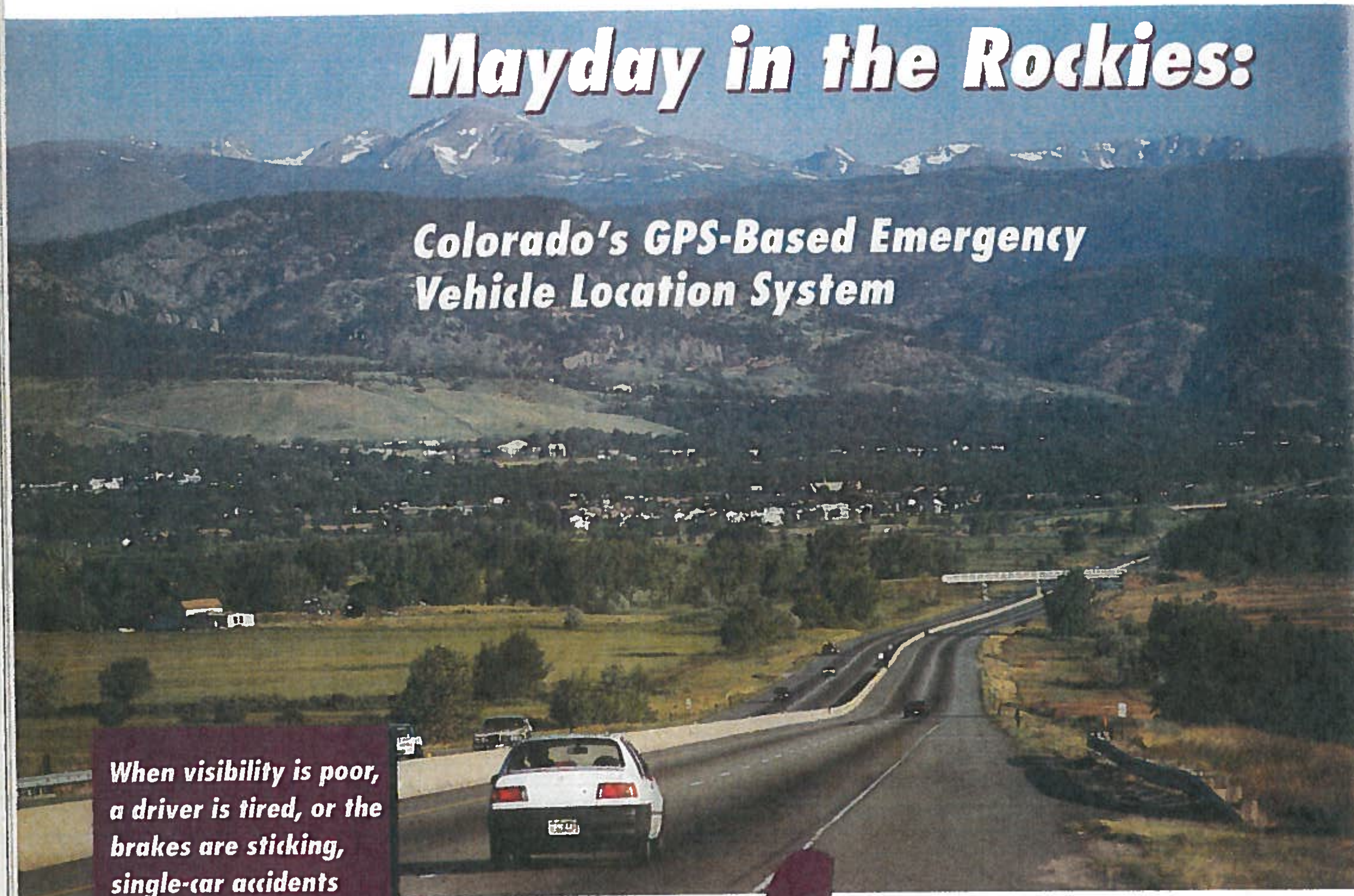
Mayday in the Rockies:

Colorado's GPS-Based Emergency Vehicle Location System



DENVER METRO CONVENTION & VISITORS BUREAU

When visibility is poor, a driver is tired, or the brakes are sticking, single-car accidents can happen. In 1991 alone, 6.11 million single-vehicle crashes were reported in the United States, resulting in the loss of almost 42,000 lives. A unique public–private partnership in Colorado is developing a prototype emergency vehicle location system that is intended to be a national model. It will send help more quickly to stranded and injured motorists, minimize stress, and save lives.

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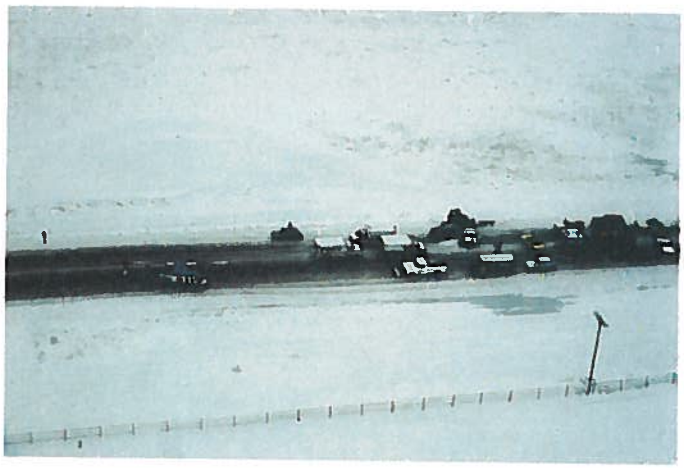
Suzanne is driving her two young children home from a school play one winter evening in Colorado. The light snow that dusted the road earlier is now falling thicker and faster. The children are unconcerned, but Suzanne, never fond of traveling in poor conditions, is trying to stay calm as visibility nears zero.

Despite her vigilance and cautious speed, Suzanne misses a curve. The car leaves the roadway, coming to rest against a tree in deep snow. Though restrained with seat belts and child safety seats, she and the children suffer minor injuries. Their vehicle is stuck out of sight and unlikely to attract help.

Countless times every year, an incident of this type can be a recipe for tragedy. The U.S. National Highway Traffic Safety Administration estimates that during 1991, 6.11 million single-vehicle roadway departure crashes were reported to police and other law enforcement agencies in the United States. These crashes resulted in the loss of almost 42,000 lives.

Today an innovative series of public–private partnerships in the United States is working toward an infrastructure for an emergency vehicle location system that, when activated by the motorist, will automatically transmit a request for help along with the vehicle's precise location to emergency services personnel. Coordinated by the federal government under the auspices of the U.S. Department of Transportation (USDoT) intelligent transportation system (ITS) initiative, the goal of these partnerships is to spur implementation of a nationwide emergency vehicle location system. ITS partnerships in the

COLORADO DEPARTMENT OF TRANSPORTATION



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DENVER METRO CONVENTION & VISITORS BUREAU

Snowy, icy conditions breed single-vehicle accidents. The Colorado Mayday project enables stranded, isolated, and injured motorists to transmit a request for help, along with the vehicle's precise location, to emergency services personnel.

states of Colorado, Washington, and New York are working on different technological and institutional approaches to meet this challenge.

One major ITS initiative, Colorado Mayday, is being undertaken by the Enterprise Group, a coalition of the state departments of transportation in Arizona, Colorado, Iowa, Michigan, Minnesota, North Carolina, and Washington; the U.S. Federal Highway Administration (FHwA); the Ontario Ministry of Transportation, Transport Canada; the Maricopa County Transportation Department in Arizona; and the Dutch Transportation Ministry. The group was formed to drive implementation of ITS-related initiatives.

The Colorado Department of Transportation (CDoT) is managing Colorado Mayday for the Enterprise Group, with funding from the state and USDoT. The Colorado State Patrol and various private-sector firms — almost all are based in Colorado — are partners in the program.

The program, which is among the first of its kind in the United States, has just passed its first milestone — prototype demonstration of the emergency vehicle location technology — and is proceeding toward full-scale testing and deployment in a test area in and around Denver.

EVERY SECOND COUNTS

Within the U.S. emergency medical service (EMS) community, it is widely accepted that a major factor contributing to the number of crash fatalities or critical outcomes is the time required for notification and response. In an emergency situation, a difference of 5 or 10 minutes can result in drastically different outcomes; and notification times do differ from place to place. For example, in 1992, data from the USDoT Fatal Accident Reporting System (FARS) indicate that the average EMS crash notification time was 4.85 minutes for urban areas and 8.95 minutes for rural areas. The large variance between the two response times is associated with low traffic density and a lack of communications facilities in rural areas.

Additionally, FARS 1992 data show that the average response time for rural areas, 11.47 minutes, was almost twice that of urban areas. This was mainly due to longer distances between crash sites and EMS base locations. However, the vague and uncertain crash locations common in both areas also increased the time between notification and EMS arrival on the scene.

In an effort to improve EMS response times and save lives on U.S. highways, FHwA has defined specific system improvement goals. These goals are meant to be responsive to characteristics of rural, urban, and interurban emergency response scenarios.

FHwA has begun the process of achieving these goals by funding a series of federal Field Operational Tests (FOTs) designed to leverage technology to improve roadway safety. Colorado Mayday is an FOT. These FOTs are typically funded through public–private partnerships involving federal, state government, and private-sector contributions and are administered by state departments of transportation with federal oversight.

AN ACTIVE PARTNERSHIP

As the ultimate end user of Mayday data, the Colorado State Patrol is a key public-sector partner, providing critical system design input from a user perspective and serving as the emergency services dispatch center during the test.

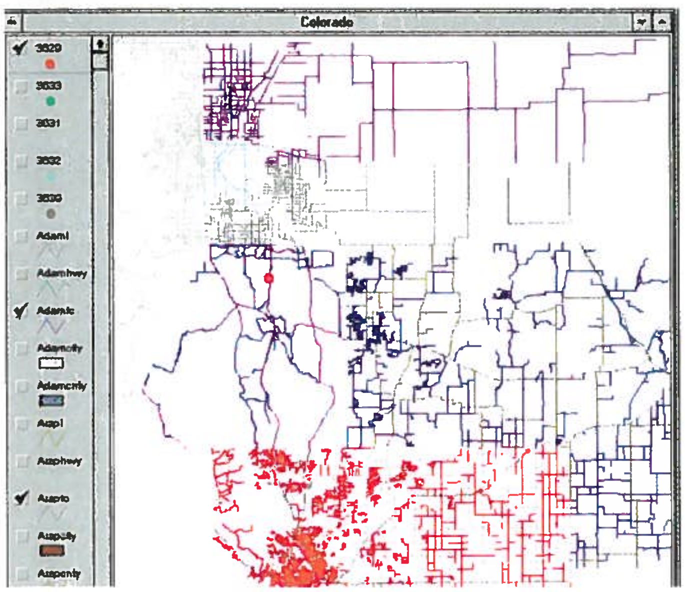
NAVSYS Corporation's LocaterNET Division is acting as the systems integrator. The corporation has built a system for the program that employs the company's patented GPS sensor and patented automatic vehicle location system design. The sensor is an all-in-view L1, C/A-code unit.

CommNet Cellular, US WEST Cellular, and AT&T Wireless Services are supporting integration of the system components with technical support, airtime for testing, and telephone communications equipment. Additionally, a key program goal is to develop a marketing plan in which cellular companies could sell emergency vehicle location service as an adjunct cellular service, thereby commercializing the service infrastructure.

Environmental Systems Research Institute, Inc., is providing one of its geographic information system (GIS) software programs and support for the dispatcher workstation equipment. Castle Rock Consultants is serving as the government's independent evaluator of the system, conducting tests designed to assess technical performance parameters in a wide range of environments.

A USER-DRIVEN DESIGN

In addition to meeting technological challenges, the project partners also have to keep the users' needs constantly in mind. To ensure the usefulness of the system, the Colorado Mayday program has involved the emergency services community from the outset in the design and implementation of the system.



A Colorado State Patrol communications officer (top) uses her public safety answering point operational experience to help in the design of the Colorado Mayday system.

The Mayday dispatcher workstation displays emergency requests from motorists on a digital map at the PSAP. On the workstation screen capture (above) an emergency request for assistance is displayed as a red dot on the map. When the dot is selected by a dispatcher, additional motorist data and greater map detail are displayed.

For a location service to succeed, public safety answering point (PSAP) dispatchers, commonly known as 911 dispatchers, must receive useful vehicle location data in a display format that can be easily integrated with their operations. The program team has conducted focus group meetings with PSAP dispatcher users to gather requirements. Unlike private-sector emergency vehicle location services currently under development, the Colorado Mayday program emergency services dispatchers — in this case Colorado State Patrol communications officers — have generated user requirements that have been incorporated into the system design.

For example, state police communications officers rely heavily on highway mile-markers. They say it's critical that the system deliver vehicle location data to a dispatcher workstation whose maps include mile-markers. Pinpointing from which side of the median the Mayday call originated is another key system goal recommended by the officers.

Of equal importance, PSAP dispatchers must be able to depend upon the reliability of the automated emergency request. An emergency vehicle location system with the false alarm rates and other ambiguities of burglar alarms will serve no useful purpose. Dispatchers insist that the system include the means to confirm Mayday requests and verify for the motorist that the call went through by way of a voice connection.

Another dispatcher-driven requirement involves digital map accuracy. Dispatchers insist digital maps used by the system must be highly accurate, especially in urban areas. A 300-meter map error in an urban setting is less than optimal, they say.

Data Rather than Voices. In addition to its uncommon approach of involving the emergency services community from the beginning, the Colorado Mayday program is unique in that it will deliver vehicle location to dispatchers as data on a workstation screen, not as a voice telling the dispatcher where the vehicle requiring assistance is located.

To understand why electronic delivery of vehicle location data to PSAP dispatchers is so much better than voice communications to the PSAP dispatcher, let's look at how some private-sector emergency vehicle location systems currently under development will work.

These other systems will generate location from the vehicle and transmit these data to a private-sector monitoring center. Such centers typically also monitor burglar alarms and other security systems and orally notify police on receipt of a real or false alarm.

When the data are received from vehicles in these other architectures, the private-sector monitoring center will phone the appropriate PSAP and orally communicate vehicle location and type of emergency to the dispatcher. In many cases, the monitoring center will be thousands of miles from the PSAP, meaning the person at the monitoring center attempting to orally communicate the location of a vehicle in need of assistance will have absolutely no familiarity with the area in which the vehicle is located.

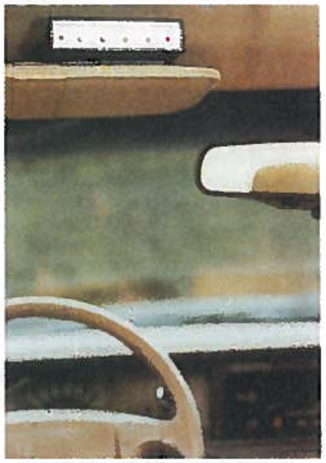
The Mayday system's architecture takes the possibility of human error out of the loop. The vehicle's precise location is electronically delivered to the dispatcher and displayed in near real time on a digital map.

That's why the Colorado Mayday public–private partnership is so unique — the private sector and the government are working jointly to build and test a system that will make data, not voice, the medium by which vehicle locations are communicated to the PSAP.

NEW TECHNIQUES

Also unique, or at least somewhat unconventional, is the architecture of the Colorado Mayday emergency vehicle location system. It is based on a client–server model in which motorist equipment and dispatcher equipment are clients, and a central GPS and database processor are the server.

Conventional emergency vehicle location systems currently under development will employ a more traditional GPS-based approach in which the computer horsepower required to calculate latitude and longitude is installed in each vehicle. The Colorado Mayday system requires only a GPS sensor that simply collects, stores, and forwards raw satellite data to a



The in-vehicle unit's button-box driver interface can be attached to the driver's sun visor or kept in the glove compartment.

The in-vehicle unit includes a button-box motorist interface, an electronic control unit for installation in the vehicle's trunk along with a cellular transceiver, and a small GPS antenna.

central server for processing.

The system consists of four principal elements.

■ The first is the in-vehicle unit (IVU), which houses a GPS sensor that collects raw GPS data when activated by the motorist. The IVU also includes interface equipment to control the communications system.

Another component of the IVU is a button box used by the motorist to operate the system and request assistance. About the size of a garage-door opener in its automobile aftermarket configuration, the button box is clipped to the driver's side sun visor and serves as a user interface for the motorist "client."

■ The communications system is a two-way cellular communications link that transmits raw GPS information and assistance requests from the IVU to the processing center.

■ The processing center server consists of a rack of processors running an operating system, a relational database management system, application software, a multiple-gigabyte disk farm, network and communications gear, and a GPS reference antenna. This server receives emergency assistance requests from IVU clients. Requests, which contain raw GPS data and vehicle identification information, are processed by the center's system to calculate the vehicle's location and type of assistance required. These data are then passed electronically to the PSAP.

■ At the PSAP facility, Mayday calls are displayed on a dispatcher workstation. Call data displayed on these "clients" include a vehicle location fix superimposed on a digital map, as well as information about the vehicle and motorist requesting assistance.

So How Does the System Work? At the time of enrollment, the IVU equipment is installed in the motorist's vehicle. This equipment includes the GPS sensor, a small GPS antenna, the button box, and communications equipment. Alternatively, the system components can be installed in a vehicle with an existing cellular phone.

At the time of enrollment, each user's personal and vehicle information are entered into a database at the processing center. These user data are stored in National Emergency Number Association format and include name, address, cellular telephone number, vehicle description, vehicle identification, in-vehicle equipment, and any pertinent medical information or special needs the motorist might have.

To initiate a request for assistance, the user presses the appropriate button on the button box. These buttons are labeled "police," "medical," "assist," and "cancel." In response, the IVU immediately activates the GPS sensor to capture raw GPS data and simultaneously compiles an emergency request message.

The cellular phone then transmits this message to the processing center. Then, following data transmission, the cellular call is forwarded directly to the appropriate dispatcher to enable voice verification of the emergency, collection of additional information, and communication of the emergency response vehicle's estimated time of arrival. This means the whole transaction can be completed with just one cellular connection.

The processing center receives the message from the IVU and calculates vehicle location from the GPS data. Once location has been calculated by the server and combined with vehicle identification information from the server database, the data are routed to the PSAP dispatcher who received the cellular call. Motorist location and subscriber information are superimposed on a digital map.

From a performance perspective, the program's goal is to complete the entire transaction — from button-box activation in the vehicle to display of location/vehicle identification data on the dispatcher workstation — in less than one minute. The majority of this time is, of course, expended in establishing a cellular phone connection between the IVU and the processing center.

What Makes This Technology Different? First, unlike conventional GPS technology, the GPS sensor is designed to provide an "instant-on" capability for emergency location. This means that on activation, the sensor immediately collects 62 milliseconds of raw GPS data; there is no power up or initialization.

Second, instead of processing the GPS data on board the vehicle, the GPS sensor just captures the short GPS raw data "snapshot," converts it into a digital data stream, and transmits these raw data back to the processing center for further data manipulation.

Third, conventional GPS receivers require that several satellites be in view to generate a precise fix. This process can often take minutes rather than seconds. The Colorado Mayday system technology includes algorithms and other methodologies that enable the system to generate vehicle location fixes with as few as two satellites in view of the vehicle.

As shown, the system currently requires manual activation by the motorist. Future service enhancements will include incorporation of an automatic activation capability. With this functionality, the IVU will be automatically activated by some form of crash sensor. Even if the motorist is injured and can't push a button, the system will summon help.

Another planned enhancement will add collision severity information to the data communicated to a PSAP dispatcher. By using a series of data sources, such as seat-belt sensors, accelerometers, or airbag activation units, the system will be able to assess the severity of a crash. This will enable EMS personnel to arrive on scene prepared for the emergency.

A third system enhancement will help deliver navigation assistance, road hazard data, and traffic information to the motorist through the IVU. By making the processing center–IVU data channel bidirectional, the system will be able to provide useful, safety-enhancing information to the motorist.