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| IALA Guideline |

1111-1

Producing Functional and Performance Requirements for the Core VTS system

Edition 2.0

Document date

Revisions to this IALA Document are to be noted in the table prior to the issue of a revised document.

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# INTRODUCTION

This document addresses the core VTS system and needs to be read together with the other G.1111 guidelines as listed below.

* G.1111 Establishing Functional and Performance Requirements for VTS systems
* **G.1111-1 Producing Functional and Performance Requirements for the Core VTS system (this guideline)**
* G.1111-2 Producing Functional and Performance Requirements for Voice Communications
* G.1111-3 Producing Functional and Performance Requirements for RADAR systems
* G.1111-4 Producing Functional and Performance Requirements for AIS and VDES systems
* G.1111-5 Producing Functional and Performance Requirements for Environment Monitoring systems
* G.1111-6 Producing Functional and Performance Requirements for Electro Optical systems
* G.1111-7 Producing Functional and Performance Requirements for Radio Direction Finder systems
* G.1111-8 Producing Functional and Performance Requirements for Long Range Sensor systems
* G.1111-9 Producing Acceptance Requirements for VTS Systems.

The main purpose of this document is to assist the VTS Authority in preparing the definition, specification, establishment, operation and upgrades of core VTS system functions. The document addresses the relationship between the Functional Requirements and the VTS system performance requirements and how these reflect into system design requirements.

The document focuses on the human aspects of the system design including:

* User Interface;
* decision support;
* data processing;
* external information exchange.

## Definitions

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| **VTS System** | – | within this document, the VTS System is the VTS software, hardware, communications and sensors. This excludes personnel and procedures. |
| **VTS Equipment** | – | within this document, VTS Equipment refers to the individual items of software, hardware, communications and sensors, which make up the VTS System. |
| **VTS User** | - | within this document, VTS User is defined as someone with either an operational, technical, or administrative need to use or access the VTS System. |

## References

1. Convention on Safety of Life At Sea (SOLAS 1974) (as amended).
2. IMO Resolution A.857(20) - Guidelines for Vessel Traffic Services (1997).
3. IALA Vessel Traffic Services Manual.
4. IALA Recommendation R0128 – Operational and Technical Performance of VTS Systems.
5. IALA Recommendation R0119 – The Implementation of Vessel Traffic Services.
6. IALA Guideline G-1045 – Staffing Levels at VTS Centres.
7. IALA Recommendation e-Nav 140 – Architecture for Shore-based Infrastructure ‘fit for e-Navigation’.
8. IALA Guideline 1118 – Marine Casualty/Incident Reporting and Recording, including Near-miss situation as it relates to VTS.
9. IALA Guideline 1128 – The Specification of e-Navigation Technical Services.
10. MIL-STD-810G - Environmental Engineering Considerations and Laboratory Tests.

# User Interface

## Introduction

The purpose of this section is to support VTS authorities in the specification and selection of the User Interface for VTS systems.

This section should be read in conjunction with IALA Recommendation V-125 ([1]).

## Definitions and References

### Definitions

The User Interface is the space where interaction between humans and machines occurs. The goal of this interaction is effective operation and control of the machine on the user's end, and feedback from the machine, which aids the VTS Operator (VTSO) gaining and maintaining situational awareness and in making operational decisions.

The design considerations when creating user interfaces are related to or involve such disciplines as ergonomics and psychology.

Specific terms used are as below:

**Maritime domain awareness** – is defined by the International Maritime Organization as the effective understanding of anything associated with the maritime domain that could impact the security, safety, economy, or environment. The maritime domain is defined as all areas and things of, on, under, relating to, adjacent to, or bordering on a sea, ocean, or other navigable waterway, including all maritime-related activities, infrastructure, people, cargo, and vessels and other conveyances.

**Traffic Image** – is the real-time presentation of vessels and objects and their movements, as well as other activities affecting maritime domain awareness.

**Chart** – A chart is a graphic representation of the maritime domain.

### References

1. IALA Recommendation V-125 - The Use and Presentation of Symbology at a VTS Centre.
2. IALA Recommendation R1014 – Portrayal of VTS Information and Data.
3. IHO S-57 – IHO Transfer Standard For Digital Hydrographic Data.
4. IHO S-101 – IHO ENC Product Specification (under development in 2015).

## Characteristics of User Interface

The User Interface (UI) of the core VTS system provides operational functionality to VTS users to enable the provision of an effective VTS. The principal goal of the UI is to provide users with an intuitive, reliable, accurate and efficient way of interacting with the VTS system.

This goal is achieved through a combination of:

* information presentation style and methodology – screens, windows, menus, status bars;
* ergonomically designed physical interface technologies such as mouse, keyboard, touch pad, roller ball, touch screen;
* visual and audible indications
* ergonomically designed UI for Voice communications, Replay and Sensors (Radar, AIS, Electro Optics, RDF, etc).

The UI should be reliable, designed and built to contribute to the achievement of the overall availability requirements of the entire VTS system. A failure of individual elements should not disable the entire UI, e.g. a failed screen should not make the UI unusable.

These following considerations are equally important but fall outside the scope of this guideline:

* ergonomically designed VTSO workstation – lighting, seating, desk arrangements, noise reduction;
* VTS Centre layout with respect to the overall VTS operational sector layout.

## Operational Requirements

### Traffic Image

The Traffic Image consists of Chart, Sensor data and Vessel presentation including their movements in a VTS area. It is important that the Traffic Image is designed to complement the VTSO’s role.

The design should ensure the display of information is appropriate to the VTSOs role and the amount of information does not degrade overall awareness of the Traffic Image.

#### Chart

In a VTS system the Chart is a graphic representation of the sea area and adjacent coastal regions including the VTS area and relevant navigational features. This Chart forms the background for the Traffic Image. The VTS Authority should specify required chart coverage, scales, layers and updating period.

In a VTS system the Chart can consist of one of more of the following:

* Electronic Navigational Chart (ENC) (e.g. based on S-57 or S-101) and;
* Raster charts (e.g. Admiralty nautical charts (ARCS));
* Other types of vector nautical charts;
* Satellite images, land maps, GIS sources, etc.

The use of up-to-date ENCs is recommended to maximise consistency with charts used on board ships.

Other factors to consider include, but are not limited to:

* cost related to maintaining up-to-date Charts;
* the requisite Chart layers selected for display;
* optional layer selection by the VTSO;
* use of locally-derived layers.

The UI should support both automated and manual management of layers. It should be possible to automatically update Charts without affecting the continuity of VTS operations.

The Chart presentation should utilise a consistent symbology set and colour palette suited to the local operating environment.

The current ENC standards, i.e. S-57/S-101, (reference [2] and reference [3]) are designed for navigational purposes and care should be taken when using them in a VTS System. Specifically, it should be ensured that the VTS UI specification includes the capability for authorised personnel to amend the portrayal of the Chart to suit the VTS operational requirements.

The Chart should support zoom and pan operations without introducing errors or distortions, i.e. all distances, depths and bearings should remain consistent during zooming and panning of the Chart.

#### Sensor data

The UI should have the ability to display sensor data in accordance with the Operational requirements defined by the VTS Authority. The display of sensor data (e.g. radar video, AIS, Electro Optics, RDF, etc) may support operational objectives and may consider factors such as:

* Real-time situational awareness;
* Recent situational awareness of vessel positions;
* Visual confirmation of the real-time Traffic Image;
* Detection and identification of small targets;
* Redundancy.

#### Vessel Presentation

Vessel presentation is addressed by IALA Recommendation R0125 (ref. [1]). Each vessel should be displayed in a consistent manner such that the VTSO can intuitively understand the true geographical position of the vessel. This is achieved by displaying the vessel symbol in its true position relative to the underlying or reference Chart. In addition, this positional information can be augmented by the presentation of the geographical coordinates of the vessel or by its bearing and distance from a selected location.

The UI should be capable of displaying all of the information associated with each vessel displayed in the VTSO’s view. The VTSO should be able to selectively choose what information to display in accordance with local operational requirements. A straight forward and intuitive method should be employed to ease selection.

The information should be displayed either in textual or in graphical form as appropriate, e.g. course and speed vectors.

### Voice communication Display and Control

Voice communication with vessels and other stakeholders within the VTS area is the most important part of the VTS system and therefore the UI for the radio equipment should be easy to use.  The Voice communications UI may be integrated with the Traffic Image presentation or may be separate.  Many modern VTS systems provide a touch screen user interface.  The VTS User may be provided with the following facilities:

* Radio selection and status
* Channel / Frequency Selection
* Squelch control
* Digital Selective Calling (DSC)
* Facilities to replay recorded conversations
* Microphone or footswitch with Press To Talk capabilities
* Headset and/or Speaker.

Details about the functional and performance requirements of the Voice communications equipment is provided in IALA Guideline 1111-2.

### Replay Display and Control

An accurate replay of the Traffic Image that was presented to VTS Users is often regarded as a critical part of the VTS system and therefore the UI should be easy to use.  The Replay UI may be integrated with the Traffic Image presentation or may be separate.  VTS systems should ensure that Recording continues while Replaying.  The VTS User may be provided with the following facilities:

* Selection of the data (Voice communications, Sensors, Data Processing) sources and time period
* Pause/Stop/Speed selection.

Details about the Recording function is provided in Chapter 4 – Data Processing of this Guideline.

### Radar Data Display and Control

Radar is often regarded as a critical sensor input for VTS systems, due to its ability to accurately detect and track objects and their movement characteristics without requiring any transmission signal from the object itself, unlike sensors such as RDF or AIS. Radar data comprises Radar video and tracks and may include both dynamic and static objects, including but not limited to vessels, navigation aids, islands, bridges, offshore structures and coastlines.

The Radar video is used to produce a Radar track and for portrayal in the Traffic Image. The Radar track is used as an input in the Tracking process. The Radar data display may include the following:

* Real time Radar video plot representing an objects present position and afterglow of moving objects representing their past positions
* Real time Radar track data (label) and symbol.

The UI should be configurable to enable the VTS User to obtain more information about the target.

The UI should be configurable to enable the VTS User to obtain more information about the performance of the radar and the ability to control its settings to suit the operational and environmental conditions.

The UI should provide monitoring facilities that provide an alert to the VTS User if a part of the radar sensor should fail and facilities that enable the switching or control of radar subsystem components.

Details about the Tracking function is provided in Chapter 4 – Data Processing of this Guideline.

Details about the functional and performance requirements of the radar sensor equipment is provided in IALA Guideline 1111-3.

Note. Masking of radar video over land areas may be used

Since the size of raw Radar video image is quite big (over a giga bytes per minute) including not only for vessel, but all the others like island, bridge, shore structure, or land, an optimizing process for VTS radar video is done by another system called radar video extractor and tracker who normally remove unnecessary video, digitize & compress the remaining video suitable for available network bandwidth before sending them to VTS center. A radar video server at VTS center receives and integrate optimized radar videos from multiple radar sites and then finally send the radar video image to VTS operating console.

Considering importance of the radar sensor information and access limit to remote site, in many cases, key components of radar systems such as transceiver, antenna, radar extractor & tracker are configured as redundant and GUI integrated on the VTS console is available for radar control. Typical examples that VTSO on duty can use for radar monitoring and control are as following:

* Radar Control;
  + Transmission on/off
  + Switch over between active and standby transceiver (in case radar system is configured as dual redundant)
  + Pulse width selection (short, medium, long, extra-long in case of magnetron type radar system, or any other different range mode names for sspa type radar system)
  + PRF selection (fast, medium, slow, very slow, etc.)
  + STC curve selection
  + CFAR selection
  + Gain control
  + Clutter control
  + Sector blanking selection
  + Profile selection
  + Antenna on/off
  + Antenna speed selection (RPM or any other indication)
  + Antenna switch over (in case dual antennas are configured)
  + Antenna polarization selection (in case multiple polarization antenna is configured)
  + Stagger on/off
  + Jitter on/off
* Radar status monitoring;
  + Operating status (Transmission On/off, Active/Standby)
  + Magnetron usage time (in case radar is magnetron type)
  + Current value on magnetron (in case radar is magnetron type)
  + PRF values (in case radar is magnetron type)
  + North alignment
  + Encoder type
  + Antenna speed
  + Modulator status
  + STC limiter On/Off
  + ACP value
  + VSWR value
  + Loaded profile
  + Forward power value
  + Noise Figure value
  + SSPA status (in case radar is sspa type)

### AIS Display and Control

AIS uses a transponder on board a ship to provide a means for locating and identifying vessels. AIS position reports received from AIS transponders will be used for Tracking and AIS static and voyage related data may be displayed within the Traffic Image. There are two classes of AIS Transponder and a special implementation for Inland Waterways:

* Class A transponders, which are regulated by IMO SOLAS (Chapter V) and are mandatory for sea going vessels
* Class B transponders, which use less transmission power and are intended for use by smaller vessels and pleasure boats
* Inland-AIS transponders, which are used for non-seagoing vessels (only position information)

Consideration should be given to the inclusion of AIS in the Data Fusion process with Radar tracks and displayed within the Traffic Image of the VTS System.

The UI may need functionality for:

* control of the update rate of Dynamic messages, which can be increased or decreased as a traffic situation requires
* deploying Virtual and / or synthetic Aids to Navigation, which will appear on the ECDIS of ships within the coverage area
* portrayal of AIS-SART transmissions
* sending short text messages for display on board the ship’s Minimum Keyboard Display (MKD).

### Electro-Optical Sensor Data Display and Control

An Electro‐Optical System (EOS) may consist of imaging devices, such as daylight CCTV, day/night CCTV, Infrared, Thermal and laser‐illuminated cameras and other imaging devices. The EOS data can provide a visual image that may assist the VTS operator in the detection, recognition and identification of vessels and / or objects within the VTS Area. The following operational features are typically provided within the UI:

* Point and Click within the Traffic Image to enable the VTS User to quickly direct the camera(s) to a position, vessel or object of interest
* A moving target (vessel) can be selected in the Traffic Image so that the camera follows its movement
* Manual Control of the camera(s) may be provided
* Ability to Record and Playback of Video data.

Electro Optic / Thermal camera derived data (video) may be overlaid in a separate window on the Traffic Display or displayed separately.

Details about the functional and performance requirements of the Electro Optic / Thermal Cameras is provided in IALA Guideline 1111-5.

### Radio Direction Finder Sensor Data Display and Control

Radio Direction Finding equipment was used to assist the VTS Operator with vessel identification prior to the introduction of AIS. For vessels that are not fitted with AIS, it can still be used for this purpose and it is also useful tool in Search & Rescue operations. A Radio Direction Finder provides a bearing line on the main Traffic Image that indicates the direction of a radio transmission. The User Interface will typically provide the following facilities:

* Channel / Frequency selection
* Colour of bearing line (for multi-channel RDF Receivers)

Details about the functional and performance requirements of the Radio Direction Finder is provided in IALA Guideline 1111-X.

### Environmental Information

The UI should be able to display information derived from the available meteorological and hydrographical sources as required for real time and forecast data.

Depending upon the nature and extent of the available data, and the operational context in which the data may be used, the data may be integrated with the Traffic Image or the data may be displayed on a standalone display device.

Details about the functional and performance requirements of the Environment Monitoring System(s) is provided in IALA Guideline 1111-5.

### Decision Support Tools Portrayal

The UI should be able to support the portrayal of Alerts (Caution, Warning, Alarm and Emergency alarm) in accordance with G.1110. The portrayal of these Alerts including thresholds often need to be configurable.

Functionality can be made available to the VTSO in a number of different implementations including, but not limited to:

* graphical 'icons’ or ‘tool buttons' often supported by short descriptive phrases. It should be possible, in the UI, to select display of buttons, text or both. User configurable 'tool bars' may be used to group tool buttons;
* context sensitive menus, with content depending on cursor location;
* dedicated function keys and/or key-stroke short-cuts.

The UI interaction should be intuitive and efficient. Wherever possible, the number of key strokes should be minimised. Input fields should be, where possible, filled with appropriate default values by the VTS System.

### Other Operational Information

As well as being able to display the Traffic Image, the UI should be able to display other VTS relevant data including AIS, AtoN, Search and Rescue, and other sources of relevant information, where appropriate. Display of these additional information sets should be selectable by the VTSO. Specifications for specific VTS implementations should include functional descriptions of the various operational information sets that are required to be displayed to the VTSO.

## Functional Requirements

From PSE:

### Traffic Image

The Traffic Image is the central part of the User Interface of a VTS System. It provides the following functionality to the VTS Operator:

* Real time presentation of vessel positions and information relating to their identity (where available)
* Chart based information and supporting graphics relating to the maritime environment
* Facilities for monitoring the speed of vessels and alerting the VTS Operator of excessive speed or low speed situations
* Facilities for protecting assets or other objects within the VTS Area and alerting the VTS Operator of unauthorised incursion into a prohibited area
* Facilities for ensuring adherence to defined routes and alerting the VTS Operator about divergence from routes or TSS
* Monitoring of Aids to Navigation and other environment monitoring sensors and providing alerts to the VTS Operator if the data exceeds pre-defined thresholds

### Radio Communication

The Radio Communications interface is the main means of providing VTS information to the on board watch keeper. It may provide the following functionality to the VTS Operator:

* Access to all VHF FM Voice Communication Channels in the maritime band
* Ability to select and change required radio channels
* Facilities to select radio equipment at an appropriate radio site for communication with a vessel
* Ability to receive DSC messages (including emergency messages and others)
* Ability to monitor call quality

### Decision Support Tools

* Supporting functionality for Decision Support Tools (See Guideline G-1110)

### Recording and Replay

Recording is an essential part of a VTS System as it provides evidence in cases of infringement of regulations. The Recording and Replay system may provide the following functionality to the VTS Operator:

* Recording of all real time sensor data
* Recording of all radio communication
* Recording of Electro optic / Thermal camera video (where applicable)
* Recording of Meteorological and Hydrographic sensor data
* Fully synchronised Replay facilities
* Replay facilities at the VTS Operator Workstation
* Facilities to download recorded data in an industry standard format

### External Interfacing

Connectivity of VTS Systems is becoming increasingly important. External Interface functionality may be provided to support the following:

* Connection to other VTS systems
* Connection to Allied Services
* Connection to third party service providers (eg Meteorological forecasts, Cloud based services)

### System Status and Control

The UI should be capable of presenting the overall status of all the major system elements/subsystems and the infrastructure. Typically, this will include:

* communications – data and voice;
* sensors;
* main Information Technology (IT) elements – software, servers, processors, PC, workstations, data storage.

It is essential that VTS users are provided with an intuitive, timely and readily accessible view of the VTS System status and health. The required level of detail may depend upon the role of the user in the system. Sub-system status may be summarised hierarchically to suit each anticipated situation.

The UI for system status and control should accommodate the specific roles and rights of the users.

The UI should provide the VTSO with the ability to enter appropriate commands to control the system sensors. However, where appropriate, the sensors should be fully autonomous.

The UI should provide for the control, operation and status of the record and replay capability.

## Specific Design, Configuration, Installation and Maintenance Considerations

### Physical Layout

The provision of Vessel Traffic Services is the prime objective of the VTSO and the physical layout of the VTS centre should serve to enhance the ability to provide the service.

The VTS centre layout should consider:

* room layout;
* ambient lighting and comfort settings;
* noise levels, background machine noise as well as voice communications;
* screen specifications, including resolution, size, etc.;
* number of screens per VTSO workstation and their arrangement;
* number of workstations and operational sectors;
* wall screen displays.

The VTS centre user environment is of paramount importance to create a comfortable and safe office type background to facilitate concentration and to minimise distractions.

Ergonomics should offer comfort for long periods of use and offer adjustments to minimise fatigue factors.

The environment should consider the advantages of air-conditioning, good and appropriate lighting, minimisation of externally and internally generated noise distractions, nearby rest facilities to minimise user downtime, and well-designed interaction with the available voice communications e.g. via voice switching system to combine telephone, hotlines, ship to shore, VTSO to VTSO, VTS to VTS, VoIP, etc.

The layout should also consider emergency procedures and the role of the VTS centre in emergencies, as part of a coherent regional or national infrastructure.

When contemplating a new or refurbished VTS centre, consideration should be given to seek ergonomic design consultancy to assist in defining the optimum design for the centre.

### Screen Layout

The monitor / display real estate design needs to consider the appropriate use of multiple windows, pop-up windows, locked and flexible window positioning, overlapping and side by side windows containing chart data, textual information and dedicated status information etc. The relative importance of each information type needs to be accommodated within the adopted design, in particular the traffic image should remain visible.

In the case of workstations employing multiple screens, care should be taken to ensure that the same concepts of window management are extended over the entire screen real estate.

It is also important to ensure that the VTSO can easily keep track of the cursor position.

The HMI should also allow selection and filtering of the presented information to tailor the display to the task in hand, including dedicated search functionality.

The HMI should also support the interactive and automated provision of help text to the VTSO. For example, hovering the mouse over a particular tool button can result in the display of a concise help reference for the use of that particular tool.

A specific button, such as F1, could be provided to enable quick and easy access to an on-line help reference menu, related to the VTS system and other specified support information.

# DECISION SUPPORT

## Introduction

Decision Support Tools process data in order to help decision-makers to assess situations and make decisions or plans. Decision Support Tools and Functions analyse and model processes, possibly involving multiple sources of information, applying temporal and/or spatial prediction to assist decision-makers in their tasks.

The subject of Decision Support in VTS is under continuous evolution to support the Operation, Planning and Management of VTS. This section contains a list of common functions which may assist in the decision making process. This list is not exhaustive and, considering current developments, there is scope for expansion of the range of available tools and functions.

VTS Authorities should consider those tools and functions that are appropriate for their operational requirements see IALA Guideline 1110 [1].

## Definitions and references

### Definitions

**Decision Support Tool (DST)** – a VTS decision support tool assists the decision-maker at an operational, planning and management level. This may be in real-time or at a tactical or strategic level.

**Decision Support Function (DSF)** – a VTS decision support function assists the VTSO at an operational level.

**Decision-maker** – a person or group with the power or authority to make decisions.

**Alert** – the provision of advice about operational issues.

**Alarm** – an Alert that requires action.

### References

1. IALA Guideline 1110 on the Use of decision support tools for VTS personnel.

## Characteristics of Decision Support Tools

Decision Support may consider such aspects as environmental monitoring and forecasts, vessel behaviour, vessel traffic development, legal criteria, incident management, organisational and operational procedures. It can correlate and combine these aspects to give validated advice.

Decision Support Tools and Functions may be self-learning, make real-time risk assessments and/or provide recorded and statistical data to the VTS Authority to improve safety, efficiency and environmental protection. In view of this, Decision Support Tools and Functions should be configured or tailored for each VTS, as appropriate. Alerts, raised by Decision Support, should be presented in a timely and relevant manner aligned to operational requirements.

Decision Support Tools and Functions are reliant on the timeliness, accuracy and integrity of the incoming data and the underlying model-based analysis of that data. Note that two decision support tools used for the same purpose may give similar, but not necessarily identical, results. Decision Support Tools may also be used to evaluate the performance of the VTS itself.

For example, as stated in Section 1, the process of establishing a Vessel Traffic Service supported by a VTS system starts with a risk assessment of a potential VTS area. The risk analysis process leads to the identification of mitigation measures which will contribute to the definition of operational requirements for the VTS.

Decision Support Tools should be able to assist decision-makers by providing facilities that aid the management of risk situations and, thereby, reduce the level of risk. In addition, appropriate Decision Support Tools may also provide a means of measuring the level of risk reduction achieved.

## Operational Requirements

Decision Support Tools may help the VTSO and other decision-makers with the implementation of the appropriate predefined and approved procedures.

Decision Support Functions aim to reduce the workload of VTSOs. They may be based upon a real-time assessment of risks associated with the traffic situation. Where the risk level exceeds a pre-defined threshold, an alarm or alert may be raised and the VTSO may be advised of the recommended risk mitigation options.

Management facilities should be provided for the adjustment of alert thresholds and the possibility of de-activation. However, it is recommended that the appropriate alarm or alert thresholds should be part of the agreed operational procedures to ensure that the deployed system is fit for purpose. Alarm and alert facilities should not generate excessive alarms that may increase VTSO workload.

To reduce repeated alarms relating to the same vessel and situation, the reporting of alarms should incorporate filtering techniques, such as hysteresis.

Management reports may be generated from alarm and alert statistics and/or VTSO actions for off-line analysis.

The following is a list of common Decision Support Functions that may assist achievement of operational requirements.

### Collision Avoidance

Closest Point of Approach (CPA) and Time to Closest Point of Approach (TCPA) are numerical indices characterizing the imminence of a close approach between two vessels. These indices must be pre-defined and interpreted together with a logical AND function. The definition of these indices should consider the range and azimuth (bearing) accuracy of the sensors, especially in the case of radar-only vessel tracking, as the sensor accuracy will impact the accuracy of the CPA and TCPA calculations.

If different areas are monitored according to different rules concerning CPA / TCPA alarms thresholds, it should be possible for the VTSOs to visualize the different zones and the associated alarm levels.

If different alarm levels are supported, the display of an alarm should provide clear indication of the criticality of the alarm.

### Anchor Watch

Anchor watch should alert a VTSO that an anchored ship has drifted beyond the safe limits of its defined anchorage. Anchor Watch zones are Monitoring Zones that are based on a given vessel position and include its legitimate movement due to tidal conditions and the relevant sensor accuracy. The boundary should therefore be derived according to the greatest distance from the anchorage point (low tide limit). The ship should remain inside this zone in all but the most extreme conditions and alerts should advise the VTSO that the vessel has drifted beyond the Anchor Watch limits.

Distances should be expressed in the standard unit of distance.

Where meteorological and/or hydrographical forecast information is available, a Decision Support Tool may be able to alert the VTSO that changing conditions could put certain vessels at risk of breaching their Anchor Watch limits.

### Grounding Avoidance

A Grounding alarm requires details of the draught of the vessel, the bathymetry and tidal information. The alarm is raised if the estimated under-keel clearance along the predicted path of the vessel is less than a pre-defined threshold. The source of draught information should be checked to ensure accuracy.

Depending on the capabilities of the VTS, the accuracy of bathymetric maps, of water height due to the tide and of the draught of the vessel, the grounding threshold may be adjusted by VTS authorities based upon their assessment of acceptable risk parameters, e.g. to allow for squat and variations in water density. It is recommended that these thresholds should be determined assuming worst case data accuracy.

### Air Draught Clearance

Air Draught is an alarm that requires the air draught of the vessel, the obstacle clearance, bathymetry and tidal information. The alarm is raised if the estimated clearance is less than a threshold.

Depending on the capabilities of the VTS, the accuracy of bathymetric maps, of water height due to the tide and of the air draught of the vessel, the Air Draught threshold may be adjusted by VTS authorities based upon their assessment of acceptable risk parameters e.g. to allow for squat and variations in water density. It is recommended that these thresholds should be determined assuming worst case data accuracy.

### Sailing Plan Compliance

Sailing Plan Compliance warns VTSOs when a ship's track is outside of the route spatial or temporal boundaries that have been defined for that specific ship.

### Area related

These warn the VTSO that a ship has, or is about to, penetrate a pre-defined area or cross a pre-defined navigational line.

International regulations, national recommendations or VTS authorities may define areas where no shipping is allowed under normal circumstances. These areas may be Traffic Separation Schemes, Special Protected Areas (SPA) or Marine Protected Areas (MPA), Prohibited zones, or Particularly Sensitive Sea Areas (PSSA), as defined by IMO or national authorities.

### Speed Limitations

These warn VTSOs whenever a ship's speed is outside pre-defined speed boundaries (SOG).

Competent and VTS authorities may define upper and lower speed limits for navigation in certain areas such as port zones and traffic lanes. To implement this functionality, sufficiently accurate and reliable speed estimation should be available to avoid false alarms.

### Incident or Accident Management

Where the VTS is tasked to support Incident Management, Decision Support Tools could help visualize and plan the allocation of resources within the incident area. These tools may help the VTS to organize different teams in order to efficiently cover a given area. This can be done with graphical overlays, identification of the resource locations and historical track display in order to identify the areas already covered during the operation. This can also be achieved by displaying zones unsuitable for navigation and factors influencing the decision processes such as the prevailing and forecast sea currents and wind conditions. It may include assistance for planning and monitoring the operation.

Where forecast data is included, Decision Support Tools may assist the VTSO or other decision makers to assess the probable impact of the incident. Drift modelling and area protection assessments may be performed on a regular basis throughout the incident to ensure that the impact of the incident is minimised.

Incident Management alerts and alarms may all be recorded and formatted into an Incident Management Report such that action can be assessed and confirmed alongside the Emergency Management Plans of the Competent Authority.

#### Specific Design and Installation Considerations

Refer to IALA Guideline 1110 [1].

# DATA PROCESSING

## Introduction

The purpose of this section is to support Competent and VTS authorities in the understanding of Data processing, its performance parameters and its contribution to the VTS traffic image (situational awareness).

The section focuses on establishment of a recognised up-to-date traffic image using the principles of target tracking and data fusion. Additionally, it introduces the issues of managing various types of information required within and outside the VTS.

## Definitions and References

### Definitions

For general terms used throughout this section refer to IEEE Std. 686-1997 IEEE Standard Radar Definitions.

Specific terms are defined as follows:

**Confirmed track** – a track that has previously passed the criteria for track initiation, tentative track formation and has been subsequently promoted to a confirmed track.

**Data Fusion** – in the tracking context, data fusion is the combining of observation updates from more than one sensor to create one track based on all available sensor information.

**False Plot** – a plot resulting from a phenomenon unrelated to VTS operation or from a reflection of an actual object.

**False Track** – a track created using sensor data that happens to behave in target-like manner but actually relates to phenomena unrelated to VTS operation or results from reflections of actual objects.

Note, the sensors and indeed the tracking process may not be able to differentiate between small detectable objects unrelated to VTS operation (birds for example) and at the same time to correctly detect and track small objects that are related to VTS operation.

**Latency** – a measure of time delay experienced in a system. Used here to indicate the time from a sensor first gathering data relating to a target, to the time the corresponding data is presented to the user (e.g. VTSO display or decision support process).

**PD**– is the probability of target detection at the output of a sensor, subsequent to plot extraction, but prior to tracking, and presentation. Note, in some systems the boundary of the sensor and its achieved PD complicate this definition – clarification may be required to avoid misunderstanding arising from, for example, data compression or video processing.

**Plot** – a generic term to describe the report resulting from a sensor observation.

**Plot extraction** – the process of determining measurement values for a sensor observation from the raw sensor data. In the case of a radar sensor, this typically consists of comparing the video level with a threshold which can be (dynamically) adapted to local background noise and clutter conditions.

**Plot to Track Association** – the process of determining correlation of new sensor plots with existing tracks.

**Radar** – as referred to in this document, this relates to all aspects of the radar from sensor through to the availability of radar information (for presentation) from one or more radar sensors to the VTSO.

**Radar track (report)** – a target report resulting from the correlation, by a special algorithm (tracking filter) of a succession of radar-reported positions (radar plots) for one object.

**Radar video** – a time-varying signal, proportional to the sum of the radio frequency (RF) signals being received and the RF noise inherent in the receiver itself. Radar video can be an analogue signal with associated azimuth reference information, and/or video data (including amplitude) in digital format.

**Sensor** – in the tracking context, a sensor is a device for observing and measuring, as a minimum, position information for a target or potential target.

**Sensor PFA** – is the probability of false alarm (plot) at the output of a sensor, subsequent to plot extraction, but prior to tracking, and presentation. This is generally expressed as an average number per unit area.

**Signal to Noise ratio** – the ratio of a measurement of the power of a return from a target vs. the local sensor noise around the location of the target

**Tentative track** – in the early part of the track lifecycle, a track is considered to be a tentative track until sufficient criteria are passed for it to be promoted to a confirmed track or for it to be discarded as a likely false track.

**Track** –the geo-spatial data, accumulated by the system, relating to an object of interest. As a minimum, this consists of unique identity, timestamp, current position and velocity, the associated quality of that information and other relevant attributes.

**Track Coasting** - a feature that maintains tracks in the absence of expected sensor updates.

**Tracking** – the process of following an object to enable historical, current and future target positional and velocity information to be displayed and otherwise processed in support of the VTS system objectives.

**Tracking PFA** – is the probability of false track at the output of the tracking process, prior to presentation. This is normally defined as number of occurrences per unit area per unit time.

**Track initiation** – this is the process of first creating a track from plots that could not be associated with existing tracks.

**Track Merging** – as two approaching tracks come together, it may not be possible for the available sensors to individually discriminate and therefore to measure their continued presence and position. If this situation persists for some time, one of the tracks may be maintained whilst the other is terminated.

**Track Splitting** – a single track may unpredictably split into two or more discernible objects which may invoke rules for track initiation on some or all of the resultant likely tracks.

**Track swapping** – the (usually unwanted) transfer of a track identity (track label) to another track. This can break the intended association between a track and a physical object.

**Track termination** – the process of permanently removing a track.

### References

1. NIMA Technical Report TR8350.2 - Department of Defense World Geodetic System 1984, Its Definition and Relationships With Local Geodetic Systems, third edition - amendment 2 (June 23, 2004).
2. IEEE Std. 686-1997 - IEEE Standard Radar Definitions.
3. IHO S-57 – IHO Transfer Standard For Digital Hydrographic Data.
4. IHO S-101 – IHO ENC Product Specification (under development in 2015).

## Tracking and Data Fusion

An up-to-date established traffic image is essential to the successful operation of a VTS. This is typically presented as a map showing fixed geographical and man-made features and moving objects to aid decision support and general traffic management of the VTS area. The traffic image is created by processing the raw data from the available sensors of the VTS network.

All individual sensor measurements have limited accuracy and are affected by random errors. In order to obtain a more reliable estimate of a target position and speed vector, measurements need to be processed.

The Tracking and data fusion process accepts sensor data from the available VTS sensor network and other available sources. Then, it attempts to combine these with existing tracks for the purposes of building a traffic image. When such data do not successfully combine with existing tracks, the Track Initiation process postulates new tentative tracks which are subsequently monitored until they either become confirmed tracks or are discarded as likely false alarms.

The resulting traffic image is displayed to the VTSO, can be used in decision support and may be provided to other agencies and allied services.

The tracking process uses models of the sensors and a set of concurrent models of the target movement to provide a best estimate of, at least, the target position, course and speed over ground (COG, SOG). These models are also used to optimise the association process to combine new measurements with the existing tracks.

Some standard terms need to be outlined for clarity (see Figure 17).



1. Typical Terminology of Tracking Functions and Processes

It is recommended that a VTS system takes advantage of data available from multiple sensors and external sources by integrating this data in an appropriate way. Integration can be as simple as overlaying, selectable, multiple layers of track data on the VTSO display but significant advantages can be gained by processing and combining the data within the Data Processing function. The use of data from all available sources can significantly improve the positional accuracy of the track and other associated track information (identity, target type, COG, SOG, manoeuvre etc.). In addition, track fusioncan include error and anomaly detection in the data from single sensors (which may incorrectly differ from other sensor derived data).

Fusion of the data can be either combining tracks created from individual sensors or introducing the raw measurements from all sensors directly into the track filtering process. In both cases, the track fusion process may have to deal with (un-calibrated) biases in the data originating from the different sensors (e.g. the North alignment of radar sensors).

In a fully calibrated system (i.e. with minimum measurement bias), the output of a data fusion tracker (multi-sensor tracker) should not reduce the quality of the information coming from the most reliable source and in general additional accuracy or other benefits should reasonably be expected. Track fusion also provides redundancy to minimise the consequences of sensor failure or poor detection.

Track fusion is an automatic process and as such, it is recommended that VTSO interaction with this process is limited.

Within this Guideline, the Tracking and Data Fusion sections consider sensor data from various sources including:

* radar sensors;
* adjacent VTS area or other agency tracks;
* AIS and Satellite AIS;
* LRIT;
* Electro-Optical Systems (EOS).

Note, contributions from mobile sensors (ship borne sensors etc.) are not normally considered, although this additional enhancement and complexity may become more widespread in the future. The availability of more data bandwidth from ship to shore may facilitate this enhancement in the future.

The design of the Tracking and data fusion process should take into account the need to translate positional information into a common geographical reference system. One common standard datum for this is WGS84. This translation process requires an understanding of the attributes of each sensor, for instance AIS provides geographic coordinates whereas radar measures position in terms of polar coordinates, i.e. range from the sensor and bearing relative to North, even though the data may have been translated at source, the measurement errors used within the track correlation process should reflect the type of data.

As mentioned above, there is also the need to accurately calibrate various sensors to the common reference system, and to each other, so that a detectable point target is measured to have a common location from all sensors providing data on such a target. Such calibration can take the form of manual set up and routine checking and/or on-the-fly identification and correction of measurement bias within the tracking process.

The time stamping of sensor data, accurately reflecting the time of observation and measurement, is essential to enable the correct and accurate traffic image to be established and maintained. Another important performance parameter to consider is communication and processing latency through the VTS system and in particular within the Tracking and data fusion process. This is a separate design consideration to that of time stamping to ensure that the data is presented in a timely fashion to the VTSO (or external system).

### Plot Extraction

The plot extraction process lies between the collection of raw sensor data and the extraction of useful information from that data. It is highly dependent on sensor type:

* An AIS, satellite AIS or LRIT plot is known to originate from a single GNSS receiver and provides a time stamped position which can be assumed, with significant confidence, to originate from one target;
* A radar or EOS plot has to be extracted from raw data using a thresholding process to separate it from noise related excursions.

In addition, multiple candidate plots may arise from one object (due to target physical size, sensor attributes etc.) and these need to be associated and reduced to one plot where possible within the extraction process.

Ambiguities may also exist in the plot measurement and they need to be resolved, or, at least, highlighted for downstream resolution.

The plot extraction process requires specialised and dedicated processing to optimise the trade-off between target detection probability and false alarm rate whilst also extracting positional data. In addition, a strong radar plot may originate from any reflecting surface or surfaces and may not be related to a vessel or object of interest. The subsequent plot to track association process contributes significantly to the selection of wanted radar plots from unwanted radar plots. Besides the extraction of single object plots, the plot extraction process may also provide additional attributes or extended object information to enable subsequent tracking of, for example, icebergs or oil slicks.

Extracted plots include the following attributes:

* time of measurement;
* measured position (Cartesian or polar) and positional uncertainty;
* originating sensor.

In addition, the plots attributes may include:

* identity;
* radial (Doppler) speed;
* physical extent of the plot;
* signal strength.

In general, the plot extraction process is fully automatic, relying on programmed algorithms tuned to optimise the process to the sensor characteristics and the topography of the coverage area.

### Tracking

#### Plot-to-Track Association

Plot-to-Track Association is the selection of the most likely track, representing the object, for each (incoming) plot and the identification of plots which do not associate with any existing track.

The extracted plots are passed to the tracking process and those which fail to correlate with existing tracks become candidates for the initiation of new tracks. Those plots which correlate successfully with existing confirmed or tentative tracks will be used to update the associating track.

Plot-to-Track association involves the forward prediction of the track attributes (e.g. position) to a time which corresponds with the time-stamped update(s) contained within the new plot. After allowance for elapsed time since last update, measurement noise and the possibility of reasonable target manoeuvre, a test for correlation with the new plot is used to either associate the plot or discard the plot (from this track). This process is repeated for all tracks (and plots) so that the discarded plots can be passed to the track initiation process.

Note: plots arrive asynchronously from any available sensor.

#### Track Initiation

The plots remaining un-associated following the plot to track association process may contain plots originating from real targets. These plots are used in the track initiation process to establish a list of uniquely identified, tentative tracks.

In general, the track initiation process is automatic but geographic limitations may be invoked upon areas where automatic initiation should and should not occur. Although VTS systems often include the possibility for manual track initiation, reliance on this method of initiation can significantly load and distract the VTSO. The dependence on this type of track initiation should, therefore, be kept to a minimum.

It can be assumed that an externally sourced (and likely to be externally maintained) track is very likely to become a track in the VTS area of interest and therefore a track can be initiated. AIS plots which have failed to associate, typically initiate a new tentative track. Radar plots, which have failed to associate, require additional confidence building algorithms before completing the initiation of new tracks.

The track initiation process in combination with the plot extraction process needs to strike a balance between the ability to detect true targets of a certain type (especially small targets) and the possible initiation of false tracks. Lowering the plot detection threshold or relaxing the initiation rules, allows more true targets to be detected at the expense of an increased false track rate. This will require system level tuning (supported by modelling if appropriate) to optimise performance and achieve the VTS operational requirements.

In other words, there is a trade-off between a higher target detection probability, a larger initiation delay or a larger false target rate.

#### Track Maintenance

Within a tracking system, the tracks generally pass through the following stages:

* tentative tracking;
* confirmed tracking (including the possibility of coasting);
* track termination.

The following sections, track updating and track validation, describe the regular repeated processing that occurs within these stages.

**Track Updating**

The extracted plots which associate with existing tracks are used to update those tracks by combining the plot data with the track predictions in accordance with the chosen tracking filter(s). Various mathematical techniques are available to forward predict and update the track position and trajectory information. These techniques vary from simple to very complex with a more or less increasing level of performance. In complex traffic situations it may be appropriate to consider the use of the more advanced algorithms.

As track paths approach or cross each other, additional rules are required to minimise the chances of lost tracks as all the available update information may tend to be associated with one rather than with both tracks. The use of AIS sensors and high resolution passive sensors reduces this possibility, but in some circumstances lost updates to one or both tracks may be inevitable. In real traffic situations, the approach of a small pilot vessel to a large shipping vessel will create this situation on an everyday basis.

**Track Validation**

Tracks should be validated against the possibility that they are, or have become, false tracks. Assessment of track quality and erratic track update behaviour may be considered as techniques to provide validation. The tracking system should be able to react quickly and initiate termination rules once it becomes clear that a false track may have been created (see Section 9.3.4.1 for further information). False tracks, from whatever mechanism, should be avoided in safety critical areas and occasionally accepted in other areas where surveillance and traffic monitoring is the priority. Note; operational requirements regarding the detection of small targets may result in an increase in the probability of false tracks.

It may be appropriated to not terminate tracks immediately when there are no sensors measurements but allow some time during which the track is coasting. In such cases, coasting rules may be defined to take into account the need for intentional track coasting such as in areas obscured from sensor coverage.

### Track Data Output

Consideration needs to be given to the output of track data to other VTS sub-systems such as the display of the established traffic image to the VTSO. The display is not normally considered to be part of the Tracking Function, but the appropriate tracking information will need to be available for display and for presentation on demand. It may also be appropriate to offer the ability to access and display raw sensor data, plot data and tentative track data.

The display of confirmed tracks is likely to be essential to the VTSO tasks and therefore it is recommended that the display HMI minimises the possibility of unintentionally hiding this information.

The HMI aspects of the display function will consider the use of symbols, colours, text etc. for the display of track information. Typically, track information will be presented onto an electronic chart (using a common reference) of the VTS area.

Track information, which might be required for display to the VTSO, includes:

* current location;
* vessel identity;
* speed and course over ground;
* track history;
* contributing sensors (and lack of updates i.e. coasting);
* associating plot data;
* destination and ETA;
* passage plan;
* cargo;
* crew and passenger details.

Note: there is a trade-off in the HMI to be considered between presentation clarity, data overload, track density and VTSO interaction to interrogate a track for additional information.

### Track Management

#### Track Termination

If a confirmed track either:

* moves outside a user defined coverage area;
* moves into a user defined non-tracking area;
* has track updates which do not follow the expected behaviour; or
* if the track cannot be updated with new plots over a certain length of time.

then the track should be terminated. In certain cases, as defined by the VTS Authority, the VTSO should receive a warning of imminent track termination, and also the VTSO may be provided with a facility, via the HMI, to manually terminate a track.

Track loss may occur as a result of targets not being detected by sensors for a certain time. Note: the loss of target detection is likely to occur in the vicinity of obstructions such as bridges, land masses etc. In order to cover expected areas of poor detection, the system may be configured to bridge gaps in coverage e.g. by coasting previously reliable tracks. The VTS Authority should address any critical areas, such as the vicinity of bridges, and explain expectations to tracking to allow VTS suppliers to design appropriate rules in such critical areas. Another source of track loss is the occurrence of target manoeuvre outside the expected behaviour.

The conditions for track termination may need to be adaptable and adjustable in different areas or traffic / weather conditions. This additional complexity may be set up on system commissioning, user adjustable or even automatically reactive to real world data.

In addition to the above there may be some special classes of tracked objects that require special track processing. Special rules may be required to allow for unexpected appearance and disappearance of submarines, the possibility of obscuration by moving objects in the area of interest or the need to track extended objects such as icebergs, oil slicks and weather effects (and to monitor their size and changes in their shape).

#### Track Identification

Tracks should be uniquely identified, noting that other methods of vessel identification may conflict or overlap, such as internal and external databases (Lloyd’s, SafeSeaNet, single-hull database, various incident/black lists, on-board identity, adjacent VTS and other allied services etc.) and local identification methods such as those arising from AIS data, voice communications and associated direction finding, camera recognition (manual and automatic).

### Environment Assessment

The VTSO may need to be informed of environmental changes which may affect VTS operations and/or the ability to detect objects within the VTS area. The VTS system may provide special features to facilitate environment monitoring and assessment including, for example, hydrographic sensors and cameras to further aid environmental monitoring.

### Tracking and Data Fusion Performance Parameters

The effective use of the VTS traffic image, reliant on accurate and reliable tracking and positioning of the objects of interest in relation to fixed and movable hazards within the VTS area, is fundamental to safe and efficient management of the VTS traffic. The following sub-sections describe the relevant parameters.

#### Input Parameters Required to Design and Implement a Tracker

Key tracking system input parameters to be specified by the VTS system designer, based on the parameters specified by the VTS Authority, include:

* range of target characteristics (size, speed, manoeuvrability, height, type etc.);
* maximum number of targets to be tracked;
* typical desirable and undesirable traffic behaviour, including traffic 'lanes', traffic density, shallow waters, low bridges, narrow waterways etc.;
* anticipated variations in weather and sea/water conditions;
* external inputs and outputs to / from the tracking function;
* acceptable VTSO interaction with the tracking function;
* sensor network design including its specific characteristics including latency.

#### Performance Parameters

The determination of performance parameters to specify a VTS tracking system design is a complex task and the achieved tracking performance is heavily dependent on the sensor data provided as inputs to the tracking process. The sensor requirements should consider information provided elsewhere in the other sections of this document.

The location and configuration of the sensor network determines the attainable performance of the VTS system. A tracker design needs to be tuned to optimize overall performance (i.e. accuracy, resolution and minimal track confusion) and the overall performance is unlikely to be constant throughout the VTS area. The VTS system design should therefore ensure that the achievable performance is aligned with the required performance for each of the areas within the VTS coverage area. It should be noted that track formation range is not the same as the sensor network detection range – this needs to be considered when deriving the network coverage and how this relates to the tracker behaviour.

Test scenarios may be developed jointly with users and the tracking experts to explore the anticipated performance of the VTS system as a whole, especially in critical (hazardous) areas of the VTS. Generic traffic test cases can be proposed for a generic sensor solution, but the resultant tracker may have weaknesses in an actual application even though it demonstrates compliance with such generic test cases.

The tracking characteristics needed are highly dependent on local conditions which should be analysed individually. The following tables discuss some of the tracker performance parameters and criteria that may be considered.

1. Typical System Tracking Performance Parameters

| Parameter | Typical span of Parameter |
| --- | --- |
| Number of confirmed tracks | From ≤ 500 to ≥ 2500 dependant on area covered, traffic density and smallest size of objects to be tracked. |
| Time for initiation of a tentative track | From 5 to 60 s, or 3 to 10 sensor observations. |
| Time for classification as a confirmed track | From 5 to 60 s, or 3 to 10 sensor observations. |
| Time from data loss to automatic track termination | ≥ 60 s, or ≥ 10 sensor observations, whichever occurs first. |
| Speed of tracked surface objects | From ≤ 50 knots to ≤ 70 knots dependant on fastest target in the VTS area. |
| Turn rate of tracked objects \*) | From ≤ 10°/s (SOG ≤ 5 knots) to ≤ 20°/s (SOG ≤ 5 knots). |
| Transversal acceleration of tracked objects \*) | From ≤ 2.5 m/s2 (SOG > 5 knots) to ≤ 5 m/s2 (SOG > 5 knots). |
| \*) The transversal acceleration = SOG \* turn rate, thus for slow moving targets the turn rate is the limitation, whereas the transversal acceleration is the limitation for fast targets. | |

1. Single Radar Sensor - Tracking Performance Parameters (specific)

| Parameter | | Receiving data from Basic radar sensor | Receiving data from Standard radar sensor | Receiving data from Advanced radar sensor |
| --- | --- | --- | --- | --- |
| Accuracy in track position | Range (relative to sensor location) | The greater of:  ≤ 0.5 % to 0.75 % of range covered by the individual radar  ≤ 5m to 10m + selected effective pulse length  or half the target extent in range | | |
| Bearing (relative to sensor location) | ≤ 1°, X-band radar sensor  ≤ 2°, S-band radar sensor | | ≤ 0.5° |
| Accuracy of track speed | Speed over Ground (SOG) | ≤ 2 knots | ≤ 1 knot | ≤ 1 knot |
| Course over Ground (COG) | ≤ 5° | ≤ 2° | ≤ 2° |
| Timing | Time from track confirmation to achievement of specified track accuracy | ≤ 120 s | | |

**Note**: the accuracy figures suggested above need to be assessed as RMS error (measured parameter vs. truth) for well-behaved (non-manoeuvring) targets in moderate environmental conditions. Positional accuracy should be verified with a small but detectable target, whereas SOG and, especially, COG should be verified using large targets moving under power (i.e. not tidal), without manoeuvre and, for the determination of COG, a recommended minimum speed of 10 knots.

1. Single Sensor - Tracking Performance Criteria

| Parameter | Discussion | Operational Consequence |
| --- | --- | --- |
| Time to initiate tracks | This can be measured from the point of first observation to either the creation of a tentative track or the establishment of a confirmed track. In addition, the contribution of the display function to latency may need to be assessed separately. | The design has to consider the trade-off between fast establishment of new tracks vs. the associated false track rate. |
| Probability of false (confirmed) tracks | This is dependent on clutter conditions, traffic density, sensor sensitivity, sensor resolution and the perceived need to detect and track very small targets – the acceptable rate should be specified per area per unit time. Typical values might be 3 to 4 per hour although this is likely to conflict with a requirement for very small target detection. | Displaying tracks which do not represent real targets will increase workload and may result in incorrect VTSO actions being taken. |
| Average false track duration before termination | The tracker should react quickly to confirmed tracks which subsequently fail to exhibit reliable track behaviour. | Continued display of tracks which do not represent real targets will increase workload and may result in incorrect VTSO actions being taken. |
| Probability of failure to confirm a genuine track | The tracker performance in combination with the sensor network should minimise the probability of failing to establish a genuine track after the first reliable sensor observation. | Delays to the establishment of a track will impact the traffic image and may result in incorrect VTSO decisions. |
| Probability of track loss | This concerns track continuity. Assuming good sensor visibility of the target, the tracking function should provide reliable and accurate track updates over the entire life time of the track. | Frequent track loss will lead to reduced confidence in the track measurement accuracy and the ability of the system to follow manoeuvring targets. In congested traffic areas, this could be critical to safe vessel passage. |
| Probability of successful management of two targets merging and then correctly splitting | In the highly likely event of two (or more) targets merging into one sensor resolution cell, the tracker should be able to use the combined and unresolved observation to update the merged tracks until after some time when the targets 'de-merge', the tracker should successfully split and update the previously merged tracks with correct numbering and track identification. | The VTSO needs to be presented with the best tracking information available before, during and after the merging event. |
| Track identity swap rate | The tracker design should minimise the probability of track identities incorrectly swapping between two tracks (and ensure that incorrect swapping is quickly corrected). | The VTSO needs to be presented with accurate and correctly associated tracking information against targets of interest. |
| The probability of multiple tracks being created from one target | This parameter is often specified for VTS applications in areas covering inland waterways in which large vessels, travelling close to the (radar) sensor location create multiple plots which result in multiple tracks. | Presentation of multiple tracks, relating to a single large object, can create confusion and inappropriate VTSO decision making. The tracker should be able to identify group behaviour within plots and tracks and reduce these to a single track representing the large vessel. The positional reference point for such a target needs to be understood and interpreted appropriately. |
| Latency of track update | This parameter needs careful definition – time of sensor observation to track update (i.e. not including display function etc.). | Minimal latency will provide a traffic image which is close to real time, but some latency is inevitable, especially when microwave links are included in the VTS network to link remote sensors sites to the VTS centre. (Satellite AIS can also suffer significant and often unacceptable latency).  Delays in presentation of the surface picture can lead to delayed awareness of the need for VTSO action. |
| Coasting period (before track termination) | The time, measured from the last track update with an associated sensor measurement, to automatic track termination. | Genuine target tracks do not just disappear (unless they are at the extremes of available sensor coverage) so the deletion of tracks is a trade-off between lost genuine tracks, prolonging of track seduction (e.g. onto clutter), and prolonging of incorrectly confirmed false tracks. |

Requirements for sensor fault detection and loss of sensor data integrity should also be considered; for example, the tracker may be used to identify consistent bias errors in the data from one sensor.

#### Additional Track Management Requirements

The tracker should be able to provide advance warning of track capacity overload.

The track capacity should be sufficient to accommodate ≥2 times the heaviest traffic predictions, including an allowance for false tracks.

## Management of VTS data

Besides the Tracking function, there are other Data Processing functions that may need to be considered within the VTS design. Typically, data processing is the collection and extraction of data to provide information.

The *data* is everything that is potentially useful and relevant to the VTS operation.

*Processing* involves summarising, analysing, converting, recording, sorting, calculating, disseminating, storing, aggregating, validating, tabulating etc.

The *information* is the result of the processing of the input data. It should be appropriately useful and appropriately clear to aid the VTSO, external users and the manual and automatic decision making processes. In the context of a VTS, there are many pieces of data, each with its own importance, validity and integrity.

Centralised data fusion aims to integrate data from different systems at regional or national level using inter-system data exchange.

Types of information may include:

* voyage data;
* vessel data;
* incident data;
* contacts data;
* charts;
* pilots and tugs;
* data of berths and capabilities plus other port resources;
* traffic analysis data;
* local hazards;
* VTS Equipment status, build state, version records;
* VTS spares and consumables stock and storage locations;
* VTS equipment fault records;
* VTS equipment scheduled and unscheduled maintenance;
* VTS personnel.

It may be appropriate to integrate shipping accounts data to automate alignment with cargo movements, shipping movements, handling charges etc. to facilitate account management by systems associated with the port (i.e. not directly associated with VTS operations). Often this functionality may be managed by the Local Port Authority (LPA).

## Recording

The recording of data will need to be considered within the VTS System design so that an accurate, consistent replay of the Traffic Image can be reproduced. This is imperative as recordings may be required for lessons learnt and accident investigation purposes.

Typically, recordings will need to be time synchronised and include Voice communications together with Tracking data and the various sensor data that comprises the Traffic Image. The recommended minimum period for recordings is thirty (30) days however longer periods based on operational requirements should be assessed.

# EXTERNAL INFORMATION EXCHANGE

## Introduction

This section describes the technical issues that need to be addressed to support the requirement for VTS systems to be able to communicate with relevant allied services, National Points of Contact for services such as LRIT, and neighbouring VTS systems. Details, regarding legal issues and processes recommended for sharing maritime data (more specifically terrestrial and satellite AIS), may be found in IALA guideline N° 1086 (ref. [1]).

## Definitions and References

### Definitions

For general terms used throughout this section, please, refer to references.

### References

1. IALA Guideline N° 1086 – The Global Sharing of Maritime Data and Information.
2. ITU-R – Radio Regulations.
3. IALA Recommendation V-145 – On the Inter-VTS Exchange Format (IVEF) Service.
4. IHO S-100 – IHO Universal Hydrographic Data Model.

## Characteristics of External Information Exchange in VTS

VTSs can be considered focal points for data since they integrate data from various sources (e.g. AIS, radar) for their day-to-day operation. This data may be shared with parties outside of VTS where there is an operational need.

Table 24 and Table 25 provide a list of purposes for maritime information exchange. This list is not exhaustive and simply provides an indication of the range and diversity of such maritime data.

1. Information Exchange between VTS and Vessel

|  |  |
| --- | --- |
| Purpose | Type of Information Exchange |
| General information exchange | Risk identification and avoidance  Monitoring of cargo, vessel status and resources  Voyage planning and execution (e.g. under keel clearance and track keeping)  Meteorology and hydrography  Cargo management (planning, loading and discharging)  Logistics support (shipboard) |
| Regulatory Compliance | Reporting  Environmental protection |
| SAR response (pending individual VTS responsibilities) | Medical and aeronautical support  Incident assistance |

1. Information Exchange between VTS and Shore-based Entities

| Purpose | Type of Information Exchange |
| --- | --- |
| Traffic management | VTS tactical support  Anchorage and berth management  Bridge and lock management |
| Hazard management | Risk analysis  Incident reporting and investigation  Contingency planning  Emergency towage and salvage |
| SAR | Medical and aeronautical support  Incident assistance |
| Logistic chain support | Voyage monitoring  Port operation  Forward planning movements  Pilotage and allied services |
| Law enforcement | Maritime contraventions  Fisheries enforcement  Customs  Port state control  Border control / immigration  Port health inspections  Security |
| Environmental protection | Pollution monitoring  Incident response  Waste management |
| Waterways infrastructure management (including inland waterways) | AtoN operations and system optimisation  Infrastructure maintenance and update |
| Maritime safety information (MSI) | NAVTEX |

## Data Management Considerations

### Suitability for Purpose

Users need to be aware of the limitations of the data to avoid taking actions based on outdated, inappropriate, incomplete, inaccurate or corrupted data.

To guarantee the quality of data exchange, the parties involved in a data-sharing agreement should establish a Service-Level Agreement (SLA). The SLA should clearly define the responsibilities for quality and delivery of the data.

It is recommended that data exchange performance is monitored in accordance with key performance indicators (KPI) as agreed in the SLA.

### Access to Information

SLAs should clearly state requirements for provision, security, confidentiality and permitted use of all externally exchanged information.

Clear and realistic principles and rules regarding access to AIS and other broadcast data should be established by the VTS Authority. These principles and rules should recognise national and international legislation and guidance.

The reception and use of data, broadcast by radio, is subject to ITU-R: Radio Regulations [2], article 17 on Secrecy.

### Data Security and Confidentiality

There are many instances where data is deemed sensitive and needs to be protected for competitive and privacy reasons. Examples of this include fleet information or location of fishing grounds. In both cases, unsecured data could compromise investors or introduce competitive advantages/disadvantages.

In many cases confidentiality is already protected by legislation but this is not universal throughout the maritime domain. Furthermore, the requirement to protect access to data may go beyond the limits of primary legislation. Confidentiality measures should to be taken to protect information to the required security level through data encryption, password protection, proper authentication, and restricted data access privileges.

Authentication means that the sending and receiving parties are able to unambiguously identify each other.

Encryption may be used to ensure that data is only accessible to authorised parties. The level of encryption required depends on the sensitivity of the data.

### Legal Limitations

Many national states, in the lawful exercise of their authority, place legal limits on the exchange and public dissemination of data and information. These include protections on intellectual and commercial property rights, and limitations on third party use of data and information.

In the course of exchanging maritime data and information in the interest of safety, security and efficiency, these limitations shall be respected and the authorities involved should be aware of their rights and obligations under law. In particular, data transmitted should be consistent with the laws of the national authority. Authorities need to be aware of any exposure to liability that might occur from their actions or inactions with regard to data and information exchange.

### Data Integrity

Data integrity is a key concern for users and providers alike. For instance, key navigation decisions should be based upon timely, accurate and consistent data.

Timely data is data that is received when needed. This may be in advance of an event or real-time as appropriate. For data that is required in advance of an event, such as notification of arrival, legislation typically determines the lead time in which the data is required by the VTS Authority. It is the responsibility of the sender to ensure that sufficient time is allocated for the data to be communicated and received ahead of the event.

Real-time data should be time stamped as close as possible to the time of capture. Network latency should also be considered when exchanging time-critical data. Within IP networks, the concept of Quality of Service (QoS) may be used to prioritise the delivery of time-critical data. In such a case, it is important that QoS be implemented from source to destination, as data may travel through multiple IP networks.

Data often travels circuitous routes undergoing multiple handovers, from source to destination, allowing for corruption to occur either accidentally or through deliberate actions. Where required, appropriate measures should be taken to avoid such data corruption (e.g. by encryption of the data).

### Data Models

Exchange of data requires an understanding of how the data values are represented and their meaning. The former is specified by data format; the latter is reflected in the data model.

The data model unambiguously defines the:

* semantics of the data fields;
* structure of the data;
* permissible ranges of a data field.

The IHO S-100 standard (ref. [4]) is a framework standard intended to allow development of data models and associated product specification for a variety of common and maritime specific information. Data models, used in the domains of maritime safety, security or, more generally, describing data for exchange by VTS, are maintained in the IHO GI Registry.

### Architecture of Sharing

Transfer of data may initiated by the sender or the receiver. This may be an automated process or require manual intervention.

### Storage

The volume of data generated and stored is, in many cases, considerable. Given that much of the historical data collected is required for analysis and planning, consideration should be given to providing adequate capacity for retaining and archiving these records.

Some formats are well-suited for transfer and sharing of data and maritime information whereas others are better suited for long term archiving of data.

### Communication Links

The transfer of data between sender and receiver requires connectivity via a network. A network comprises appropriate hardware and software interconnected by communication channels. In the maritime world, both aboard ship and shore side, data links may consist of a combination of wired and wireless network segments.

Different technical solutions and architectures can be used when establishing a data sharing network. Consideration should be given to the:

* physical distance between the sending and receiving parties;
* services provided by the network;
* quality of services requested by the users;
* constraints on infrastructure.

Global sharing of maritime data and information can take place either through the internet or through dedicated private networks. The internet is public, while dedicated networks are generally closed. Consideration should be given to the security related characteristics of these network types.

Systems used for global sharing of maritime data and information are in reality a network of networks. When designing a network for global sharing of maritime data, consideration should be given to transmission protocols, bandwidth limitations, communication / data distribution strategy, security aspects such as authentication and confidentiality as well as data integrity.

A selection between the options available should be based on a number of criteria, including the type of data being transferred, volume of data, types and number of clients connected to the network.

Although bandwidth cost is in decline, the value of conveyed information has to be balanced against the cost of transmitting it. Additionally, the required data transmission speed needs to be assessed and agreed in context with associated costs. Another trade-off is the speed at which the data needs to be transmitted. Higher bandwidth links infer higher costs.

1. EXAMPLE OF AN ANNEX - LANDSCAPE

Body text

1. example of ANNEX heading level 1

Body text

* 1. example of annex heading level 2

Body text

* + 1. Example of annex heading level 3

Body text

* + - 1. Example of Annex heading level 4

Body text

1. Example table caption

| No | Title/Topic | IMO References | Requirements | Possible Audit Questions | Remarks |
| --- | --- | --- | --- | --- | --- |
| 1 | Table text | Table text | Table text | Table text | Table text |
| Table text | Table text |
| Table text | Table text |

1. EXAMPLE OF AN APPENDIX TITLE
2. APPENDIX HEADING 1

Body text

* 1. APPENDIX HEADING 2

Body text

* + 1. APPENDIX HEADING 3

Body text

* + - 1. Appendix Heading 4

Body text

1. (EXAMPLE ANNEX TITLE)
2. Introduction (Example Annex Heading 1)

Body text.

* 1. Example of ANNEX HEADING Level 2

Body text

* + 1. Example of annex heading level 3

Body text

* + - 1. Example of Annex heading level 4

Body text

1. PERMITTED COLOUR PALETTE

The IALA colour palette is divided in 3 palettes of different level of hierarchy that has to be respected.

Corporate colours (Not shown)

IALA’s corporate colour palette is directly inspired from the colours in our logotype:

* dark blue
* white
* yellow
* gradient blue

Primary & secondary colours

The primary colours are to be applied in complement with the corporate colours.

This second level of colours gives rhythm and helps to segment our publications.

The secondary colours are used to highlight information, titles in a minor proportion only.

These colours can’t be replaced by other tints.

**PANTONE PROCESS CYAN C CMYK :** C 100

**RGB :** R 0 - G 159 - B 223

**CMYK : 50 % OF THE TONE RGB :** R 131 - G 208 - B 245

**CMYK : 50 % OF THE TONE RGB :** R 148 - G 217 - B 213

**CMYK : 50 % OF THE TONE RGB :** R171 - G 219 - B 233

**CMYK : 50 % OF THE TONE RGB :** R 178 - G 193 - B 237

**PANTONE 326C CMYK :** C 81 - Y 39

**RGB :** R 0 - G 175 - B 170

**PANTONE 7703 C**

**CMYK :** C 79 - M 2 - Y 10 - K 11

**RGB :** R 0 - G 181 - B 208

**PANTONE 660 C CMYK :** C 88 - M 50

**RGB :** R 64 - G 126 - B 201

**CMYK : 20 % OF THE TONE RGB :** R 212 - G 237 - B 252

**CMYK : 20 % OF THE TONE RGB :** R 213 - G 240 - B 237

**CMYK : 20 % OF THE TONE RGB :** R 216 - G238 - B 245

**CMYK : 20 % OF THE TONE RGB :** R 218 - G 223 - B 246

**PANTONE 258 C CMYK :** C 51 - M 79

**RGB :** R 153 - G 80 - B 159

**CMYK : 50 % OF THE TONE RGB :** R 201 - G 169 - B 208

**CMYK : 50 % OF THE TONE RGB :** R 183 - G214 - B 155

**CMYK : 50 % OF THE TONE RGB :** R 246 - G 174- B 135

**CMYK : 50 % OF THE TONE RGB :** R 157 - G 157 - B 156

**PANTONE 739 C**

**CMYK :** C 78- Y 95- K 5

**RGB :** R82 - G 174 - B 50

**PANTONE 2347 C**

**CMYK :**M 88 - Y 100

**RGB :** R 230 - G 56 - B 17

**PANTONE COOL GRAY 11 C CMYK :** K 100

**RGB :** R 87 - G 87 - B 86

**CMYK : 20 % OF THE TONE RGB :** R 232 - G 221 - B 288

**CMYK : 20 % OF THE TONE RGB :** R226 - G 238 - B 217

**CMYK : 20 % OF THE TONE RGB :** R 253 - G 224- B 208

**CMYK : 20 % OF THE TONE RGB :** R218 - G 218 - B 218

**CMYK : 10 % OF THE TONE RGB :** R 237 - G 237 - B 237

Guideline

Recommendation

Model Course

PRIMARY COLOURS

SECONDARY COLOURS