RF playing a key role in transportation telematics

Traffic management and traveler information systems are depending more and more on RF technologies, and the role of RF is just beginning.

By Mike Juha

RF technology is playing an increasingly important role in roadway traffic management. This prompts many questions: What does RF technology do for traffic management? How is traffic managed? Don't drivers just travel when and where they want to?

RF and data radios

Data radios make it practical and economical to collect data from thousands of sites along major metropolitan roadways and freeways. Traffic monitoring sites are usually spaced one-half or one-quarter mile apart along the length of each roadway or freeway across an enormous geographic area (such as the freeways in Los Angeles shown in Figure 1). Wiring traffic monitoring sites with copper wire or optical fiber to collect data over such a large region has been a major cost to traffic management agencies. As a result of the wide-area network, traffic agencies spend a substantial portion of their budget on the cost of installing and maintaining all this field wiring.

Several years ago, traffic engineers recognized that wireless data collection could free agencies from the burden of maintaining a network of field wiring. Initially, low-power unlicensed spread spectrum radios, which were limited by line-of-sight transmission paths, were used. The traffic agency was placed in the position of being a radio network manager. Repeater sites were needed to overcome terrain barriers to line-of-sight transmission, and frequencies had to be managed to enable service to all the traffic data gathering sites. These burdens limited the deployment of wireless data collection to isolated remote sites where wiring costs would have been prohibitively high, such as the site shown in Figure 2 on the 680 freeway near Sunol, Calif.

More recently, wireless data networking has become a commercial reality with the availability of cellular digital packet data, or CDPD. CDPD uses the cellular telephone system to carry data. The widespread deployment of cellular telephones enables data collection from freeways and roadways in major metropolitan areas. CDPD service is available for a low cost compared to wired network alternatives. CDPD also delegates the job of network manager to a cellular service provider, allowing the traffic agency to focus its resources on managing traffic. Consequently, traffic agencies are beginning to adopt CDPD for data collection in lieu of using a wired network, and in some cases are retrofitting existing sites where wiring maintenance has been a problem.

Figure 1. Traffic management nightmare.

RF: The enabling technology

Traffic has been detected by wire loops embedded in the pavement of roadways and freeways for roughly 40 years. As our freeways and roads have become more congested for longer periods of time each day, traffic engineers have sought other means of detecting traffic that do not require wire loops in the roadway. Wire loops fail when pavement cracks or deforms under heavy truck traffic. Failed loops are replaced by closing each lane, cutting a new slot in which to embed new wires, installing the wires, and then filling the slot with a sealant. With freeways busy with traffic for most of the day, loop replacement is usually done at night. While this reduces the congestion created by lane closures, it increases the cost of the work. A significant part of the cost of the work is associated with the safety measures involved in closing lanes of a busy roadway or freeway at night.

Over the past ten years, traffic engineers have experimented with many alternatives to wire loops. Among these alternatives are video detection, infrared sensing, acoustic sensing, laser scanning, and radio distance and ranging (radar). The same qualities that have made radar the choice for guiding airplanes into airports allowed it to prove itself as the only truly all-weather roadway traffic detector. Radar does not care if it is sunny, raining, snowing, windy or foggy. It works well under all of these conditions, while other sensors can be blinded by them.

Roadway-traffic detecting radar works the same as the radar used to guide airplanes into airports, only on a smaller scale with a range of hundreds of feet rather than several miles. When used as a traffic detector, a radar system is aimed across the roadway at an angle perpendicular to the paths of vehicles as shown in Figure 3. The radar detects the range

Figure 2. RF data radio components in a remote location.

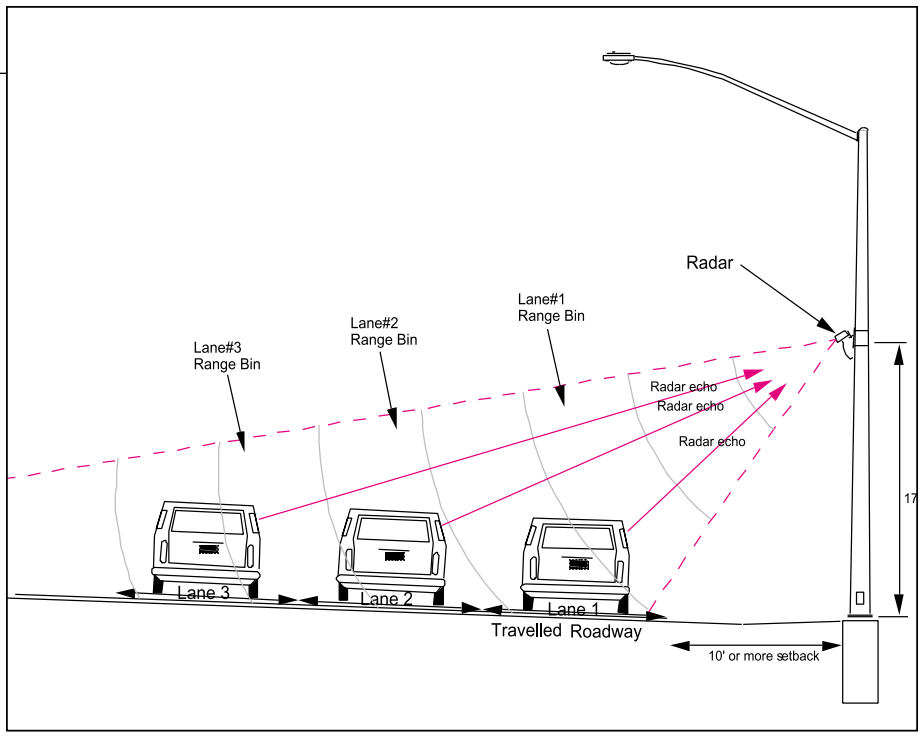

Figure 3. Radar signal propagation diagram.

distance to vehicles passing through its radio beam, and measures the time the vehicle dwells in it. This allows the radar to identify the lane in which each vehicle is moving and also allows the radar to count the vehicles and estimate their speed. Vehicle counts and speeds are the information that traffic management systems need to manage traffic.

Wireless ranging in traffic detection

A growing number of traffic agencies are using radar as an alternative to embedded wire loops. For example, Figure 4 shows a site in San Jose, Calif. on Route 237 where traffic in all lanes in both directions is monitored by radar and the data reported via radio modem to a traveler information system called TravInfo. Route 237 is one of Silicon Valley's congested roadways, mandating that installation be done without closing traffic lanes. Radar met this requirement by using existing lighting poles well off to the side of the roadway. Field wiring was minimized by obtaining power from the street lighting circuit in the same pole used to mount the radar and radio modem. Twenty-two sites like this were installed for TravInfo at an average cost-per-site of less than $10,000. In keeping with its reputation as a high-technology environment, the San Francisco Bay area already has nearly 100 sites with radars deployed as traffic detectors. Many of these are connected to the Caltrans traffic management center using radio modems.

Traffic management 101

So how is traffic managed? Traffic data are collected from along roadways and analyzed to find locations where there are rapid declines in vehicle speeds with coinciding rapid increases in vehicle dwell time in a lane (vehicles are slowing and dwelling for several seconds at one spot in a lane). When an incident (or accident) happens, the vehicles immediately upstream of the accident slow quickly to a stop and try to maneuver into other lanes. This leads to a rapidly growing backup of slowing traffic. If several lanes are blocked and traffic is already heavy, the growing backup is stopped vehicles. By detecting this unusually sudden slowing or

Figure 4. Online monitoring site.

stoppage of flow, the traffic agency can identify an incident location and dispatch resources to respond to the emergency. Selecting the right resources is often done by viewing video from the nearest freeway surveillance camera to determine if the fire department and tow trucks must be sent. This may not sound like traffic management, but for every minute an incident blocks lanes, it will take 10 minutes to dissipate the traffic backup after the lane blockage has been cleared. Dispatching the right resources promptly can eliminate hours of freeway traffic backup.

In addition to incident detection and incident response, traffic data are used to manage ramp-metering. Traffic data from the freeway upstream of a ramp indicate how much freeway capacity is already used. The ramp-metering software adjusts the rate at which vehicles are admitted to the freeway to ensure that traffic volume does not exceed the capacity of the freeway. This keeps the freeway moving, while slowing traffic on the approaching entrance ramps. The long queues of vehicles waiting to enter the freeway during rush hour help to convince some drivers to alter their commuting schedule to less-congested times or less-congested routes.

This presents two examples of how RF technology is helping traffic management today. Many other RF technology devices already in use, such as toll tags for toll payment, and GPS units on buses sending bus location via radio modem to enable bus stop displays of when the next bus will arrive and what its schedule will be.

RF's traffic future

The number and types of RF devices available is growing rapidly, and their applications will grow just as fast. The critical ingredient is innovative thinking by both transportation agencies and technical personnel familiar with RF technology.

The next time you are stuck in traffic, consider how RF technology can devise new ways to address problems with congestion. Simply put, to manage traffic, it is necessary to know where it is. RF technology can provide better information on where traffic is and how it is changing. The existing wired networks used by transportation agencies have consumed much of their budgetary resources. RF technology can radically reduce the costs of installing and maintaining the information-gathering networks, and this can make more agency funds available for better traffic management.

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About the author

Mike Juha is with EIS Electronic Integrated Systems, a manufacturer of radars used to detect and manage traffic congestion on freeways and streets. Juha's area of responsibility is California, where traffic congestion has been a problem for decades, and where California's Department of Transportation is taking a proactive role in adopting wireless communications and non-intrusive sensors (radar and other RF applications) to manage congestion. He can be reached at: *mikejuha@earthlink.net*