

# Real-Time Traffic Operations Data Using Vehicle Probe Technology

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## ABSTRACT

The vehicle probe industry is emerging as a viable means to monitor traffic flow, delivering both speed and travel-time information for the purposes of advanced traffic management systems and advanced traveler information services applications, as well as supporting a myriad of other transportation agency requirements, including monitoring the impacts of construction activities, planning, and engineering. Meanwhile, the high cost of installing and maintaining fixed-point loop detectors is driving transportation authorities to consider both outsourcing traffic monitoring and developing new methods of detection. Vehicle probe technology, as discussed in this paper, encompasses two primary methods: GPS data obtained from fleet management services and geo-location schemes that leverage cellular phone infrastructure. The proliferation of GPS and mobile data services is fueling these industries and strengthening the demand from travelers for accurate real-time traffic information. One of several ongoing procurements for such data is sponsored by the I-95 Corridor Coalition. As technical advisor to the Coalition, the University of Maryland assisted in developing an appropriate procurement strategy for acquiring vehicle probe data services. This paper reports on various aspects of vehicle probe technology, including technology differentiation, lessons learned from previous demonstrations, risk assessment, intellectual property issues, and institutional barriers for adopting and leveraging new technology.

**Key words:** cellular—GPS—traffic data—vehicle probe data

## **INTRODUCTION**

### **Vehicle Probe Technology**

Vehicle probe technology is emerging as a means of monitoring traffic without the need for deploying and maintaining equipment in the right-of-way. In contrast to speed sensors, vehicle probes directly measure travel time using data from a portion of the vehicle stream. Commercial vehicle probe data services primarily include the use of cell phones and automated vehicle location (AVL) data. Early demonstrations of such systems relied heavily on a single method or technology. However, services are emerging that combine information from multiple probe sources and technologies, as well as data from existing fixed-sensor networks, into a comprehensive traffic information service.

Adoption of such technologies is being driven by the high cost of deploying and maintaining fixed-sensor networks, including loop- or radar-based detection. Concurrently, demand for comprehensive traffic monitoring is growing, both from travelers, who need accurate, real-time data, and transportation agencies, which need to assess the performance of the system as a whole. The cost for gathering traffic data, either from probe-based or traditional speed sensors, is declining due to both the proliferation of technology and the emergence of businesses dedicated to traffic data collection and dissemination. Traffic data collection within a transportation agency has traditionally been application-specific and geographically constrained, such as with the need to actuate a traffic signal or collect speed and count data for planning purposes. This “stovepipe” method is being replaced by comprehensive traffic monitoring across the entire roadway system. Such an approach feeds not only legacy applications, but also supports the growing demand for advanced traveler information services (ATIS) data, such as travel time and congestion reports, and performance measurement data that assesses and improves the efficiency of existing highway operations.

### **Vehicle Probe Technology as Used by the I-95 Corridor Coalition**

The I-95 Corridor Coalition is a partnership of state departments of transportation (DOTs), regional and local transportation agencies, toll authorities, and related organizations, including law enforcement, transit, port, and rail organizations. The partnership area ranges from Maine to Florida (including the District of Columbia), with affiliate members in Canada. I-95 Corridor Coalition members work together to reduce congestion, increase safety/security, and ensure that the entire transportation network supports economic vitality throughout the region. In order to achieve this mission, the Coalition initiated a regional traffic monitoring system in 2006 that will act as a continuous source of real-time transportation system status information along a major portion of the corridor. Construction and maintenance of the system was outsourced. Rather than specifying a particular technology in the request for proposals (RFP), the technical requirements for the system were based on the need to support a broad range of ATIS, advanced traffic management systems (ATMS), engineering, and planning applications for the Coalition and its members without deploying additional infrastructure in the right-of-way. However, with outsourcing comes the burden of defining data ownership and usage and dissemination rights and restrictions. By specifying the minimum data rights needed to support all intended applications, the RFP allowed vendors to individually craft approaches that satisfied the needs of the Coalition while protecting the commercial viability of the traffic data for the vendor. These aspects, as well as an evaluation methodology that emphasizes risk management and requires demonstrated ability to meet technical specifications, promise to deliver an effective traffic monitoring resource for the East Coast of the United States.

## TECHNOLOGY DIFFERENTIATION

As a whole, probe vehicle technology differs in concept from spot speed sensors in several respects, as summarized in this section.

### Probe Vehicle Technology

Key aspects of cell phone and AVL probe technology include the following:

- Vehicle travel time is measured directly.
- Only a sample of all vehicles is monitored.
- Speed is inferred from travel time.
- Volume is inferred from sample size.
- Speed estimates are space-mean speed (as opposed to point speed or time-mean speed)
- Roadside infrastructure is minimized or eliminated.
- Quality of data is based on the percent of vehicles monitored.

Each probe vehicle technology possesses unique characteristics, as summarized below.

#### *Cell Phone Probes*

Cell phone probes cover any method used to infer the location of vehicles by use of cell phones and their associated tower infrastructure. Methods vary between vendors and fall within two broad categories. Signaling information, such as tower hand-off timing, is the most prevalent category, while the other category uses embedded assisted GPS technology within user phones. Whichever method is used, any cell phone approach requires a partnership with a major cell phone carrier within the region. This reliance has proven to be a critical risk factor in more than one demonstration project. Demonstrations in the United States and deployed systems abroad have proven the technology's ability to monitor traffic flow on freeways (Haghani, Yang, Hamedi 2007). Smith and Fontaine (2006) provide a summary of the results of various demonstrations in North America, for the reader's reference.

However, results on lower class roadways have shown less success. Cell probes have difficulty differentiating the traffic between closely spaced facilities, such as between frontage roads and the adjoining freeway. Moreover, no known cell phone demonstration to date has been able to consistently and successfully assess traffic on signalized arterials.

#### *Automated Vehicle Location Services*

AVL system information is gathered by established commercial businesses. Such systems rely on GPS receivers to track individual vehicles in a fleet, and locations are periodically reported via satellites, radios, or cellular data services. The proliferation of low-cost wireless data services, combined with the reduction in price of GPS receivers (driven by the consumer market), has increased not only the number of fleets utilizing AVL, but has also increased the reporting frequency of vehicles. Initial AVL systems adopted by long-haul trucking fleets relied on satellite communications and reported location once every 30 minutes, on average. Current systems report location more frequently, such as once every 5 to 10 minutes. With the reduction in costs, AVL systems are being used in regional fleets, such as taxis, buses, and short-haul truck delivery. As a result, the growth rate of GPS data available from AVL services is estimated to be 60% to 100% per year. The quality of traffic information derived from AVL data depends on the quantity and distribution of vehicles reporting through AVL systems. These distributions tend not to be uniform. For example, long-haul trucking tends to avoid peak hours in metropolitan areas. As a

percentage of traffic, long-haul trucking tends to be low during peak traffic demand and high during off-peak and nighttime hours. Other fleets reporting AVL data exhibit their own patterns and peculiarities depending on the nature of the fleet business.

### *Toll-Tag Technology*

A third class of probe vehicle technology exists, based on automated toll-tag systems. This technology shares the same attributes as the cell phone and AVL probes, but requires additional toll-tag readers to be deployed in the right-of-way. Unlike cell phone probes or AVL data, toll-tag systems are owned and maintained by road authorities or organizations closely aligned with public transportation management.

### *Probe-based Technology Market*

The market trend is currently not leaning toward any single technology. Vendors often merge or blend data from multiple sources, including data obtained from fixed-sensor networks owned by public entities, with data collected using their own proprietary collection methodologies and possibly with data from partners who are able to augment the data collection network for specific geographic regions or specific types of roadways. Costs of data from probe-based services cannot be assessed at this time. All of the deployments to date in North America have been demonstration projects, although Wisconsin is currently deploying an operational system that is not yet active. Project costs have ranged from \$200 to \$5,000 per mile per year for collected data.

### **Fixed-point Speed Sensors**

In contrast, fixed-point speed sensors (loop detectors, in particular) generally have the following attributes:

- Traffic volume and occupancy is measured directly.
- Traffic speed is inferred from occupancy based on an average vehicle length.
- Travel time is inferred from a network of sensors.
- Quality of travel time data is dependent on the density of the sensor network.
- Equipment in the right-of-way is required.
- Cost of deployment has historically been high.
- The technology has been historically maintenance-intensive.

Several new fixed-point sensor technologies are emerging based on radar, acoustics, and other sensing concepts. Such systems are less intrusive to deploy and maintain because such devices are mounted away from the roadway on adjacent structures, such as a light pole or overhead sign truss. This minimizes installation costs as well as traffic disruption during installation and maintenance, and it avoids pavement penetration. In some instances, wireless data communications and solar and wind power technology have been integrated to further reduce the cost of the supporting infrastructure. Vendors have introduced new business models to allow for outsourcing so that the road authority purchases only a data subscription (similar to that of probe vehicles) while the vendor is responsible for installation and maintenance. Although technology has enhanced the cost competitiveness of point detection, these sensors are still subject to the same fundamental constraints as loop detectors in that the quality of traffic data is proportional to the density of sensors in the study area, and equipment is required in or immediately adjacent to the right-of-way.

## **PRESSURES TO ADOPT PROBE-BASED TECHNOLOGY**

Pressures are converging on state DOTs and road authorities to consider probe-based technologies.

The first pressure, as discussed above, is the historic cost of owning and maintaining a network of fixed-point sensors, particularly magnetic loop detectors. The large expense of deploying fixed-sensor networks and the fiscal and manpower burden of maintaining such networks are driving state DOTs and regional and municipal road authorities to consider probe-based services. New speed sensor technology (such as acoustics and radar) is remedying some of the concerns of spot-speed sensing based on loops. However, spot-speed sensing is inherently limited to the spatial deployment of sensing stations and cannot scale geographically as easily as probe-based solutions do at a lower cost.

Second, the primary responsibility of transportation agencies has been, and continues to be, the construction and preservation of the travel way. Under fiscal and manpower constraints, outsourcing typically occurs in skill areas that are not among the core competencies of the vested employees. At present, the sensing and data gathering functions needed to support ATIS and ATMS fall into this category.

Third, the proliferation of low-cost wireless data communications is also fueling the appetite of consumers for real-time travel data and timely reporting of slowdowns and road closures across the entire highway system. Probe methods offer a viable means of acquiring a systemwide view without the investment of a massive fixed-sensor network. Customer satisfaction was once based primarily on the quality of ride and the extent of the highway network. However, customer satisfaction, particularly in congested metropolitan areas, is now based on efficient management of limited highway capacity and communication of such data to customers to allow them to avoid slowdowns related to incidents and congestion.

In summary, traffic data collection within a transportation agency has traditionally been application-specific and geographically constrained, such as the need to actuate a traffic signal or collect speed and count data for planning purposes. This “stovepipe” approach is being replaced by comprehensive traffic monitoring across the entire roadway system that serves many applications. Such an approach feeds not only legacy applications, but also supports the growing demand for ATIS data, such as travel times on variable message signs, 511 and web 511 information, and performance measurement data that assesses the efficiency of existing highway operations.

### **I-95 TRAFFIC MONITORING PROJECT**

The I-95 Corridor Coalition initiated a vehicle probe project in 2006 to provide comprehensive, multistate traffic flow monitoring along the corridor. The objective is the acquisition of traffic flow information based primarily on probe technology for both freeways and signalized arterials. The information produced by this project will be used to support a number of Coalition activities, such as corridorwide traveler information, incident management, and performance measurement. The wide-area coverage provided by this project is designed to support the unique planning, engineering, and operational needs of a heavily traveled corridor.

Member agencies will benefit from the vehicle probe project by receiving traffic flow information relevant to their respective jurisdictions. It is anticipated that they will use the information to support the operation of 511, display travel times on variable message signs, and manage traffic during incidents. Coalition members will also be able to utilize the contract developed for this project to expand coverage

within their jurisdictions, develop information websites, and interface with existing traffic management systems.

By pooling the resources of several states, this project attempts to bridge jurisdictional boundaries in order to provide long-distance travelers with information relevant to inter-jurisdictional highway travel. Additionally, this project will provide the information needed to support implementation of long-distance diversions that are characteristic of major incidents that have a multistate impact.

The Coalition will contract with a probe data provider that will be selected based on a review of proposals. The RFP was released on April 27, 2007. It is anticipated that a contract will be awarded by the end of 2007, with traffic data available by summer 2008. The contract will be based on the purchase of data and does not include procurement of any hardware or software, except for the ancillary services that may be requested by member agencies.

Critical points of the RFP are summarized as follows:

- No particular probe technology is specified. The approach is limited only to methods that do not require additional physical equipment to be located in the right-of-way. Vendors can take advantage of data from existing systems that rely on field assets, such as loops, radar, or toll-tag systems.
- Specifications regarding the quality of the data were determined based on the intended uses of the data. The specifications limit the error in reported speed (and associated travel time) under varying roadway conditions.
- Data service will be validated by an independent agent on behalf of the Coalition.
- The vendor must supply a risk assessment for both the vendor and the Coalition. If service is dependent on third party contracts, evidence of the sustainability of such contracts is required.
- The vendor retains full ownership of data for resale in the commercial market. Minimum data rights are defined to support the intended applications within the Coalition. Vendors may propose additional restrictions (or fuller rights to the data) in the proposals. Any additional data rights (or restrictions) will be assessed as part of the RFP evaluation process.
- The vendor may provide data using any one of a number of common formats, technologies, and data standards. However, the vendor must be able to transform or translate that format into whatever format is needed for integration into Coalition members' data systems as part of ancillary consulting services. The ability to transform the data format into ITS standard protocols is required.
- The base contract (and associated funding) is planned for the first three years, with options to renew for an additional seven years. Supplemental funding to extend the contract beyond the initial three years is to be provided by Coalition members. Supplemental funding is not guaranteed, but based wholly on the success of the project and its critical role in corridor operations.
- Coverage will include I-95, beltways, parallel freeways, parallel signalized arterials, cross-linking freeways, and cross-linking arterials. The Coalition prefers full coverage on all road classes for a limited geographical area, rather than coverage of only higher class facilities along the whole corridor.
- Evaluation and award of the contract will be based on the best value for the Coalition.

## CONCLUSIONS

Traffic monitoring through the use of probe vehicle technology is emerging as a viable means of developing comprehensive traffic monitoring systems without a large investment in physical assets

deployed in the right-of-way. Although new methods for detecting speed and volume are lowering installation costs and minimizing maintenance, probe-based methods of measuring travel time can easily scale across large networks without additional infrastructure in the right-of-way and its associated costs and maintenance burden. Probe vehicle technology is fundamentally different than fixed-point detectors, in that probe technology provides a direct measure of travel time, while any method of fixed-point detection infers travel time from a network of speed sensors.

Demonstrations of probe technology have been successful for freeway applications, but the technology remains unproven for signalized arterials. The I-95 Corridor Coalition is moving forward with an aggressive program to procure travel time and speed data through an outsourcing program that utilizes technologies that do not require road-side equipment. Vendors are not restricted from using existing fixed-sensor data. The specifications for quality of data, ownership, and dissemination rights were determined based on the intended applications of the data within the Coalition, allowing the vendor to propose innovative solutions with minimal constraints. If successful, the program will provide a means for the Coalition and its members to procure the quality traffic data to meet the expectations of its customers, support legacy applications, and assess performance of existing infrastructure to enable planning and engineering.

## REFERENCES

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