



IALA GUIDELINE

G1111-6 PRODUCING REQUIREMENTS FOR ELECTRO OPTICAL SYSTEMS

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1. INTRODUCTION

This Guideline presents a common source of information to assist VTS Providers in the understanding of Electro Optic / Thermal Sensors and their contribution to the VTS traffic image (situational awareness) as well as guidance of how the VTS Provider should specify the Functional and Performance Requirements. The VTS Provider should note that it is important to determine the performance requirements of Electro Optic Sensors. The required performance should be clearly defined relative to the vessels / targets that are to be monitored.

Copying parameters from a manufacturer's data sheet is not recommended.

This guideline considers the application of electro optic / thermal sensors to different VTS operational areas (e.g. inland waterways, Harbours, Coastal regions and offshore). It includes considerations relative to environmental conditions such as weather, sea conditions, geographical constraints, and obstructions that pose challenges to the performance of electro optic / thermal sensors.

Specific maritime security requirements, possibly identified by the International Ship and Port Security code, are not considered within this guideline.

1.1. THE IALA G1111 GUIDELINE SERIES

This Guideline is one of the G1111 series of guideline documents. The purpose of the G1111 series is to assist the VTS Provider in preparing the definition, specification, establishment, operation, and upgrading of a VTS system. The documents in this series address the relationship between the operational requirements and VTS system performance (technical) requirements and how these reflect into the overall system design requirements.

The G1111 series of guideline documents present system design, sensors, communications, processing, and acceptance, without inferring priority. The guideline documents are numbered and titled as follows:

- G1111 Establishing Functional & Performance Requirements for VTS Systems and Equipment
- G1111-1 Producing Requirements for the Core VTS System
- G1111-2 Producing Requirements for Voice Communications
- G1111-3 Producing Requirements for RADAR
- G1111-4 Producing Requirements for AIS
- G1111-5 Producing Requirements for Environment Monitoring Systems
- G1111-6 Producing Requirements for Electro Optic Sensors
- G1111-7 Producing Requirements for Radio Direction Finders
- G1111-8 Producing Requirements for Long Range Sensors
- G1111-9 Framework for Acceptance of VTS Systems and Equipment

2. OPERATIONAL OVERVIEW

This guideline is a part of the overall G1111 guideline and considers the operational application of Electro Optic systems. The use of such sensors can aid vessel identification and will assist in ensuring navigational safety for all types of vessels. Optical cameras are generally used during hours of daylight and thermal cameras can enable use during times when there is little or no daylight.

Cameras may be fixed in position for continuous monitoring of a single area or they may be able to pan, tilt and zoom in order to find, monitor and follow a particular target. A camera installation may contain a single camera or

multiple cameras (typically, one optical camera and one thermal camera may be mounted on the same Pan, Tilt, Zoom unit (PTZ)). In general, all cameras comprise the following components:

- Imaging device
- Lens
- Mounting (and camera housing)

Selecting the most appropriate site for the camera is critical to its effective operation and selecting the right imaging device and lens will ensure that it will be able to provide the required performance.

The operational use of cameras will vary across different VTS implementations. Cameras are often used to provide supplementary information but occasionally they may be used as a primary means of surveillance. Through integration with the target tracking functionality of the VTS System, a camera may be controlled to automatically maintain a moving object in (or near) the centre of the viewing screen. Such functionality can be particularly useful when monitoring a vessel of special interest. The VTSO would simply need to allocate a camera to a particular vessel and then the camera would follow the position of the vessel whilst it is within the line of sight operational range of the camera.

When a camera sub-system is to be included in a VTS solution it is important to consider the VTS software that is controlling the camera. Control of the camera will be from the VTS Operator Workstation and the CCTV image may be integrated as a window that can be overlaid on the Traffic Image or displayed on a separate monitor. However, the important criteria will be the way in which the VTSO interacts with the VTS system to manage the cameras and to view the images. The functions should all be easily accessible and simple to use and should ensure that the VTSO is always aware of the area under camera surveillance.

When determining the operational requirements of a camera it is important to be clear about what the camera(s) will be required to achieve. If the requirement is to identify a vessel, then it is necessary to define how to positively confirm the identity of a vessel. There may be a unique feature to a vessel or it may have a registration number painted on the side. It could also be by reading the name from either the bow or stern of the vessel. In all cases, achieving effective identification requires an appropriate resolution image of that feature to enable the VTSO to make the positive identification. The distance of the vessel from the camera, the resolution of the camera and the capability of its lens will therefore be important selection criteria. If the VTSO will be required to read the name of a vessel, then the camera and its lens must provide an image on the VTSO's CCTV monitor that is of appropriate resolution to enable the name to be read. The image must also be stable and clear.

Typical Operational requirements might include:

- R1 The ability to identify a bulk carrier at a distance of "X" km from an optical camera by reading the name on the bow of the vessel. In this case, the character height of the vessel name should be stated.
- R2 The camera unit should automatically pan to follow a vessel target designated to the camera by the VTSO. The image of the vessel should be maintained at or near the centre of the CCTV screen on the VTS operator workstation.
- R3 A fixed camera could continuously monitor a prohibited area.
- R4 A thermal camera could be used to monitor vessels staying overnight in an anchorage.
- R5 A camera could be used to measure the air draught of a vessel.
- R6 The VTSO should be able to display multiple CCTV feeds at his Operator Workstation
- R7 All camera video should be recorded and shall be able to be replayed, time synchronized with the Traffic Image playback

3. PRODUCING FUNCTIONAL AND PERFORMANCE REQUIREMENTS

3.1. IMAGE RESOLUTION

When producing functional and performance requirements for the Electro Optic components of a VTS system, the starting point is the monitor on which the VTSO will view the CCTV images. Clearly, the resolution of the monitor should not be less than the resolution of the Imaging device of the camera or picture resolution will be lost. For example, if both the camera and the monitor offer Full HD image resolution, then there will be no loss in image quality between the camera and the viewing monitor. If the camera has a resolution of Full HD but the monitor has 4k resolution (3840x2160 pixels) then even though the monitor is of a higher resolution, the image resolution on screen will only be Full HD. The quality of the viewed image will never exceed the resolution of the camera imaging device. Similarly, if the camera imaging device has a resolution of 4k but the monitor has only Full HD resolution, then image quality will be lost because the viewing monitor cannot display better than its own resolution.

It is also worth considering that if four camera images are to be displayed on a single monitor, in a “Quad Display” format, then the monitor resolution should be four times the resolution of the cameras.

The VTS Provider should ensure that the camera’s imaging device resolution is not degraded by choice of display monitors.

3.2. FIELD OF VIEW

Field of View is one of the most important criteria in selecting an optical or a thermal camera. It is normally specified in degrees and therefore a narrow angle for field of view will provide longer range (zoom) capability. VTS Providers should therefore ensure that they clearly define the field of view requirements for an optical camera when including it within the VTS System specification.

The resolution that is viewable on screen determines the quality of the viewed image, but the minimum detail that the VTSO will be able to interpret is determined by the field of view of the camera lens. For example, if the camera and monitor are of Full HD resolution and the horizontal field of view of the camera lens is 19.2 m¹, then each pixel on screen will represent 10cm in the real world. However, if the field of view of the camera lens is 19.2 km, then each pixel on screen will represent 100 m. So, whereas it will be possible to easily see people moving around on the deck of a vessel when the camera has a field of view of 19.2 m, if the field of view is 19.2 km, it would be impossible as a person of 2 m height would be considerably smaller than the size of 1 pixel on the screen.

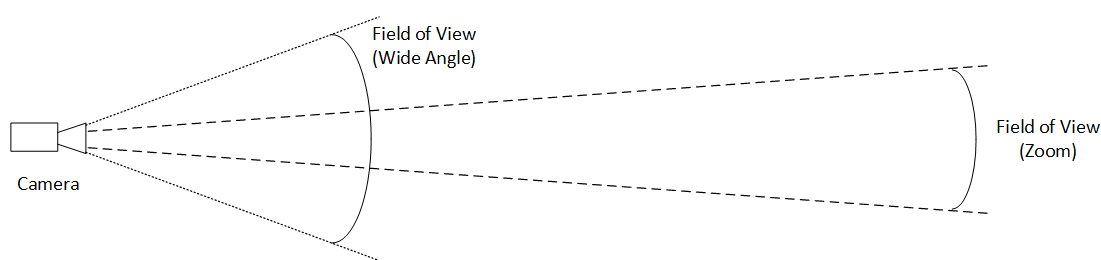


Figure 1 Field of View (normally specified in degrees)

When reading the name of a ship using an optical camera, it will be necessary to know the height of the characters and the field of view of the lens. As mentioned above, if the horizontal field of view is 19.2 m (vertical field of view = 10.8 m) using an HD resolution camera, then each pixel will be representing 10 cm x 10 cm. Therefore, as

1 Note: A Field of View of 19.2 m would equate to a vessel 2.2 km from the camera if viewed through a lens with a field of view specification of 0.5 degrees.

illustrated below, to clearly read that name of the ship it would be best if each letter were written within a matrix of at least 16x16 pixels. This would mean that the characters would need to be at least 160 cm high (16 x 10 cm) and wide. This can also be specified in terms of pixels per meter (in this case it would be 10 pixels per metre). However, it is possible that the name could be read within an 8x8 pixel matrix and in such a case, each letter would only need to be 80 cm high but if the characters are only 40 cm high (pixel matrix of 4x4) or 20 cm high (pixel matrix of 2x2), then the name of the ship will be unreadable.

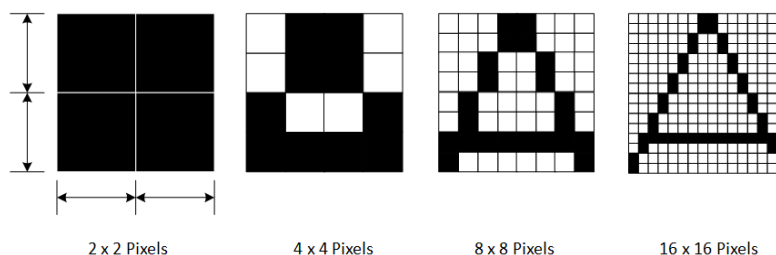


Figure 2 Example of how resolution per pixel impacts readability

The VTS Provider should ensure that the camera's field of view will enable the required image to be presented on CCTV display monitor.

3.3. SENSITIVITY

The sensitivity of an optical camera defines the minimum light conditions in which it can operate. To be clear, optical cameras do not provide a good image at night unless external illumination is used. For VTS purposes, if camera based imagery is required at night, a thermal camera should be used. In general, modern optical cameras have good low light performance and can operate well as the light fades but to continue the use of a camera unit at night, a dual headed camera with a thermal imaging device on the same PTZ unit is necessary.

VTS Providers should determine whether camera imagery is required at night.

3.4. PTZ CHARACTERISTICS

The important factors about the PTZ unit are its pan/tilt speed and its stepper motor angular resolution. The pan/tilt speed of the PTZ unit will determine how quickly the camera can move onto a target and the azimuth resolution determines the minimum azimuth step for positioning the camera.

The pan/tilt speed determines how quickly the camera can react to an instruction to go to a particular bearing. For example, if the camera is instructed to pan 100 degrees and the pan speed of the PTZ is 20 degrees per second, then it will take 5 seconds for the camera to align on the target. At 50 degrees per second, it will take 2 seconds. If the reaction time is important, then a PTZ with a high pan/tilt speed should be specified.

If the camera is to be used for monitoring targets at long range then the azimuth resolution will need to be as fine as possible. A PTZ that uses a stepper motor with 3600 steps will be able to be positioned to 0.1 degree accuracy. If a vessel is 10 km from the camera, this will mean that the camera can only be positioned in approx. 17.5 m intervals along the target. If a target is at 20 km, then the camera positioning will be every 35 m. So, the greater the precision of the stepper motor function of the pan/tilt unit then the more accurately the camera can be positioned on a target and the smoother it will pan at slow speed.

3.5. THERMAL CAMERAS

Thermal cameras should be used for surveillance when there is insufficient light available for an optical camera to function. Thermal cameras detect infrared radiation (IR) from an object and can clearly show objects of different temperatures. In general, the image from a thermal camera will be monochrome, and it is unlikely that the zoom lens capability of a thermal camera will match the capability of an Optical zoom lens. Therefore, the selection of a thermal camera should be based on a specific need requirement and the camera should be positioned accordingly. It is also worth noting that the lens of a thermal camera should not be sprayed with water by a wash/wipe system.

Thermal cameras may be cooled or uncooled. A cooled thermal camera will provide improved granularity of the thermal image and with the ability to detect the smallest of changes in temperature. Modern uncooled thermal cameras provide a good quality thermal image but typically have lower thermal resolution. However, uncooled cameras have a lower capital cost and lower operational costs.

A cooled thermal camera will have regular operational costs. The coolant has to be changed at regular intervals (typically every 2 – 5 years). This task normally requires the camera to be returned to its original manufacturer and may typically be away from the VTS site for between 8 – 14 weeks (depending on location). For this reason, it is recommended that a complete spare should be held at the customer premises for easy substitution in the event of a failure and to provide cover when the operational camera requires coolant change.

3.6. INSTALLATION AND MAINTENANCE CONSIDERATIONS

The EOS should be specified taking the above considerations into account. This should also consider maintenance access, cleaning, lightning protection, vibrations and wind load. The build-up of ice in some climates should also be a consideration.

3.6.1. DURABILITY AND RESISTANCE TO ENVIRONMENTAL CONDITIONS

3.6.1.1. Vibration

EOS systems may be susceptible to performance degradation due to excessive vibration of the installation. This is particularly relevant in strong wind conditions if the EOS device is installed on a radar tower.

VTS providers should consider whether the supporting infrastructure for the EOS requires anti vibration mountings and is able to handle the expected environmental conditions. Where appropriate, picture stabilization software may be used.

3.6.1.2. Specific environmental safeguards

VTS providers should require EOS systems to have the following external and internal environmental safeguards where appropriate:

- Lens wash/wipers (optical cameras only)
- Replaceable clear lens filters to protect exposed optics
- Internal heaters and anti-condensation capabilities (where appropriate)
- Lens protection, e.g., for thermal cameras.

3.6.2. DATA COMMUNICATIONS

EOS data has significant demands on available bandwidth and due consideration should be given to ensure that sufficient bandwidth is available. The higher the camera resolution, the greater the demand for data bandwidth. Bandwidth requirements can be reduced by using video data compression techniques. It is recommended that VTS providers consider using standard video data compression for EOS data, such as MPEG-2 (*IEC 13818-2*), H.263 or H.264. An added benefit of data compression is reduced storage requirements for recordings. Depending on the EOS system, proprietary compression techniques could be considered, however these may not necessarily improve the bandwidth efficiency.



It should be noted that when using a particular video data compression technique, image quality may be reduced as compared to uncompressed data.

Modern Cameras are typically supplied with direct digital output. Where cameras are selected that do not have digital output, it is recommended that digital encoders are included in the overall design and installed at the sensor head. The reason for this is that analogue signalling will require a separate network infrastructure, whereas encoded video can be distributed across existing networks.

3.6.3. MAINTENANCE

The routine maintenance effort for EOS sensors can be quite considerable. In particular, high-end, thermal and laser-gated sensors may include features, such as coolant change, housing wash and wipe and PTZ units that require maintenance of the mechanical parts. This has significant impact upon EOS MTBF figures. VTS providers should consider these issues when selecting such devices.

Given that EOS sensors are often installed high on towers or on dedicated poles, care should be taken to ensure that access for cleaning, maintenance and replacement is taken into account.

4. DEFINITIONS

Specific terms and definitions used in this Guideline:

<i>Detection</i>	The VTSO can observe an object on the water surface.
<i>Recognition</i>	The VTSO can recognize an object and classify it according to its shape (such as a container ship or a ferry boat)
<i>Identification</i>	The VTSO can positively identify the object (e.g., ship name)

The definitions of terms used in this Guideline can be found in the *International Dictionary of Marine Aids to Navigation* (IALA Dictionary) and were checked as correct at the time of going to print. Where conflict arises, the IALA Dictionary should be considered as the authoritative source of definitions used in IALA documents.

5. ABBREVIATIONS

Please refer to IALA *G1111 Establishing Functional and Performance Requirements for VTS Systems* for an extensive list of abbreviations and acronyms covering the entire *G1111* series. This section identifies abbreviations that are related to optical and thermal cameras only.

EOS	Electro optic sensor
PTZ	Pan, tilt and zoom
IR	Infrared

6. REFERENCES

- [1] Electronics Industry Association (EIA) Recommended Standard RS-170.
- [2] Convention on Safety of Life at Sea (SOLAS) (Chapter V, Regulation 12).
- [3] IEC 529 Degrees of protection provided by enclosures (IP Code).
- [4] IEC 721-3-6 Classification of environmental conditions.
- [5] IEC 60945 Maritime Navigation and Radio Communication Equipment and Systems.



- [6] IEC 60825-1 Safety of laser products.
- [7] ISO/IEC 13818-2 Generic coding of moving pictures and associated audio information: Video.
- [8] ITU-T H.263 Video coding for low bit rate communication.
- [9] ITU-T H.264 Advanced video coding for generic audio-visual services.