# ELECTRO-OPTICAL SYSTEMS

## Introduction

An Electro-Optical System (EOS) consists of imaging devices, such as daylight CCTV, day/night CCTV, Infrared- and laser-illuminated cameras.

Imaging devices (or sensors) provide visual situational awareness and can be used as primary VTS sensors, as additional sensors to Radar, AIS and other sensors and for perimeter and building surveillance.

When used as a VTS sensor, EOS data may be integrated into VTS applications to provide the VTSO real-time situational awareness within the range of the EOS equipment.

## Definitions and References

### Definitions

The following definitions are used within the context of an imaging system:

**Detection** – The VTSO can observe an object on the water surface.

**Recognition** – The VTSO can recognize an object and classify it according to its shape (such as a container ship or a ferry boat)

**Identification** – The VTSO can positively identify the object (e.g. ship name or MMSI)

### 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 Radiocommunication 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.

## Characteristics

An EOS is made up of the following components:

* the imaging device that produces the actual electronic image;
* the lens that creates the field of view and focuses the incoming light onto the image device;
* the sensor housing;
* for Pan, Tilt, Zoom (PTZ) EOS, the electromechanical system that moves the camera and allows the lens to zoom in and out.

In most cases, EOSs are used in limited areas, not necessarily covered by other sensors, or are used to provide supplementary information, such as visual identification. In some cases, EOS are used as the primary surveillance system, for example, within a port, harbour or locks.

Within the context of EOS, there is an extensive range of technology and characteristics available. These characteristics range from simple, short range, day light only surveillance capability up to very sophisticated long-range thermal and day / night capable technology.

Additional characteristics to be considered with regard to EOS include, the use of fixed cameras versus the benefits of pan, tilt, zoom (PTZ) cameras, as well as width and depth of field of view, image sensor resolution, and light sensitivity.

The level of sophistication of the EOS determines whether the sensor continues to operate in less than optimum conditions, i.e. in fog and rain and during night time. This aspect should be taken in to account when considering the use of EOS for VTS surveillance.

The output of an EOS can be displayed on a dedicated display or be integrated within the VTS traffic situation display, including the control of the EOS system itself.

In order to support high definition video with useable frame rates, data bandwidth requirements for remote high-definition EOS sensors can be very demanding. Care should be taken in analysing the bandwidth requirements when planning the implementation of high-definition EOS sensors.

Where more than one camera is installed to cover a VTS area, it may be desirable for the output from multiple cameras to be provided in one composite picture.

In addition to the sensors themselves there is also a wide range of image processing capability available. These capabilities range from simple video presentation to sophisticated image processing including image recognition and analysis, automated tracking and alerting/alarm capabilities.

## Operational Requirements

### Sensor Site Selection

Factors to be taken into account, when deciding on where to place an EOS sensor, include:

* the desired line of sight, field of view and the required operational range for the sensor;
* the availability of existing infrastructure, such as power, data communications and physical security;

Where possible, consideration should be given to co-locating a new EOS sensor with existing or planned sensors, e.g. radar.

* maintenance should be considered in view of access to the camera location, the replenishment of consumables (e.g. wiper liquid) and installation of replacement parts as well as vehicle access;
* the presence of strong and/or intermittent light sources that can adversely affect the performance of the EOS sensor, in particular for low-light and infrared cameras;
* the presence of man-made structures, such as cranes, cooling towers and chimneys, all of which can either block the field of view or significantly affect local environmental conditions – consider, for instance, emissions from cooling towers.

### Sensor Selection

Requirements to be considered, when selecting a particular type of EOS, include:

* VTS night time operation – extended night operations in a particular area will typically require use of low-light, day/night, IR- or even laser-illuminated capable imaging sensors;
* the intended use of the EOS as either primary sensor for the area or the anticipated use as a supporting sensor;
* the typical environmental conditions in the operational area.

Prevailing dust conditions, the proximity to salt sprays, the occurrence of heavy rains and high ambient temperatures and so on, will dictate the minimum technical capabilities of the imaging sensor.

### Detection, Recognition and Identification

Performance should be carefully considered when specifying the detection, recognition and Identification requirements for an EOS sensor. This should include at what maximum range a VTSO should be able to detect given targets in given conditions.

### Recording and Replay

EOS sensor data should be recorded automatically where regulations permit. VTS Authorities should be able to replay this data synchronised with other sensor recordings. Replay of EOS data should not interfere with the on-going VTS operation and may require separate display systems.

The impact of storage requirements for high-resolution video data, especially if several EOSs are used, can be quite significant. The VTS Authority should carefully consider the quality of recording as well as meeting the legal requirements for the storage of historical data.

## Functional Requirements

### Pan, Tilt and Zoom

EOSs can be fitted on a fixed platform or mounted on an electromechanical PTZ frame. The latter allows a considerable amount of freedom in pointing the EOS to a target or a particular area of interest.

Fixed sensors are typically placed so as to provide general surveillance of a fixed area of interest, such as fairways and approaches to bridges and locks.

PTZ sensors can be controlled directly by the VTSO, typically using a joystick or keyboard. PTZ sensors can be a shared resource between, for example, a Harbour Master and VTS, therefore the VTS Authority may need to publish a code of practice to govern EOS sensor operation.

Depending upon the level of integration with the VTS system, the PTZ could also be controlled through the VTS application.

The VTS application could:

* control the sensor via automated tracking of a target, observed by the VTS;
* configure the sensors to react to various events, such as:
* Anchor watch violations;
* Traffic separation violations.
* allow the VTSO to direct a PTZ sensor to survey a specific area, zone or activity, for instance, pilot boarding and disembarking operations;
* allow the VTSO to set up automated scan sequences to cover selected areas in turn.

### Precision and Repeatability

Precision refers to the ability to set the pan, tilt and zoom to the requested position within a certain tolerance. Repeatability refers to the ability to reliably recreate a certain setting.

The required degree of precision will depend on the application of the EOS. For example, a long range surveillance sensor, at maximum zoom will have a narrow field of view. Therefore, in this case, the PTZ should have a high degree of precision. Conversely, an EOS sensor with a wider field of view will not require such a precise PTZ. In both cases, the repeatability should be more or less the same.

### Auto Focus

Focus should be an intrinsic and automated function within the EOS and should be specified accordingly.

### Image Processing

EOS systems are susceptible to vibrations, due to wind or nearby equipment, such as a rotating radar antenna. VTS authorities should consider specifying anti-vibration capabilities in the EOS, such as image stabilizers.

There are many processing techniques available which enhance images or derive information from images and these continue to evolve. For example, objects within the field of view of the EOS can be tracked by the EOS, allowing the EOS to automatically follow a designated target.

VTS authorities should work with equipment suppliers to determine which of these techniques and the resulting capabilities are appropriate for the VTS in question.

### Configuration

VTSOs should only need to have access to an agreed set of operational functions. Configuration, tuning, maintenance and advanced set-up functions should be restricted to designated support personnel.

## Design, Installation and Maintenance Considerations

The EOS should be specified taking the considerations in Section 1 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.

### Durability and Resistance to Environmental Conditions

#### Vibration

EOS systems may be susceptible to performance degradation due to excessive vibration of the installation. This is particularly relevant in strong wind conditions.

VTS authorities should ensure that the supporting infrastructure for the EOS is able to handle the expected environmental conditions and meets any appropriate building regulations.

#### Specific Environmental Safeguards

VTS authorities should require EOS systems to have the following external and internal environmental safe guards where appropriate:

* lens wash/wipers;
* replaceable clear lens filters to protect exposed optics;
* internal heaters and anti-condensation capabilities;
* mechanical lens protection – e.g. for thermal cameras.

### Data Communications

EOS data has significant demands on available bandwidth and due consideration should be given to ensure that sufficient bandwidth is available. Bandwidth requirements can be reduced by using video data compression techniques. It is recommended that VTS authorities 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 infrastructure, whereas encoded video can be distributed across existing networks.

### 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 cooling, housing wash and wipe and PTZ units that require maintenance of the mechanical parts. This has significant impact upon EOS MTBF figures. VTS authorities 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 in to account.

### Laser Safety Precautions

Some types of EOS sensors use laser devices to illuminate the area of interest. Such equipment should conform to IEC 60825-1 (ref. [6]) and relevant national standards.