HTS
Extending Your Vision

A Division of Quest Solution Inc.

VRS for Parking Systems - Overview

Version 1.4

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Table of Contents

About This Document

This document provides an overview of HTS products, configuration and sample projects for parking system, using Vehicle Recognition Systems (VRS).

List of Acronyms

Acronym	Meaning
ANPR	Automated Number Plate Recognition
BW	Black and white
FOV	Field of View
IR	Infrared
LAN	Local Area Network.
LED	Light Emitting Diodes
LPR	License Plate Recognition (same as ANPR)
OCR	Optical Character Recognition
PMS	Parking Management System
SDK	Software Development Kit
VMD	Vehicle Motion Detector
VRS	Vehicle Recognition Systems

Related and Referenced Documents

1. N70 –IP camera for medium speed LPR - datasheet

2. LC3000/3100 Fan-less lane controller - datasheet

3. LC4000 Rackmount server - datasheet

4. SeeControl Client SDK Reference Guide v4.1

5. Controller application user manual v4.1

6. SeeControl user manual v4.1

Items 1-3 are available on HTS website, while items 4-6 are on the support page.

Chapter 1

Introduction

Purpose & Scope

This document provides a technical overview of the implementation of the Vehicle Recognition Systems (VRS), in order to support automated car park systems.

Product Description

The systems are installed on the car park traffic lanes, in entrances, exits and internal locations. At its basic form, a single camera enclosure is mounted on a pole at the side of the lane, viewing the front and/or the rear view of the passing vehicles along the lane. Each such unit might be triggered by a loop detector or SW trigger. The camera captures several images of the vehicle in near-Infrared (IR) and/or visible spectrum. The system, operated by a lane controller normally installed inside an enclosure near the lane or inside the gate cabinet, extracts the plate number by License Plate Recognition (LPR, also known as ANPR). It then reports the result to the central server. Image files are also saved on disk and sent over the network. The system can also open a gate for authorized vehicles listed in a white list, or alert on vehicles listed in a black list.

Figure 1.1 shows a typical installation of a front and rear capture LPR system, including a gate arm that is controlled by the system.
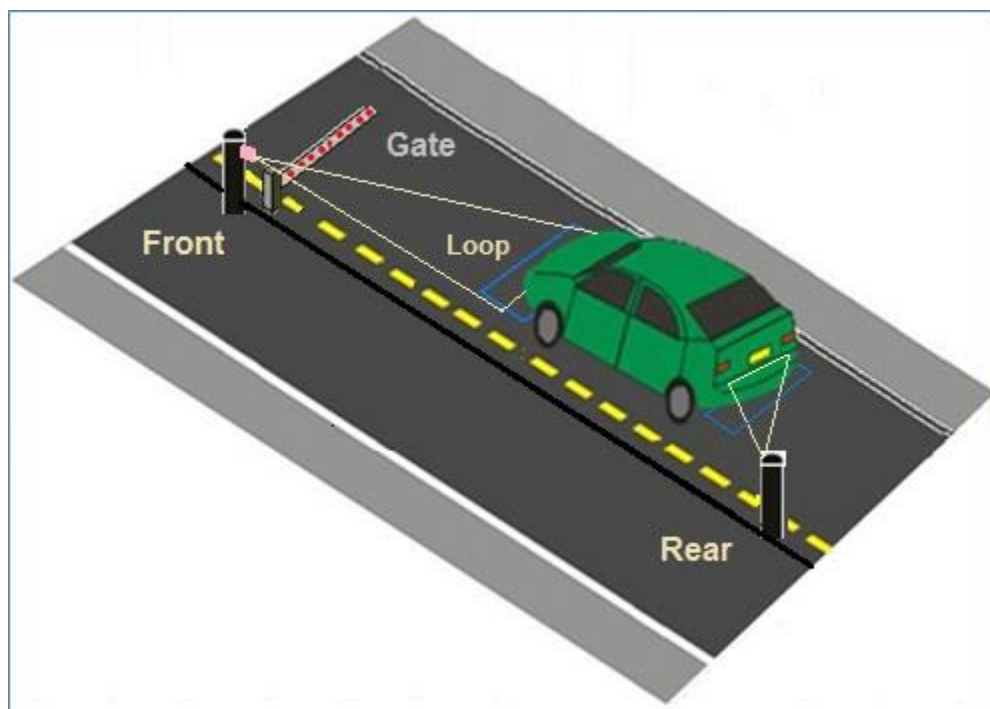

Figure 1.1: Illustration of a front and rear capture LPR system

Imaging unit

The recognition system is based on imaging units that capture the front or rear of the vehicle in order to extract the registration number. The imaging unit includes a camera and built-in powerful LED illumination units. HTS supplies turnkey systems which include various types of imaging units that are geared for low to medium speed installations.

On the right side is the N70 imaging unit –the HTS LPR camera/illumination unit which is best fit for the job. It is available in different spectrums which optimize the image quality of the license plate.

Other HTS imaging units are available.

A detailed information on the imaging units, as well as other components, are provided in the remainder of this document.

Figure 1.2: N70 Imaging unit

The imaging units are controlled by a lane controller that determines the timing of the image capture using various types of triggers, optimizes the camera parameters, reads the images, extracts the license plate and additional parameters using the renown HTS recognition engine, then outputs the results to the VRS server.

VRS Architecture

The Vehicle Recognition System (VRS) architecture includes a network of imaging units that are connected to a number of lane controllers, which report the results to a VRS server (one or more). The modular design, which is scalable and flexible, allows various configurations in order to fit to the project's needs.
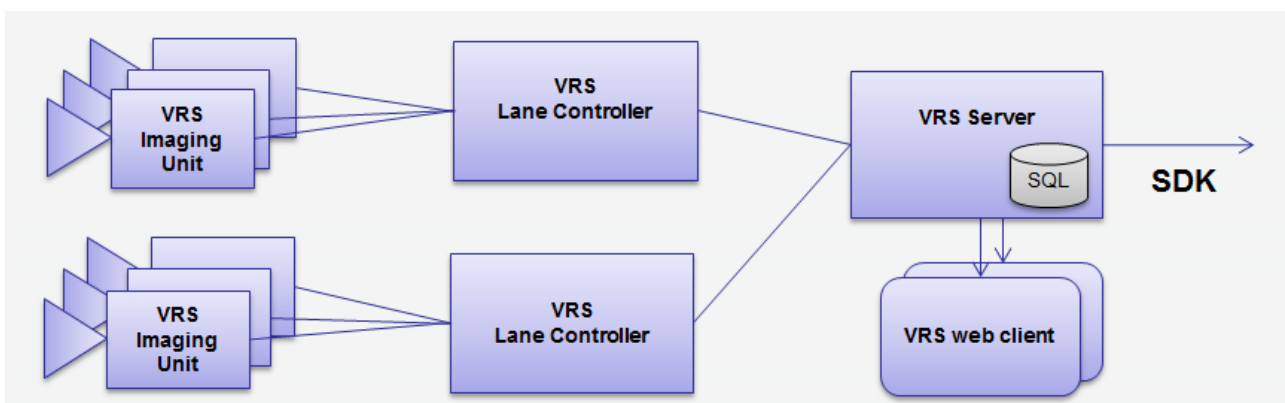
Figure 1.3: VRS architecture

The VRS server (powered by the SeeControl service) receives the intermediate results from the VRS lane controllers and determines the overall results. It stores the events in MS SQL database, displays the event using a multi-platform web application, and allows the user to monitor the

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results, query the history, and receive alerts on preconfigured lists (Hotlist). It can export the data to external systems using an interface which is provided in a SDK, or tailored to specific interfaces types.

Features

The LPR systems for parking systems have the following features in common. These are the major features:

- **High accuracy** – the required accuracy is high, as few mistakes are allowed.
- **High capture rate** – the system must capture all the vehicles entering or exiting the car park, with few exceptions.
- **Low vehicle speeds** – vehicles travel at speeds up to 50 kmh (30 MPH).
- **Short distances** – the cameras are normally mounted at short distances (typically 3-7m) from the trigger location.
- **Detection** – the best trigger for the toll systems is the loop detector, although other SW triggers can be used.
- **Indoor/Outdoor** – parking systems could be indoor or outdoor.

About the Company

Quest Solution Inc. via its HTS division (HTS) is a recognized leader in the LPR/ANPR market, based on its Optical Character Recognition (OCR) technology.

The company was founded in 1992 and is headquartered in Salt Lake USA, with R&D offices in Israel. HTS was acquired by and became a division of Quest Solution Inc. (2018).

With customers in over 50 countries around the globe, HTS provides OCR driven LPR solutions for a wide range of parking, access control, and transportation applications. To date more than 15,000 lanes are powered by HTS LPR systems. The HTS solutions are extensively deployed in the parking, safe city and access control verticals. In challenging environments, HTS Vehicle Recognition Solutions (VRS) are engineered to provide high-performance and reliability in all weather conditions both day and night.

Chapter 2

Sample projects

Hundreds of sites are now monitored by HTS solutions across the globe, with projects ranging from small parking lots with single entry/exit lane with dozens of parking spaces to large shopping centers and airport parking facilities with dozens of lanes and tens of thousands of parking spots. This chapter provides a sample of the projects.

Las Vegas Casinos

Since 2016 most Las Vegas hotels started to charge for parking in their properties. HTS LPR systems were deployed in many of the hotels.

In this outdoor installation the N60 imaging units, another HTS product, were installed on the rear of the lanes. For each lane there are two imaging units – one black and white (with 730nm IR illumination) and the other color (with white illumination).
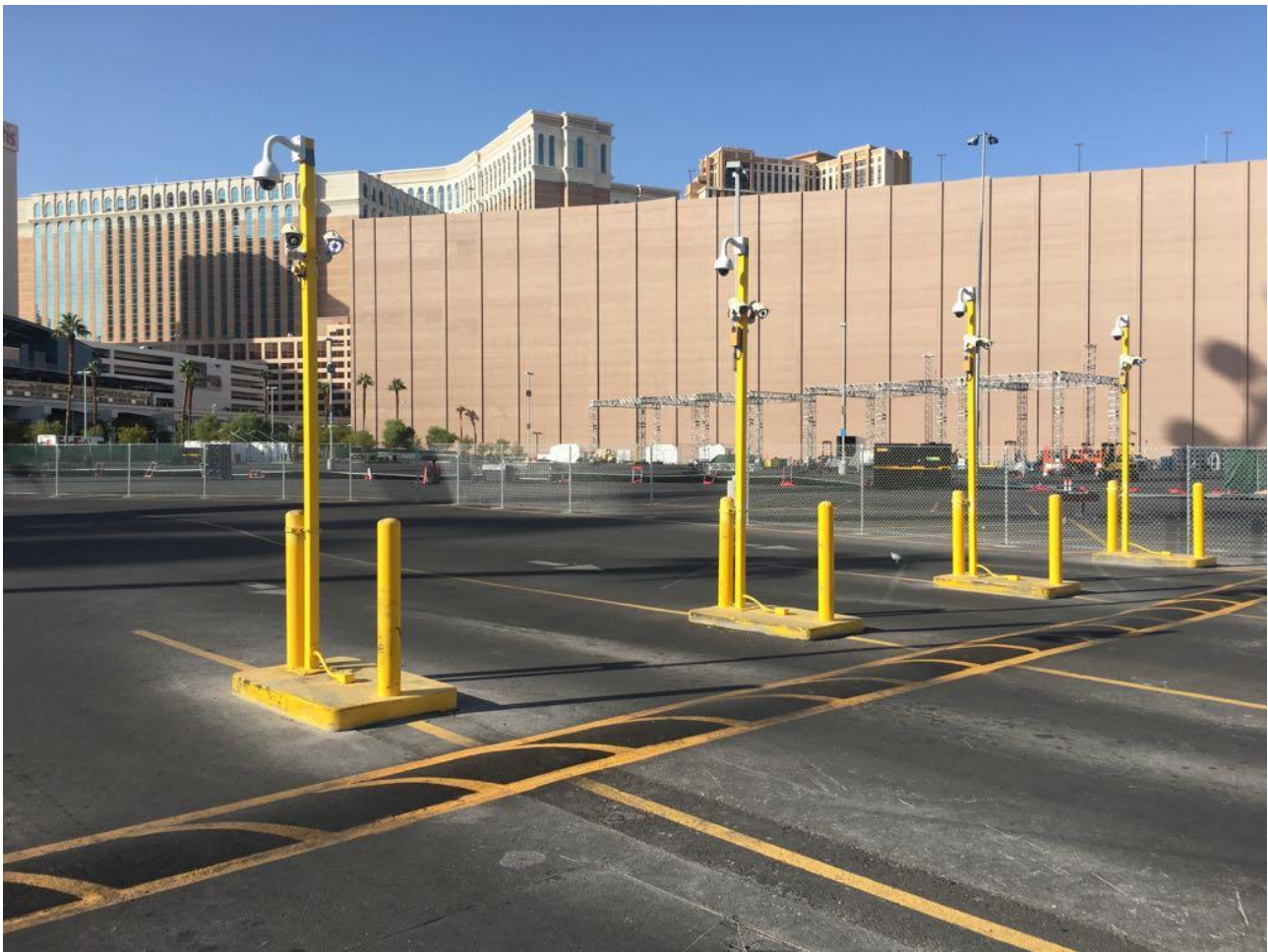

Figure 2.1: LINQ Casino parking in Las Vegas, Nevada

Tel Aviv Municipal parking

Dozens of parking lanes were installed with HTS LPR systems to read the plate registration on all the entrances and exits of the city parking lots in Tel-Aviv, Israel. Similar systems were installed in other parking facilities across the country.   A central control room was connected to all car parks in order to monitor the operation and resolve exceptions.

These systems were based on a single black & white N60 imaging unit with IR 850nm illumination. The gate arm on the entrances opened after the driver removed the printout of the ticket with a print of the plate registration. The gate arm on the exit lanes were opened only if the driver paid the ticket and was approved to go out of the car park.

Figure 2.2: Municipal Parking in Tel-Aviv, Israel

Shopping Centers car parks

HTS systems were installed in many USA shopping centers. These indoor installations were based on twin imaging units on each lane, one with black and white (IR 730/850nm) and the other with color (white illumination).

The cameras were mounted on the ceiling just above the center of the lane.

Figure 2.3: Shopping center in Los Angeles, USA

In another shopping center the cameras were mounted outdoors on a side pole. This project, in Florida, both twin of imaging units (IR 730nm and White) were mounted in the center divider between two entrance lanes.

Note that the 730nm near-IR illumination is seen as faint reddish, as some of the infra-red spectrum is visible to Human eye.

Figure 2.3: Bayside Market place, Miami, USA

Airport car parks

HTS has installed LPR systems in many of the major US airports. The systems are installed on the entrance and exit gates of the airport.

In addition to the gate systems, the airports require additional parking solutions to handle the vast number of parked cars (some over 10,000 spots):

- Parking inventory – a mobile system mounted on a truck, that records the registrations of the parked cars and maps their location. This is used to track the location of the cars in these huge parking facilities, and to monitor the duration of their extended stay.
- Handheld LPR system – a hand held device that allows manual reading of parked cars

Figure 2.3: Sacramento gate systems

Chapter 3

Architecture

The Vehicle Recognition System (VRS) is based on a modular design consisting of 3 levels. The first level is the imaging units –camera/illumination units that view the vehicle. More than one imaging units can be mounted per lane, such as the front and/or rear, and more units can optionally focus on the driver and/or passenger side for security purposes.

The units connect through a Gigabit connection to the Lane Controller – the LC3000. This fanless computer includes the Controller Application component that controls the process, has video buffers that hold the video streams from the imaging units, controls the triggers that time the process, and holds the Optical Character Recognition (OCR) engine that extracts the license plate information. The lane controller then sends the results to the VRS Server which is operated by the SeeControl service. The VRS server (LC3100) collects the results from the lane controllers in order to determine the result of each vehicle, stores the results and images paths on the SQL events database, matches the results to a number of hot lists, and allows viewing and controlling the systems via web browsers. The VRS server can also report the results to an external system, such as a Parking Management System (PMS) via an interface that is supplied in a Software Development Kit (SDK).
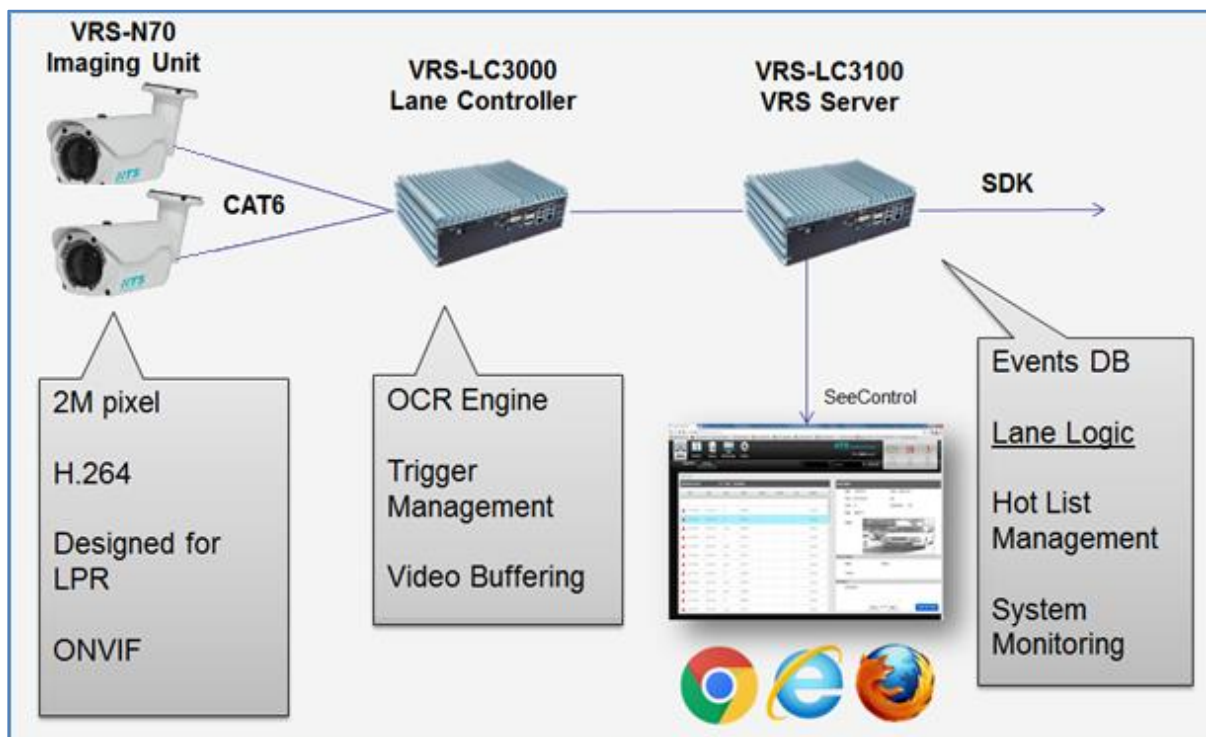

Figure 3.1: VRS system

The following chapters provide more details on each of the three VRS levels: Imaging units, Lane Controller and VRS server.

Chapter 4

Imaging units

N70 Imaging units

The N70 imaging unit is the front end of the parking LPR system. This rugged compact IP camera includes built in illumination, software-controlled lens, and is based on a state-of-the-art CMOS sensor. Its specifications are listed below:

Camera	
Sensor Type	CMOS (1/2.8'')
Shutter Type	Progressive scan (rolling shutter), True WDR
Lens	10x AF Optical Zoom Lens (5mm to 50mm)
Effective Pixels	Full HD (1920x1080)
Distance	3m – 25m (10 ft. - 80 ft.)
Angle of view	54.0° (H) ~ 4.9° (H)
Built in illumination	IR 730nm/850nm/White
IR Filter	Included
Operation	
Video compression	H.264 (Baseline, Main, High Profile)/MJPEG
Frame rate	25/30fps and 50/60 fps
Triggers	Hardware and Software (VMD)
Mechanical and Environmental	
Weight	1.2 kg (2.7 lbs.)
IP rating	IP66
Vandal rating	IK10 without front glass
Connectors	RJ-45, Power & alarm I/O
Operating temperature	-40°c ~60°c / -40°F ~140°F
Power requirement	PoE+ (IEEE802.3at class4 only), DC12V (19.2W)

The mechanical dimensions are:

Chapter 5
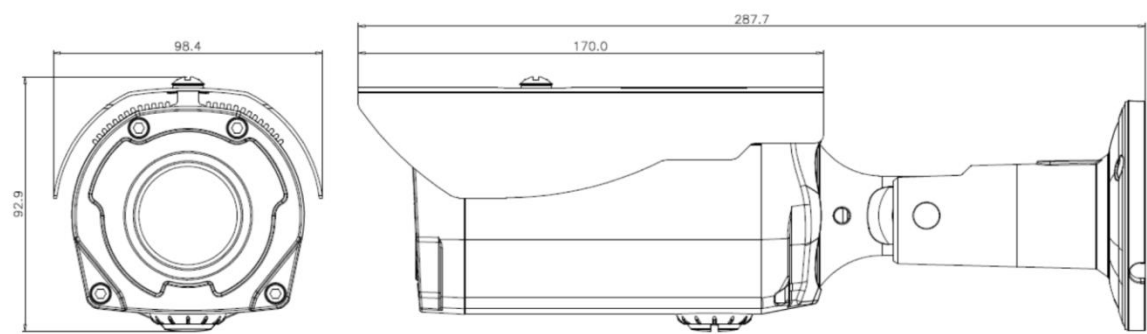
VRS Controller

Hardware

A VRS controller is required for controlling the camera units and the OCR process. The VRS controller is fan-less and designed to be mounted near the lanes, located either in a cabinet or inside the gate arm cabinet.

The LC3000/3100 controller has 4 Network Interface Controllers (NICs), where up to 4 imaging units could be connected to via a Cat 5e/Cat6 network connection. The imaging units can also be connected via a switch or POE+ switch, handling a maximum of 8 imaging units.

There are three models –

- LC3000 (Lane Controller)
- LC3100 (Lane Controller + SeeControl server).
- LC3100 extended – server with larger RAM and SSD

Both LC3000 and LC3100 are based on the same hardware, and the only difference is the image that is pre-programmed on it..

The LC3100 server image comes with both the VRS controller and the SeeControl server. It therefore can support both the front end and the back-office functions. In small sites a single LC3100 can perform all functions of the VRS system.

The modularity of the VRS system also allows using multiple SeeControl servers. Each lane controller can report to a single or multiple SeeControl servers. For example, a toll project with x number of toll stations, each toll station will report to a local SeeControl server, and to a central SeeControl server in parallel for global tolling functions.

The specifications are listed in the following page.

System Common Features		LC3000: Lane Controller	LC3100: Lane Controller & VRS Server in One	LC3100 Extended
CPU	Intel® Quad Core™ i7-6700TE			
Memory2 SO-DIMM DDR4		8GB	8GB	16GB
Dimensions	260mm x 175mm x 79mm (10.2" x 6.9" x 3.1")			
Mounting	Wall mount - by mounting bracket 2U Rackmount (Optional)			
Power Input	35W			
Voltage	6V to 36V, DC-in			
Weight	3.8 kg (8.38 lb.)			
OS Support	Win7			
Certifications	IEC, CE, FCC, EN			
Controller App		√	√	√
SeeControl (1)			√	√
MS SQL express			√	√
Interfaces				
Storage SSD		256 GB	256 GB	1TB
Serial	4 COM RS-232/ 422/ 485			
LAN 4 Gige				
USB Ports	6 USB 3.0 (External)			
DVI 2 ports.				
Expansion	3 SIM card socket (External)			
GPIO	16 Isolated DIO			
Environment				
Temperature	Fan-less; -40°C to 75°C			
Humidity	5% to 95% Humidity, non-condensing			
Vibration During Operation	IEC 60068-2-64 SSD : 5Grms, 5Hz to 500Hz, 3 Axis			
Shock Protection	- IEC 60068-2-27 - SSD : 50G @ wall mount, Half-sine, 11ms			

Controller Application

The Lane Controller is powered by the Controller Application. It interfaces the cameras over the network, builds up video buffers for each of the IP cameras, controls the trigger mechanism, performs the OCR process to extract the plate location and data, determines the overall result of the recognition, then displays and exports the information and archives the images.

A sample of the main display is shown in the following figure. On the top left side are viewing tabs (live, query). Under these tabs are user options (settings, live, clear events, viewing options). Below are tabs with the connected cameras, and the last image captured from the selected camera. On the bottom left side are the recognition results for the selected camera, while on the right side are the system events (inputs, recognition results, server transmissions).

For a detailed description – refer to the controller application user manual (reference #5).

Figure 3.4: Sample main display of the controller application

SeeControl server

Overview

SeeControl is the comprehensive Back-Office Management System for HTS's Vehicle Recognition System (VRS). VRS is a state-of-the-art, image recognition system that identifies tracks, and stores vehicle images and license plate data for a variety of applications, including:

- Safe City for highways and urban environments

- Access Control

- Parking Management

- Toll Collection

  SeeControl is designed to monitor the health and maintenance of your vehicle recognition systems at a site or cluster of sites, all from your command and control facility.

SeeControl enables data fusion, reporting, and management of specialized lane-based Controller Applications, thus streamlining system performance. Its flexible data handling capabilities allow for highly-customizable information management and report generation.

Back Office

The Back-Office of the VRS architecture is the SeeControl service. SeeControl is based on a tiered architecture, in which each component can be hosted on separate hardware platforms, or together on the same workstation:

- **Service.** The SeeControl service collects vehicle entry information that is generated by the Controller Application and stores the information on the SQL database.

- **Client.** The SeeControl command and control client is a web application used to access and process the information stored on the database.

- **Third Party Client.** Third party clients can interact with the SeeControl service using the SeeControl Client SDK.

- **Database.** The SeeControl database stores events that are generated by Controller Application. It also maintains links to images stored on the SSD drive of the SeeControl server.

- **Internet Information Services** (**IIS**) – A web server application supporting client browser protocols, such as HTTP.

  SeeControl operates on **64-bit** Windows operating systems only.

These components are shown in the following illustration. On the left side are the front-end elements of the VRS architecture – the imaging units and the VRS Lane Controller. The VRS Lane Controller send the extracted license plate information and images to the SeeControl Server. The Server is based on a service that controls the systems, an MS SQL database that stores the results and contains the definitions of the system, and an IIS web server application that support client browser protocols, including the users.
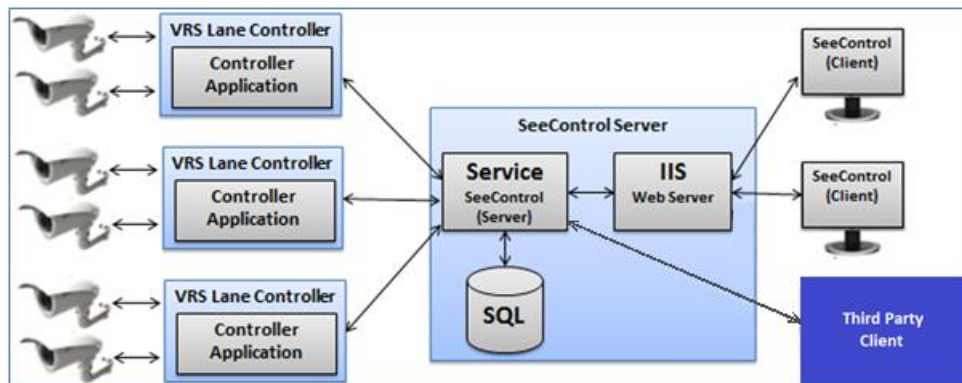

Figure 4.1: System Architecture

Third Party client interface

SeeControl Client SDK provides an interface from the server to the third-party client application. Refer to the SDK document (reference #4) for a complete definition of the interface.

The SDK also includes a Lane Controller simulator that simplifies the off-line integration process.
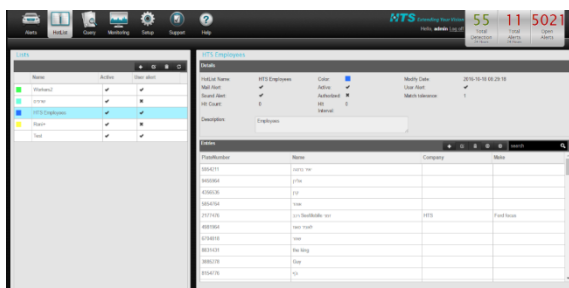
User interface

SeeControl presents a live view of the alerts to the user via a graphical user interface and supports query operations of the past events. A sample of the user interface screens is shown here:

Real time alerts and events display:

Hot lists definitions (white lists that can open the gate, black lists for alerts):

Queries (search for vehicles(s)) in the SQL database history:
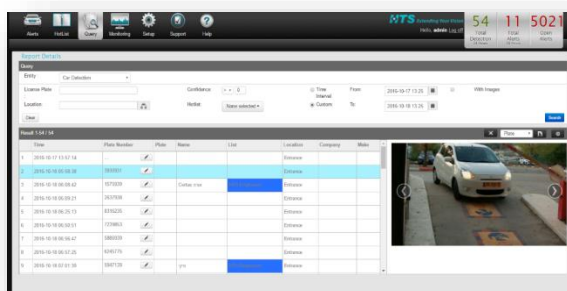
Monitoring (system health and histogram of captured parameters):
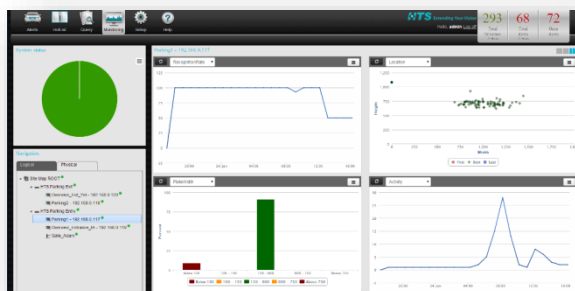
For a detailed description of SeeControl – refer to its user manual (reference #6).

Interface Extensions

SeeControl interfaces to the 3rd party includes a rich set of extensions. The core interface extensions are listed in the following diagram:

Chapter 7

Installation design

This chapter provides recommended installation practices and guidelines.

Connection diagram

An example of a parking installation is illustrated in the following figure. There are 2 lanes: one gated and the other free flow, using a single imaging unit on the ceiling above each lane viewing the rear of the vehicle.
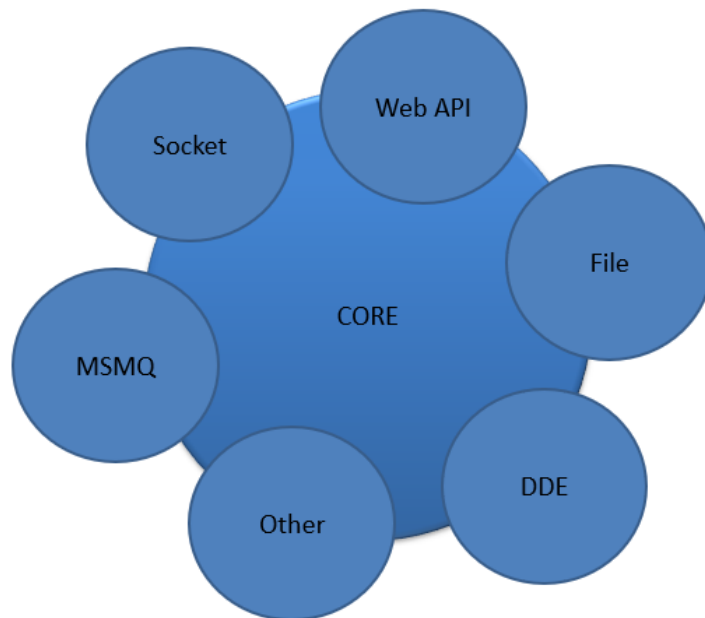
In this example a lane controller (LC3000) connects to 2 imaging units (N70s) via a POE+ switch, wired with Cat5e or Cat 6 cables. The switch connects to one of the 4 Gigabit NICs on the lane controller. The switch also connects to an Adam 6060 network IO device. The I/O device input connects to the loop detectors (assuming single lane detectors) and via its relayed output to the gate on one of the lanes.

All lane controllers will be connecting via the network to the VRS server, which is powered by the SeeControl server. This could be a LC3100, which will be shipped by HTS fully configured and ready for operation, or on the parking lot server which should be installed and configured by HTS support.
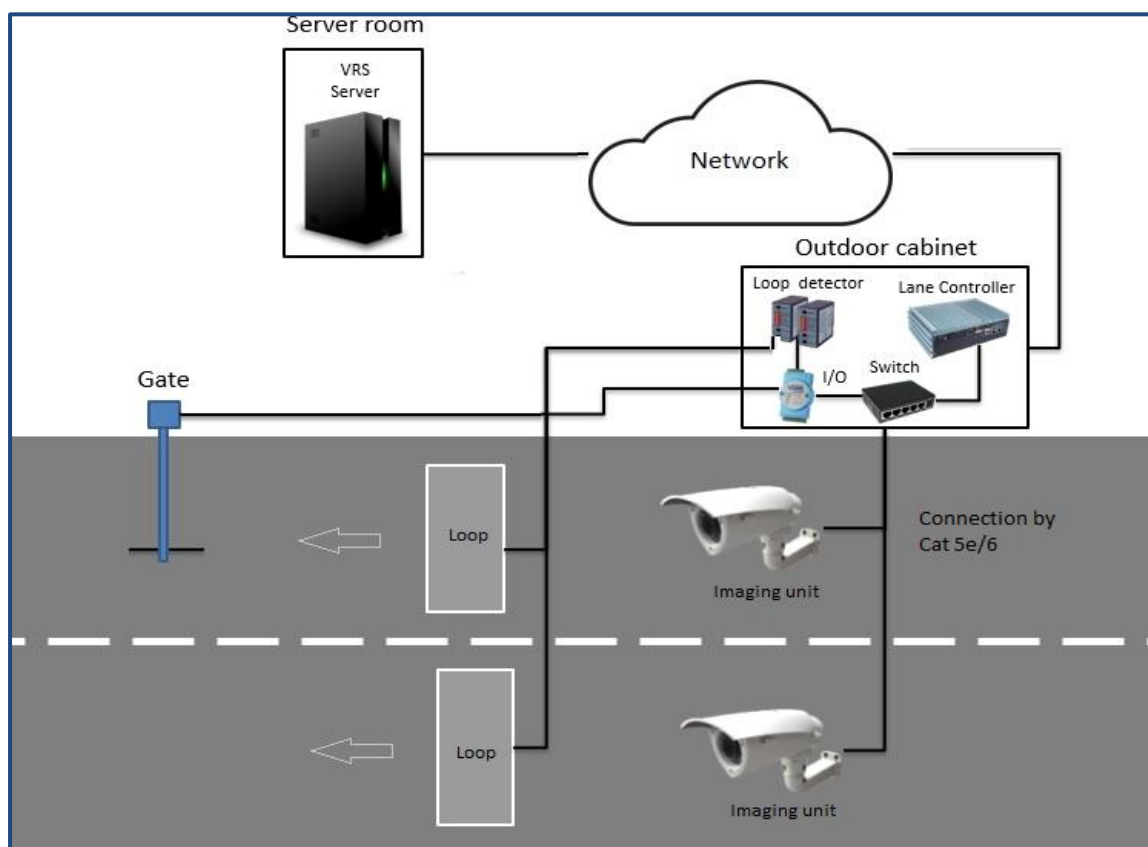

Figure 5.1: Typical installation example

Wiring considerations

The following considerations can guide you in the installation:
- Use cat5e/6 network cables to establish a gigabit network connection to the imaging units. Maximum rated distance is 100m (300ft), although it is recommended to use shorter ranges.
- From the lane controller to the VRS server the connection is advised to also run at gigabit speed, but a lower speed 100 or wireless could also suffice, as the event results are not data heavy.
- Rather than using a POE+ switch to network and power the cameras, you can also use a power supply for each camera and connect the network cable directly to the Lane Controller NIC.
- Maximum number of imaging units that can connect without a switch are 4, but there are necessary connections that should be made to the VRS server and to the network I/O.
- Up to 8 imaging units can be serviced by one Lane Controller.
- If there is not gate control, then the Adam network I/O device can be avoided by connecting the loop detector to the inputs of the imaging unit. If there are 2 imaging units per lane, only one of the imaging units should be connected to the detector.

Trigger – Loop detector

Triggering the recognition event is done by the lane controller sensing a change in the loop. The state of the loop is determined in the loop detector, which operates a relay that opens or closes a dry contact (no voltage) pair of signal and common outputs. The pair of wires are connected to the input signal of the camera, or to the Adam 6060 network I/O device. The state is read by the controller application, which then starts the sequence of a recognition event, resulting in a report to SeeControl server on the plate registration number and associated images.

When a vehicle steps on the loop, the loop detector changes it dry contact state from "open" (no contact) to "close" (contact), and when the vehicle steps out of the loop it drops from "close" to "open". This is termed as "rising" signal or "falling" signal in the trigger parameters of the controller application.

Here are some insights on the best location for the loop, depending on front or rear capture:

- **Front loop** – signals the start of the front capture when the vehicle steps on the loop. It should be away from the final stop of the vehicle in order to allow some time for the recognition process. It also will be used, perhaps with some time delay, for the overview capture of the driver face, preferably after opening the window.

- **Rear Loop** – signals the rear capture when the vehicle leaves the loop. It should be at a distance from the stopping position of the private vehicle, but when it is still in motion. Since this requirement extends the length of the overall range from the gate arm to the area camera, it might push the rear pole to be outside of the lane area.

Gate Arm

Gated parking facilities require adding a gate control. Most installations the gate arm is controlled by a 3rd party software interface. In case the LPR system should control the gate, then the system requires an output, which is commanded by SeeControl for automatically opening the gate for white-listed vehicles. This can be either from an imaging unit's output, or via the Adam 6060 IO network device.

LPR Configurations

There are several typical LPR configurations: front, rear and stereo. The following pages detail these configurations, describing a single lane as an example.

For some countries, the LPR system is based on a single illumination spectrum, e.g. 730nm or 850nm, which is illuminated by the N70-IR Imaging Unit. In USA car parks it is advised to add another visible (color) imaging unit. In such case there will be 2 cameras per viewing side (front, or rear, or both).

Front capture

This configuration is the popular in European and Central/South American parking stations where all vehicles have a license plate in the front side. The images are captured from the front of the vehicle. In most cases a single imaging unit is required, working in IR (850nm).

The trigger is done when the vehicle steps on the loop, a mode of trigger that is referred in the Controller Application as the "rising" edge of the detector signal. The loop is placed near the gate arm, but at some distance as to allow the car to continue moving a meter or so before stopping, in order to capture several images while the vehicle is still moving.

These are the components of the front capture system:

- N70 imaging unit on the front
- LC3000 for up to 8 N70s
- LC3100 for each toll plaza
  Either: POE+ switch
    Or: Power supply for each N70
- Adam6060 network IO (optional)
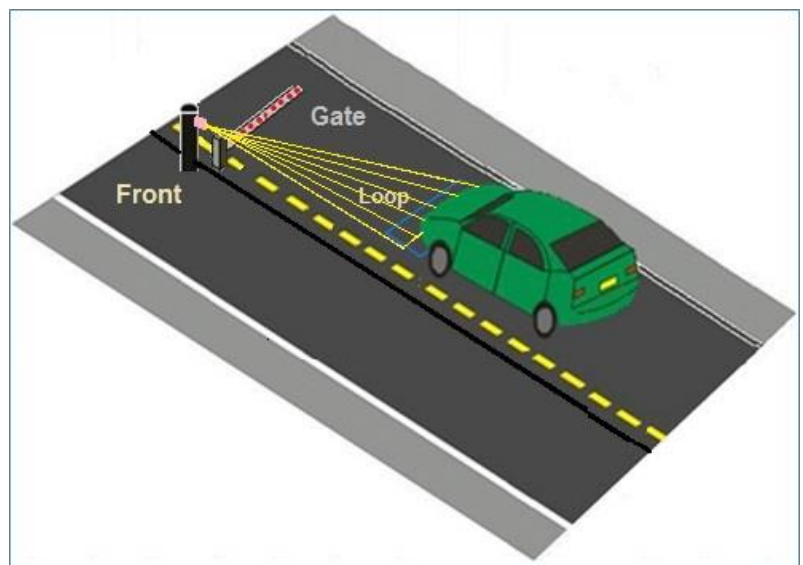- Loop and its detector for each lane

Figure 5.1: front capture

Rear capture

   This configuration is required in countries, such as United States, where the front plates are not mandatory. The imaging unit is placed on the rear, and the system is triggered when the car passes the loop. In USA plates it is recommended to have both an IR (730nm or 850nm) and an additional white illumination color camera.

   The trigger is done when the vehicle leaves the loop end, what is termed as "falling" signal from the loop detector.

The components of the rear capture system are as follows:

- N70 imaging unit(s) for each lane
- LC3000 for up to 8 N70s
- LC3100 for each toll plaza Either: POE+ switch/: power supply for each N70
- Adam6060 network IO (optional)
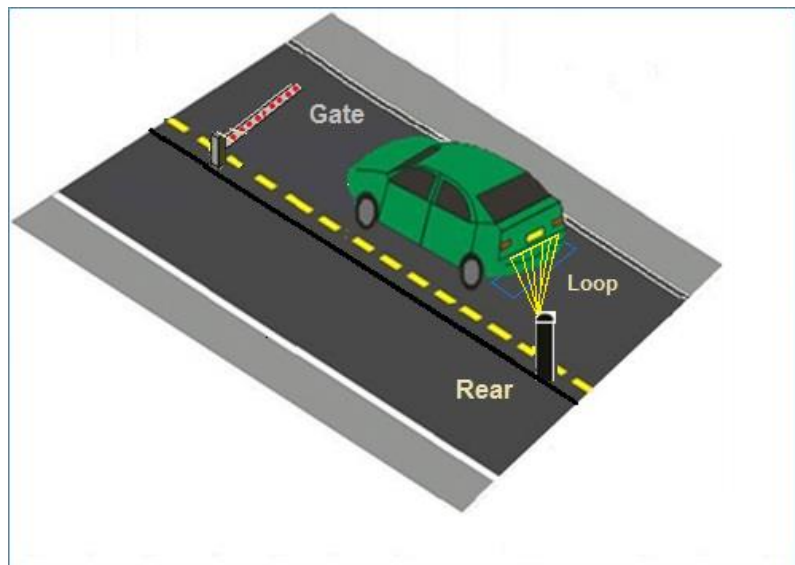- Loop and its detector for each lane

Figure 5.2: rear capture

Front and Rear capture

This configuration increases the recognition rate and confidence, as it views 2 different views of the same vehicle identity. For each side of the vehicle there is a single imaging unit, for European countries (IR), or two imaging units (IR and white) for USA plates.

- 2 (or 4) N70s for each lane
- LC3000 for up to 8 N70s
- LC3100 for each toll plaza
- Either:
     Either: POE+ switch/power supply for each N70
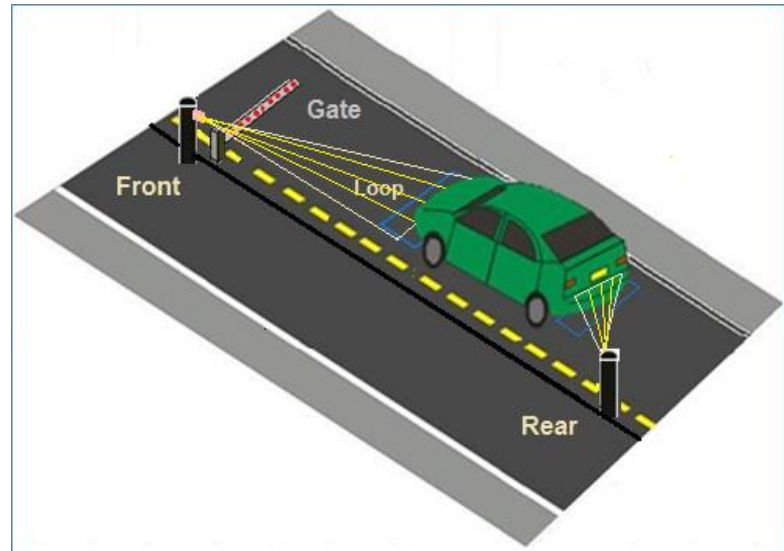- Adam6060 network IO (optional)
- Loop detector for each lane

Figure 5.3: Front and rear capture

General installation recommendations

The following are tips how to maximize the installation to achieve best performance. Of course, there are always site-specific limitations that might need alternative solutions. Please consult with HTS support on resolving such exceptions.

Field of view considerations

To achieve a maximum read rate, the camera should see all passing plates within the field of view. However, the captured images must have enough resolution to identify the letters and numbers with best accuracy and confidence. This is a tradeoff between sufficient field of view (to capture all plates) and the size of the observed plates.

Here are some tips:

- The plate size of USA plates is 30cm (1ft). For reading the plate at 200 pixels - about 10% of the 1920 pixels on the width of the field of view – then the effective field of view will be 300cm (10ft), which fits to a standard 350 cm (11.5ft) lane.
- If the lane is wider, then consider narrowing it down. Otherwise, consult with HTS.

Side pole installation

Common installations have the imaging units mounted on poles. These are the recommendations regarding poles:

- The imaging unit should be as close as possible to the traffic, so the side view angle is minimized
- Protect the imaging unit by a bollard
- Height of camera/illumination is between 1.2m (4ft) to 2.4m (8ft)
- Range of camera/illumination unit 5M (16ft) diagonal from the detection point (start of loop for front capture, or end of loop for rear)

Ceiling installation -Rear capture

For indoor parking, it is advised to mount the cameras from the ceiling, above the middle of the lane. Due to bumper to bumper situations, the camera should not be too far, so the next car will not obscure the rear plate. The height of the camera above ground should be slightly more than twice than the horizontal range from the camera to the detection point (end of the loop on rear installation).

For example, for a 2.5m (8ft) heigh ceiling the range should be slightly more than twice – 5.5m (18 ft).

For a higher ceiling, such as 3.6m (12ft), it is advised to lower the camera with a bracket by 1m (3ft) to 2.6m (9ft).

The figure here shows a typical exit lane, with rear capture, and the recommended locations for the imaging units.
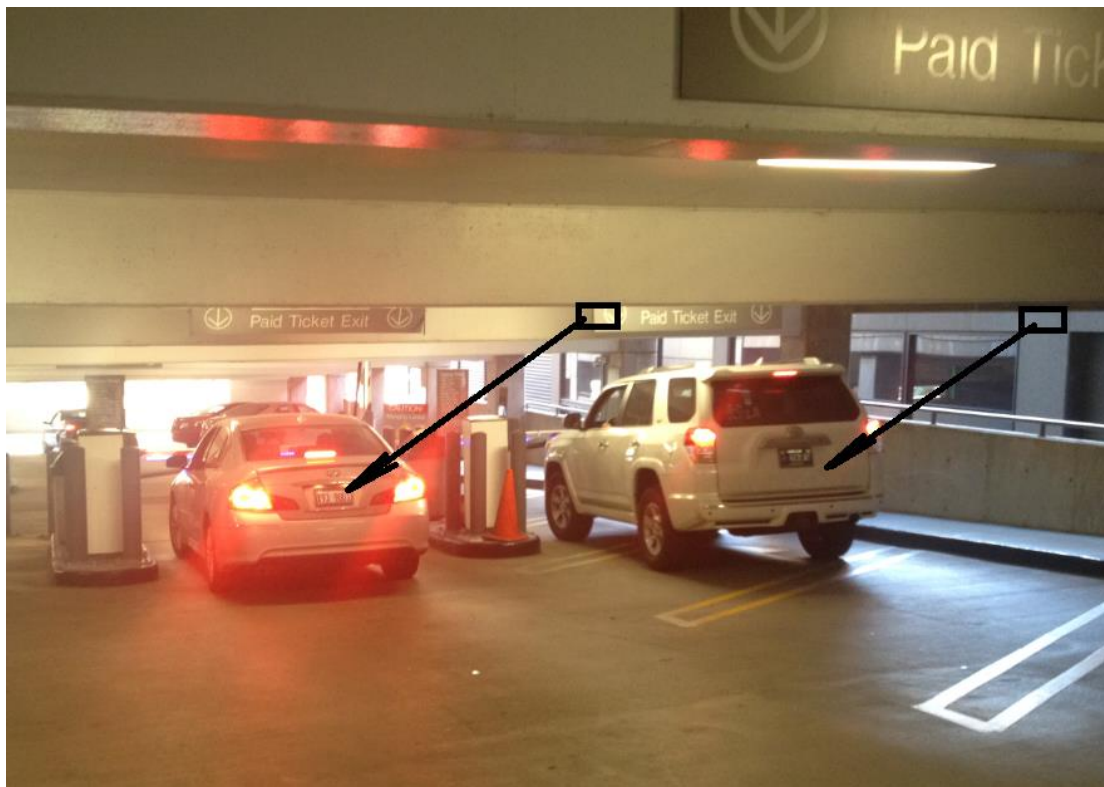

Figure 5.5: rear capture from ceiling

Ceiling installation -front capture

An example of a front capture is here on the right. The twin camerasare mounted on the ceiling before the gate arm.

The loop detector placed before the gate arm triggers the Lane Controller to read the images and extract the license plate before the car reaches a stop.

The ratio of range to height should also be at least twice.

Figure 5.6: Front capture from ceiling

Ticket machines and LPR

In many parking sites there are ticket machines that control the car park operation. The first configuration listed below shows a pre-capture case where the vehicle registration is captured prior to the ticket machine, sent to the parking management system, and printed on the ticket.
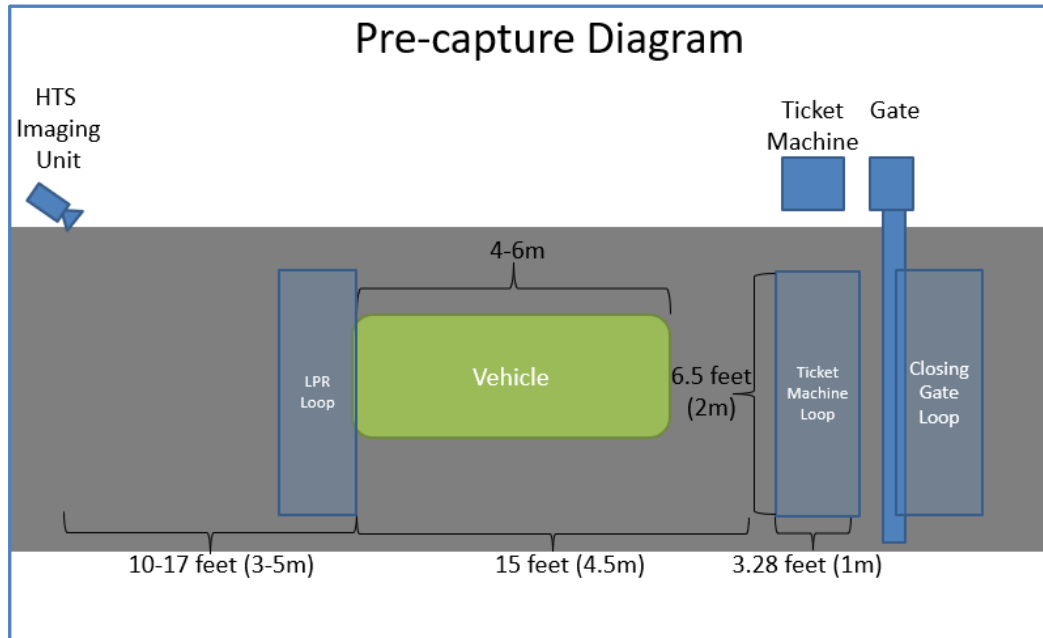

Figure: Pre-capture case

Another type of integration is after the vehicle enters to the car park, and the LPR data is reported to the Parking management System (PMS) for recording the parking time.
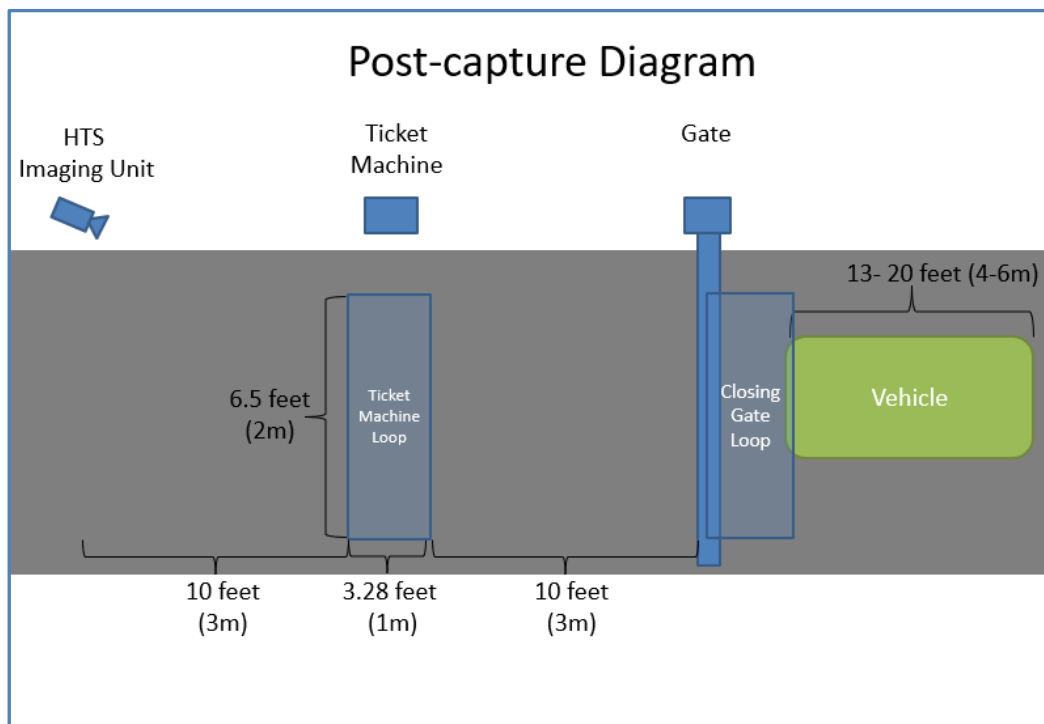

Figure: Post-capture case

Chapter 8

Planning a parking site

Guidelines

The physical outlay of the parking site dictates how and where to locate the lane controllers. These are the guidelines:

- Try to cluster the lanes with the imaging units within a short distance to their connected Lane Controller, placing the Lane Controller in the center of that cluster. This will meet the cable length limitation and reduce the costs of trenching and wiring.

   For example, if there are 2 lanes on the north side of the car park, and much farther on there are 2 lanes on the south side, then use 2 Lane Controller on each end rather than pulling long lines to use just one lane controller.

- Mount the lane equipment inside a weatherproof cabinet, or inside the gate arm cabinet. Make sure the components, especially the loop detector, are easily accessible for service by a certified technician.

- Limit the number of imaging units per lane controller. Although the maximum units per lane controller is 8, but if the lane controller is down, then many lanes per controller will make all of them inactive.

- Balance the traffic load on the lane controller, so the throughput during rush hours do not cause response delays. For example, have a mix of entry and exit lanes on the same controller as both lanes will not be active at the same rush hour.

- Use POE+ switch to have both power and networking connections to the N70 imaging units

Support

Always it is best consulting with HTS support team on how to optimize the layout of the equipment on the car park.

Document Revision History

Rev	Date	Author	Change	Sections affected
1.1	Mar 6, 2019	YH	Original writing	All
1.2	Mar 8, 2019	YH	Additional information	All
1.3	Mar 8, 2019	YH	Misc Corrections	Chapters 1, 5
1.4	Mar 9, 2019	ER	Misc. corrections	All; chapters renumbered