming environment to another, in the process upgrading to Y2K-compliant systems. During this work, which was extensive, a date/time module from a piece of the old system was inadvertently carried into the new architecture. The problem went unnoticed for years until the system underwent performance testing in 1998. If it hadn't been found and fixed, Warwick said, communications would have malfunctioned on Jan. 1, 2000. But it was fixed, and BART is relatively certain that trains will run on New Year's Day.

The newer train destination signs on BART station platforms have been another source of Y2K problems. They are, in effect, PCs, according to Warwick, and their software is not Y2K-compliant. The vendor agreed to replace the faulty parts, free of charge. "Our position is that they should have known," Warwick says. In general, all vendors should be contacted to assure that their products are compliant. Many now have Web sites with Y2K product information.

As an extra precaution, BART will stop all trains in a station precisely at midnight, Dec. 31, 1999. That way, if some problem does appear, the system can be shut down and reinitialized seconds into 2000 without having to strand passengers in tubes or on tracks. If the reboot fails, Warwick says, the year can be set temporarily to 1972 on the machine that runs train operations, but he doubts that step will be necessary. Testing of Y2K remediation starts in April and should be completed by early June.

BART found Y2K problems in some of its newer platform destination signs, which are essentially PCs; the vendor replaced them free of charge. Although BART has conducted a thorough remediation program for its computer systems, as a precaution, every BART train in service will be stopped in a station at midnight Dec. 31, 1999.

Robin Cody, Department Manager of Information Technology for BART, handles computer systems for everything but the trains, as he puts it. He participated in a Y2K conference for transit authorities in January, 1999, in large part because the Federal Transit Administration (FTA) has said that all transit agencies must demonstrate Y2K compliance by June of 1999 or risk losing FTA funding.

As of January 1999, though, Cody said it was still difficult to get firm answers from vendors and power suppliers on Y2K issues. Cody is particularly concerned about embedded chips, pieces of software that are built into the hardware. Not only can problems show up in unexpected places, but they make certifying Y2K compliance difficult. "You can test a date-sensitive chip three different ways and come up with different answers," he says. "The only way to have

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confidence in a result is that it becomes repeatable." Cody recommends and welcomes independent reviews to validate results and testing methodologies.

In the case of BART, having contingency plans for systems and applications is only part of the preparedness picture. He has established a clear chain of command through an Emergency Operating Center (EOC). Cody has canceled leaves and vacations close to the end of the year to ensure things go smoothly and to monitor computers, systems and applications during the turnover.

FHWA's Expedited Aid

From this survey of California transportation agencies, it appears that no jurisdiction can simply assume that its transportation facilities are Y2K-compliant. Even if a neighboring jurisdiction using software from the same vendor is free of problems, advises Joel Markowitz, the information systems coordinator for the Metropolitan Transportation Commission (MTC), an agency can't be sure that everything is fine. Software is continuously being revised, and new versions have alterations that can be hard to detect.

According to an FHWA memo sent out Sept. 29, 1998, "Federal-aid highway funds may be used for Y2K fixes either as a direct cost through a Federal-aid project or as an indirect cost built into the State's indirect cost rate."

Markowitz is currently surveying MTC members on their Y2K compliance. Responses weren't compiled at the time this article was written. The FHWA, he points out, has made Y2K compliance a top priority.

The FHWA's outreach worker for Y2K programs is John Mc Cracken, a transportation engineer based at FHWA headquarters in Washington. Funding for Y2K compliance projects will be expedited, he says, but agencies still must apply through the standard channels.

According to an FHWA memo sent out Sept. 29, 1998, "Federal-aid highway funds may be used for Y2K fixes either as a direct cost through a Federal-aid project or as an indirect cost built into the State's indirect cost rate." Mc Cracken recommends interested parties contact their local FHWA division offices.

He has been running workshops on Y2K preparedness around the country. TechTransfer will be running one with the FHWA on June 9 at Richmond Field Station. (See below for details.) "Obviously time is short," he said in late January. "We're looking to provide guidance and bring local government people together to share their experiences, with a focus probably on contingency planning. We are stressing that Y2K is a top priority. Freeway or street reconstruction may be deferred, but Y2K has a set deadline."

The Technology Transfer Program Institute of Transportation Studies UC Berkeley presents

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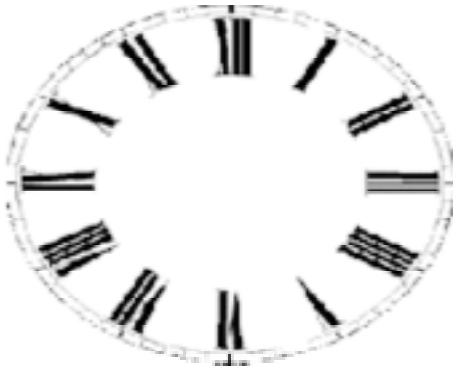

Wednesday, June 9th 1999 8:00 a.m. – 4:00 p.m.
Richmond Field Station, Room 445

AGENDA

- **Welcome John Mc Cracken, FHWA**
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FHWA Year 2000 page, with links to FHWA programs and resources with state government Y2K links, Y2K programs and experiences, including case studies.

www.itsa.org/y2k

ITS America's Y2K page, links to major, reputable Y2K information sources, including federal, state and regional governments.

www.nhtsa.dot.gov

National Highway and Safety Administration site.

http://pti.nw.dc.us/Y2K/index.html

Public Technology Inc. and the National League of Cities, National Association of Counties and the International City/County Management Association have joined forces to help make local appointed and elected officials aware of Y2K impacts.

www.year2000.ca.gov/

California 2000 Project Home Page, California Department of Information Technology (DOIT) information and links.

http://y2k.policyworks.gov

FHWA Commercial Off the Shelf Software Registry, listing of some software's Y2K status.

www.year2000.com

A popular site on all things Y2K set up by the subject guru Peter de Jager.

www.Y2Ktoday.com

Infrastructure Defense, Inc.'s site, which covers industry news including transportation.

www.itaa.org/year2000

Information Technology Association of America Year 2000 Home Page has many links plus Outlook, a free weekly newsletter delivered by e-mail.

http://nawgits.com/

National Associations Working Group for ITS Home Page, association of state, local, federal transportation officials and agencies involved in Intelligent Transportation Systems, supported by DOT-FHWA. Valuable links to transportation agencies.

www.state.mn.us/ebranch/admin/ipo/2000/2000.html

Minnesota Year 2000 Web site, details best practices for remediation.

www.gao.gov/y2kr.htm

General Accounting Office Y2K Web site, testimony and reports on Y2K remediation efforts and guides.

American Planning Association

Transportation Division

Facilitated Workshop

CRITICAL ISSUES IN TRANSPORTATION PLANNING

SeaTac Airport Auditorium
Saturday, April 24, 1999
8:30 a.m. to 5:00 p.m.
(followed by winebar reception)

Led by Don Steiger, Senior Regional Planner for Caltrans District Five (Monterey Bay), the workshop will provide a seminar-like exploration of critical areas of transportation planning today. Outcomes from the seminar will be carried to the second invitational workshop sponsored by the Transportation Research Board on "Refocusing Transportation Planning for the 21st Century."

Discussions are organized into three parts: 1) issues surrounding efforts to mainstream ITS projects into the planning and programming process; 2) progress and pitfalls on the way to using performance measures for planning and programming; and 3) a discussion with Gloria Jeff, Deputy Administrator of FHWA, on options for integrating TEA-21's planning processes with the NEPA review process. (Note: FHWA is planning revision of both regulations in the near future). Other discussants include: Jim Gosnell, Director of Planning for SCAG; Chris Sinclair, SAIC and lead instructor on some of the Federal Professional Capacity Building courses; Reid Ewing of LDR Associates; Bob Puentes from ITS-America; Jim Bunch, Mitretek's Project Manager on the large, TRB-funded performance measures project.

Detailed agenda and registration information available by e-mail or fax from Linda Howe, Transportation Division Chair. Fax your request to (510) 231-9591 or send e-mail to <lhowe@its.berkeley.edu>. Fees: $45 / $50 for Division members, $80/$90 for non-members (division membership is $30). Breakfast, lunch, and reception are included in the fee. Corporate sponsors include the Port of Seattle, Parsons Brinckerhoff, and CH2M Hill.

ITS Training Calendar

To register for one of the courses below call UC Berkeley Extension Registration at (510) 642-4111. For a catalogue or more details on courses, call (510) 231-9590, or visit our Web site at <www.its.berkeley.edu/techtransfer>. Course EDP numbers, dates, locations and fees are listed below. Fees are two-tiered, with a subsidized rate for public agencies provided with funds from the Cooperative Training Assistance Program (CTAP).

PLANNING AND POLICY

Understanding and Using FREQ*

**Caltrans employees should coordinate enrollment in any lab course through Les Jones, Program Chief, Office of Travel Forecasting at Caltrans. He can be reached at Calnet 4643330.*

Richmond	April 21-23	EDP496117	$270/$450

Y2K Traffic Control Systems Workshop

Richmond	June 9	EDP486456	$65/$150

TRAFFIC ENGINEERING AND SIGNALIZATION

Fundamentals of Traffic Engineering

Ontario	June 7-11	EDP485169	$250/$525

Fundamentals of Roadway Lighting

Sacramento	May 19-20	EDP486134	$125/$295

Traffic Calming

Richmond	May 12	EDP486225	$65/$150

PROJECT DEVELOPMENT AND MANAGEMENT

Introduction to Inspection Practice

Ontario	May 20-21	EDP486316	$125/$295
Emeryville	June 17-18	EDP485136	$125/$295

Project Engineer/Project Manager Training

Stockton	May 3-5	EDP486324	$175/$395

Update: The Highway Capacity Manual

Yuba City	April 28-30	EDP486290	$175/$395
Ventura	July 26-28	EDP485128	$175/$395

INFRASTRUCTURE DESIGN AND MAINTENANCE

What's New in Asphalt Paving

Riverside	June 2	EDP485110	$65/$150

Fundamentals of Geometric Design

Burbank	July 22-23	EDP485151	$125/$295

Automated Landslide Warning Systems

Riverside	May 12-13	EDP486217	$125/$295

Rockfall Hazard Mitigation

Truckee	June 17	EDP486233	$65/$150

Fundamentals of Applied Open Channel Flows and the HEC-RAS Program

Sacramento	June 21-23	EDP485177	$175/$395

Introducing HEC-RAS Version 2.1

Sacramento	June 24-25	EDP485185	$125/$295

TECHNOLOGY TRANSFER PROGRAM UNVEILS NEW LAPTOP COMPUTER LAB

The Institute of Transportation Studies Technology Transfer Program inaugurated its new portable computer lab at the Richmond Field Station in December 1998 with a hands-on workshop attended by thirty-one traffic engineers who came to learn how to install and use new intersection analysis software based on chapters from the recently updated *Highway Capacity Manual*. At least six more courses using the new lab have been scheduled for spring. The general response of lab users has been a resounding "Wonderful!"

The portable lab is equipped with 26 Chembook 7000, high-end, laptop computers with full-color, 15-inch, active-matrix screens, large enough to be comfortably shared between two people. The machines were purchased with revenues from the Cooperative Training Assistance Program (which is funded by Caltrans and California's regional transportation planning agencies). Establishment of the lab will enable the TechTransfer Program to support increasing demand for hands-on workshops for transportation planners and engineers on choosing, understanding and using a variety of software. Before establishment of the portable lab, such classes had for the most part to be conducted in expensive, hard-to-schedule, rented facilities, since the University's various teaching labs are almost always occupied by classes and researchers.

One of the big advantages of equipping the lab with laptops — rather than standard desktop computers — is the flexibility and relative portability that can be achieved. Physical set up of the new lab takes about three hours in just about any classroom. In theory that room can be anywhere. However, Linda Howe, Director of TechTransfer, says that the lab most frequently will be set up in and around the Bay Area or, on occasion, taken to Sacramento for a special session.

According to Howe, people prefer learning software through hands-on activities. Although TechTransfer did consider constructing a traditional training lab, space on campus is at a premium, and permanent labs are hard to justify unless they're fully occupied most of the time. The portable lab concept grew out of discussions with Caltrans staff about how to serve the growing need for lab-based learning access all over the state.

Outrageous 'Road Rage'

A bibliography compiled by Catherine Cortelyou of the Harmer E. Davis Transportation Library, Institute of Transportation Studies

For these materials, write to Interlibrary Lending, ITS Library, 412 McLaughlin Hall, University of California, Berkeley, CA 94720-1720; telephone us at (510) 642-3604; send a fax to (510) 642-9180 or e-mail us at <itslib@uclink4.Berkeley.edu>.

Aggressive Driving

A report by Louis Mizell, Inc. prepared for the AAA Foundation for Traffic Safety. Washington, DC, 1997. 16p.

This is the report everyone cites in the media and congressional hearings, and it is the basis for legislation and public policy as well as some imaginative safe-driving campaigns. It is touted either as the justification for anti-"road rage" legislation and enforcement or as an example of bad statistics and wrong-headed analysis. The report was no doubt shaped by the AAA Foundation's charge to research "all incidents of violence that involved traffic altercations and use of vehicles as weapons." It is based on a review of extreme cases. The study is peppered with dramatic accounts of drivers attacking others with weapons ranging from golf clubs to an M-60 tank. Most useful are two lists: one enumerating behaviors such as lane-blocking which are known to have incited violence in other drivers, and a shorter checklist addressing personal stress reduction and attitude adjustment. The report is also available full-text on the AAA Foundation's Web site <www.aaafts.org/Text/Research/agdrtext.htm>. (Perhaps for balance, when the report is downloaded from the Web it comes bundled with two short British studies which probe more deeply into possible causes of driver aggression and urge a more cautious evaluation of data before declaring a "road rage" epidemic.)

"Road Rage Versus Reality"

By Michael Fumento. In *Atlantic Monthly*, Vol. 282, No.2, August 1998, pp. 12-17.

Acknowledging a very real need to improve driving safety, the author charges that the "road rage" concept is more a product of media hysteria than a statistically proven epidemic. Among his points: that there is no measurable definition and therefore no meaningful statistics. The oft-cited study commissioned by the AAA Foundation for Traffic Safety (above) is targeted for its statistical flaws and various experts are scathingly dismissed. In the process, the author provides an interestingly written overview of "road rage" as a public fear and a public policy issue. Read this, and you'll take the next "road rage" headline with a grain of salt.

Strategies for Aggressive Driver Enforcement

Washington, DC: National Highway Traffic Safety Administration, 1998. (DOT HS 808 744). 16p.

Public and policy-makers' perceptions of "road rage" have generated a number of approaches to improving driver education and behavior. One method is enforcement. This brief handbook guides and encourages local agencies in enforcement actions against dangerously aggressive drivers. Target drivers are those "who often commit multiple violations as they try to make up time or get ahead of others on the road." The booklet begins with a broad description of program goals and objectives and lists about a dozen suggestions for developing a community enforcement program. Several examples of existing programs and suggested media activities are also provided.

Aggressive Driving: NETS 1998 Planner

Washington, DC: Network of Employers for Traffic Safety, 1998. 7p.

A compact information kit for employee safety programs, this packet is characterized by common sense and genuine yet unintentionally funny material. It contains a reproducible poster and cartoons. The single-page handout for employees examines simply and without condescension the emotions of the driver and adds 10 firm instructions on "what to do if you encounter an aggressive driver." Also included is an unfortunately silly "Aggressive Driver Self-Test." NETS maintains a Web site with additional road rage and driver safety information <http://www.trafficsafety.org>.

Road Rage Test: Are You an Aggressive Driver?

The Car Show Web site <www.carshowtomt.com/poll.htm>. 2p.

This 40-question self-test is balanced, and taking it can be an educational or enlightening experience. Answering Always, Often, Sometimes or Never, a driver taking this test will encounter some unexpected questions such as "Do you have a spouse or friend that tells you to calm down?" "Do you get impatient waiting for passengers to get in?" The test then gives instructions for self-ranking on a continuum of low to high hostility. Perhaps an interesting tool to kick off a discussion.

Aggressive Driving: Are You at Risk?

Washington, DC: Surface Transportation Policy Project, 1999. 35p.

Aggressive driving deaths are much higher in places with uncontrolled sprawl development where the car is the only way to get around, according to an analysis of 1996 federal data in this new study. In a ranking of the largest metropolitan areas nationwide, Riverside-San Bernardino topped the list for deaths due to aggressive driving. Congestion level was not found to be a factor in this death rate (Boston's ranking was relatively low, for instance), but statistically significant relationships were found with miles of highway per resident and low use of walking, cycling or transit for the journey to work. Older, more compact communities were found to have less aggressive driving. The authors conclude that land use planning and travel mode alternatives may need to find additional means to reduce traffic fatalities. The report includes metropolitan area data, including 24 locations in California. It can also be found on the Web at <http://www.transact.org/aggressivedriving99/default.asp>.

A Traffic Safety Drama "Every 15 Minutes"

Traffic crashes are the leading cause of death among teens in the United States. In California alone, nearly 18,000 teen drivers are injured or killed every year. A substantial number of these crashes are caused by a driver who has ignored advice not to mix drinking and driving. Although young people can grasp the widely publicized statistics proving that driving and drinking are a dangerous combination, they are often blinded by a sense of personal invincibility which pushes them to take risks that endanger not only themselves but others.

The "Grim Reaper" Takes His Toll

"Every 15 Minutes" is a dramatic program aimed at raising the awareness of young people about the real hazards of drinking and driving. The program, which employs role-playing strategies that are meant to shock and appeal to the emotions, was developed by the Chico Police Department in 1995 and has been used widely in California. Imagine this scenario: A person dressed as the "grim reaper" enters a classroom of high school students and quietly escorts one of the students from the room. This continues throughout the day — students disappear one by one. A uniformed officer and a counselor enter the classroom and read each student's obituary to those remaining in class. The parents of each "living dead" student are given their child's death notification by an officer or chaplain. Although these death notifications are simulated, overwhelming displays of emotion are expressed. Throughout the day, the living dead place their tombstones in a temporary cemetery on the school campus so classmates can mourn their loss.

Later, a simulated drunk-driving collision is staged on school grounds for the entire student body. It begins with a pre-recorded 911 call that triggers an emergency response by law enforcement, firefighters, paramedics and the coroner. Each agency uses the drill as a training exercise which simulates real-life responses. Paramedics treat one student for minor injuries. A second critically injured student is trapped inside a vehicle and must be rescued by firefighters using the "Jaws of Life." In a highly dramatic scene, a third student is declared dead and removed by the coroner. The fourth student, designated as the drunk driver, is given a field sobriety test and is arrested for driving under the influence. After the collision, the drama continues for the students involved in the crash. Officers book the drunk driver into jail. After booking is completed, the drunk driver must call a parent or guardian to explain what he or she has done.

A mock crash at East Nicolaus H.S. in Sutter County, CA.

Emergency medical responders transport the critically injured patient to a local trauma center where doctors simulate attempts to save his or her life. Unable to do so, the doctor has the grave task of notifying the student's parents of their child's untimely death. Organ procurement team members discuss the option of organ donation with the parents of the deceased teen. Meanwhile, the student who died on-scene is taken to the morgue, weighed and measured, and placed in a body bag until a family member can identify the body.

A Retreat for Reflecting

At the end of the day, law enforcement chaperones take the living dead to an overnight retreat. Once the students become members of the living dead, there is no contact with family or friends. At the retreat, the students participate in team building activities and learn first hand from people who have been involved in or affected by a drunk-driving collision. The evening ends as the students write letters to their loved ones, expressing the thoughts they would convey if they had not been killed on that particular day.

On the second day the living dead students return to school to attend a student body assembly with their parents. During the assembly, everyone watches a video of the previous day's events. After the video, several of the living dead students read excerpts from the letters they wrote the night before. They share what it felt like to die without having the chance to say good-bye. Other members from the community explain how they are personally affected on a daily basis when someone makes a poor choice involving alcohol. The assembly concludes with a call to action challenging everyone in the auditorium to make responsible choices when alcohol is involved. After 24 hours on an "emotional roller coaster," parents and living dead students are reunited. Parents and teens are typically overwhelmed with emotion and gain a new sense of love and commitment to one another. After the assembly, everyone gathers at a reception. The program helps the students see members of their community in a different light. They are no longer just cops, doctors, paramedics or firefighters, but also friends, mentors and human beings who care about the kids in their community.

This unique program was developed by the City of Chico through a Department of Alcoholic Beverage Control (ABC) GALE grant. Chico won the Excellence in Community Policing Award from the National League of Cities the following year. The program brings together law enforcement, the Department of ABC, California Highway Patrol, local hospitals, emergency medical responders, schools, businesses and service clubs and takes eight to ten months of careful planning.

The Department of ABC provides matching grants to agencies and organizations interested in presenting an "Every 15 Minutes" program. Agencies interested in applying should contact Investigator Kathy Schneider, the "Every 15 Minutes" Project Coordinator, at (916) 263-7916.

Martin Wachs Named ITS Director

Martin Wachs was named Director of the Institute of Transportation Studies at the University of California, Berkeley, on Jan. 15, 1999, after serving as acting director since August 1998.

ITS Director Martin Wachs

Wachs, 57, is nationally known for his leadership on transportation policy and currently serves on the Executive Committee of the Transportation Research Board. At UC Berkeley, he holds joint appointments as Professor of Transportation Policy in the departments of City and Regional Planning and Civil and Environmental Engineering. He also directed the University of California Transportation Center from 1996 until his recent appointment as ITS director.

"I plan to keep the Institute strong in all of its dimensions and high on the university's agenda. I'm very interested in technology transfer, improving our already excellent library and increasing our work in traffic safety. Most of all, I want to strengthen our contribution to policy-making in California," he said.

Wachs came to Berkeley in 1996 after 25 years at UCLA, where he had been a faculty member in Urban Planning since 1971. There he won several awards for outstanding teaching and took an active role in the public policy debate over what type of transit system Los Angeles should build.

The Bronx native said his interest in transportation and urban planning dates back to his childhood, when he traveled New York City via public transit.

Wachs holds a B.A. in Civil Engineering from the City University of New York. He earned his master's and Ph.D. degrees in Civil Engineering from Northwestern University.

Harmer E. Davis: In Memoriam

Harmer E. Davis, professor emeritus of civil engineering at the University of California, Berkeley, and founder of what is now the University of California Institute of Transportation Studies, died Dec. 24 at his home in Walnut Creek, Calif. He was 93.

Davis was an international leader in transportation policy and the founder of the nation's first program combining research and teaching in transportation issues. The model established by Davis in 1947, which includes a close collaboration with the State of California's highway department, has since been followed by many states.

The California legislature asked the University of California to set up an Institute of Transportation and Traffic Engineering to help train the engineers who would be needed as the state upgraded its roads and airports after World War II. Davis, then an associate professor of civil engineering, was picked to help organize the Institute. He toured the United States looking at the few programs then existing at universities and in state and federal highway departments, then combined these ideas into a pioneering center located on the UC Berkeley campus. In 1948 he was asked to become its statewide director, and he served in that capacity until his retirement in 1973.

During his tenure, Institute members conducted significant research on airport runway design and lighting that has had a major impact on how airports are designed and operated today. Other members looked at highway design and traffic control, among other things.

The Institute has always maintained close ties with the state highway department, now called Caltrans, and in the early years trained many engineers who went on to work for the state. Affiliated transportation centers soon opened at UC Irvine and UC Davis, eventually becoming independent institutes in the 1970s. As director, Davis participated in many highway, air and urban transport activities, and served as advisor to various legislative and public affairs groups. He had extensive involvement with transportation developments throughout the country, especially with regard to the planning, financing and development of highways and airports.

A member of the National Academy of Engineering, Davis received many honors during his lifetime. Among these were ten awards and medals from the American Society of Civil Engineers. He also was an honorary member of the American Public Works Association and in 1959 chaired the executive committee of the Highway Research Board of the National Research Council.

Davis was born on July 11, 1905, and raised in Rochester, New York. He subsequently obtained his B.S. (1928) and M.S.(1930) in civil engineering from UC Berkeley. He was immediately hired as an assistant professor of civil engineering and remained on the faculty for 45 years, where he served as chair of the civil engineering department from 1955 until 1959.

His early research involved the engineering properties of concrete, asphalt and soils. During World War II, though, he conducted research on the resistance of materials to the impact of shells. He was also known as an excellent teacher, with a special talent for dealing with students.

Tougher Rules for Guardrail Ends and Four Designs That Meet Them

By David Royer

Last year brought significant changes to standards for guardrail end-terminals. Since October 1, 1998, the Federal Highway Administration (FHWA) has required that all newly constructed guardrail end-terminals on federally funded roadway and safety improvement projects meet the National Cooperative Highway Research Program (NCHRP) Report 350 crash test level 3 criteria. In response, highway agencies, including Caltrans, adopted new guardrail end-terminal design standards that met the new crash test criteria. They apply to all barriers and barrier end-terminals, including guardrail end-terminals. It is hoped that adoption of the new design standards will reduce collisions for the motoring public and help to limit a public agency's exposure to liability claims.

The proprietary Slotted Rail Terminal 350 shown here is one of four types of guardrail end-terminals that meet new NCHRP crash test criteria. Three others are pictured on page 15.

NCHRP 350 crash test criteria were developed in 1993 as an enhancement of NCHRP 230 criteria. Level 3 crash test criteria include 100 KPH (62 MPH) impacts at various angles by vehicles equivalent to a 1500-pound mini-compact automobile as well as a 4400-pound pickup truck. The test is successful if the vehicle hitting the guardrail is gradually stopped or safely redirected. No debris may penetrate the passenger compartment or fly into the road or encroach on other traffic. Generally, a vehicle must remain upright during and after the collision and not be redirected into adjacent traffic lanes. To pass the test, the end treatment should not spear a vehicle that strikes it head-on or at an angle or cause it to vault or roll. For crashes along the main guardrail section, the end treatment should have the same redirectional characteristics as the standard guardrail. Finally, the velocity with which an unrestrained passenger strikes the interior of the vehicle should not exceed 12 meters per second, and subsequent vehicle deceleration should not exceed 20 gs. Preferred values are 9 m/s and 15 gs, respectively.

Most recommended NCHRP 350 guardrail end-terminals are "gating" end-terminals. This means that when a vehicle strikes the guardrail end at an angle before the third post (and not head on), it breaks through and penetrates behind the rail. A recovery area behind these terminals is recommended. Within the recovery area there should be no fixed objects or slopes greater than 3:1.

In the early days of guardrails, there was little attention paid to guardrail end-terminals. Indeed, when a vehicle hit the end of the guardrail, the rigid rail often impaled the vehicle. Or, when a vehicle hit the guardrail very near its end, the first posts just pulled out of the ground, destroying the guardrail's structural integrity.

Earlier attempts to improve the safety of end-terminals resulted in anchoring the end of the rail with a non-breakaway cable anchored in the ground or turning the rail end downward, and anchoring it directly into the ground (i.e. "Texas Twist"). While these attempts resolved the spearing and structural integrity problems, they introduced violent deceleration rates, causing vehicles to vault and overturn.

In the early 1980s, the Breakaway Cable Terminal (BCT) end-terminal was developed. Since this design also had a cabled end-anchor, it had good redirective capability when struck in the main guardrail sections. When a vehicle collided directly with the end-terminal, the first two posts of the rail broke away, releasing the cable anchor. Also, in this design the end-rail curved back 1220 millimeters (4 feet) in a parabolic flare that allowed it to bend away upon impact. While this was a significant improvement over previous designs, the impact deceleration was still too great for smaller vehicles, and they frequently overturned. The BCT failed to meet the new NCHRP 350 crash test criteria.

Today there are four basic types of guardrail end-terminals that meet new NCHRP 350 crash test criteria. The following types have been approved by Caltrans for use on California state highways and are recommended for either retrofit or new installations by city and county agencies.

Slotted Rail Terminal 350

This proprietary design has a 1220-mm (4-foot) parabolic flare offset, similar to the BCT. However, this terminal has slotted weakened sections in the rail, which reduce its column strength and make it less likely to penetrate a vehicle that strikes it. The bolts have been removed from most of the posts in the parabolic flare and a strut inserted between the steel tube foundations of the first two end posts, which enables these two posts

A sliding extruder terminal (ET 2000).

A guardrail with a buried end-terminal.

A guardrail with an attenuated end-terminal.

Photographs by David Royer

to act together to resist cable loads resulting from downstream impacts. In addition, the first nine wood posts have two holes drilled into them, one at ground-line and one below ground, to make them break away upon impact. When struck on the end, the cable releases, and the rail bows away from the posts, bending at the weakened (slotted) locations. The vehicle impact is attenuated by breaking the weakened posts. When this terminal is struck in the side at or beyond the third post, the cable maintains the structural integrity of the rail, and the vehicle is safely redirected. This design serves as an excellent retrofit system for older flared-end (i.e., BCT) terminals.

Sliding Extruder Terminals

The proprietary extruder terminal (ET2000) was originally developed at Texas A & M University by the Texas Transportation Institute (TTI) and licensed to manufacturer Syro Inc. The extruder terminal consists of an extruder shoe, a modified cable anchor connected to a steel tube foundation and eight weakened wood posts. No flare is provided with this end treatment; the end-rail is straight. When hit end-on, the impact energy is dissipated as the extruder shoe travels back along the rail, breaking the weakened posts as it goes. At the same time, the w-beam rail is fed through the extruder shoe, which flattens the rail and directs it out to the back, away from the vehicle. A quick-release cable attachment allows the w-beam to feed into the extruder during end-on impacts. The extruder shoe is reusable and can be reinstalled when the terminal is repaired following a collision. Since this system is straight and has no flare, it is ideal for new installations where a flare cannot be accommodated, such as next to a down slope, drainage facility or ditch, behind a fixed curb or at the edge of the roadway right-of-way. Also, it is an excellent retrofit system for older non-flared end-terminals.

The Buried End-Terminal

The buried end-terminal is used where the roadway runs through a cut section so that it is possible to terminate the guardrail in a backslope. This treatment entirely eliminates the dangers of an untreated end and greatly reduces the opportunity for vehicles to penetrate behind the rail. The entire exposed barrier is intended to redirect impacting vehicles. To the extent possible, the design parameters for the terminal sections are the same as for a standard section of guardrail. Proper rail height should be maintained throughout the flare, and the flare rate should be kept as flat as possible. It is important that the end be securely anchored into the backslope to prevent the rail from pulling out when any section of guardrail is hit. Since the backslope keeps the guardrail end from being hit, the end does not have to meet any impact attenuation criteria, only redirection criteria.

Attenuated End-Terminal

This design utilizes an attenuator to protect the end-terminal of double-sided guardrails in medians and gore areas (those shaped like a "V"). In these situations the guardrail end is simply anchored by a cable connected to a buried concrete anchor that does not break away in a collision. To meet the new safety standards, NCHRP 350-approved sand-barrel arrays or proprietary impact attenuators are commonly used to protect an end secured in such a way. The force from an end-on impact is attenuated by displacing sand in the barrel array or by collapsing the sections of the impact attenuator. This is an excellent retrofit system.

The above examples are not the only ways to design guardrail end-terminals to meet the new safety criteria. Local agencies should make independent decisions on products and designs. Future enhancements are expected to include even better functioning guardrail end treatments, which will work like today's highly engineered impact attenuators. Some features that we can expect to see are: the elimination of gating, lower deceleration rates, better vehicle stability, designs for a wider variety of speeds (prevailing speed designs of 40 KPH to 130 KPH, as opposed to a fixed 100 KPH) and designs for test level 4, 5, and 6 (trucks and buses).

All new installations, as well as modifications or repairs to existing guardrail end-terminals, should conform to NCHRP 350 crash test criteria. All older (non-BCT) end-terminals and high-accident locations should be considered prime candidates for retrofit projects.

David Royer is the TechTransfer Field Engineer for Southern California.

For more information on this subject:

NCHRP Report 350 from TRB Publications (202) 334-3214;

Caltrans Traffic Manual, standard plans and approved devices, from Caltrans publications (916) 445-3520;

Proprietary manufacturers' product standard plans and specifications: Energy Absorption Systems Inc. (312) 467-6750; Syro Inc. (800) 644-7976; Roadway Safety Services Inc. (847) 487-9810;

AASHTO Roadside Design Guide, from AASHTO publications (800) 321-3475;

Caltrans Local Programs Procedures Report LPP-99OX.

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Please send a **Statement of Interest** including the following information: 1) current resume, including professional associations and presentations; 2) 1000 words describing a) your specific area of expertise, b) your approach to adult education, c) why you would like to work with our program and d) the resources or special qualities you would bring to instruction; and 3) the names, addresses and phone numbers of three recent references who know your work. Please indicate any interest in on-line or distance learning applications.