Technical Memorandum

Tallahassee License Plate Reader Deployment Project

License Plate Reader Operations

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List of Acronyms

AMBER .... America's Missing: Broadcast Emergency Response
ANPR .... Automatic Number Plate Recognition
DMS .... Dynamic Message Sign
ETC .... Electronic Toll Collection
FDOT .... Florida Department of Transportation
GPS .... Global Positioning System
GUI .... Graphical User Interface
LPR .... License Plate Reader
OCR .... Optical Character Recognition
ORT .... Open Road Tolling
RTMC .... Regional Transportation Management Center
SAE .... Society of Automotive Engineers
SR .... State Road

1. Introduction

This paper supports Florida Department of Transportation's (FDOT) data collection attempts to enable the FDOT to provide travel times on dynamic message signs (DMSs) in the Tallahassee area. The current recommendation is to deploy license plate readers (LPRs) to collect raw license plate data, analyze this data to produce usable travel times, transfer the travel-time data to the City of Tallahassee regional transportation management center (RTMC), and then publish travel times on area DMSs. The DMSs are not yet installed; contracting for their installation is expected to begin during the fall of 2006.

Section 2 of this paper provides background information on other LPR projects, with a focus on those used to generate travel times. *Sections 3* and *4* describe how an LPR system works and discuss the data flow. Privacy issues are discussed in *Section 5* and the recommendations for proceeding are provided in *Section 6*.

2. Background for License Plate Reader Projects

This section describes various existing LPR projects. It does not describe all such projects, but provides highlights for some representative samples. Because we are proposing to deploy LPRs in this project specifically to collect data to support the calculation of travel times, most of the examples we provide will focus on that application. We will, however, provide other examples to demonstrate how LPRs can support other applications as well.

2.1 Travel Times

Where traffic congestion and delays are a problem, LPR systems are able to collect travel times to support traffic management and traveler information functions. Examples of such systems include:

- The United Kingdom Highways Agency uses automatic number plate recognition (ANPR) to collect travel-time data to support its national traffic information Web page.[1]
- The Arizona State Road (SR) 68 Work Zone project used an LPR system to monitor travel times to ensure that traffic was maintained at certain minimum thresholds during construction.[2] License plate readers have also been deployed along four arterial roads in the metropolitan Phoenix area to support the posting of roadway travel times to nearby DMS devices.
- The Orlando Metro Area Probe Test compared transponder data collection and LPR data collection for the purpose of providing travel times.[3] In addition, LPRs have been deployed to collect travel times as part of the FDOT's *i*Florida project.[4]
- The Scottish Journey Time System Trial used LPR technology to collect driving times.[5]
- The Hawaii Department of Transportation is considering the deployment of a LPR-based travel-time data collection system in the near future.

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[1] The Web page is located online at http://www.highways.gov.uk/traffic/traffic.aspx.

[2] More information on the Arizona SR 68 Work Zone project is available online at http://www.tfhrc.gov/pubrds/02may/01.htm.

[3] *Technical Memorandum No. 3 – Field Test of the Potential for Using Probe Vehicles to Determine Arterial Travel Times in the Orlando Metropolitan Area – Final Report* (July 2003)

[4] More information regarding the FDOT *i*Florida Surface Transportation Security and Reliability Information System Model Deployment project is available online at http://www.iflorida.net/.

[5] More information regarding the Scottish Journey Time System Trial is available online at http://www.scotland.gov.uk/library5/transport/sjt_summ.pdf.

2.2 Other Applications

While this paper primarily addresses travel times, some other LPR functions that can be performed should also be noted, such as:

- Vehicle identifcation for tolling, both as support for transponder-based electronic toll collection (ETC) systems and as the primary vehicle identification system for open road tolling (ORT) functions
- Access to secured facilities, where the system compares a vehicle's license plate against a database of authorized vehicles
- Identification of "vehicles of interest" to law enforcement, such as those identified by America's Missing: Broadcast Emergency Response (AMBER) Alerts or homeland security alerts
- Creating a database of vehicles that enter a specific area to correlate any criminal activity
- Speed enforcement, or "section control," as it is referred to in Europe, where a ticket can be generated if a vehicle's average speed between two checkpoints, as derived from its travel time, exceeds the speed limit

3. License Plate Reader Operations

This section describes how LPRs operate and how they can be used to generate travel times.

3.1 Technology Description

An LPR system is comprised of several different pieces of technology. At the most basic level, the technology can be categorized as either roadside technology or central system technology. These categories are discussed in the following subsections.

3.1.1 Roadside Equipment

The following operations will be performed at the roadside. The specific technologies used to perform these functions will not be addressed in this document.

- Provide presence detection functions.
- Provide a LPR that will operate in all weather and light conditions without distracting drivers.
- Provide on-site optical character recognition (OCR) functions.
- Focus one or more cameras on the cross section of a road.
- Read license plates that pass through the capture zone(s).
- Provide periodic plate number batch transfers that, depending on the system configuration, may have been truncated, scrambled, or otherwise anonymized; a time stamp; and site location identification, referred to as LPR data, to the travel-time central server.
- Provide ongoing health monitoring.
    - Keep statistics, such as valid reads versus images.
    - Track the operational status of components.
    - Provide alerts if health monitoring reveals problems, such as failed components, low read rates, etc.
    - Transfer the status archive to the central system regularly.
- Provide low-profile, nonobvious vandal proof equipment.
- Provide time synchronization (i.e., system heartbeat).

A schematic diagram of the roadside equipment is shown in Figure 3.1 and a photograph of an installed LPR is shown in Figure 3.2.

In addition, existing infrastructure is recommended for use with LPR installations. A typical installation will require:

- A place to mount the reader (preferably a bridge)
- Connection to an electric power source
- A communications system, which can be wireless or wireline

Figure 3.1 – Schematic Diagram of Roadside Equipment

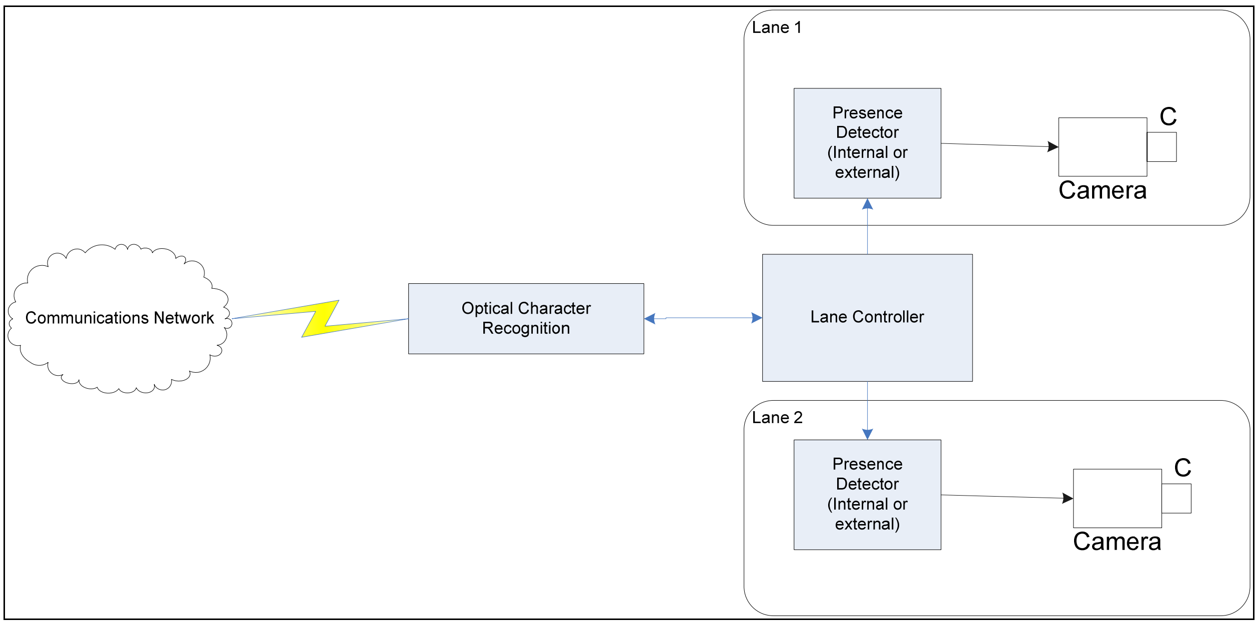
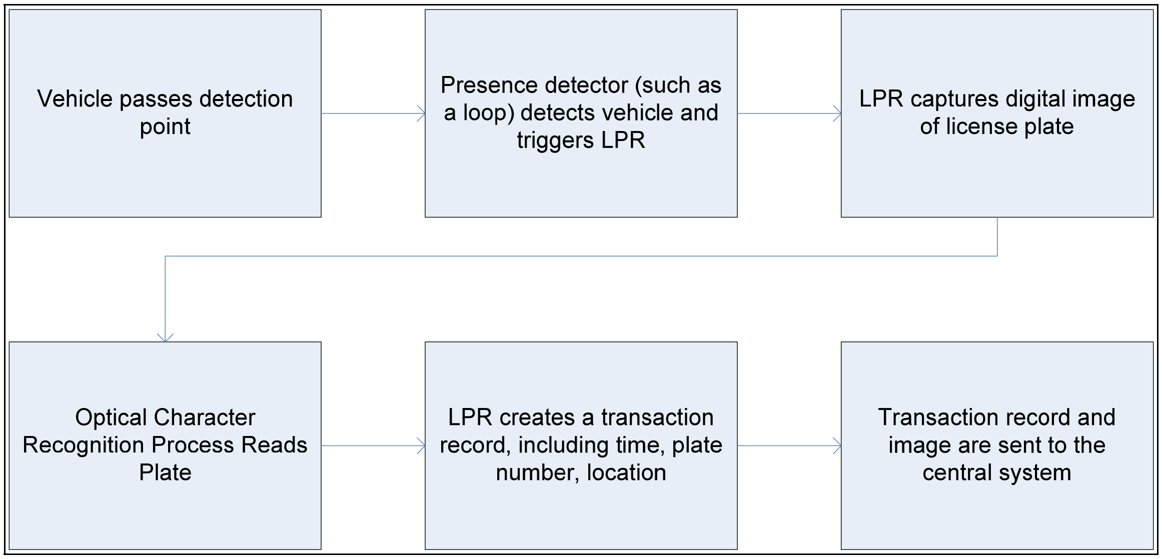


Figure 3.2 – Installed License Plate Reader

Once the equipment is deployed, the vehicle identification process at the roadside works as depicted in Figure 3.3.

Figure 3.3 – Roadside Vehicle Identification Process



3.1.2 Central System Equipment

The following elements will be used at the central server:

- Time synchronization management system, which will link to the field equipment
- Health monitoring, including:
  - Alerting functionality
  - Archive
  - Real-time status shown on a graphical user interface (GUI)
- Plate data retrieval
- Data anonymizing or scrambling[6]
- Elimination of plate data taken from images with low quality/likely inaccuracies
- Plate matching to support the creation of travel times
- Travel-time calculation for individual vehicles and filtering of data
- Calculation of an aggregate travel time for the roadway segment(s)
- Data archive

[6] Note that some systems perform the data anonymizing or scrambling function at the roadside.

- Aggregated data output consistent with recognized ITS standards (e.g., Society of Automotive Engineers (SAE) *J2354* standard data)[7]

Note that the central system is primarily software-based, especially when compared to the device-oriented nature of the field equipment. The implication of this is that the FDOT will need to procure the appropriate software to perform these functions. While this paper focuses on the operations of the LPR system as opposed to the procurement, the following list represents, at a high level, the options for procuring the software.

- Procure the field equipment and the software from the same vendor through a competivive procurement
- Procure the field equipment and the software from different vendors through competitive procurements
- Procure the field equipment through a competitive procurement and use existing FDOT contractors to provide the software

3.2 Constraints

Like all technologies, LPRs face certain operational constraints. The key constraints include:

- **Power —** License plate reader systems need a dedicated power connection. They require too much energy to function using solar power or batteries.
- **Communications —** License plate reader systems need dedicated communications, though the system can be wireless or wired.
- **Character Recognition —**: There are a number of issues that affect how well an LPR is able to identify the alphanumeric characters on a license plateincluding:
  - Weather conditions (although these can be mitigated somewhat with the use of infrared light sources)
  - Layout of the license plate, including background colors, font color, and font shape
  - Variety among license plates[8]
  - Location of the infrastructure on which LPRs can be mounted

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[7] Society of Automotive Engineers, *SAE J2354 – Message Set for Advanced Traveler Information System (ATIS)* (Version 2, February 2004). More information regarding the SAE standards is available online at http://www.sae.org/standardsdev/.

[8] Note that Florida has approximately 100 different liense plate designs, although 85 percent of all the license plates are the standard design.

3.3 List of Vendors

The following is a list of vendors for LPR systems:

- Transport Data Systems (More information is available online at http://www.transportdatasystems.com.)
- PIPS Technology, Inc. (More information is available online at http://www.pipstechnology.com/.)
- Extreme CCTV® (More information is available online at http://www.extremecctv.com/home.php.)[9]
- American Traffic Solutions (More information is available online at http://www.atsol.com/.)
- Atom Imaging Technologies (More information is available online at http://www.atomimaging.com/.)
- Remington-Elsag Law Enforcement Systems (More information is available online at http://www.remingtonelsag.com/.)
- G2 Tactics, Inc. (More information is available online at http://www.g2tactics.com/index.html.)
- JAI PULNiX® (More information is available online at http://www.pulnix.com/.)[10]

3.4 System Differences and Operational Implications

Because there are a wide variety of LPR vendors, each system is likely to have different strengths and weaknesses, and differing abilities to generate travel-time data on the roadway in question. This suggests that the procurement method be based on functional requirements (i.e., what the FDOT wants the system to accomplish) rather than on technical specifications (i.e., how the system performs its function).

[9] Extreme CCTV is a registered trademark of Extreme CCTV, Inc.

[10] JAI PULNiX is a registered trademark of JAI PULNiX, Inc.

4. Data Use and Analysis

The key to this project is to develop a system that generates useful travel times from LPR data. This section describes the process by which individual LPR reads are used to calculate travel times, discusses possible uses for travel–time data, and compares the data from an LPR system to other types of traffic data.

4.1 Data Flow

The process begins when a vehicle detector, which can be part of the LPR or external, such as a loop detector, alerts the LPR that a vehicle is in the LPR capture zone. The LPR captures the image of the vehicle's license plate, and the system's OCR software converts the image to an alphanumeric string. This data, along with the time, reader location, and. in some systems, an estimate of the accuracy of the read, is then sent to the central server.

Either at the individual LPR or in the central system, the raw license plate data is modified to protect privacy. This is generally done by either encrypting the plate reads using the same encryption code so that each plate is encrypted in the same manner each time or by truncating some of the characters from the plate, so that the full plate number is never used. The encrypted or truncated value is then used through the rest of the process, so that no individual's license plate number is stored or used within the system.

This process is repeated for data coming from all of the LPRs within the system. The central server has the ablity to match reads from different LPR stations, which allows the system to calculate each vehicle's travel time between readers. At a regular, configurable interval, all of the individual travel times between two adjacent readers are used to calculate an average travel time. One of the challenges in performing this calculation is ensuring that outlier data (generally a read from a vehicle that left the roadway and then re-entered it between readers) is filtered out. This can be done in a variety of ways, such as by using the median value over the time period rather than the mean, or by looking for bimodal distributions and then taking the mean of the grouping that represents the shorter travel time.

Once average travel times for each segment have been calculated, they can be combined to provide an estimated travel time for any contiguous combination of segments on one or more roadways.This can either be done in the same system, or the segment travel times can be passed to the system that will disseminate travel times — the Tallahassee RTMC, in this case. Regardless of where in the process the aggregation is done, there must be an interface between the LPR system and the system used to disseminate the travel times. This interface should follow commonly utilized ITS standards.

4.2 Comparison to Other Data Sources

It is useful to understand the strengths and weaknesses of LPR-generated data compared to other possible data sources. The table below lays these out.

Table 4.1 – Comparison of Data Collection Technologies

	Technology	Strengths	Weaknesses
Segment-based Detection	LPRs	• All vehicles are potentially probes • Reliable technology	• Some questions about accuracy • Perceptions of privacy violation • Requires extensive infrastructure • Latency issues for travel times
	Toll Transponder Readers	• Reliable technology • More accurate than LPRs in positively identifying each vehicle	• Perceptions of privacy violation • Requires extensive infrastructure • Requires a substantial transponder base to be in circulation • Latency issues for travel times
	GPS-equipped Vehicles	• Reliable technology • Accurate	• Requires access to global positioning system (GPS) data from fleets, etc. • Requires large amounts of processing power and proprietary algorithm to calculate travel times • Latency issues for travel times
Point Detection	Loop Detectors	• Accurate when installed correctly	• Expensive to install and maintain • Challenging to use point detection for travel times
	Nonintrusive Detectors	• Easy to install • Cheaper than LPRs or loops	• Requires ongoing fine-tuning (depending on the technology) • Challenging to use point detection for travel times

5. Privacy Issues

One of the key questions that should be asked before deploying an LPR system is whether the system violates any laws relating to the expectation of personal privacy. *The Florida Constitution* provides:

> *Every natural person has the right to be let alone and free from governmental intrusion into the person's private life except as otherwise provided herein.*[11]

While there has been significant case law interpreting this provision, there has been none that addresses the issue of whether reading (and then encrypting) a license plate number could constitute an invasion of privacy.

The general rule is that license plate numbers are not private information because the number, since it is attached to the outside of the vehicle, can be seen by anyone.[12] There are no Florida cases that have addressed this particular issue, but federal courts have ruled that "because they are in plain view, no privacy interest exists in license plates."[13] Moreover, the increasing use of technologies, such as BootFinder™,[14] which reads license plates and compares them against a list of offenders, suggests that there are no privacy laws that would prevent the deployment of a vehicle-of-interest project.

It is important to note, however, that just because it is legal to deploy such a system does not mean that there will not be a privacy risk. Public perception can be at least as important as the legal requirements and the technical solution. While people will likely be comfortable with the system as described, there will, at the same time, be concern about potential abuses. It is a rule of thumb that approximately one-third of the population is indifferent to potential privacy violations, one-third are extremely sensitive to them, and one-third are pragmatic about them, weighing the potential benefits and costs of potential privacy infringements individually. It is the latter group that will be most important, since the most concerned group will probably not be swayed by good intentions. The keys to addressing issues related to perception of privacy violations are as follows:

- Design the system in such a way as to protect individual privacy to the maximum extent that is consistent with the objectives of the project.

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[11] *The Florida Constitution, Article I, Section 23, Right of privacy*. Available online at http://www.leg.state.fl.us/.

[12] Glancy, Dorothy, *Privacy on the Open Road* (2004), Ohio Northern University Law Review, Volume 30, page 295.

[13] *United States vs. Walraven*, 892 F.2d 972 (10th Cir. 1989)

[14] BootFinder is a trademark of G2Tactics, Inc. More information is available online at http://www.g2tactics.com/bootfinder.html.

- Provide full information about the system's benefits, along with a full description of how the system is designed.
- Acknowledge that the media will likely air or print sensationalist stories about privacy violation; be proactive and make the story about the benefits rather than about potential privacy concerns.

Related to overarching privacy issues are concerns that the system might be used for purposes other than generating travel-time calculations. While this document notes that LPR technology has been used elsewhere for speed enforcement, it is our emphatic recommendation that this system not be used for that purpose here; attempting to do so would almost certainly create a backlash against the technology. Rather, use of this system should be restricted only to its most supportable and least controversial applications.

6. Recommendations

We recommend that the FDOT proceed with a procurement for the installation and operation of an LPR-based system to support the display of travel times on DMSs in the Tallahassee region. The procurement, which is discussed in more detail in a companion paper, should include the following:

- Functional requirements for data accuracy, reliability, and latency of the data collection system
- Locations for deployment of LPRs
- Functional requirements for the interface between the data collection system and the Tallahassee RTMC
- Privacy protections