The Exploratory Advanced Research Program Fact Sheet

Advanced Vehicle Tracking Technologies

Sensing and Monitoring Individual Vehicles in Traffic Flow

Exploratory Advanced Research . . . Next Generation Transportation Solutions

As the Nation moves into a future of increased automated traffic technologies, transportation managers will need new tools to monitor traffic and control flow. Effective traffic management will require sensing and monitoring systems that provide information at the level of individual vehicles. Because of this, the Federal Highway Administration (FHWA) Exploratory Advanced Research (EAR) Program is supporting research that uses ultra wideband (UWB) radar to identify and track individual vehicles as they move through traffic. The Advanced Vehicle Tracking System (AVTS) project, conducted by Honeywell Corporation and Time Domain Holdings, in collaboration with the University of Minnesota, will recognize and track individual vehicles, rather than aggregated vehicle patterns, and will work without relying on vehicle-based technology that provides information about location or movement. Small-scale highway tests of AVTS show that the system can sense individual vehicles and identify them based on size and movement. Further refinement of the technology will provide managers with an important new tool to improve traffic monitoring capabilities.

The Need for Improved Vehicle Sensing

Current vehicle sensing relies on three technologies, each with technical shortcomings that limit their ability to monitor and track the demands of automated highways and traffic management. *Inductive loop detectors* use wire coils embedded in the road surface. The coils provide vehicle counts, estimate vehicle speed, and measure elapsed time between consecutive vehicles. Inductive loops are expensive to install and maintain, cannot individualize vehicles, and cannot detect stationary vehicles. *Microwave radar sensors* rely on continuous-wave (CW) Doppler radar or frequency-modulated continuous-wave (FMCW) transmissions. CW systems rely on highly directional antennas and can calculate vehicle speed but cannot detect stopped vehicles. FMCW systems can detect stopped vehicles and provide instantaneous measurement of distance to a stationary or moving vehicle, but cannot provide information about vehicle speed. *Video imaging systems* provide information on vehicle counts, speed, and separation, and can create a visual record of traffic activity within a limited field of view. The systems are expensive to install and maintain and may be vulnerable to poor lighting conditions or weather-related visual obstruction, such as precipitation or high winds.

UWB Radar Advantages

UWB radar transmits pulsed radiofrequency (RF) energy signals at very high (GHz-level) bandwidths. The rapid pulsing of the RF signal means that UWB is highly resistant to multipath interference, which occurs when a transmitted signal is distorted by atmospheric refraction or reflection. Another advantage of UWB radar is its ability to use a technique called coherent pulse integration to operate over distances suited to traffic monitoring without signal-to-noise degradation. The UWB radar used in AVTS research has a detection range of approximately 400 ft and can provide measurement accurate to roughly 4 in, making it possible to detect differences in height, length, and width of vehicles, thereby enhancing the system's ability to discriminate among vehicles moving through the field of view. The AVTS operates at a high scanning rate (>1 kHz) suited to real-time tracking of multiple vehicles.

Identifying and Tracking Individual Vehicles

The AVTS being developed by Honeywell researchers uses units consisting of four radars that will be arrayed in a rectangular configuration along a section of roadway. Each radar is capable of multistatic receiving. The radar receives its own reflected signal and the reflected signals of three other radars in the rectangular network, which means that each radar gets 16 instantaneous views per signal of each vehicle in the rectangle. The radars in a rectangle fire sequentially; each radar transmits

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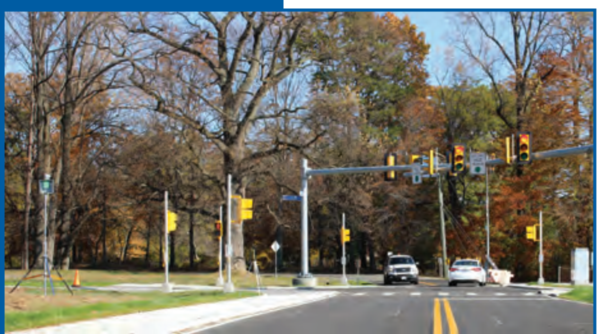

In field trial, pole-mounted AVTS radar provided accurate tracking display of vehicles traveling in opposite directions and vehicles turning at intersection.
Source: FHWA.

Photo page 1:
Battery-powered AVTS radar housed in weatherproof case on adjustable-height tower.
Source: FHWA.

50 signals per second. Thus, each rectangle unit sends data from 200 scans per second to a vehicle recognition engine (VRE)—software that uses probability hypothesis density algorithms to recognize multiple targets—and a tracking computer. The VRE creates an individual signature for each vehicle and presents the vehicle size, direction, and speed as a unique track on a user display. The VRE will hand off salient information as vehicles move to adjacent rectangles, making it possible to identify and track individual vehicles as they move along the roadway.

AVTS radar units are battery powered and housed in weatherproof nonmetallic enclosures mounted on an adjustable-height pole with tripod support. Initial testing of the AVTS showed that positioning the radar unit at a height of 20 ft with an antenna angle of 15 degrees yields the most informative signal: the height prevents one vehicle from blocking the radar's view of a vehicle in an adjacent lane; the tilt angle minimizes ground reflections that might clutter the signal and confound tracking calculations.

In tests conducted along a four-lane arterial roadway, the AVTS demonstration system—consisting of the pole-mounted UWB radar, VRE, and user interface display—successfully tracked a single vehicle traveling along the roadway and turning at an intersection and two vehicles traveling in opposite directions along the roadway. The system also tracked two trucks—a large commercial truck and a tractor-trailer; both vehicles appeared as two separate tracks on the system display because the current VRE software has not been tuned to model large vehicles.

"This research represents an important step forward in our ability to accurately and rapidly collect complex traffic data," says Robert Ferlis of FHWA's Office of Operations Research and Development. "Future traffic management and control systems will require detailed high-frequency acquisition and exchange of data, particularly information about speeds and locations of individual vehicles that UWB radar can provide."

EXPLORATORY ADVANCED **RESEARCH**

What Is the Exploratory Advanced Research Program?

The EAR Program addresses the need for longer term, higher risk research with the potential for transformative improvements to transportation systems—improvements in planning, building, renewing, and operating safe, congestion-free, and environmentally sound transportation facilities. The EAR Program seeks to leverage advances in science and engineering that could lead to breakthroughs for critical, current, and emerging issues in highway transportation—where there is a community of experts from different disciplines who likely have the talent and interest in researching solutions and who likely would not do so without EAR Program funding.

To learn more about the EAR Program, visit www.fhwa.dot.gov/advancedresearch. The Web site features information on research solicitations, updates on ongoing research, links to published materials, summaries of past EAR Program events, and details on upcoming events.

Learn More

For more information about EAR Program projects involving UWB radar, contact Robert Ferlis at 202-493-3268 (email: robert.ferlis@dot.gov).

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