Best Practices Guide

Valerus SmartAnalytics

XX306-20-00

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Document Number: 8009-8306-20-00 Product specifications subject to change without notice. Issued: 9/18

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1 Introduction

This document describes best practices when deploying Valerus SmartAnalytics video analytics solutions at your site. These guidelines will assist you to install and implement the system in an optimal configuration that is customized to the specific business requirements and physical setup of your site(s). Utilizing these best practices that are gathered by Valerus professionals throughout the years, you will be able to maximize the value of the solution while minimizing potential false detections and inaccurate information.

The document provides comprehensive information on various aspects and scenarios of deployments. The appendices provide additional general information regarding cameras and lighting.

2 Performing a Site Survey

The integrator must perform a comprehensive Site Survey of the particular site on which a deployment of Valerus SmartAnalytics video analytics is planned, with the objective of identifying site parameters that may affect the ability to satisfy both project requirements and video analytics performance requirements.

The following items are documented in the Site Survey:

- **Requirements**: Detailed video analytics requirements, to be used as acceptance criteria for the deployed solution
- **Cameras**: Cameras used (with their site layout) or planned to be used with video analytics
- **Video Management System (VMS)**: Valerus
- **Recording, Viewing and Monitoring**: physical location of the recording, viewing and monitoring clients and servers
- **Forensics/Statistics**: If utilized, specifying operator locations, interfaces, data retrieval mechanism, retention time and export format
- **Network infrastructure**
- **Failover requirements**
- **Lighting conditions**
- **Environmental factors**

3 Verifying Valerus SmartAnalytics Products Deployment Requirements

This section describes Valerus SmartAnalytics' offering of video analytics solutions and will help you map deployment requirements to existing product capabilities and verify if the requirements can be implemented. Contact Vicon Technical Support if you're uncertain about how a specific requirement can be implemented. If you identify a requirement which cannot be currently met, go back to the end user and help them modify the requirement so that it can be met.

Vicon's offering includes the following applications:

- **Valerus SmartActions Real-Time Detections and Alerts**
  - Defining events and scenarios and receiving real-time alerts when such events are detected
- **Valerus SmartSearch Video Search**
  - Searching through recorded video after an incident to locate specific video footage
- **Valerus Business Intelligence**
  - Analyzing motion patterns, counting and generating statistical reports

3.1 Real-time Video Analysis and Alerts

The following table describes the Valerus SmartAction real-time video analytics features available with Valerus SmartAnalytics' video analytics product.

Application	Main Usages	Reference image
Person moving in an area	Detects and generates an alert when a person enters or moves within a user-defined region. Typically implemented to protect indoor and outdoor sterile zones. Event generation can be filtered by direction of movement, time, distance travelled, and speed.	
Person crossing a line	Detects and generates an alert when a user-defined virtual line is crossed by a person. Can be used in both indoor and outdoor environments. Typically used for perimeter protection (including fence trespassing) or for detecting illegal movements (wrong way). Also used to detect a person entering or leaving a designated area. Allows definition of a particular crossing direction as a detection criterion.	 
Person tailgating	Detects and generates an alert when two persons cross a user-defined virtual line, in a particular direction, within a short timeframe. The virtual line, direction and timeframe are user-defined. Typically used to alert against illegal access through an access-controlled point.	
Person loitering	Detects and generates an alert when a person is present in a user-defined region for a user-defined duration. Typically used to detect potential security threats.	

Application	Main Usages	Reference image
People crowding	Detects and generates an alert when crowd gathering occurs within a user-defined region. Users may define detection criteria such as: the rate of region coverage, in percentage, and duration.	
People Occupancy	Detects and generates an alert when grouping (specific number of people gathering) occurs within a user-defined region. Users may configure the number of people in a group, and the duration of gathering.	 
Vehicle moving in an area	Detects and generates an alert when a vehicle moves in an area. Event generation can be filtered by direction of movement, time, distance travelled, and speed. Typically used for roads safety and parking lots security applications.	
Vehicle crossing a line	Detects and generates an alert when a vehicle enters or leaves an area. Configurable criteria are: virtual line to be crossed, distance travelled (before and after the virtual line is crossed), and speed.	

Application	Main Usages	Reference image
Tailgating vehicle	Detects and generates an alert when two vehicles cross a user-defined virtual line, in a specific direction, within a short timeframe. The virtual line, direction and timeframe are configurable. Typically used to detect illegal access within an access control point, such as a parking lot.	
Stopped vehicle	Detects and generates an alert when a vehicle stops in an area for a period. Area and time are user-defined. Typically used to detect vehicles stopping in restricted areas, on highway shoulders, or generally for illegal parking.	 
Vehicle Speed Analysis	Detects a decrease in vehicles average speed in a predefined area for longer than a predefined time threshold.	
Suspicious object	Detects and generates an alert when an object is left unattended in an area for a period. Area, object size, and time are user-defined.	

Application	Main Usages	Reference image
Asset protection	Detects and generates an alert after a user-defined asset is removed. The time that lapses for the alert to be issued following the asset removal is user-defined.	
Lighting Detection	Detects a light (signal) appearance in a predefined area of the camera field of view longer than a predefined time threshold.	
Detection of moving people or vehicles on PTZ presets	Detects and generates an alert when a person or vehicle enters, moves in, or exits a user-defined area, or crosses a user-defined virtual line, on PTZ camera presets. The PTZ camera presets tour, detection time on each preset and direction/zones are user-defined.	
PTZ auto-tracking originated by detection on PTZ presets	Detects when a person enters, moves in or exits a user-defined area, or crosses a user-defined virtual line, and immediately starts to autonomously track them while controlling the PTZ camera movements to keep the target in the field of view. The PTZ camera presets tour is user-defined. Detection time on each preset is user-defined.	

3.2 Valerus SmartSearch Video Search

This section describes the forensic and post-event analysis applications of Valerus SmartSearch video search and analysis capabilities.

Valerus SmartSearch offers an intuitive search engine that allows you to execute search queries based on the following parameters and criteria:

- Target Type – people, vehicles, static objects
- Event Type – moving, stationary, crossing a line, occupancy, crowding
- Search by color and/or size
- Search within defined time frames
- Search on selected cameras or group of cameras

Search for Similar Targets – Once a target is observed, a search can be conducted to locate additional appearances of the same or similar target in the recorded video.

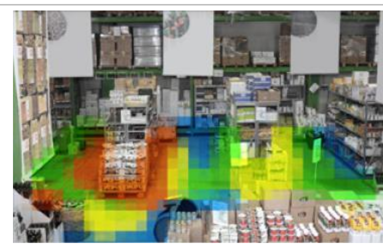
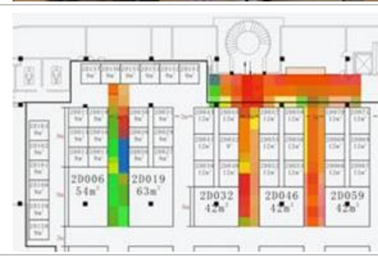
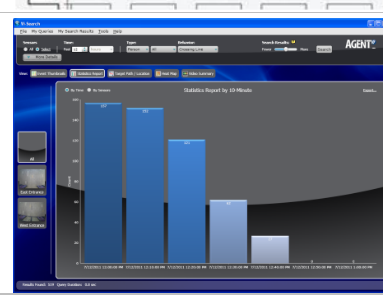
The following table shows the available output results for these queries.

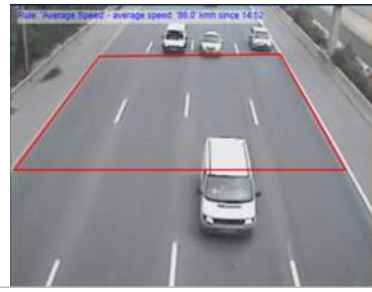
Application	Main Usages	Reference Image
Thumbnail based investigation	• Searches for particular events or targets in a specified group of cameras and within a defined time frame. • Results are provided as thumbnails, representing associated video playback segments. • Thumbnails are shown in digital zoom, and metadata annotation, highlighting the relevant target at the time of the event. • The associated video playback is provided with digital PTZ and metadata annotation. • Selected Thumbnails can be exported as video clips of a standard video format (AVI).	

Application	Main Usages	Reference Image
Video summary	Facilitates effortless debriefing of multiple search results through one condensed clip that consolidates all search results.	

3.3 Business Intelligence

This section describes the business intelligence applications of Valerus Business Intelligence capabilities.

Application	Main Usages	Reference Image
People counting	Counts people crossing a virtual line in a predefined direction. Various types of statistical reports can be generated in different timeframes, such as overall daily traffic, traffic density hot spots, and a comparison between specific hours and days.	
Heat maps - occupancy and dwell time display as hot zones	Enables visualization of occupancy levels in specified areas in the camera's field of view (or across a site map associated with multiple cameras) for easy identification of high/low occupancy zones.	
Motion path analysis	Produces graphical presentation of all motion paths in a scene (or across a site map), for identification of trends / anomalies. Also used for forensic investigation. Video playback can be activated for each path.	
Site Map	Enables 'Heat Map' and 'Motion Path Analysis' functionalities on a site map, indicating multiple cameras fields of view on a single map.	
Statistical analysis	Summarizes video search results and generates comprehensive statistical reports, for specified group of cameras and within a defined time frame.	

Application	Main Usages	Reference Image
Vehicle counting	Counts vehicles crossing a virtual line in a predefined direction. Various types of statistical reports can be generated in different timeframes, such as overall daily traffic, weekly and monthly comparisons, traffic density hot spots, comparison between specific hours and days, etc.	
Vehicle Speed Analysis	**Provides key metrics for highway operators through vehicles speed information analysis.**	

4 Determining Camera Type

This section describes how to select cameras for a site where the cameras are not yet installed or selected. Select from three main camera types:

- **Fixed CCD\CMOS**

This is the most common camera type used with video analytics.

There is a long list to choose from, ranging from analog cameras to megapixel IP cameras.

Analytics performance can be increased by deploying the capabilities of:

1. Wide Dynamic Range
2. Automatic switching between day and night

- **Thermal**

Select a thermal camera in case of either:

- Limited or no lighting is available at night -or-
- You want the detection to cover large distances (over 80 meters) with a single camera

It is not advisable to deploy thermal cameras with rules utilized to detect stationary targets such as:

- Stopped Vehicle
- Suspicious Object
- Asset Protection

- **Pan-Tilt-Zoom (PTZ)**

PTZ cameras are used with analytics in the following case:

- To cover a large area with a smaller number of cameras.

  In this case, the PTZ is set to tour between several presets and perform event detection at each preset. Note that only a limited set of rules apply to detection on presets, including: ‘Person/Vehicle moving in an area’ and ‘Person/Vehicle crossing a line’

The tables below provide additional information on camera types:

Sensor and imaging:

Type	Characteristics	Main Usage	Compatibility with Video Analytics
Standard CCD / CMOS	Commonly used color camera	Any common scenario	Very high
Thermal	Infra-Red radiation imaging (temperature based)	Complete darkness Very long distances	Very high
Extreme low-light	Capable of producing a viewable color image at 0.3 Lux or less, due to very long iris exposure time	Poorly lit scenes with almost complete darkness	Very low
Panoramic/ Fish Eye	Circular image – usually 180° / 360°	Wide panoramic coverage of an area with a single camera	Currently limited to people counting, person crossing a line, person moving in an area

Form factor:

Type	Characteristics	Main Usage	Compatibility with Video Analytics
Box/Bullet	Box-shaped body requires mounting arm or pole	Commonly used Indoor / Outdoor camera	Very high
Dome	Dome shape, usually with built-in enclosure. Ceiling, wall and arm / pole mounting	Commonly used Indoor / Outdoor camera	Very high
PTZ	Motorized Pan-Tilt-Zoom	Wide-range coverage Operator controlled view	Specific models for specific applications

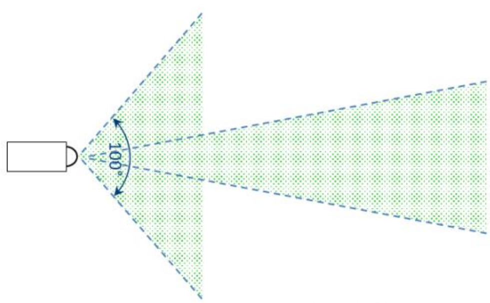
5 Determining Camera Placement and Field of View

Based on analytics rules requirements, selected camera types, and recommended detection distances, you can next determine camera placement and required fields of view for each camera. See also Appendix A – Camera Placement Principles.

5.1 Camera's Viewing Angle

It is recommended to use cameras with viewing angles (horizontal FOV) that are narrower than 110°.

Fisheye cameras or cameras with a horizontal field of view that is wider than 110° may suffer from image warping that degrades analytics performance.



5.2 Optimizing the Field of View

1. To determine the ideal field of view (FOV) for video analytics per camera, the following main criteria should be taken into consideration: **Maximum target distance**: The maximum distance between the camera and the analyzed target, allowing reliable analytics. Determined by the camera's viewing angle and the size of targets at maximum distance.
2. **Minimum target distance**: The minimum distance between the camera and the analyzed targets, allowing reliable analytics. Determined by the camera's viewing angle and the size of targets at minimum distance.
3. **Target separation**: A camera's field of view is considered to have good target separation if there are minimum occlusions caused by adjacent or close-by objects, allowing a complete view of each target separately. Good target separation is a key to successful deployment of video analytics in scenes which are non-sterile.
4. **Camera resolution**: Valerus SmartAnalytics supports resolutions of 320x240 (160x120 on thermal cameras) and higher including HD and megapixel resolution, although analytics accuracy will not be improved by resolutions higher than D1.

Each of the above criteria can be altered based on the following guidelines:

Increase Maximum Target Distance	Decrease Minimum Target Distance	Improve Target Separation
Increase target magnification by using longer focal lengths	Decrease target magnification by using shorter focal lengths	Increase the tilt angle while striving for 90-degree angle (camera looking straight down)

Decrease the camera's tilt angle* to extend the camera's vertical viewing angle / maximum viewing distance	Increase the camera's tilt angle* to shorten the 'dead-zone'	Use higher mounting heights to achieve top-down viewing in wider areas across the field of view
-	Use greater mounting heights to produce lower-sized targets which do not suppress the maximum allowed target size	-

* Zero degrees tilt angle refers to cameras mounted parallel to the ground.
90-degree tilt angle refers to cameras mounted orthogonally to the ground (looking straight down)

Conclusion:

- For long-range field of view, use increased focal length and low tilt angle. The minimum viewing distance can be compensated by adding a single camera at the top of the camera chain.
- For short-range field of view, use short focal lengths, high tilt angle (as close to 90 degrees as possible), and higher mounting. The higher the camera is, the higher the tilt angle required.
- For non-sterile scenes with continuous presence of multiple people and / or vehicles, and for crowded environments, optimize target separation by using large tilt angles (90 degrees or as close as possible to it) and higher mounting. Height and tilt angle compensate each other in this case.

Adequate Field of View (FOV) and Area of Interest (AOI):

- Position the camera so that it mostly occupies the AOI. Exclude irrelevant areas from the FOV such as the sky and other non-important regions. Try to keep the AOI centered in the FOV.
- Avoid concealments and truncations of detected targets as much as possible. The view of the AOI is best without physical obstacles such as trees, buildings, poles, signs, and any other static object that may obstruct the view of the target (person, vehicle or static object).
- Avoid vegetation, puddles, and running water in the AOI.

5.3 Determining Effective Range

The effective range for reliable analysis and detection is determined according to target size criteria which differ from one scenario to another.

- The different scenarios are detailed in the below table: Size range criteria are based on the relative size of targets in the FOV. They are required for reliable analysis of people, vehicles, and static objects. Size range criteria are used across typical scenarios of camera mounting and scenes learning.
- 'angled' refers to cameras positioned with a tilt angle of 20°-50° (cameras tilted at an angle of 0°-20° or 50°-85° present views that are not optimal for analytics and are therefore not recommended)
- 'overhead' refers to cameras positioned with a tilt angle of 85°-90° (cameras tilted at an angle of 50°-85° present views that are not optimal for analytics and are therefore not recommended)

See Appendix A – Camera Placement Principles for more details regarding the Camera Placement Design Tool.

- **Size range for people analysis, as a % of the FOV**

Scenario	Camera Orientation*	Minimum Size Criteria	Maximum Size Criteria	Example
Walking / running / loitering / crowding	Angled	Target height is greater than or equal to 5% of the total image height	Target height is less than 33% of the total image height	See Reference 1.1 below
Walking / running / loitering / crowding	Overhead	Target width is greater than or equal to 5% of the total image width	Target width is less than 20% of the total image width	See Reference 1.2 below

- **Size range for vehicle analysis, as a % of the FOV**

Scenario	Camera Direction*	Minimum Size Criteria	Maximum Size Criteria	Example
Moving target on a single lane road / street	Angled Vehicle is viewed from its side	Length (end to end) is greater than 5% of the image width	Length (end to end) is less than 20% of the image width	See Reference 2.1 below
Static target on a single lane road / street	Angled Vehicle is viewed from its side	Length (end to end) is greater than 5% of the image width	Length (end to end) is less than 40% of the image width	See Reference 2.1 below
Moving target on a multi-lane road / highway	Overhead/Angled mounted on gantry or angled camera on high pole (6 meters or more)	Size is greater than 0.25% of the total image size	Size is less than 4% of the total image size	See Reference 2.2 below
Static target on a multi-lane road / highway	Overhead/Angled mounted on gantry or angled camera on high pole (6 meters or more)	Size is greater than 0.25% of the total image size	Size is less than 10% of the total image size	See Reference 2.2 below
Moving target in an open area (parking lot, open yard)	Viewed from multiple directions including front and back with angled cameras	Size is greater than 0.25% of the total image size	Size is less than 6% of the total image size	See Reference 2.3 below
Static target in an open area (parking lot, open yard)	Viewed from multiple directions including front and back with angled cameras	Size is greater than 0.25% of the total image size	Size is less than 10% of the total image size	See Reference 2.3 below

- **Size range for static objects analysis, as a % of the FOV**

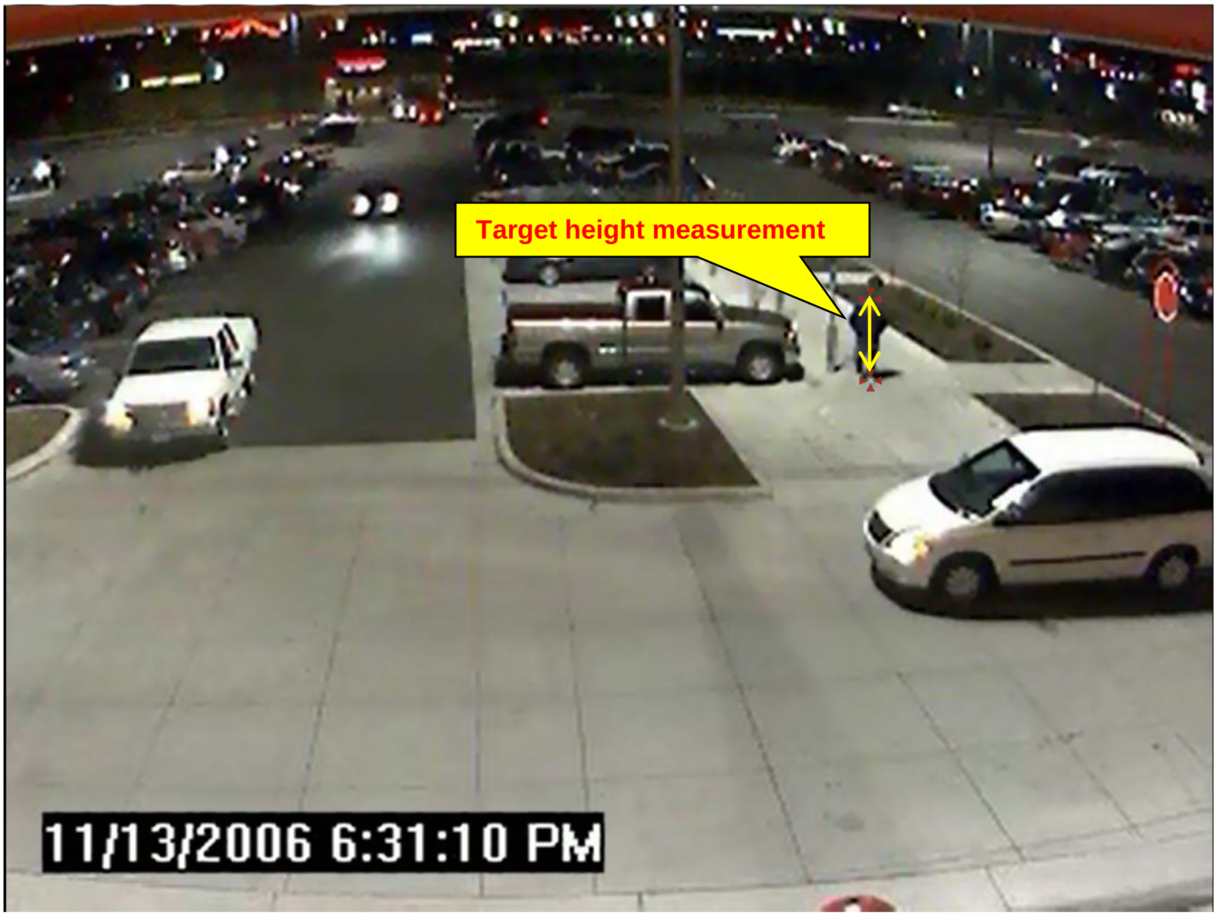
Scenario	Camera Direction*	Minimal Size Criteria	Maximal Size Criteria	Example
Low activity scene Good illumination Non-appearance of shadows, reflections, glare	Overhead/Angled	Target size (visible area) is greater than 0.25% of the image size	Target size (visible area) is less than 10% of the image size	See Reference 3.1 below
Any indoor/outdoor scenario with good illumination	Overhead/Angled	Target size (visible area) is greater than 1% of the image size	Target size (visible area) is less than 10% of the image size	See Reference 3.2 below

* While overhead camera mounting is generally advised for ideal performance in non-sterile environments (due to the principle of target separation), it is explicitly required for some functions and scenarios, mainly for people counting, and directional based detection rules in high activity scenes

5.3.1 References

5.3.1.1 Reference 1.1

Walking / running / loitering / crowding with an angled camera.
Person's height is approximately 8% of the image height.
The size is within the allowed range for all person-related video analysis functions.



5.3.1.2 Reference 1.2

Walking / running / loitering / crowding with an overhead camera.
Person's shoulder width is approximately 9% of the image width.
The size is within the allowed range for all person-related video analysis functions.


Target width measurement

5.3.1.3 Reference 2.1

Vehicle driving / stopping with an angled camera and side view

Vehicles length is approximately 30% of the image width.

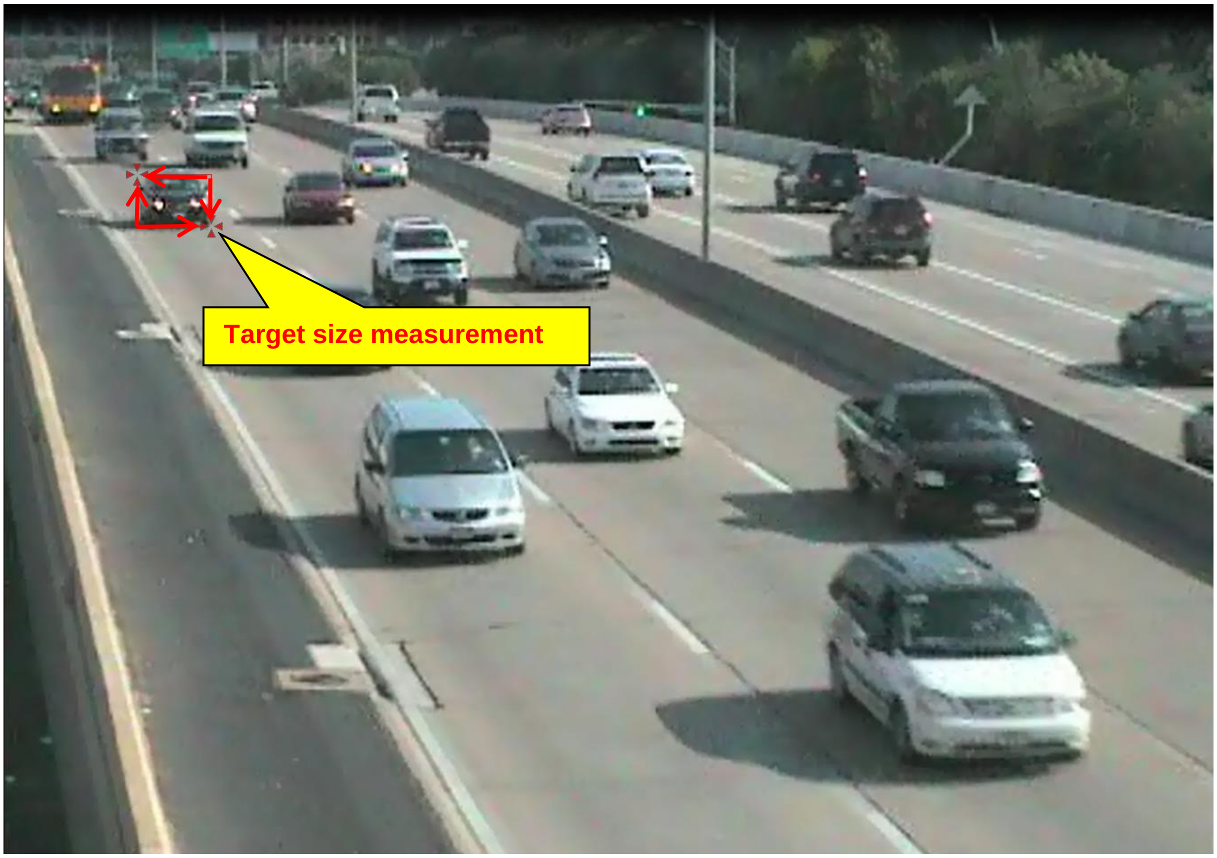
The size of the vehicle is within the allowed range for stopped vehicle, and too large for moving vehicle analysis.

5.3.1.4 Reference 2.2

Vehicle driving / stopping on multilane road / highway, with angled / overhead camera mounted on gantry or high pole.

Vehicle area size is approximately 0.3% of the image resolution.

The size of the vehicle is within the allowed range for driving and stopped vehicle.



5.3.1.5 Reference 2.3

Vehicle driving / stopping in an open area with an angled camera
Vehicle's area size is approximately 2.5% of the image resolution.
The size of the vehicle is within the allowed range for driving and stopped vehicles.

5.3.1.6 Reference 3.1

Analysis of static objects / bags left behind.

The relative size of the trash can (see measurement below) is approximately 1.1% of the image resolution.

The object is within the allowed size range for any static object analysis scenario.

5.3.1.7 Reference 3.2

Analysis of static objects / bags left behind

In the field of view below, note the two medium-sized bags placed next to each other on the sidewalk. The bounding rectangle measures the relative size of the two, emphasizing a best-case scenario of a very large bag. However, the resulting size is approximately 0.15% of the image resolution, and the conclusion is that this particular FOV is not suitable for reliable detection of objects left behind on the far end pavement, even when restricting the criteria to large suitcases.

6 Implementing a Lighting Solution

One of the most crucial points to take into consideration in an analytics deployment is the amount of light available during operational times. A high-quality image is critically important for successful video analytics deployments, and so light considerations are key to ensuring high-performance video analytics.

Guidelines are provided below for best practices when deploying analytics under different lighting conditions for achieving the best possible performance. Please disregard this section when using thermal cameras.

Comprehensive performance testing on site is achieved when you can identify the target you want to detect in all lighting conditions, 24/7.

See also Appendix B – Lighting Principles.

6.1 Camera Low Light Performance

Security cameras utilize several key elements to control the amount of incoming light and thus improve image quality in poor lighting conditions. The main elements that impact the amount of incoming light are size of sensor, iris / aperture, gain level and shutter speed.

Auto-iris: When properly implemented, auto-iris maintains correct exposure levels and usually delivers moderate and gradual brightness changes. So, if you need to operate video analytics across varying lighting conditions, it is best to choose cameras which support auto-iris.

Auto-shutter speed adjustment: Since the negative impact of slow shutter speed can always be expected when motion occurs, don’t rely exclusively on automatic shutter speed capabilities to properly compensate for video analytics under poor lighting conditions, since the capability to properly detect motion is essential.

Automatic Gain Control (AGC) and Noise Reduction Filters (DNR): In practice, the combination of AGC and DNR usually results in rapid contrast changes (aka ‘video breathing’) accompanied by a certain level of remaining noise. Both are known as negative factors for video analytics as they manifest in rapid pixel changes often interpreted as nuisance motion, which increases the probability of false alarms.

Recommendations

- Avoid manual / fixed customization of the iris, shutter speed and gain which aims to improve image quality at night, due to the negative impact of such adjustments during daylight hours
- Favor day/night cameras that can adjust to nighttime conditions and light changes utilizing auto-iris functionality, optionally combined with moderate AGC and shutter speed control, over day/night cameras supporting AGC with static or fixed iris control. A good example of this technology is called P-Iris.

6.2 Determining Quality of Lighting Conditions

See Section 13.2.1, Vicon Lighting Categories, on page 54 for details on SmartAnalytics lighting categories for video analytics.

6.3 Handling Poor Lighting with IR and Thermal Imaging

After determining the best method to improve nighttime video quality, be aware of rules of thumb when applying each. Here are the main ones:

Considerations when deploying IR illumination (some are also relevant for white light illuminators):

- There is a wide range of IR illuminators and price points. In most cases, higher cost illuminators will provide better image quality, longer distances and longer lifetime.
- IR suffers from shallow depth of view, meaning that a single illuminator is mainly useful when used for either short range or longer ranges, but not both. If you need to cover a range of more than 10 meters, you may need to combine short and mid-range illuminators for the same camera.
- Every illuminator has a different beam width, allowing it to cover a particular width of the field of view. Wider angles allow shorter distances and vice versa. Make sure to choose an illuminator with an angle of view as close to the camera's angle of view as possible.
- Use day-night cameras containing IR cut-filter (which disables IR during daytime or in good lighting conditions) unless the camera is only used in dark scenes.
- Always focus the cameras at night when the IR is in action (IR cut-filter is off), to bypass the known IR focus shift issue.
- IR achieves greater distances indoors than outdoors. IR range indicated by vendors is usually based on indoor scenes. According to performance review indications found in the public domain, when deploying IR outdoors, expect to achieve detection distances that are half to a third of the distance indicated in the IR lighting product specification.
- The illuminator should be mounted at least 1 meter below the camera.

Considerations when deploying thermal cameras:

- The main criteria of video quality for reliable analytics when utilizing thermal imaging is the contrast level differences between the detected target objects and their surrounding background.
  Higher contrast differences mean better quality. While the level of contrast difference is directly impacted by the temperature difference between the target object and its surroundings, the actual figures vary in different environmental conditions (temperature, humidity, etc.) and distances.
  As a result:
  - Pay close attention to the vendor's specifications regarding achievable distances and how they are impacted by the environmental conditions.
  - Test the camera performance in the field in varying conditions.
    See also Testing Lighting Performance.
- Some thermal cameras adopt various techniques to dynamically control their imaging sensitivity in varying conditions. These methods sometimes result in rapid luminance and contrast changes. Since video analytics uses increased sensitivity when deployed with thermal cameras, it may lead to nuisance false alarms caused by these rapid changes. Consult with the camera vendor to ensure that the camera allows some level of control or disabling of these functions.

6.4 Lighting and Camera Placement: Additional Considerations

Sufficient lighting level is the most common criterion to consider when deploying analytics. There are, however, additional challenges for video analytics concerning the way that light and camera placement impact image quality.
Here are the main issues to consider and how to resolve them:

<table>
<tr><th>Issue</th><th>Example</th></tr>
<tr><td>Wide Dynamic Range (WDR) scenes:
Scenes containing a wide range of lighting conditions, including extremely bright and dark areas, will generate an image where the dark areas are completely dark, and the bright areas are saturated.
Common scenarios involve indoor scenes with natural light coming from the outside (windows, entrance or garage doors, etc.), or scenes containing shadowed areas.</td><td></td></tr>
<tr><td colspan="2">Resolution:
Use a camera with good WDR functionality or, alternatively, consider using a thermal camera.</td></tr>
<tr><td>Direct light from vehicle headlights combines an extreme WDR situation with low illumination, resulting in an extensive glare around the headlights and complete darkness around it.</td><td></td></tr>
<tr><td colspan="2">Resolution:
Cameras used for video analytics should not be directed towards vehicle headlights. Avoid using the same camera for LPR and video analytics. If headlights reflect blindingly on a road or wet surface:
Low severity level
Select a camera with advanced WDR function or IR illumination combined with IR band pass filter lens
Medium severity level
Use a slow shutter speed combined with IR illumination
High severity level
Select thermal cameras</td></tr>
</table>

Direct sunlight 'blinds' the camera and generates 'sun spots' caused by reflected light, similarly to the human eye when looking towards a strong light.	

Resolution:

1. Exclude the sky from the camera's field of view
2. Note the course of the sun during the day and position the camera so that it will not face the sun directly at dusk and dawn
3. Avoid placing the camera in front of windows, otherwise use curtains or plants to cover the blinds as much as possible

Shadows in the FOV	

Resolution:

Video analytics can handle moderate shadows and reflections. When dealing with shadows in a controlled, narrow-angled scene such as in deployments of people counting or tailgating where the camera is placed above an entrance or close to a door, consider placing a carpet (preferably grey colored) on the floor to eliminate the shadows. In extreme situations, use thermal cameras.

The table below summarizes the main lens and camera imaging functions and features to be considered and provides observations and recommendations for each.

Function / Feature	Observations and Recommendations
High resolution (above SVGA)	• Higher resolutions *do not* increase the detection range • Poorer image quality in low light conditions compared to SD resolution • Improved image quality during daytime WDR scenes
Auto-Iris / Manual Iris	• Auto-Iris is mandatory for outdoor locations with varying lighting conditions • Manual Iris is a suitable alterative only for constant lighting conditions • Fixed Iris should be avoided
AGC	Standalone AGC functionality (which is not part of a combined module such as P-Iris or multi-function low-light capability) is usually a negative factor and should be avoided or disabled.
WDR	Highly recommended for WDR scenes during daytime, if a high quality 'true' WDR is used (aka multi-exposure WDR)
Advanced extreme low light techniques	Doesn't overcome the need for external illumination in low-light conditions under 5 lux, due to its disadvantages. It may, however, eliminate the need for illumination in higher lux levels.
Integrated IR	Meaningless in most scenarios except for in cases of extremely short ranges such as deployments of people counting or asset protection with FOV range of up to 4-5 meters.
IR cut filter	Mandatory when using IR illumination during daytime.
IR band pass filter	Recommended when using IR and dealing with glare from ambient lights.
Varifocal lens	Mandatory when the FOV and AOI are not strictly determined at the stage of choosing the cameras, and when the FOV and AOI may change in the future. Highly recommended in any other case since it allows fine tuning the FOV.
Interchangeable Lens	Mandatory when needing to achieve extremely wide or extremely long (zoomed) FOV beyond the capabilities of the default camera lens. It's highly recommended to choose cameras with interchangeable lens when the FOV and AOI are not strictly determined at the stage of choosing the cameras.
Auto-focus	Highly recommended as it significantly simplifies the focusing process, especially when the cameras are mounted high and/or in locations that are hard to access.

7 Best Practices for Specific Analytics Applications

This section provides best practices for:

- Perimeter Protection
- Business Intelligence for retail environments
  - People Counting
  - Heat Maps, Target Path Analysis
- Traffic Management

7.1 Perimeter Protection

Main Objectives

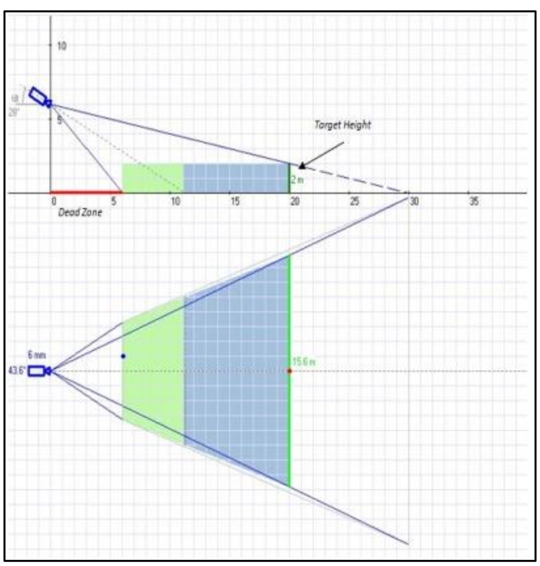
- Detect intruders approaching or loitering along the perimeter barrier (usually fence line or wall)
- Detect intruders crossing the perimeter barrier

Relevant Analytics Rules

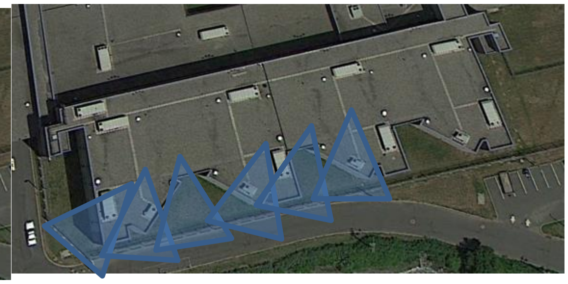
- Person crossing a line
- Person moving in an area
- Person loitering

Camera Mounting Principles

- Make sure that poles are stable in winds (if you mount cameras on poles) because pole movement decreases analytics performance. Standard electricity poles are insufficient as they sway excessively in wind.
- Calculate the ‘dead-zone’ and detection range for the cameras being used, to determine the distance between cameras.

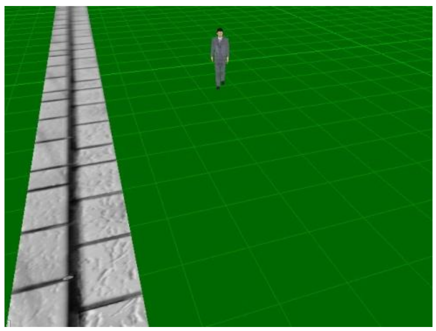
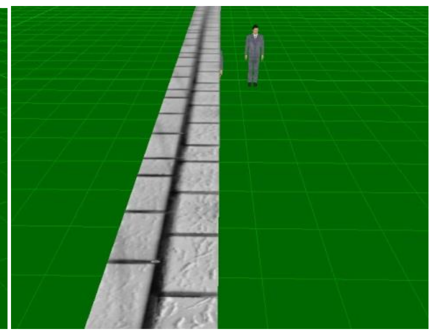


- Point the camera view *along* the perimeter so that movement of intruders is captured in an orthogonal direction relative to the camera when approaching the perimeter.

Good **Bad**

- Point the camera so that it views and protects the inner or outer area of the perimeter. Don’t attempt to point the camera so that it views both sides of the perimeter.

Good **Bad**

- Position the cameras so that each ‘dead zone’ is covered by the adjacent camera. In the following example, the Green colored cameras cover the blind spots of the opposite cameras located in the corners of the perimeter. With this deployment method, there are no dead-zones.

Perimeter Protection: Typical Camera Layout

Recommended Camera Spacing

When protecting long perimeters, camera counts are a key parameter as they have a significant impact on the overall deployment cost.

To minimize the required number of cameras while not compromising on probability of detection, follow these rules of thumb:

Camera Type	Maximum Coverage Distance
Visible light CCD or CMOS	Up to 80 meters
Thermal with sensor resolution 160x120	Up to 250 meters
Thermal with sensor resolution 320x240	Up to 600 meters

7.2 Business Intelligence for Retail Environments

Main Objectives

- Collect and analyze information about the movements of people
- Enable generation of statistical data such as reports, graphs, heat maps (hot zones) and motion path maps

Relevant Analytics Applications

- People counting
- Heat maps
- Target path analysis

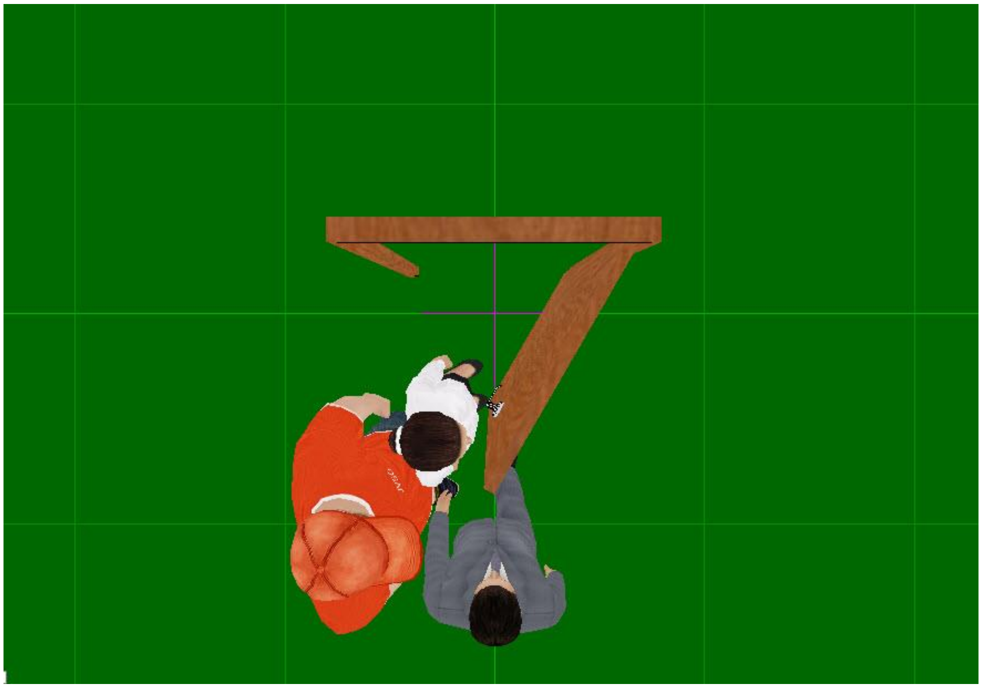
7.2.1 People Counting

Main Objective

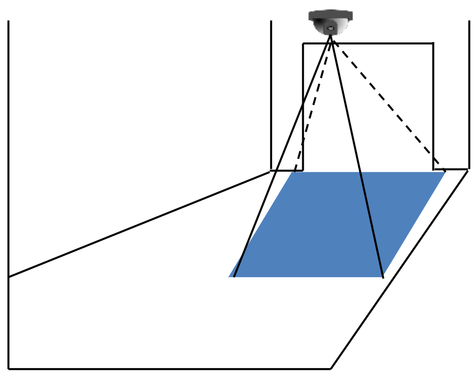
Cumulative counting of people entering or leaving an area

Camera Mounting Principles

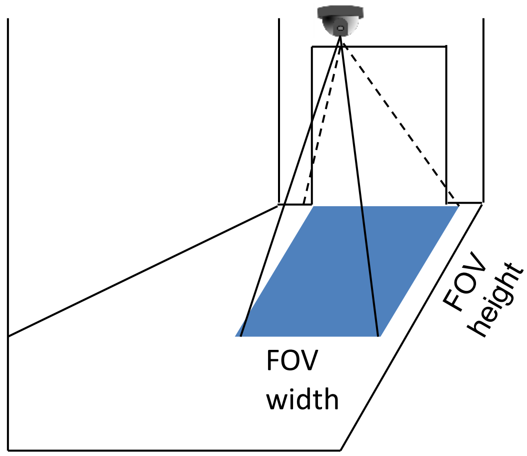
- Position the camera so that the angle between the lens position and the ground (tilt angle) is approximately 90 degrees.
  Image received by cameras with overhead mounting provides a complete top-down view of targets in the center of the FOV and the close surrounding areas, meaning that the visible areas of the people passing will mainly include heads and shoulders.



- Position the camera inside the building so that it covers the whole width of the entrance, and sees the area from the entrance inwards



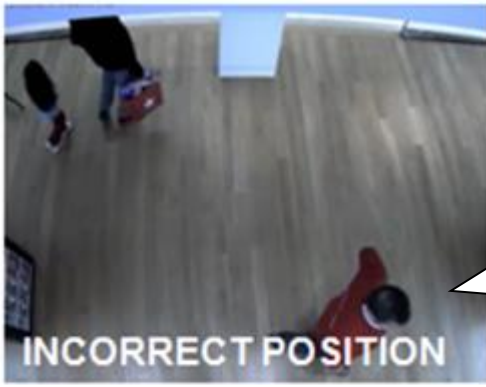
- Ensure adequate FOV.
  - FOV width should be 20% wider than the entrance width.
  - FOV height should be 2 meters or more.
  - Calculate width and height while considering the height of the person at the edges of the FOV.
  - Shoulder width should be no more than 20% of image width.



Non-Optimal FOV

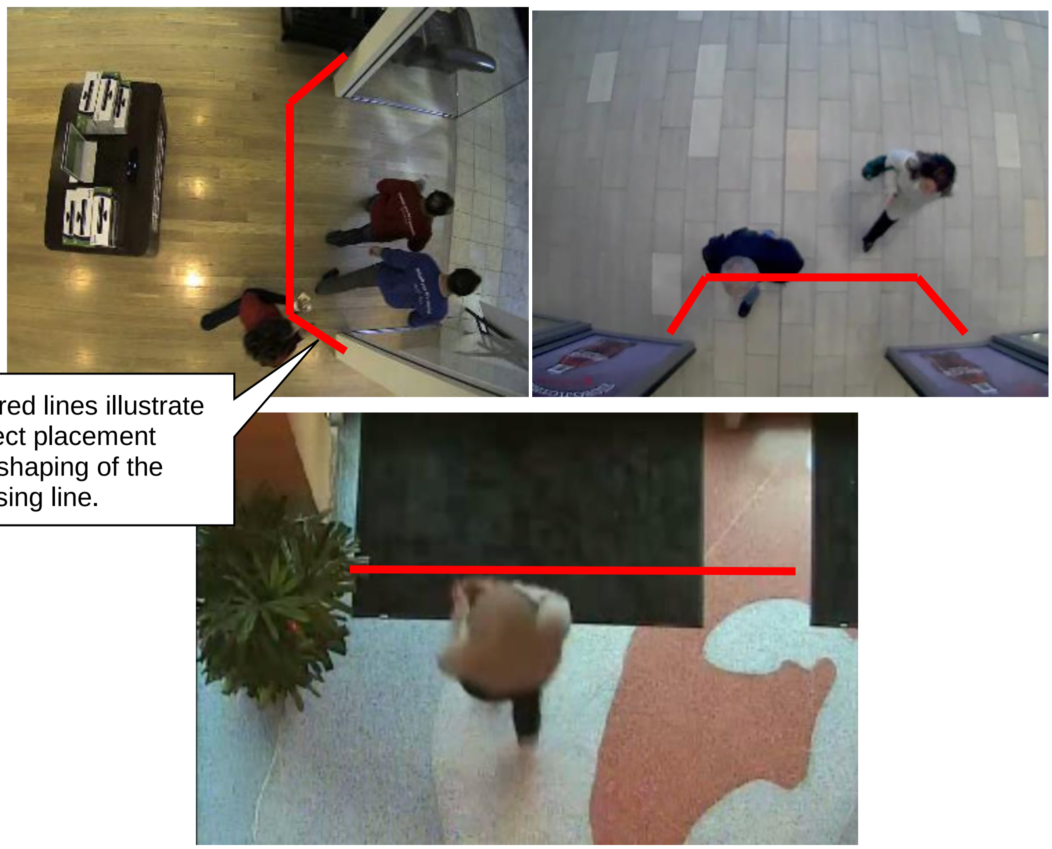
The camera is not mounted in an overhead orientation as required and thus negatively impacts on counting performance due to a range of resulting issues, including increased diversity of people sizes across the FOV, minimum crossing distance of the counting line, and truncations.

The camera is mounted too low, generating a FOV where the size of the person significantly exceeds the required maximum.



The camera position is too distant from the entrance / exit point and thus negatively impacts on counting performance due to a range of resulting issues, including incapability to draw the counting line so that it will cover the whole entry/exit area, angled orientation of the view and truncations at the entrance/ exit point.

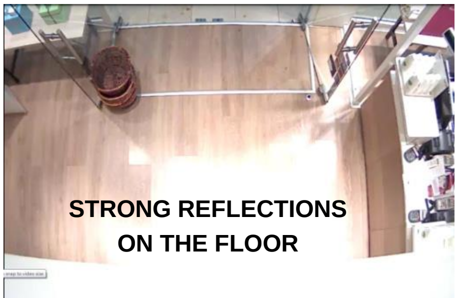
Optimal FOV

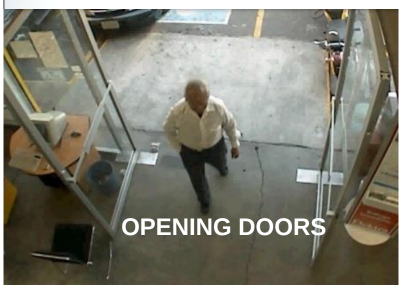


The red lines illustrate correct placement and shaping of the crossing line.

Environmental Conditions

- Ensure proper lighting conditions
- Beware of pale ground surface and reflections from the floor
- Avoid disturbances in the FOV such as opening doors, carts, presence of staff members, etc.





Configuration Procedure

1. Calibrate each sensor before configuring analytics rules on it. Calibrate using Automatic Scene Learning (ASL) during traffic / operation times: Using ASL you can calibrate multiple sensors simultaneously and thus save considerable time and human resources in large-scale video surveillance networks containing tens of cameras. Verify correctness of ASL results once completed.
2. Draw the counting line horizontally, in the middle of the FOV, and set its direction.
3. The counting line should be drawn so that any individual passing through the counting point from any direction will cross it. Draw an open polygon if necessary.

4. Observe the on-screen-display counter for a few minutes during activity times and confirm that the counting is performing accurately.
5. Evaluate counting accuracy and confirm that it meets expectations.

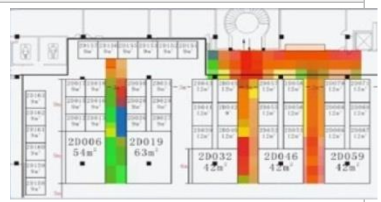
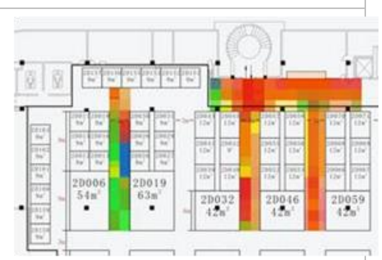
Accuracy Evaluation Procedure

Accuracy evaluation must be performed during traffic / operational times.

1. Configure the people counting rule while enabling recording on the same camera.
2. Confirm that the first individual crossing the line after the counter reset is counted by checking the counting overlay on top of the camera image in Valerus SmartAnalytics.
3. Leave the system for one hour.
4. Export the relevant one-hour video footage, as well as counting report from Valerus SmartAnalytics.
5. Perform a manual count over the recorded footage. Repeat the process twice and ensure that you receive precisely the same result.
6. Compare the manual count with Valerus SmartAnalytics’ counting report and calculate the accuracy accordingly.

7.2.2 Heat Maps and Target Path Analysis

This section describes the Heat Maps and Target Path Analysis video analytics functions.

Function	Main Objective	Usability	Examples
Heat Maps	Measures and accumulates the head-counts and dwelling times of customers across a single camera's field of view and/or across a site view map. Visualizes the areas with the greatest frequency and activity using colors emphasizing hot zones. Allows exporting to Excel datasheets with statistical data linked to locations across the camera and site map views.	Video Search continuously stores in the database information referring to individuals dwelling in the FOV. The Video Search client is then used to configure queries looking for all appearances of people dwelling in the FOV across particular timeframes. The FOV of a single camera, or, alternatively, a site map image associated with multiple cameras, is divided into area grids. Cumulated results are calculated and presented for each grid. Color is used to indicate the relative intensity of each grid, creating a colored heat map. The heat map view can indicate accumulated staying time, number of people, and number of people exceeding the dwell time, across a chosen timeframe.	  
Target Path Analysis	Analyzes movement patterns of customers and generates graphical paths representing the track of each individual, across a single camera's field of view and/or across a site view map. Analyzes store traffic to identify the dominant traffic paths. Identifies regions that do not attract customer	Video Search continuously stores information referring to individuals dwelling in the FOV, in the database. The video search client is used to configure queries for people dwelling in the FOV. The target path view renders a graphical route for each individual, on top of the camera or site map views	

Function	Main Objective	Usability	Examples
	traffic, or which result in bottlenecks.		

Camera mounting principles (applies to all three analytics functions above):

- Camera can be mounted in either overhead or angled position
- Position the camera so that it mostly covers the monitored area
- Position the camera above or across the aisles
- A ceiling height of at least 2.75 meters is recommended for overhead cameras. If ceiling height is less, contact Vicon Technical Support.

Configuration procedure (applies to Heat Maps and Target Path Analysis):

- Run ASL during traffic / operation times. Verify correctness of ASL results once completed.
- Verify that Video Search is enabled on the cameras.
- When utilizing site map, utilize the Map Management tool to import the site image and to associate cameras with the map.

7.3 Traffic Management

7.3.1 Main Objectives

- Detects safety scenarios such as vehicles stopping on road shoulders, traffic obstacles and accidents, pedestrians walking on the side of the road.
- Statistical analysis of traffic to enable generation of statistical data measuring traffic rates, trends, and peak times.

7.3.2 Relevant Analytics Rules

- Vehicle counting
- Stopped vehicle
- Person moving in an area
- Average speed analysis and traffic congestion detection

7.3.3 Camera Mounting Principles

The following criteria refer mainly to vehicle counting, average speed analysis, and traffic congestion. It's assumed that other relevant analytics rules will be utilizing the same cameras. Nevertheless, the provided criteria are the strictest, otherwise wider criteria can be applied to the other rules while relying on the size criteria as indicated in table #2 under Determining Effective Range.

- Cameras can be mounted on road gantries or on poles residing on the side of the road
- Cameras should be directed towards the traffic. When mounted on road gantries they should be positioned in a direct line towards traffic. When mounted on side poles, they should be turned diagonally towards traffic as shown here:

Image on left shows a view from a camera mounted on gantries. Middle and right images show views from cameras mounted on poles and directed diagonally towards traffic.

- Vehicle's total size in pixels should be no less than 0.25% and no more than 4% of the image resolution
- Stopped vehicle allows a wider maximum size criterion, where the total size of a vehicle should be no more than 10% of image resolution
- Alternatively, when monitoring a single-lane road, the camera can be pointed so that it views vehicles from the side, and in this case the size range refers to the length of the vehicle which should be no less than 5% and no more than 20% of the image width

7.3.4 Guidelines and Tips

- Accuracy evaluation procedure for vehicle counting is similar to the suggested procedure for people counting
- Accuracy evaluation process for average speed analysis and traffic congestion is challenging, mainly due to lack of reference data to compare with. Nevertheless, it's recommended to evaluate accuracy in three different ways (all three should be applied):
  - Generate a statistical report during peak times, suffering from heavy traffic / congestion. You should expect values ranging between 0-30 km/h (0-18 mph).
  - Generate a statistical report during low traffic times. Assuming you're monitoring a highway, you should expect values ranging between 80-120 km/h (50-75 mph).
  - Since the capability to detect traffic congestions is based on average speed analysis, ensure you're reliably detecting congestion once it occurs. Note that traffic congestion utilizes an average speed threshold to detect. The threshold value is configurable.
  - When detecting pedestrians walking on the side of roads or along the shoulders, you may experience false alarms generated by shadows of vehicles driving in the nearest lane. In such cases it's recommended to narrow down the AOI to exclude these shadows.
  - Glare from vehicle headlights as well as light reflections from puddles are very common in roadway deployments. It's highly recommended to pay extra attention to these issues at night and to respond accordingly as explained in sections Handling Poor Lighting with IR and Thermal Imaging and Lighting and Camera Placement: Additional Considerations. Thermal cameras are a last resort when these issues are extreme and badly impact performance.

8 Determining Analytics Capabilities to be Applied to Each Camera

Based on operational requirements and camera positioning, create a table listing the analytics capabilities to be applied to each camera. This is necessary to determine analytics license requirements.

9 Defining Where/How Analytics Results will be Viewed

Real-time events will show in the Valerus VMS client. Using the Valerus SmartAction application is also an option that can be used to view live and archived analytics alerts. You'll most probably have an application in use for alarm monitoring and you'll require the analytics alerts to be displayed in it. Verify that your application is integrated with Valerus and can receive and correctly display the alerts. If your application is not supported, some customization work will need to be done to support event display.

When using the search feature, that,too, is typically launched from Valerus; running the Valerus SmartSearch application is another option.

10 Determining Required Hardware & Software Specification

Refer to Vicon's Valerus SmartAnalytics guide for details on servers.

11 Determining Licensing Requirements

Based on the information collected in sections 8, 9 & 10 above, determine the number and type of camera analytics licenses required.

In addition, check if you'll need the following special licenses:

11.1 SQL License

Microsoft SQL Server 2008/2012 Standard R2 or Enterprise is required in the following scenarios:

- Large deployment
- Fail over / redundancy server
- Video Search deployment

Note that Vicon does not sell this license.

11.2 Redundancy License

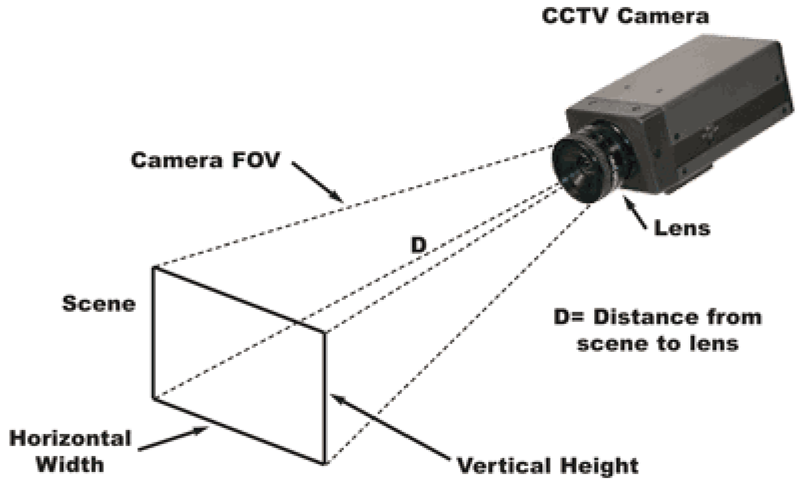
A Redundancy is available upon request. Speak to your Vicon representative.

12 Appendix A – Camera Placement Principles

12.1 Basic Principles

Camera field and angle of view:

Camera field of view is usually characterized by the combination of distance and scene dimensions (image width and height)

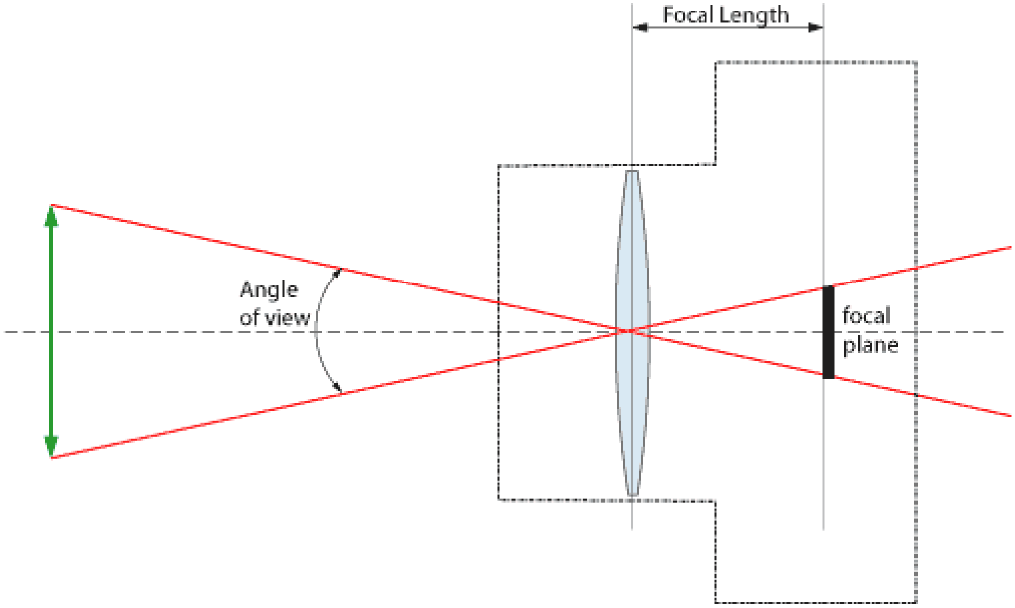


Scene dimensions for a given distance are determined by the camera's angle of view. Camera's angle of view is determined by the focal length of the lens being used.

Focal Length

The focal length of a lens is the distance between the optical center of the lens and the image sensor. The longer the focal length, the more it "magnifies" the subject.

The diagram below illustrates the reciprocal relations between the focal length, angle of view, and image magnification (aka zoom level).



Conclusions:

- Short focal length provides a wider angle of view, generating a wide (zoomed-out) image
- Long focal length provides a narrower angle of view, generating a narrow (zoomed-in) image

+

focal length

viewing angle

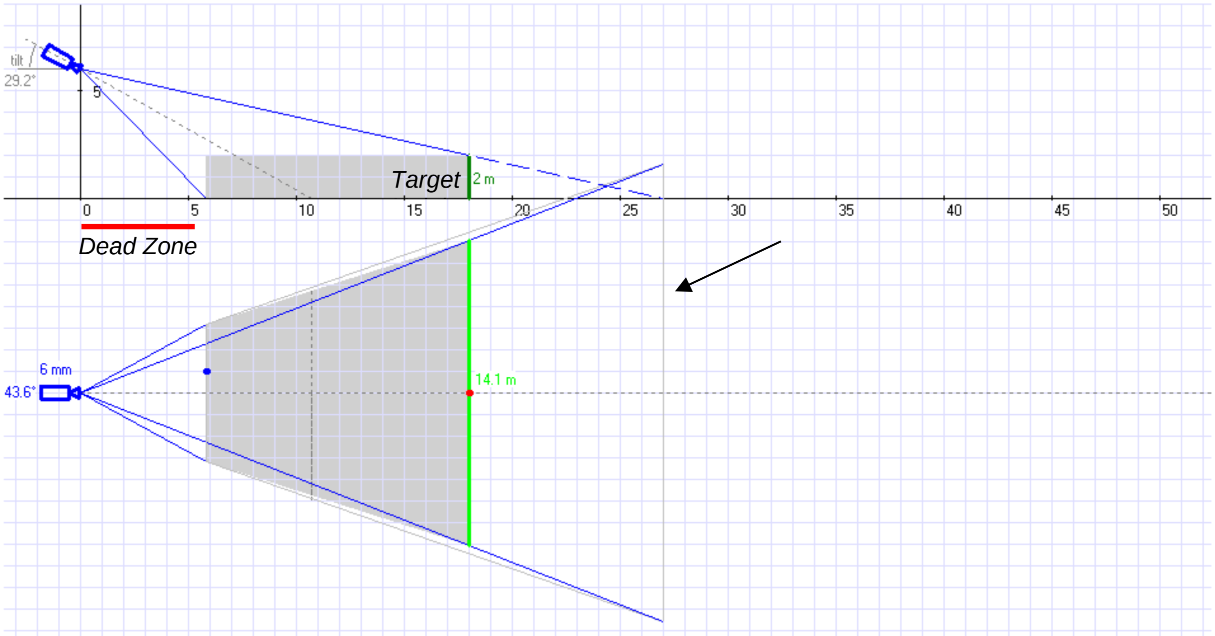
magnification

Focal Length Impact on Field of View

28mm 50mm 70mm 210m

12.2 Camera Mounting Options and Impact on Field of View

Angled mounting and tilt angle:



Tilt angle is the angle between the camera's lens position and the ground, as illustrated in the above diagram. The relevant tilt angle range is between 0 to 90 degrees.

Angled camera mounting refers to positioning a camera with a tilt angle less than 85-90 degrees. In practice, angled cameras are typically positioned with a tilt angle varying between 10 to 40 degrees.

Dead-zone:

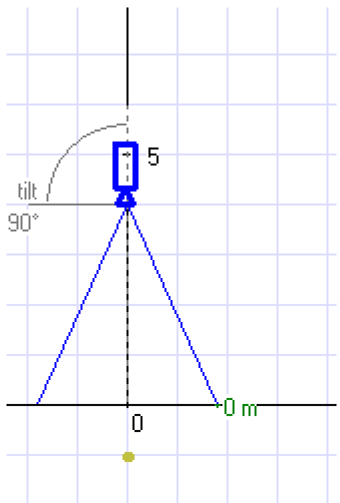
The area between the position of the camera and the closest viewing point is referred as the dead-zone.

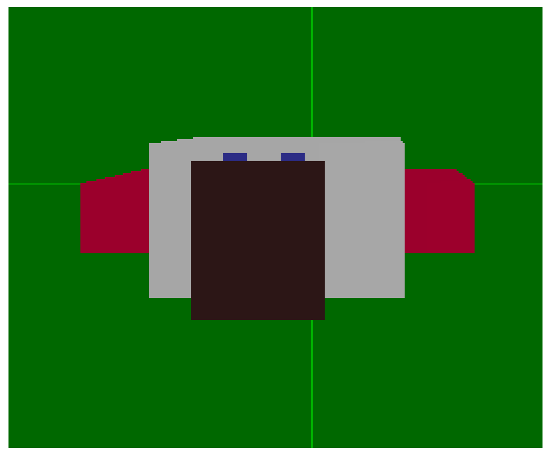
The camera is completely blind across the dead-zone. In other words, this area is excluded from the camera's field of view.

Detectable height and area:

This is the maximum height that can be detected at a particular distance from the camera. The detectable height decreases when the distance from the camera is increased. Therefore, maximum viewing distance is determined according to the point where the detectable height is equal to the expected target height, and the detectable area, aka effective field of view, is the area between the closest viewing point (end of dead-zone) and the maximum viewing distance.

Overhead mounting:





Overhead camera mounting refers to positioning a camera so that the angle between the lens position and the ground is approximately 90 degrees.

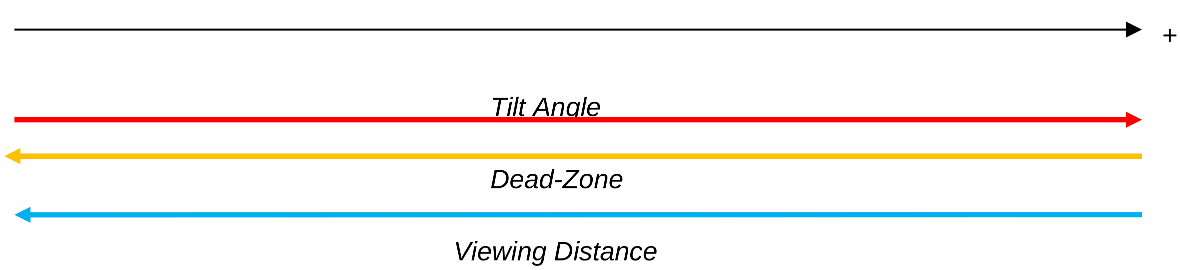
Image received by cameras with overhead mounting provides a complete top-down view of target objects placed in the center of the field of view and the close surrounding areas, meaning that the visible areas of people will mainly include their heads and shoulders, and similarly, rooftops of vehicles.

Image received by cameras with angled mounting provides a side view of target objects in the field of view, meaning that the visible areas of people will include a complete image from head to toe, and similarly, complete side views of vehicles, from end to end, relative to the angle that the vehicle is positioned towards the camera.

Target objects viewed by overhead cameras gradually transform into an angled-view form when they become distant from the center of the field of view.

Target objects viewed by angled cameras gradually transform into an overhead-view form as the camera's mounting height increases.

Correlation between tilt angle, dead zone and viewing distance for a given lens and camera height:



Conclusion:

- Decreasing the tilt angle increases the viewing distance as well as the dead-zone
- Short range detection is typically achieved with increased tilt angle towards overhead mounting which eliminates the dead-zone

12.3 Camera Placement Design Tool

To perform criteria verification, identify the scenarios relevant to your case and measure the size of target objects using one of the following methods:

- Use a camera design tool to determine the pixel-per-meter/feet ratio for a given camera at the minimum and maximum distances, and calculate the size criteria according to the relevant scenario.
  Vicon offers a pixel-per-foot calculator on its website. Anothef such recommended tool is the **IP Video System Design Tool** which can be found at www.jvsg.com . This type of tool allows users to input the various camera parameters (resolution, focal length, installation height, etc.) and place the cameras on top of a map or satellite image to view the resulting coverage areas for each camera.
- If cameras are already placed, you can retrieve relevant footage and screenshots, with relevant target objects in the field of view, and calculate their relative size using an on-screen pixel measurement tool. A recommended tool is **Meazure** which can be found at http://www.cthing.com/.

13 Appendix B – Lighting Principles

13.1 Camera Low Light Performance

Security cameras utilize several key elements to control the amount of incoming light and thus improve image quality in poor lighting conditions. Main elements impacting amount of incoming light are size of sensor, iris / aperture, gain level and shutter speed.

A camera generates images by transforming incoming light, reflected off the objects in the scene, into a signal. The amount of incoming light determines image quality, and therefore poor lighting conditions lead to poor image quality.

Iris / Aperture:

This is the element controlling the opening level of the lens. Similarly, to an eye pupil, the iris / aperture opening level needs to adjust to light changes so that the opening will increase when the lighting conditions drop, allowing more light into the sensor and vice versa. High opening level during times of high illumination will result in overexposure, where the received image is too bright and the level of details is significantly decreased.

Gain level:

While an image is represented by a square area of pixels each of which is the result of transforming light energy into signals, the sensitivity of the pixels to light is called gain. Increasing the gain level raises the sensor’s sensitivity to light and thus allows it to capture more details in low light conditions compared to low gain levels.

The clear benefit of using high gain levels is receiving brighter pixels and thus compensating low light conditions. However, there is also a clear disadvantage, as high gain significantly increases the amount of noise in the image, aka graininess. Grainy images have negative impact on video analytics, since the noise/grain is expressed by rapid pixel changes which on one hand consume more bandwidth (and in turn further decreases image quality, assuming that bandwidth is restricted) and on the other hand will usually be treated as nuisance motion which increases the probability of false alarms.

Shutter speed:

The image sensor is exposed to a certain period for each generated frame. Exposure time is defined by shutter speed (slow speed means long exposure, and vice versa). Shutter speed highly impacts the amount of light to be used to generate the frame image, as it allows acquiring light for relatively long periods.

The clear benefit of using slow shutter speed is that it significantly increases the amount of light for each image, which highly compensates for poor lighting conditions. However, there is a significant disadvantage due to a blurring/ghosting effect generated by movements in the field of view. The effect results from pixel averaging taking place during the long exposure time within each frame.

Camera vendors use various techniques to allow for full utilization of these functionalities while compensating for their disadvantages. The table below summarizes the negative impacts of each function and the common compensation techniques used with each.

Function	Disadvantage / Negative Impact	Compensation
Wide iris / aperture	Overexposure during daytime	Auto-iris functionality
Slow shutter speed	Blurred images during motion	Auto-shutter speed adjustment functionality
High gain	Noisy images	• Automatic gain control (AGC) • Noise reduction filters (DNR)

Conclusion:

Poor lighting conditions are one of the main challenges in achieving good image quality in general, and adequate image quality for video analytics. While video analytics has unique constraints, typical low light enhancement techniques adopted by camera vendors are usually insufficient for video analytics. The remaining questions are:

- How do you determine that your lighting conditions are sufficient for a particular case?
- What can you do to improve image quality for video analytics, given that lighting conditions are poor?
- Are there any additional challenges concerning light besides poor lighting conditions?

13.2 Determining Quality of Lighting Conditions

Determining quality is always subjective, especially when lighting quality is concerned. Moreover, different definitions for different goals should be expected, for instance, some conditions may be sufficient for manual inspection and recognition while insufficient for video analytics, or vice versa.

The following guidelines do not intend to provide the know-how for properly designing lighting systems for a given site. In-depth lighting concepts and measurement techniques are complex, requiring dedicated lighting engineering skills. The recommended best practice is to determine if the existing conditions are adequate for video analytics and if not, to implement tools and methods to overcome lighting limitations to meet the requirements.

Of the parameters relevant to light measurements, the two most significant for qualifying light quality in the context of video analytics are lux level and uniformity factor.

13.2.1 Vicon Lighting Categories

Category	Lux Level		Uniformity Factor
Good lighting for video analytics	Greater than 20	and	Greater than 0.4
Testing required*	Between 5-20	and	Greater than 0.4
Bad lighting for video analytics	Less than 5	or	Less than 0.4

* Lighting may still be sufficient for reliable analytics depending on cameras used and the required analytics functionality, but it’s recommended to deploy 1-2 cameras to simulate the detection scenarios at maximum distances and to verify that the results are as expected, as part of a preliminary test phase. You can test the analytics performance on site, or, alternatively, record the video during the simulations, export it, and test it offline using a standalone demo system.

Now that a strict definition for sufficient lighting is established (Vicon lighting criteria) you should survey the site, verify that the criteria are met and if not, take actions. The first step is to categorize the site according to the following categories:

- Indoor / domestic – internal areas
  Relates mainly to uniformly lit indoor spaces, including office rooms, halls (for example, in jails or hospitals), corridors, stairways, restaurants, etc.
- Indoor / domestic – well lit, wide areas
  Relates mainly to uniformly well lit, wide-area, indoor spaces, such as large retail stores, security areas at terminals, malls, interior campus areas, etc.
- Indoor / domestic – external areas
  Relates mainly to non-uniformly lit indoor spaces, usually wide areas, with potential light challenges such as mixed indoor and outdoor lighting, glares and reflections, and potential for crowded areas. Sites in this category include terminals, museums, waiting areas, casinos, etc.
- Outdoor nighttime detection in public areas
  Relates mainly to exterior urban locations (streets, parks, squares)
- Outdoor nighttime detection at critical infrastructure and industrial areas
  Relates mainly to perimeters and exterior areas surrounding airports, seaports, railways, farms, industrial areas, etc.

- Outdoor nighttime detection on roads
  Relates to any type of motorway road from private side roads to multilane highways.

Specific recommendations for each category are:

Indoor / domestic – internal areas

In this space it's usually not required to measure lux levels. Instead, ask if lights are always turned on when the analytics is operational. If they are, the chances are that lighting conditions are sufficient for video analytics. If they aren't, you must improve the lighting. In this case, recommended options are:

- Use cameras with integrated IR
- Use add-on IR illuminators
- Use add-on white light LED illuminators

See also Handling Poor Lighting with IR and Thermal Imaging.

Indoor / domestic – external areas

Unlike the previous category, it's usually insufficient to rely on existing lighting when deploying video analytics in external areas within indoor / domestic facilities. Wide areas, crowd potential, tendency of non-uniform lighting, and other aspects, increase the chances that the existing lighting will be insufficient. To determine if existing lighting is sufficiently effective, it's recommended to:

- Verify that Vicon lighting criteria are met
- Note if shadows and reflections are present when performing a site survey. These can potentially negatively impact video analytics performance.

If lighting is sufficient and Vicon criteria are met, it should guarantee effective video analytics. If Vicon lighting criteria are not met, implement one of the following options:

- Use cameras with integrated IR
- Use add-on IR illuminators
- Use add-on white light LED illuminators
- Use thermal cameras

If strong reflections and/or shadows are present:

- If the AOI is relatively narrow and the scene is controlled, for example, when utilizing overhead cameras for people counting, you can place a rug on the floor or paint it to mitigate the negative impact on analytics
- Check the option of monitoring an alternative area which doesn't experience a similar challenge
- Test video analytics performance as a preliminary step before implementing the required analytics functionality across the designated area
- If poor performance is experienced during the test, consult with Vicon's Technical Support team
- Consider using a thermal camera if all other options fail
- Avoid deploying video analytics in this particular area if you obtain poor results during your test and neither of the above recommendations is sufficient to bypass the issue
- Define the camera in Valerus SmartAction as 'Outdoor' rather than 'Indoor'

Outdoor nighttime detection in public areas

- Are the AOIs well-lit with street and/or road lights?
- Are the AOIs uniformly lit so that lighting conditions are unchanging when viewed by the naked eye?
- Are Vicon lighting criteria met at the maximum detection ranges?

If lighting is sufficient and Vicon criteria are met, it should guarantee effective video analytics. If Vicon lighting criteria are not met, implement one of the following options:

- Use cameras with integrated IR
- Use add-on IR illuminators
- Use add-on white light LED illuminators
- Use thermal cameras

See also Handling Poor Lighting with IR and Thermal Imaging.

Outdoor nighttime detection in critical infrastructure and industrial zones

Verify if the areas are well lit and meet Vicon lighting criteria. If the criteria are not met, implement one of the following options:

- Use thermal cameras if you need to detect at ranges longer than 60 meters / 200feet
- Use add-on IR illuminators
- Use add-on white light LED illuminators

See also Handling Poor Lighting with IR and Thermal Imaging.

Outdoor nighttime detection on roads

- Are the areas of interest well-lit with road lights?
- Does the road lighting apply to an official road lighting standard?
  (If so, it will provide a higher level of confidence than the Vicon lighting criteria, which may sometimes be challenging to measure in this environment. Nevertheless, ensuring Vicon lighting criteria, if feasible, should guarantee lighting sufficiency).

If the above criteria are not met, implement one of the following options:

- Use thermal cameras
- Use long-range IR illuminators

Thermal cameras are considered the best option in this case, since they can overcome common glare and backlight issues typically generated by vehicle headlights at night, unlike IR illuminators which can be expected to suffer from these challenges.

See also Handling Poor Lighting with IR and Thermal Imaging.

13.3 Handling Poor Lighting with IR and Thermal Imaging

IR

The term IR, when indicated for surveillance cameras, specifically refers to near Infra-Red radiation, which is a particular range of wavelengths in the light spectrum that cameras can “see”, while being invisible to the human eye. There are two common methods to utilize IR with surveillance cameras, either by deploying add-on IR illuminators or by utilizing integrated IR cameras, containing built-in IR LEDs around the camera’s lens.

Thermal cameras

The term refers to cameras utilizing thermal imaging, meaning that the image is created based on heat radiation from any object in the field of view.

IR and thermal cameras share two important characteristics:

- They allow cameras to “see” in conditions that humans perceive as complete darkness
- They don’t utilize any visible lights and are thus ideal for covert/discrete deployments and have no negative contribution to lighting pollution. On the other hand, if adding a lighting source is considered as an advantage (as it helps to increase the general visibility of the surroundings, and reduce crime), a white light LED illuminator should be considered as an alternative to IR.

The main conceptual difference between the two, however, is that while IR should be considered as an illumination method allowing the production of high-quality B/W video at night (and disabled during daylight hours), thermal cameras provide a low-detailed thermal image showing objects as high-contrast ‘blobs’ at all times.

The table below summarizes the advantages and disadvantages of each, including a third option of white light LED illuminators. As indicated in the previous section, LED is also an option in some cases.

Characteristic	IR	Thermal	LED
Relative cost (including camera cost, assuming entry-point, un-cooled, thermal cameras and average-price IP cameras from market leading vendors)	Ranges from low cost (indoor, low end) to high cost (long range, high quality IR combined with short range IR)	High	Medium
Appearance	None Ideal for covert / discrete deployments No light pollution	None Ideal for covert / discrete deployments No light pollution	Visible light source Helps in crime prevention
Detection range in complete darkness*	50-60meters, depending on the IR and camera types	Approximately 300-400 meters with low-mid range un-cooled cameras, depending on the camera and lens	Approximately 50 meters, depending on the illuminator and camera types
Capable of capturing details (recognition)	Yes, in B/W	No, can be used for detection only	Yes, in color

Characteristic	IR	Thermal	LED
Capable of dealing with direct vehicle lights and light reflections	No	Yes	No
Capable of dealing with glare caused by ambient light or nearby flashing lights	Yes, if using IR lighting with an IR band pass filter lens	Yes	No
Capable of dealing with lighting issues during daytime (strong shadows, WDR scenes, backlight)	No	Yes	No

* Average figures

13.4 Testing Lighting Performance

It is generally advised to test the lighting when deploying outdoor analytics at night, and to confirm that it's sufficient. Two methods are provided below. Both can be carried out after the cameras (and additional lighting, when applicable) are properly mounted onsite.

Before conducting the tests, it's mandatory to make all relevant camera adjustments that will be used once the system is deployed.

Eye test

This test utilizes a workstation with a PC monitor / LCD display showing the images produced by the relevant cameras in their native resolution. You can connect the workstation to a VMS or directly to the camera / encoder web-page to receive the images.

Lighting eye test for detection and analysis of people

Place a person in the detection area and watch them on the monitor while their hands are adjacent to their body. Verify that you can identify the person on the screen. Take a screenshot and then ask the person to raise their hand. Verify that you can identify that their hand is raised and take another screenshot. Look at both screenshots and verify that you can identify on which screenshot the hands are adjacent to the body and on which the hand is raised.

Repeat the test 3 times, placing the person in 3 different positions: at the closest viewing distance, at the most distant viewing distance, and at a middle point.

Lighting eye test for detection and analysis of vehicles

Park a vehicle in the detection area so that it's viewed from its side. Watch it on the monitor and verify that you can identify a vehicle. Take a screenshot of it and then park it so that it's seen from its front. Verify that you're able to identify a vehicle and take another screenshot. Look at both screenshots and verify that you're able to identify which vehicle is seen from its side and which from its front.

Repeat the test three times, parking the vehicle in three different positions: at the closest viewing distance, at the most distant viewing distance, and at a middle point.

If you're seeking to monitor traffic on active roads, take a few snapshots showing vehicles across the detection range. Take a close look at these screenshots and verify that you're able to identify the wheels, doors (side doors or trunk, depending on the viewing angle), and the top of the vehicles, across the various positions in the field of view.

Contrast measurement test

This test is based on measuring and calculating the luma level difference between potential targets and their close surrounding area (background). The test procedure is similar to the previous test except that the determination phase is performed using the screenshots taken at the various locations, as explained in the eye test.

- Apply the same scenarios as for the eye test and take the relevant screenshots.
- For each screenshot, measure the grey-level (luma) of the target (person or vehicle) at 3-5 points, equally spread across its background.
- Measure the grey-level (luma) across 5 points across the background of the target. Write down the values of the brightest and darkest points measured on the target and across the surrounding area.
- Determine the normalized peak points of the target and its background in the following manner:
  - If the target is darker than its background, determine the brightest point measured on the target as the target's peak point and the darkest point measured on the background as the background peak point.
    If the target is brighter than the background, use the inverse values (darkest point on the target and brightest point on the background).
  - Determine the normalized peak point by calculating the average value of the measured samples across the target and average it with the peak point. For instance, if 15,18,22,27,36 are the points measured across the target and 15 is the peak point, then the normalized average is calculated as follows:
    Average of (15,18,22,27,36) = 24 (rounded).
    The normalized average is the average between the peak point (15) and 24 which is 20 (rounded).
- Determine the normalized peak point of the background in a similar manner.
  - Verify that the absolute difference between the luma peak points of the target and its surrounding area is greater than 16 grey levels. Perform the same verification with the two brightest points (one on the target and one across the surrounding area).

  Example (to illustrate the process):

  - Convert the image to grayscale
  - Use an image editor or measurement tool which allows pinpointing areas and displaying their color level (the **Meazure** tool was used in the example below).
  - Measure 3-5 points equally distributed across potential targets at the maximum detection distance, as shown in the two examples below. Note that when measuring RGB levels of grey-level images, the RGB level is similar to grey-level / luma.

- In this example, the person target is darker than its background and therefore its peak point is the brightest point measured, which is 42. The average of the measured samples across the person is 27. The normalized peak point is the average of 27 and 42 which is 34. Perform the process across 5 points in the surrounding background, as shown in the two examples below.

- The calculated normalized peak of the background in this case was 65. The absolute difference of 34 and 65 is 31, which means that the lighting conditions reflected by the contrast levels are sufficient.

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