

Appendix 12

White Paper: License Plate Recognition

License Plate Recognition

DATA COLLECTION

WHITE PAPER SERIES

May 2014

#2
vol.

Kimley»Horn
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Introduction

This is the second in a series of white papers intended to strengthen the Park+ User Group experience through enhanced education and application of modeling principles. This white paper discusses addressing ongoing data collection needs through the use of license plate recognition (LPR) technology. The Park+ model utilizes parking occupancy data as one of the primary calibration inputs. As such, the accuracy of the model depends on the ability to collect good parking occupancy data in the field. LPR technology provides a more streamlined and efficient approach in the field and also creates tabular data fields that can be input into the Park+ model easily.

History of the License Plate¹

The use of license plates in America is older than the automobile. The first record of vehicular registration plates dates back to the 1850's, with horse drawn carriages in Philadelphia, PA requiring registration to be identified on the carriage in letters at least four inches high. The advent of the motor vehicle accelerated the use of license plates, with New York becoming the first state to require license numbers in 1901 and Massachusetts becoming the first state to issue a standard statewide plate in 1903. Between that time and the 1950's, all states began to issue license plates and require a vehicular registration fee for operation on public roads; however, plate types and configurations varied widely from state to state. In 1956, license plates began to become standardized across jurisdictions, with standard plate sizes (12" x 6") dictated at the request of auto manufacturers.

In the 1930's, the license plate took on a secondary use, providing a retroreflective surface that was more easily identified at night. The first retroreflective license plate was issued in New Mexico in 1936, using glass beads embedded in the plates for retroreflectivity. The issuance became more widespread in the late 1940's, and these plates have long been endorsed by U.S. law enforcement office for improved safety through increased nighttime visibility.

Prior to World War II, most states required front and back license plates to improve the opportunity to read and identify plates from both sides of a vehicle. During the war, the practice was limited to one plate to conserve resources needed for manufacturing defense products.

After the war, most states returned to the dual license plate practice. However, many states are beginning to only require one plate to save manufacturing costs. Today, there are 19 states that do not require both a front and back license plate, identified in **Table 1**. Further advancements have evolved the license plate in the last 50 years, including:

- In the 1970's states began to introduce distinctive background graphics to depict their state's distinct landmarks or historical events. While attractive, they add another layer of complexity for law enforcement when trying to distinguish between jurisdictions.
- In the 1990's digital printing technology allowed manufacturers to move away from raised and embossed characters on plates and instead produce flat, digital-printed plates. These new printing processes have also increased the visibility of license plates, further distinguishing between the characters and the background graphics.
- In the near future, new technologies such as two dimensional bar codes can provide an even more legible and readable plate when combined with automated reading technology. These advancements could further enhance the readability and accuracy of both human-read and license plate recognition technologies.

These advancements in license plate technology have made it more efficient and effective to utilize license plate recognition technology to observation and record license plates. In the parking data collection realm, this provides a perfect platform to improve operations and efficiency for large areas of data collection.

**TABLE 1 - STATES
REQUIRING ONE
LICENSE PLATE**

Alabama
Arizona
Arkansas
Delaware
Florida
Georgia
Indiana
Kansas
Kentucky
Louisiana
Michigan
Mississippi
New Mexico
North Carolina
Oklahoma
Pennsylvania
South Carolina
Tennessee
West Virginia



¹ Best Practice Guide for Improving Automated License Plate Reader Effectiveness through Uniform License Plate Design and Manufacture" (July 2012). American Association of Motor Vehicle Administrators.

License Plate Recognition

The use of automated license plate reader systems is becoming increasingly popular throughout the world. Generally, the technology is known as license plate reader (LPR), automated license plate reader (ALPR), or automated number plate reader (ANPR), and the terms are fairly interchangeable. The technology uses image processing to identify vehicles through their license plates. Various industries, such as parking enforcement, access control systems, and law enforcement, have begun using the technology, with growth of the technology projected to be exponential over the next ten years.

A typical LPR system uses cameras to capture images of the front and/or rear of a vehicle. The images are sent through image processing software that analyzes the image and extracts license plate information (using the retroreflective properties of the license plate). In an enforcement setting, the system will use real-time database matching, which is helpful in scofflaw or stolen vehicle enforcement.

While the system seems simple enough, consistent challenges affect the accuracy of the system – jurisdictional license plate designs, varying fonts, graphic designs, cleanliness, coverings, and the presence of only one license plate to name a few. The inconsistencies can result in misreads, diminishing the effectiveness of enforcement efforts. In the data collection realm, these misreads can impact the accuracy of the data being collected. While the prevalence of misreads is unclear, some studies have shown misreads can be as high as 20%, which would severely impact the accuracy of data collection efforts.

Later in this document, we will explain how we overcome typical LPR misreads to improve data collection accuracy.

Two types of LPR units are typically available—mobile and stationary. For the purposes of this white paper, we will focus on mobile units. A mobile LPR is one that is mounted on a vehicle for the purposes of reading license plates over a large coverage area. A mobile LPR unit can include between one and four cameras, depending upon its purpose. Typical components of a mobile LPR unit include:

- Cameras for capturing images of plates
- Image processor, typically trunk mounted
- Mobile data terminal, typically mounted near the driver, which receives alerts registered from the processor

ALTERNATIVE USES FOR LPR

- Recovery of stolen vehicles
- Amber Alerts
- Open road tolling (pay by plate)
- Congestion charging
- Parking enforcement
- Access control
- Traffic studies
- Electronic vehicle registration
- Automatic speed enforcement
- Asset recovery
- Insurance fraud investigation
- On-street parking enforcement
- Travel or journey time calculations
- Security monitoring



Data from the processor can also be transmitted and/or stored in a back-office software application. The capture and transfer process typically follow these steps:

1. Detect the vehicle and license plate
2. Locate the license plate in the image
3. Extract license plate characters from the license plate background
4. Identify the license plate number
5. Determine the license plate jurisdiction
6. Transfer capture results to the back-end system

In the data collection process, these steps are performed, but only the detection of the vehicle and unique license plate are necessary for a valid observation of a parked vehicle.

When capturing images with the LPR cameras, there are typically two approaches. The first approach captures a single still image of the license plate using controlled illumination, lens settings, and field of view to optimize the read. This approach would be used to capture the best possible image of the offending plate. A second approach captures multiple images as the vehicle travels through the cameras field of view. This approach requires the system to perform adjustments to flash, shutter, and gain of the cameras, almost instantaneously as the vehicle moves.

Monochrome (black and white), color, and infrared cameras can be used, although black and white cameras tend to yield the best resolution and are generally the most cost effective. Color cameras separate characters from graphic backgrounds, which help to distinguish jurisdictions. Color cameras do not perform especially well at night due to their need for white light to produce accurate color information.

Potential Data Collection Applications

While LPR is most often used for enforcement purposes, Kimley-Horn saw an opportunity to introduce this technology in our parking studies practice (particularly Park+) as a means of automating collection efforts and improving overall accuracy and effectiveness. The remainder of this document will discuss our pilot study and subsequent investment in this technology, as well as typical data collection processes to consider as you begin to explore LPR data collection.

Prior to that discussion, here are a few data collection opportunities to consider using LPR

- **PARKING OCCUPANCY** – Use the images and information captured in the typical LPR collection process to compare number of plate reads against facility capacity to understand overall utilization.
- **PARKING DURATION/TURNOVER** – Compare license plate reads from the LPR unit against subsequent reads of the same block face or facility to understand overall parking duration. This effort will require short duration trips through a defined circuit. Many studies capture turnover or duration in increments as small as 15 minutes and as long as one hour.
- **PARKING FREQUENCY** – Use stationary LPR units to capture the frequency with which a vehicle enters a parking facility. This can be especially effective in situations where vehicles will enter and leave a facility to take advantage of free time periods (e.g., First Hour Free) by leaving and returning.
- **TRAFFIC COUNTS** – Use stationary LPR units to capture license plate information to count the number of vehicles at an intersection or on a segment of roadway.
- **ORIGIN/DESTINATION** – Use the registration information from license plates captured through stationary LPR units along a segment to understand drivers' origin points and destinations.

LPR vs Traditional Data Collection Methods

Traditional data collection methods require multiple data collection analysts in the field, either on foot or in a vehicle, manually counting and recording vehicular occupancy in a parking facility. LPR data collection allows for a more streamlined approach, typically reducing field staff required since the collection efforts become automated through roof-mounted cameras. The analysis of data is also streamlined, since the cameras offload the data into a reporting structure that allows for quick calculation of parking occupancy data, rather than returning to the office to catalogue hand-tabulated facility counts. The removal of hand tabulation inherently increases accuracy as it eliminates misreads of hand-written data. Calculating parking occupancies with the traditional method is largely manual, which increases human error and requires a more extensive review of data to ensure accuracy, increasing the hours spent analyzing and reviewing the data.

Kimley-Horn's LPR Technology

In the fall of 2013, Kimley-Horn pilot-tested and purchased AutoVu SharpX LPR cameras (and the associated LPR processing unit) to evaluate the system's potential to improve traditional data collection methods. After a successful pilot testing effort, Kimley-Horn purchased the LPR system and has used the system to collect parking occupancy data for several projects throughout the U.S.

The LPR equipment Kimley-Horn utilized to conduct data collection includes:

- Two mobile LPR cameras
- Trunk port that acts as a server and processing unit for the system
- A GPS tracker that identifies location of plate reads by address and XY coordinates
- In-unit laptop/tablet containing the following programs:
 - » Patroller software
 - » Security Desk software



AutoVu Sharp X LPR camera



The AutoVu Sharp X LPR cameras are positioned at a 45 degree angle to collect the varying heights and positions of license plates and for parallel and 90 degree parking.



• LPR Pilot Study

The 2013 pilot study focused on testing the use of LPR to increase efficiency and accuracy in parking data collection efforts. This evaluation was largely initiated out of the need for higher-quality data collection practices and standards for the Park+ practice. In addition, the LPR system streamlined the data collection process by reducing labor and time associated with the collection and processing of data.

Testing was conducted across two different settings. The first tested the limits of the LPR system across a variety of different “problem scenarios.” The second tested accuracy in a variety of actual data collection settings. All tests were conducted by multiple Kimley-Horn employees to provide parallel manual data collection efforts, observe driving tendencies, and provide additional input on troubleshooting efforts.

The first testing types – those intended to measure problematic areas – were conducted on a small scale, typically in a handful of surface parking lots that provided a variety of lighting, access, and parking configurations. These tests were intended to evaluate the abilities of the LPR system against potentially adverse field collection scenarios. Testable factors included measuring “read accuracy” against:

- Angled parking
- Perpendicular parking
- Poorly lit garages
- Tight travel lanes
- Wide travel lanes
- Peak afternoon sun
- Shaded parking
- Variations in plate types and designs
- Driving speeds

These tests were conducted in Phoenix, Arizona. The initial test results were favorable and indicated that the equipment would perform well against the tested conditions. The predominant “misread” was found in newer plate variations and with backed-in vehicles, since Arizona does not require a front license plate. The following section presents initial findings and corresponding troubleshooting methods used

in the initial data collection testing. Some of these troubleshooting elements were tested both in the initial “problem solving” phase and the subsequent field data collection testing period.

• Initial Experiences in the Field

The initial “problem testing” of the LPR system in the field provided a few observations on the LPR system’s capabilities to retrieve accurate data for facility parking counts. Each of these potential pitfalls were met with troubleshooting attempts.



BACKED-IN VEHICLES – The most notable contributor that affected accuracy rates involved the presence of backed-in vehicles. In Arizona, no front plate is required, which caused an instant misread as the LPR unit is unable to capture any type of read from these vehicles. During testing, manual counts were compared against the counts of the LPR unit to evaluate the impact of backed in vehicles on vehicle count accuracy. The initial results of the data collection were less than ideal, with misreads ranging from 18 to 43 percent of vehicles in a facility, with the overwhelming majority occurring due to backed-in vehicles (discussed in greater detail in the following sections).



TROUBLESHOOTING ATTEMPT –

In an effort to offset the presence of backed-in vehicles, the data collection team created a process to manually count backed-in vehicles using a handheld counter. At the end of the collection process, these manually counted reads were added to the actual reads by the LPR unit and then compared to the full manual count. The hand-counted method resulted in a much more accurate reading.



NEW AND VANITY PLATE DESIGNS – During initial testing, it was observed that the cameras were unable to read newer, redesigned plates including new custom variations of Arizona plates. Based on this observation, it was determined that plates not included in the existing LPR database could impede accurate parking counts. Also, the system had difficulty capturing vanity plates, especially when traveling at an average speed of about 10 miles per hour.

LACK OF PLATE RETROREFLECTIVITY –

Throughout testing, it was observed that certain license plates had a form of film covering them. Some were installed purposefully as part of the license plate covering, while others were from the plate being dirty, or in some cases, being essentially disintegrated (this was most prevalent in Arizona, which faces harsh weather conditions in the summer months). It turns out that Arizona license plates come in two types, where one has raised and embossed characters and the other plate has flat digital printed characters. The embossing on the raised plates was found to most be the most likely to disintegrate, due to the Arizona sun. This strange phenomenon removed all retroreflectivity from the plate and prevented the license plate from being read by the LPR cameras.



TROUBLESHOOTING ATTEMPT –

Some, but not all, of these new and vanity plates were more easily read when traveling at a much lower speed. However, this low speed may not be ideal for efficient data collection. Although we were unable to account for license plate designs that are not entered into the system (i.e., the new Arizona Golden Rule plate), the LPR program allows for users to “manually capture” license plates that cameras are unable to read. This “manual capture” could be used on vanity plates, new plate designs, and obstructed plates. Additionally, this manual capture allows users to send new plate images to the system vendor, who may add this new plate into the system for future collection efforts.



TROUBLESHOOTING ATTEMPT –

When a disintegrated Arizona plate was not captured by the cameras, attempts were made to see if lowering speeds would allow time for cameras to capture the image. In some cases, the additional time for obstructed plates allowed the cameras to capture the parked vehicle. In most cases, though, all retroreflectivity of the plate had been removed, which the system could not account for.

SUN – Glare from the sun caused misreads, especially when reflecting off metallic or other similarly shiny license plate coverings. However, this phenomenon was very rarely observed.



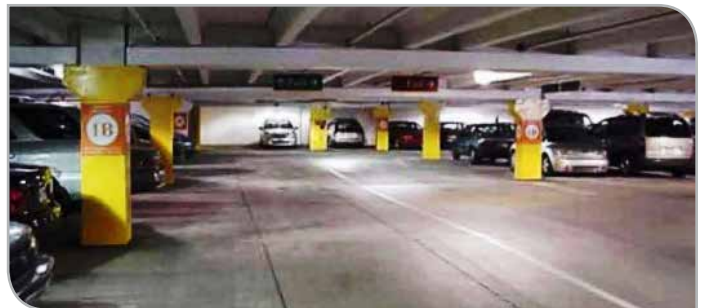
GEOPOSITIONING IN GARAGES – During testing, it was determined that the mobile GPS unit, which is used to track positioning of the images, could not project accurate coordinates for counts within a garage because the structure blocks the satellite connection with the unit. The results mapped garage reads anywhere from 1 foot to 1 mile away from their actual read location.



TROUBLESHOOTING ATTEMPT –

Not much can be done to improve the accuracy of GPS in garages, considering the enclosed nature of the facilities. Although disadvantageous, GPS coordinates are not absolutely critical in calculating parking occupancy counts because offload times can be used as an identifier in the collection and data analysis processes.

TURN RADIUS – When driving through a parking facility, turning radii and corner configuration of travel lanes are a potential misread point for capturing parked vehicles. When leaving one aisle and turning down another, the camera is unable to capture vehicles on the inner corner of the turn as they are too close to the vehicle and are outside of the LPR collection window.



TROUBLESHOOTING ATTEMPT –

Based on this observation, the most important step in capturing accurate data is the proper configuration of camera position and proper management of capture times. Proper configuration of the camera position is required to best capture the range in heights and positions of parked vehicle plates. This requires taking the time to calibrate, test, and recalibrate cameras until the cameras are in the most optimal position to capture plates. While the extra time needed to properly position and reposition cameras increases time spent in the field, the time proved to be beneficial as the data collected better reflected occupancies observed manually.

Managing capture times requires the user to use the pause and resume functions on the mobile computing system to set effective capture configurations. For example, three-bay garages will often require some single-side counts, which utilize only one camera, to capture a bay without double counting previous bays. The image above depicts a situation in which the right camera should be paused so that license plates in the passing aisles are not collected, as those vehicles would have already been collected when driving down that aisle. Recalibrating camera positioning and understanding when it is beneficial to use a single side of the camera system allowed data collection to reach optimal accuracy levels, rectifying most of the initial inaccuracy experienced in the field.

Although met with initial obstacles in reaching ideal accuracy rates in parking occupancy rates, the troubleshooting processes improved overall accuracy and efficiency in data collection, supporting the belief that the LPR system provides a greater benefit to the data collection process when compared to traditional collection methods. The results were sufficiently favorable for us to proceed to the second phase of testing – actual field data collection within a large area. The results of the field data collection tests are detailed in the following section.

• Field Data Collection Tests

To simulate settings that would be experienced during actual parking data collection, employees went into the field for three to five hours to capture parking occupancy rates in surface lots, garages, and on-street settings. These tests were conducted within surface lots and parking garages in a number of different locations including Tempe, AZ; Fort Collins, CO; Houston, TX; and Beverly Hills, CA. The first two sites were used to test the accuracy of the system. The second two sites were used to test the transferability of the system, including ease of remote calibration and ease of training additional users in the field.

For the test which evaluated the accuracy of the system manual counts and LPR counts were collected in parallel to identify disparities between the two data sets. These disparities indicate limitations in the LPR collection capabilities. The first series of accuracy tests were conducted on August 16 in Fort, Collins, Colorado, at the Colorado State University campus. The second series of tests were conducted on August 20 in Tempe, Arizona. The final series of accuracy tests were conducted on August 26, again in Tempe. The following tables detail the findings of each test.

TABLE 1 - STATES REQUIRING ONE LICENSE PLATE

FACILITY TYPE	MANUAL COUNT	LPR	% DIFFERENCE
Surface	86	72	16%
Surface	41	41	0%
Surface	27	20	26%
Surface	100	93	7%
On-Street	42	35	17%
Surface	201	172	14%
On-Street	21	22	5%
Garage	137	121	12%
Garage	151	123	19%
Surface	83	61	27%
Surface	83	75	10%
Surface	79	77	3%
Surface	73	69	5%
Garage	158	158	0%
Surface	173	162	6%
Surface	193	172	11%
Garage	146	138	5%
AVERAGE MISREAD % PER FACILITY			10%

The testing at Fort Collins was the first in-field data collection using the LPR data collection, and the results were mixed as to the overall accuracy of the system. While certain lots saw accuracy rates within five to ten percent of actual observed occupancies, the overall average misread was 10 percent. A closer look at the results indicates that the accuracy of the readings improved during the data collection, largely due to repositioning and recalibrating the equipment mid-collection. This proved to be one of the first effective lessons – camera position and calibration are critical to the success of the data collection efforts.

The **second test** was conducted for a series of surface parking lots and parking garages within Downtown Tempe, Arizona – a state that does not require front license plates. For this test, the data collection team performed a manual count parallel with the LPR counts for comparison. When comparing LPR and manual data in the field, the

difference between LPR and manual counts was high and unacceptable, indicating that the testing setup was not accurate enough to predict overall parking occupancy. It was realized that backed in vehicles severely impacted the collection of accurate parking, and was likely the biggest obstacle to accurate data gathering using the LPR system. On the final few facility passes, the data collection team attempted to manually count the backed in-vehicles after completing the overall count. The number of backed-in vehicles was almost exactly the delta between the LPR counts and manual counts.

The **third test** was conducted in Downtown Tempe, Arizona, within three parking garages and a number of surface lots, similar to those found in Test 2. One step that differs largely from Test 2 was that manual counts were conducted for backed-in vehicles, and the results were included with the automated LPR reads to better reflect the total number of vehicles in the facility. Similar to the previous tests, manual counts of all vehicles in the facility were collected for comparison purposes. The combination of LPR and manual counts for backed-in vehicles decreased misreads to a total of five percent of the manually counted total. In a few instances, LPR counts were greater than manual counts, such as in the City Hall Garage Test 3. This higher difference was a result of the LPR unit catching reflective objects, such as wall-mounted signs. Even with these misreads, the low percentage that impacts the overall accuracy of the facility is normalized among the greater data collection efforts, and the data collection team decided it was not a significant hindrance to overall accuracy of the system.

TEST 2 – TEMPE, ARIZONA – DOWNTOWN TEMPE

**It should be noted that Colorado requires both front and back license plates, which greatly improved the accuracy of the initial testing session.*

FACILITY	TEST	MANUAL COUNT EXCLUDING BACKED-IN VEHICLES	LPR	% DIFFERENCE
US Airways Garage	Test 1	1206	929	23%
	Test 2	1138	826	27%
Hayden Square	Test 1	172	101	41%
	Test 2	152	86	43%
City Hall Garage	Test 1	245	160	35%
	Test 2	217	145	33%
Brickyard Garage	Test 1	170	138	19%
	Test 2	159	101	36%
Surface Lots	Test 1	78	61	22%
	Test 2	54	42	22%
Centerpoint Garage	Test 1	733	468	36%
	Test 2	598	417	30%
Farmer Lot	Test 1	55	45	18%
	Test 2	51	40	22%
AVERAGE MISREAD % PER FACILITY				29%

TEST 3 – TEMPE, ARIZONA – DOWNTOWN TEMPE

FACILITY	TEST	MANUAL COUNT INCLUDING BACKED-IN VEHICLES	LPR	% DIFFERENCE
City Hall Garage	Test 1	239	229	4%
	Test 2	239	229	4%
	Test 3	216	219	1%
Centerpoint Garage	Test 1	674	611	9%
Brickyard Garage	Test 1	173	160	8%
Surface Lots	Test 1	254	258	2%
AVERAGE MISREAD % PER FACILITY				5%

After completing the detailed testing in Tempe, Arizona, the data collection team took the equipment on the road for testing in remote sites, primarily to test the ability to calibrate in the field on the fly, as well as train non-familiar users with the equipment. The first such test took place in Houston, Texas, in the Rice Village area. During this test, one Kimley-Horn employee and one City of Houston employee alternated the driving and collection positions to determine the variability in collection techniques. The testing also included a complete tear down and reassembly of LPR equipment in the field to determine any impacts to accuracy. Based on the recorded LPR counts and the observed data, the presence of misreads was between five and ten percent of total counts.

Similar tests were conducted in Beverly Hills, California. In these tests, Kimley-Horn employees performed brief training for city parking staff and then helped them assemble the LPR unit onto the enforcement vehicle. Under this test, on-street parking observations were evaluated. Through several phases or iterations of a predetermined route, the staff member was instructed to drive with one camera on, both cameras on, and alternating between cameras. The results were then transferred back to the Kimley-Horn office in Phoenix for review. The results indicated that the on-street routing with one camera was the most accurate and provided the best level of detail for parked vehicles on the curb side. When operating with both cameras, the camera on the traffic side of the vehicle recorded passing vehicles, which created disturbances in the counts and lowered the overall accuracy.

• Additional Field Data Collection Efforts

After completion of the pilot testing period and purchase of the equipment, Kimley-Horn has continued to use the LPR unit to enhance data collection techniques in communities throughout

the country. Most of these efforts are in support of the Park+ modeling process, but some are simply to provide quality data to help strengthen parking planning processes. A few examples of these efforts include:

- **ATLANTA, GA** – LPR data collection was conducted over a three-day period in 37 surface lots and garages in Downtown Atlanta, amounting to 8,200 spaces. The results of the data collection effort and parking occupancy calculations provided a better understanding of parking demand in Downtown parking facilities.



- **ASHEVILLE, NC** – Parking counts were collected over a ten-hour period in 51 of Downtown Asheville's parking facilities, amounting to a total of 5,568 spaces. The parking occupancies calculated as a result of this data collection effort were utilized to update Asheville's Park+ model. The updated occupancy data included in the model better reflect the current parking demands of the Downtown area, which can then be utilized to inform management decisions regarding provision of parking.



- **TEMPE, AZ** – LPR data collection was conducted in Downtown Tempe to determine occupancy and identify parking demand in Downtown facilities. Data was collected in one day from 7:00AM to 5:00PM, surveying 12,756 spaces in 89 parking facilities. The occupancy data collected provided the basis for developing the Downtown Tempe Park+ model.



Data Collection Processes and Procedures

Now that we have covered the why and what of data collection using LPR, we would like to conclude with a brief primer on how to collect the data. Many of these elements are covered throughout the paper, but this section provides a typical work flow for conducting LPR data collection.

In general, the following steps should be considered when collected parking occupancy data with an LPR unit.

- 1. PRE-PLAN DATA COLLECTION EFFORTS IN THE OFFICE** – Prior to going into the field, the data collector should determine the key elements of the collection process, including routing, collection time periods, facilities to count, and known facility capacities. If necessary, the collector should also prepare notifications of data collection, either pre-delivered or carried in the vehicle, to help interested parties understand the process and needs associated with the data collection efforts.
- 2. SET UP EQUIPMENT** – If your system is like Kimley-Horn's, you will need to position cameras on the roof of the car and set up processing equipment. For most communities that use LPR units for enforcement efforts, this step can be skipped as the equipment will be permanently mounted on the vehicle.
- 3. CALIBRATE** – Use the in-vehicle computing system to test the positioning of the cameras to ensure a proper mount. If needed, perform a small area test to determine the accuracy of the system. If the potential misreads are too high, reposition cameras for optimal license plate reads.
- 4. PERFORM FACILITY-BY-FACILITY DATA COLLECTION** – Based on the predetermined routing and facilities to collect, the collector should begin data collection and follow the assigned route to ensure that timing of counts is comparable between hourly reads. After completing the counts within a facility, the collector should offload the LPR counts, which will send the reads from that facility back to the vendor's database for use in reporting. The collector should also manually document the offload timestamp, as

well as manual counts of backed-in vehicles. Following this method, the collector should complete the daily cycle of data collection (based on predefined collection times).

- 5.** Once the collector is back in the office, they should use the vendor's back-end system software to create reports that document offload time and plate reads. This combination of offload times and plate reads will be used to define facility occupancy for each cycle of data collection. Once the reports are created, they can be offloaded to a tabular format (e.g., .xls or .csv file formats), which will be input into a custom database that sorts and reads the offload times. The collector will need to manually input the documented offload times and facility capacities in the database. This is defined further in the following section.
- 6.** Once the data is in the database, the collector can push the data through a pivot table that will provide the hourly occupancy counts for each facility.

These six steps represent the primary steps associated with the data collection. Following those steps should provide the collector with the basic framework for completing LPR data collection. However, based on our experiences in the field, we offer the following lessons learned to help strengthen each of the elements of the process, including Pre-Planning, In the Field, and Back at the Office.

PRE-PLANNING²

- Identify which facilities you are interested in collecting parking occupancy data for and for what period of time
- Determine the parking capacity for those facilities
- Create tables to use in the field that include the facility name and a placeholder to write down offload timestamps
- Print a spreadsheet for each hour of data collection
- Plan the most efficient route before collecting data at each facility. This includes determining the locations of any one-way streets and construction zones.
- Drive the route prior to conducting data collection to circumvent any additional obstacles not previously realized.

²It is assumed that users of the LPR system have a permanently mounted unit, rather than a mobile LPR unit that needs to be set up prior to each data collection effort

The resulting Excel document is a robust spreadsheet that identifies information related to each read captured during data collection, including:

- Plate images
- Event timestamp (the time the plate was captured)
- Latitude and longitude coordinates of the read
- Offload timestamp (the time the data was sent to Security Desk)
- License plate numbers

	A	B	C	D	E	F	G	H
	Plate image	Context	Event timestamp	Manual	Latitude	Longitude	Offload timestamp	Plate read
1	image	image		capture				
2			10/8/2013 9:42:38 AM	False	0	0	10/8/2013 9:52:07 AM	BVN1244
3			10/8/2013 9:42:39 AM	False	0	0	10/8/2013 9:52:07 AM	958YRV
4			10/8/2013 9:42:40 AM	False	0	0	10/8/2013 9:52:07 AM	281TFS
5			10/8/2013 9:42:40 AM	False	0	0	10/8/2013 9:52:07 AM	KEC9068
6			10/8/2013 9:42:41 AM	False	0	0	10/8/2013 9:52:07 AM	BIP6363
7			10/8/2013 9:42:42 AM	False	0	0	10/8/2013 9:52:08 AM	8PWB102
8			10/8/2013 9:42:42 AM	False	0	0	10/8/2013 9:52:08 AM	AQ818A
9			10/8/2013 9:42:43 AM	False	0	0	10/8/2013 9:52:08 AM	8UJ636

Modifying the Reporting Process

The report created by the Security Desk software provides detailed information related to the license plate reads captured during data collection. The typical default reports do not provide much detail in relation to vehicular occupancy, as they are configured to provide information about the license plate reads observed during the collection process. However, after evaluating the reporting capability of the software program, Kimley-Horn determined that creating reports grouped by capture time or offload time will yield the best results, especially when compared to ingress and egress times from the observed parking facility. These reports are linked with a unique Microsoft Excel workbook that Kimley-Horn created specifically for the purpose of evaluating LPR offloads.

For Kimley-Horn data collectors, the process for capturing accurate data reads includes using offload time stamps in the field to catalogue the entry and exit from each facility. The automated reads captured within each parking facility are offloaded immediately after exiting the facility. These offload timestamps are used to identify the groups of plate reads within that facility. All reads with the same offload timestamp are grouped and considered to represent the same facility.

Offload timestamp	Facility
11/20/2013 8:56:56 AM	A8
11/20/2013 9:09:31 AM	B6
11/20/2013 9:26:10 AM	B8
11/20/2013 9:38:00 AM	B9
11/20/2013 9:39:39 AM	C1
11/20/2013 9:46:11 AM	D1
11/20/2013 10:01:51 AM	D2
11/20/2013 10:03:10 AM	E1
11/20/2013 10:07:18 AM	E2
11/20/2013 10:11:01 AM	E6
11/20/2013 10:13:23 AM	E7
11/20/2013 10:28:09 AM	COURT
11/20/2013 10:33:15 AM	G4
11/20/2013 10:50:51 AM	H3
11/20/2013 10:58:27 AM	I9
11/20/2013 11:04:09 AM	I14
11/20/2013 11:10:59 AM	I2
11/20/2013 11:12:44 AM	I2A
11/20/2013 11:15:54 AM	J3
11/20/2013 11:17:33 AM	J1
11/20/2013 9:57:41 AM	COURTHOUSE

Row Labels	Sum of Capacity
A1	29
A10	121
A11	15
A12	16
A2	25
A3	169
A4	16
A5	8
A6	15
A7	25
A8	85
A9	52
B1	42
B10	15
B11	50
B12	182
B13	20
B14	10
B15	15
B16	14
B17	44
B18	26
B19	178

A separate table was created on another sheet within the workbook to identify the capacity for each parking facility. These capacities are used to define the denominator in the parking occupancy calculation for each hour of data collection. The labels within this table correspond back to a designated naming convention for the parking facilities within the study area.

In the event that the location for collection is in one of the states that do not require both front and back license plates, another sheet provides a location for the data collector to input the manual counts from each facility observation. These manual counts would have been hand collected in the field and described by the facility location and the offload time.

The final step in the analysis process is to push the LPR counts through a pivot table that combines the manual counts and the capacities and sorts the data by hour to provide an hourly occupancy table. This hourly occupancy table provides measured occupancy levels for each individual facility during the day. Because our process was intended to provide an easily updatable data source for our Park+ model, the final output tables are set up to easily transfer to ArcGIS for joining and transferring data into the parking shapefile within a community's Park+ model.

% Cap	xc Event D	xc Event H										
	11/20/2013											
Facility		9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM	7:00 PM
B2		47%		72%		51%					89%	
B3		61%		60%			69%		54%		95%	
B4		44%		50%			50%		93%			
B6		28%		77%		71%			59%	48%		
B7		17%		53%		63%			40%			
B8		19%		48%			57%		50%		48%	
B9		43%					55%		50%		33%	
C1		35%		50%			50%		50%		19%	
C14		55%			59%		73%		68%		59%	
C18		6%					28%		11%			
C2		12%		25%			26%		19%		11%	
C2A		14%		29%			43%		29%		50%	
C4				20%			8%		16%		52%	
C5		21%					67%		58%		60%	
C6		50%					117%		100%		67%	
C7		37%			48%		59%		48%		27%	
County Deck			67%		59%			50%		35%	5%	
D1		37%			48%		58%		67%		48%	
D2		8%	21%		26%							29%
E1			50%		80%		70%			109%	98%	
E2			104%		84%		58%				81%	
E3			8%		36%		13%		19%		11%	
E4			49%		16%		9%		12%			
E6			49%		44%		44%		69%		64%	
E7			88%		84%		73%		71%		39%	
E8		23%			50%		46%			43%	42%	