White Paper

Florida Department of Transportation

Cell Phone Location System

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Final Version 2

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List of Acronyms

ATMS ..... Advanced Traffic Management System
DOT ..... Department of Transportation
FIU ..... Florida International University
GDOT ..... Georgia Department of Transportation
GPS ..... Global Positioning System
HOV ..... High Occupancy Vehicle
I-64 ..... Interstate 64
I-75 ..... Interstate 75
I-94 ..... Interstate 94
I-95 ..... Interstate 95
KDOT ..... Kansas Department of Transportation
LOS ..... Level of Service
MDOT ..... Maryland Department of Transportation
MMTIS ..... Multi-Modal Traveler Information System
Mn/DOT ..... Minnesota Department of Transportation
MoDOT ..... Missouri Department of Transportation
MPH ..... Miles per Hour
RFP ..... Request for Proposals
SR ..... State Route
TTECP ..... Travel Time Estimation Using Cell Phones
UDOT ..... Utah Department of Transportation
VDOT ..... Virginia Department of Transportation
WisDOT ..... Wisconsin Department of Transportation

1. Introduction and Executive Summary

The purpose of this paper is two-fold. It will summarize recent research into the use of cell phone location technology for traveler information and traffic information purposes, and it provides a summary from interviews with project staff of some key features of recent projects. It also includes a brief description of how cell phone location technology works, and why state departments of transportation (DOTs) are interested in investigating its potential.

The following is a summary of the key outcomes of this paper.

- Because cell phone companies always know, within a certain radius, where a cell phone is located, it is possible to derive travel speeds from this data.
- Doing so is usually much cheaper than deploying traditional detection equipment, such as loop detectors, cameras, or radar-based sensors.
- Cell phone location systems generally provide adequate information on freeways during free flow.
- Data is less accurate during congested periods and for arterials.
- There are few independent evaluations of cell phone location data.
- One of the most-used metrics, “average error,” is a misleading measure of the accuracy of the technology

In addition, there are legitimate questions related to privacy issues, business models, and intellectual property that are not addressed in this paper.

2. Description of the Technology

In order to manage their systems and route calls, cell phone carriers are able to generally tell where a cell phone is. At the very least, they know that it is within a certain range of a specific cell phone tower. As cell phones travel across an area, their connection to the network is handed off from one cell phone tower to another. It is at this hand-off point that cell phone carriers have the most knowledge of the phone's location. They can make this data available to cell phone location companies, who combine it with other data, apply their proprietary algorithms, and estimate the speed of the phones. They then must determine which cell phones are in vehicles, assign those vehicles to specific roadways, and calculate speeds or link travel times on those roadways.

3. Research to Date

There have been several recent research studies that have addressed whether cell phone location data is adequate to support traffic management and traveler operation needs, including:

1. Florida International University (FIU), *Travel Time Estimation Using Cell Phones (TTECP) for Highways and Roadways* (January 29, 2007). This study is referred to herein as the *FIU Report* and is available online at http://www.dot.state.fl.us/research-center/Completed_Proj/Summary_TE/FDOT_BD015_12_rpt.pdf.

2. URS Corporation, *Data Evaluation for Cellint Cellular Probe on Freeways* (April 2007).

3. Smart Travel Laboratory, Center for Transportation Studies, University of Virginia, *Wireless Location Technology-Based Traffic Monitoring Demonstration and Evaluation Project* (May 26, 2006). This study provides an evaluation of the AirSage deployment in Hampton Roads, Virginia.

4. University of Maryland, *Cellular Probe Data Evaluation Case Study: The Baltimore Multi-Modal Traveler Information System (MMTIS)* (October 2006). More information regarding the Baltimore MMTIS is available online at http://www.baltometro.org/content/view/655/423/.

With the exception of the *FIU Report*, each of these focuses on a specific deployment and is discussed below, including descriptions of the individual projects. Much of the *FIU Report* also summarizes existing projects, so those portions of that study are also discussed below in the descriptions of the individual projects. The remainder of this section summarizes the high-level findings of the *FIU Report*.

The scope of the study was to investigate the maturity and potential application of cell phone location technology for traffic management and traveler information. The researchers solicited input from over 30 companies, asking for descriptions of technology, patent numbers, deployment status, and so forth. Of the 30 companies contacted, the following provided enough information for the researchers to assess their technologies and deployments.

- AirSage
- Cellint
- Delcan / ITIS Holdings
- Globis Data, Inc.
- IntelliOne Technologies Corporation

Based on their review of these companies and their deployments, the researchers made the following findings:

- There were generally good results in free-flow conditions.
- There is no evidence that travel times and speed estimations are accurate in heavy congestion or for arterials.
- Many providers use "average error" as a metric to demonstrate accuracy. This is not a valid tool, as the average will, by definition, be dominated by times and segments when there is no congestion.
- More study is necessary to determine how effective cell phone location technology can be useful across a range of traffic applications.

The point about average error is worth discussing in more detail. Imagine one roadway segment on which data is being collected and assume that the data is collected in 15-minute time intervals. This will yield 96 discrete data points every day for that segment. If, as is probable, speeds derived from cell phones are more accurate during free-flow periods than during congested periods, the averages might look something like those provided in Table 3.1.

Table 3.1 — Sample Average Error Averages

PERIOD	AVERAGE ERROR (MILES PER HOUR [MPH])
Entire Day	6.2
Peak Periods (2 hours each in the a.m. and p.m.)	16.6
Nonpeak Period	4.1

Thus, it is clear that using a full-day report of average error can minimize the magnitude of error when it most matters, during congested periods. The same analysis would apply geographically as well, in that average speeds on noncongested roadways will minimize the magnitude of the reporting error on congested roadways. Potential users of speeds or travel times derived from cell phones should be wary if the only data they receive from their potential provider is average error information.

4. Specific Deployments

The remainder of this paper discusses specific projects, in the United States only, which are using cell phone location technology to provide speeds or travel times for traffic management or traveler information purposes. It also includes pilot projects in which state DOTs or their research institutions have investigated the feasibility of cell phone location services.

Table 4.1 summarizes the deployments and is followed by additional information gathered from interviews with the public-sector project manager as well as any published evaluations.

Table 4.1 — Deployment Summary

GEOGRAPHIC COVERAGE	PROVIDER	CLIENT	STATUS
Hampton Roads, Virginia	AirSage	Virginia DOT (VDOT)	Pilot Test
Interstate 75 (I-75) between Atlanta and Macon, Georgia	AirSage	Georgia DOT (GDOT)	Pilot Test
State Route (SR) 400 in Atlanta	Cellint	GDOT	Deployment
Tampa	IntelliOne	Not Applicable	Pilot Test
Baltimore, Maryland	ITIS Holdings	Maryland DOT (MDOT)	Pilot Test
Missouri (Statewide)	ITIS Holding	Missouri DOT (MoDOT)	Deployment
Kansas City, Kansas	Cellint	Kansas DOT (KDOT)	Deployment
Salt Lake City, Utah	AirSage	Traffic.com (for the Utah DOT [UDOT])	Deployment (currently in testing)
Interstate 394, State Route 85, County Road 81, Minneapolis, Minnesota	AirSage	Minnesota DOT (Mn/DOT)	Pilot Test
Interstate 94 (I-94) between Milwaukee and Madison, Wisconsin	AirSage	Wisconsin DOT (WisDOT)	Deployment
Interstate 95 (I-95) (from Maine to Florida)	To be decided	I-95 Corridor Coalition	Deployment

4.1 Hampton Roads, Virginia

AirSage covered 90 centerline roadway miles in the Hampton Roads area. The project began its deployment in December 2002. Originally scheduled to last 12 months, the evaluation was finally concluded in December 2005. AirSage claimed that, at that point, it only had 25 percent of the data that it would ultimately have. No evaluation was conducted based on the purported full data set.

The results, documented in the University of Virginia report (refer to Item 3 in *Section 3* of this paper), shows that data was generally good at high speeds, but not good at lower speeds, as shown in Table 4.2.

Table 4.2 — Hampton Roads Data Summary

SPEED (MPH)	AVERAGE DIFFERENCE (MPH)	DATA POINTS OFF BY MORE THAN 20% OF ACTUAL SPEED (%)
0 – 30	24.7	57.0
30 – 45	8.5	10.8
45 – 60	8.7	7.2
> 60	9.5	13.9

The researchers concluded by noting that:

- The data could not support the Virginia Department of Transportation's (VDOT) operations for traffic management.
- Data was acceptable at high speeds, but errors were 20 percent or higher when speeds were below 30 mph.
- Travel time was not reliable on arterials or congested freeways. There were errors exceeding 15 mph 84 percent of the time.
- AirSage could not provide data on reversible high occupancy vehicle (HOV) lanes on Interstate 64 (I-64).
- AirSage could not provide a confidence measure to allow the VDOT to assess how accurate the data was.

When the team from FIU reviewed this deployment, they noted, in addition to the above, that, when speeds were slower than 22 mph, the average error was 25 mph, or 113 percent, of the actual speed.

4.2 Interstate 75 between Atlanta and Macon, Georgia

The Georgia Department of Transportation (GDOT) has been conducting a pilot test of AirSage technology on approximately 80 miles of I-75 between Atlanta and Macon. This project was not discussed in the *FIU Report*, nor has there been any evaluation to date. All information in this section comes from a conversation with Mark Demidovich, GDOT Assistant State Traffic Engineer.

The project was started to test whether cell phone location technology could provide the acquisition of data in rural areas at a lower cost. To date, AirSage has not been able to completely meet the project limits. The middle segment of the project still does not have data. The GDOT originally had a good working relationship with AirSage, but that relationship has deteriorated over time, and AirSage has not been able or willing to correct some problems with the project.

URS will be evaluating the data, but has not yet completed its report. The GDOT expects to have the report sometime this summer.

4.3 Georgia State Route 400 — Atlanta Metropolitan Area

The GDOT has contracted with Cellint to provide speed information on 12 miles of the SR 400 freeway, along with arterials both parallel to and intersecting with the freeway. Information in this section comes both from discussions with Mark Demidovich, as well as from the URS report referenced in Item 2 in *Section 3* of this document. The GDOT started the project to get some detection in place quickly after fiber optic cable was destroyed during construction. The GDOT used an informal bid process and selected Cellint. The project was up and running 3½ months after the contract was signed. In general, the GDOT has been very happy with the project data. The URS report, which compared the cellular location data to data from the GDOT's advanced traffic management system (ATMS) and floating car data, found that the cellular data was comparable to the ATMS data.

The report's findings, however, suggest that Cellint also has accuracy issues during low speeds. For example, the 90 percent confidence interval was 24 mph at speeds ranging from 10 to 20 mph. In other words, between 10 and 20 mph, the system could only guarantee that a datapoint was accurate within a range of 24 mph. Thus, data reported as 15 mph could, in reality, be anywhere between 3 mph and 27 mph. This suggests that the system does not necessarily provide accurate data at low speeds. The GDOT and URS believe, however, that these results might be caused, at least in part, by small sample sizes during low flow periods.

4.4 Tampa, Florida

IntelliOne performed its own test in the Tampa area in which it purported to demonstrate the accuracy of its data. There is no independent evaluation of the test. The *FIU Report* noted that the test was done with cell phones in continual use, which makes them much easier to track and locate, as compared to cell phones that are on but not in use. Consequently, this test is not a valid demonstration of IntelliOne's accuracy, as it did not match real-life conditions.

4.5 Baltimore Metropolitan Area

This pilot project, conducted by Delcan and ITIS Holdings for the Maryland State Highway Authority, was one of the earliest deployments of the current generation of cell phone location systems. The data was tested during 2006 by the University of Maryland. (Refer to Item 4 in *Section 3* of this paper.) The report found that average errors were approximately 10 mph on freeways and 20 mph on arterials. The quality degraded significantly during a.m. and p.m. peak periods, rendering the average error metric somewhat suspect. Quality also degraded significantly during periods of low levels of service (LOS).

The *FIU Report* discussed the findings as well, and found that results were generally good on most freeways but speeds were overpredicted on arterials. It also noted that congestion affected data quality. At LOS F, in particular, more than 80 percent of the sample was off by more than 100 percent.

4.6 Missouri Statewide Data Collection Project

This project, deployed by Delcan and ITIS Holdings for the Missouri Department of Transportation (MoDOT), began in January 2006. The original contract called for 5,500 miles of coverage within six months of the notice to proceed. As of June 2007, the contractor had provided data for 70 miles of freeway and had not conducted any evaluation of the data.

4.7 Kansas City Scout

Cellint, working with the Kansas Department of Transportation (KDOT), collected speed information and generated slowdown reports for portions of the Kansas City Metropolitan Area in Kansas and Missouri. This was done as part of a no-cost pilot test conducted during 2006; the test is no longer running. Mark Sommerhauser, a MoDOT employee and the ITS Project Manager for Kansas City Scout, said that the KDOT was not actively planning to do any kind of cell phone project, but Cellint approached them with the offer of a no-cost pilot test, since Cellint already had the infrastructure to support services it was providing to its cell phone carrier. The KDOT and Kansas City Scout looked at this as an opportunity to assess the feasibility of a cell phone location system. There was no official evaluation but an informal analysis by Kansas City Scout staff showed the following:

- A red-yellow-green speed map provided by Cellint matched reasonably well with camera views.
- Speed trends tracked speeds reported by detectors, but were often off by 5 mph.
- There was not enough data during overnight periods to provide speeds, but Cellint admitted that at the beginning of the project.
- Cell phone data matched the trend line of detector data, but seemed to exaggerate the peaks and valleys.
- There was a lag of as much as 8 to 10 minutes, according to Kansas City Scout, or as little as 3 to 4 minutes, according to Cellint, between when slowdowns occurred and when they were reported.

In general, Mr. Sommerhauser felt that the technology shows promise, subject to the constraints mentioned above, but that it is very important to understand the ultimate use of the data.

Because there was no formal evaluation, the *FIU Report* noted that there is not enough data, nor are there sufficient metrics, to assess the accuracy of the information provided by Cellint.

4.8 Salt Lake City, Utah

Traffic.com currently provides traffic information via a Web page in the Salt Lake City area. It is currently assessing AirSage data for use in its traveler information program, but has no public information on data quality. Traffic.com staff would not comment on the status of their assessment. The *FIU Report* discussed AirSage's claims as to the accuracy of the data, and found that, even though the red-yellow-green color maps from Traffic.com and Utah Department of Transportation (UDOT) roughly matched each other, that was not sufficient to confirm that the data was accurate. This is because:

- The assessment is not independent.
- The maps were mostly green, which means the roads were not congested, so it says nothing about AirSage's ability to provide accurate data during congested periods.
- Three colors, as opposed to actual speeds, do not provide enough granularity to provide meaningful analysis.

4.9 Minnesota

The Mn/DOT has recently begun a test of AirSage's data on one freeway and two arterials in the Minneapolis metropolitan area. Information in this section comes from a conversation with Bernie Arseneau, Mn/DOT Project Manager, and from a presentation Mr. Arseneau made at the ITS America 2007 Annual Meeting.

The project began because AirSage contacted high-level officials at the Mn/DOT and urged them to conduct a test. Mr. Arseneau, as state traffic engineer, was tasked to manage the project. He views it as a test and thinks it is a worthwhile exercise. At the same time, he is skeptical about whether the data quality will be good enough to support the Mn/DOT's needs, particularly on arterials.

Because the project has just begun, they do not yet have any data available for analysis. A final report is expected by the end of the summer.

4.10 Interstate 94 and Parallel Arterials between Milwaukee and Madison, Wisconsin

This project is in the early implementation stage. All information comes from discussions with Dean Beekman, Project Manager for the Wisconsin Department of Transportation (WisDOT). This project began with a request for proposals for noninfrastructure-based traffic information. The intent is to assess the quality, with the ultimate result of using the data for an eventual 511 system and for traffic management. The WisDOT selected AirSage to provide data on I-94 and parallel arterials, and also selected Inrix to provide data on another route using a global positioning system (GPS) probe as opposed to a cell phone solution.

The project is still in its early stages. Roadway links have been defined and AirSage has provided some data, but the data has not been integrated into any systems yet, nor has an evaluation been conducted. The University of Wisconsin will evaluate the data.

4.11 I-95 Corridor Coalition

The I-95 Corridor Coalition is soliciting proposals for noninfrastructure-based traffic data services. It is assumed that cell phone location firms will be among the bidders for this project. The purpose of the Coalition's request for proposals (RFP) is to support the development of a regional traffic monitoring system that acts as a continuous source of real-time transportation system status information within the Corridor. The RFP will lead to a three-year contract, with extensions allowed should the Coalition so desire. Proposals are due on June 22, 2007.

5. Conclusions and Recommendations

It is our opinion that cell phone location technology is still not mature enough to support moving forward with a project that is intended to provide decision-quality data. That being said, however, it may be beneficial for the FDOT to consider a test using the following items as guidance:

- Consider testing several data providers against one another on the same set of roadways.
- Test a mixture of freeways and arterials, and make sure that congested roadways are included in the test.
- Open the test to other probe-based data providers, rather than simply cell phone location providers.