Document Revisions

This document has been reformatted in accordance with the IALA template

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**IALA Recommendation V-128**

**On**

**Operational and Technical Performance Requirements for VTS Equipment**

**Edition 4.0**

**[Date Issued]**

**Edition 3.0 – June 2007**

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

|  |  |  |
| --- | --- | --- |
| **Date** | **Page / Section Revised** | **Requirement for Revision** |
| May 2005 | Addition of Appendix 6 – Hydrological and Meteorological equipment | Appendices added as they are completed to ensure all aspects of VTS equipment are covered. |
| December 2005 | Restructured to include operational performance requirements.  Appendix 2 amended to reflect new annex on operational performance requirements.  Appendix 6 renamed to Appendix 5  Appendices 1,3,4,6 added | Appendices added as they are completed to ensure all aspects of VTS operations and equipment are covered. |
| June 2007 | Editorial changes to correct errors in paragraph numbering, cross references etc.  Structure of appendices harmonized, part of Appendix 2 moved to new IALA Guideline (Establishment of Radar Services)  Clarification of text, few sentences in Appendix 1 and 2. | Inconsistence in cross references, table of contents etc. in edition 2.0  Varying structure of individual annexes  Users of the document provided ideas to clarification of text on some subjects. |
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|  |  |  |

IALA Recommendation on Operational and Technical Performance Requirements for VTS Equipment

(Recommendation V-128)

THE COUNCIL:

**RECALLING** the function of IALA with respect to Safety of Navigation, the efficiency of maritime transport and the protection of the environment;

**NOTING** that Chapter V (12) of the International Convention for the Safety of Life at Sea 1974 (SOLAS 74 as amended) requires Contracting Governments planning or implementing VTS wherever possible to follow the guidelines adopted by the Organization by Resolution A. 857(20);

**NOTING ALSO** that IMO Resolution A.857(20), Annex section 2.2.2 recommends that in planning and establishing a VTS, the Contracting Government or Governments or the competent authority should inter-alia establish appropriate standards for shore and offshore-based equipment;

**NOTING FURTHER** that National Members provide shore infrastructure to support the aim of IMO to improve the safety of navigation and the protection of the environment;

**RECOGNISING** that that IALA fosters the safe, economic and efficient movement of vessels through improvement and harmonisation of aids to navigation, including vessel traffic services, worldwide;;

**RECOGNISING ALSO** that harmonisation of vessel traffic services would be enhanced by the introduction of international technical performance requirements for VTS;

**HAVING CONSIDERED** the proposals by the IALA VTS Committee on Operational and Technical Performance Requirements for VTS;

**ADOPTS** the proposals by the IALA VTS Committee on Operational and Technical Performance Requirements for VTS in the annex of this recommendation; and,

**RECOMMENDS** that National Members and other appropriate Authorities providing Vessel Traffic Services take into consideration the appropriate Operational and Technical Performance Requirements contained in the Appendices to this recommendation when establishing appropriate standards for shore and offshore-based VTS:

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Annex

**Operational and Technical Performance Requirements for VTS Equipment**

1. CORE OPERATIONAL REQUIREMENTS FOR VTS
2. Introduction

In 1997 the IMO Maritime Safety Committee adopted Regulations for Vessel Traffic Services (VTS) that have since been included in SOLAS Chapter V (Safety of Navigation) as Regulation 12.This Regulation specifies the responsibilities of contracting governments to arrange for the establishment of VTS in certain vulnerable areas under their control.

The purpose of this Recommendation is to assist the VTS authority in the definition, establishment and upgrades of a VTS system. The document addresses the relationship between the Operational Requirements and VTS system performance requirements. More specifically:

* Recommended capabilities of the System vs. VTS Services provided
* Sensors
  + Radar
  + Automatic Identification System (AIS)
  + Radio Direction Finders (RDF)
  + Electro-Optical Equipment (EO)
  + Hydro/meteo
* Communications between ship and shore
* Data Processing and Display
* External Information Exchange
* Test and acceptance criteria

## Abbreviations

|  |  |
| --- | --- |
| AIS | Automatic Identification System |
| ASL | Above Sea Level |
| CCTV | Closed Circuit Television |
| CPA | Closest Point of Approach |
| EIA | Electronics Industry Association |
| ETA | Estimated Time of Arrival |
| ETD | Estimated Time of Departure |
| IALA | International Association of Marine Aids to Navigation and Lighthouse Authorities |
| IEEE | The Institute of Electrical and Electronic Engineers |
| IMO | International Maritime Organization |
| ITU | International Telecommunication Union |
| MMSI | Maritime Mobile Service Identity |
| MRCC | Maritime Rescue Co-ordination Centre |
| nm | Nautical Mile |
| RDF | Radio Direction Finder |
| RMP | Recognized Maritime Picture |
| S-band | 2.0 – 4.0 GHz |
| TCPA | Time to Closest Point of Approach |
| VHF | Very High Frequency |
| VTS | Vessel Traffic Services |
| VTSO | Vessel Traffic Services Operator |
| X-band | 8.0 – 12.0 GHz |
| º | Degree |
| ≤ | Less than or equal to |
| ± | Plus or minus |

## Supporting document

|  |  |
| --- | --- |
| IEEE Std 686-1997 | IEEE Standard Radar Definitions |
| The International Organisation for Standardisation (ISO) | ISO 8729 Ships and marine technology – Marine radar reflectors |
| EIA Standard RS-170 | Electronics Industry Association Recommended Standard RS-170 |
| IALA Guideline 1056 | Guideline for VTS radar service |

# Core Operational Requirements for a VTS System

The main functions of a VTS are to mitigate risks associated with shipping and to improve efficiency. The different types of risks and environments have led to various types of VTS including coastal and offshore, port, estuary or inland VTS.

For instance a coastal VTS assist the safe and expeditious passage of shipping through coastal waters, particularly where there is a high density of maritime traffic or an area of environmental sensitivity or through difficult navigation conditions. Similarly, a port, estuarial or inland VTS support shipping when entering or leaving ports and harbours or when sailing along rivers or through restricted waters.

An important task of an offshore VTS is to avoid ships collisions with offshore structures e. g. oil platforms and wind farms.

All VTS types may offer, in principle, all services as defined in the IMO resolution A.857(20). When determining the required performance of a VTS system, the following should be taken into account:

* The identified risks
* The type of VTS (coastal and offshore, port, estuary or inland VTS)
* The VTS services to be provided (INF, TOS, NAS)
* Requirements from Allied Services
* Types and number of targets
* The geographical area
* Prevailing meteorological conditions

All the above factors determine the complexity of the traffic situation. In addition, specific operational requirements such as the need to detect small targets in adverse conditions or ice monitoring, may increase the required performance.

In order to facilitate the definition of required performance, three levels of capabilities for VTS are defined as follows:

* • Basic – performance for a VTS area with low complexity, where an Information Service and/or a Navigational Assistance Service will be provided.
* • Standard – performance for a VTS area with low or medium complexity, where an Information Service, Navigational Assistance Service and /or a Traffic Organisation Service will be provided.
* • Advanced – performance for a VTS area with high complexity and/or specific operational requirements.

A risk assessment and the determination of the specific operational conditions shall be made by the VTS authority prior to the allocation of capabilities.

## Allocation of Capabilities to meet Operational Requirements

Requirements of the VTS equipment may have a high impact on acquisition and life-cycle costs of a VTS system and therefore is paramount to properly allocate capabilities to satisfy Operational Requirements..

**A specific capability could be assigned to an entire VTS area or to particular subsections as illustrated in the example shown in Figure 1**



1. Example of assigned capabilities in a Generic VTS area, by the VTS authority

Advanced capability was chosen in areas (A, B and C) for the following reasons:

* Dangerous cargo imposes a high risk to environment and populated areas
* Security, including the need for detection of small targets
* Dense traffic in a complex separation scheme including a bridge crossing

Standard capability was chosen in areas (D, E and F) for the following reasons:

* • Wind farm close to a traffic lane imposes a navigational hazard
* • Traffic in confined areas such as Ports and Inland waterways

Basic capability was chosen for the remainder of the VTS area (G)

# VTS System Considerations

## General

A VTS System should have the capability to be flexible and easily upgraded and maintained alongside the routine operations of the VTS Centre without the need for interrupting the service.

## Availability

VTS Centres should operate within a dual server environment to minimise disruption to normal operations.

The requirements for the availability of Communications are a matter for the VTS Authority to determine.

## Recording, Archiving And Replay

Provision should be made for the storage, security, retrieval and presentation of this information.

The data type, resolution and period of time for which information gathered by a VTS is required to be stored should be identified in internal procedures. This time period should be such that it allows for the full retrieval of data post-incident/accident, in compliance with national requirements and those of the incident/accident investigation procedures of the VTS authority and other authorised parties. This type of information should include:

* Communications, internal and external as defined in IALA Recommendation V-127;
* Sensor data, i.e. data used to generate the traffic image such as radar, CCTV, AIS and long-range sensor data;
* Shipping information data, i.e. vessel and cargo data, including vessel movement information;
* Meteorological and hydrological data;
* Data from other sources if relevan;
* Synchronization of voice / track data

The IMO recommends a minimum of 30 days for the time-period to allow for the full retrieval of data post-incident/accident. The VTS authority should define the period of time and temporal resolution of sensor data and other tracking performance parameters depending on traffic density and types of tracks.

If required by the VTS Authority, the data should be recorded automatically and capable of being replayed onto a separate replay system.

Recording, Archiving and Replay

The period of time for which information gathered by a VTS is required to be stored should be identified in internal procedures. This time period should be such that it allows for the full retrieval of data post-incident/accident, in compliance with national requirements and those of the incident/accident investigation procedures of the VTS authority and other interested parties. This type of information may include:

* Communications (internal and/or external)
* Sensor data (i.e. data used to generate the traffic image such as radar, CCTV, AIS)
* Shipping information data ( e.g. vessel and cargo data, including vessel movement information)
* Meteorological and hydrological data, and
* Data from other sources.

Provision should be made for the storage, security, retrieval and presentation of this information.

IALA Recommendation V-127 On Operational Procedures for Vessel Traffic Services Edition 1 June 2004

# Back up and fall-back arrangements

## Redundancy

Depending on the services that a VTS is to carry out, the radar coverage can be:

* nil (automatic identification systems, voice communication and reporting only);
* partly (covered areas chosen intentionally with some blind sectors);
* totally by one radar sensor (without any blind sectors);
* totally by two or more radar sensors (for large VTS areas and to cover for shadow effects of other vessels). Stereographic processing of images from 2 or more radars may also be utilised for elimination of false (ghost) echoes.

Error! Reference source not found. specifies the recommended availability for individual radar sites and suggests the redundancy typically employed. Overlap in coverage may reduce the need for equipment redundancies at the individual radar site.

1. Redundancy

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Availability and redundancy** | | | | | | | |
|  | | Recommendation level | | | | | |
| Basic | | Standard | | Advanced | |
| Recommended availability for the individual radar site | | 99 % | | 99.7% | | 99.9% | |
| Accessibility to site | | Easy | Difficult | Easy | Difficult | Easy | Difficult |
| Redundancy typically required | Yes |  |  |  | X | X | X |
| No | X | X | X |  |  |  |

1. Performance Functions

|  |  |  |  |
| --- | --- | --- | --- |
| Parameters / Capability | Basic | Standard | Advanced |
| Path, time and track prediction, |  |  | X |
| CPA, | X | X | X |
| TCPA, | X | X | X |
| Anchor watch, |  |  | X |
| Vessels vector, | X | X | X |
| Course, speed and label/identity, | X | X | X |
| Collision alerts. | X | X | X |

### Availability

The VTS authority should define the requirements for the availability of the radar service. The recommendations for availability are listed in Error! Reference source not found below.[[1]](#footnote-1)

1. Availability

|  |  |  |  |
| --- | --- | --- | --- |
| Availability for radar service | | | |
|  | Type of Capability | | |
| Basic | Standard | Advanced |
| Recommended availability for the radar service | 99 % | 99.6 % | 99.9 % |

Availability is defined in IMO Resolution A.915 (220 Ref.40) as:

“The percentage of time that an aid, or system of aids, is performing a required function under stated conditions. The non-availability can be caused by scheduled and/or unscheduled interruptions”.

Where the coverage from two or more radar sites provides overlapping coverage, as long as one of the radars is available and provides similar capabilities in the area of waterway normally covered, the requirements for radar service are met. Thus from a service perspective, unusable time for a waterway can be calculated as the time when any portion of the waterway is without a usable radar.

The radar coverage provided by adjacent countries, may, if agreed, be taken into account when calculating the performance of the VTS radar. In addition, in areas of high traffic where two waterways meet with converging traffic the location of radar sites should be determined in a manner that minimises shadowing.

Single coverage: Unless dual coverage is provided throughout the whole coverage area, some VTS sites provide a mix of overlapping and single radar coverage. VTS sites that provide single coverage to at least some portion of a waterway are considered to be single coverage sites.

4.1.2 Calculation

Administrations may choose to calculate service availability using one of two methods:

- by waterway model, or

- by radar site/ radar site combination model

Waterway availability model: In this model administrations need to define which waterways are high risk and which waterways are low risks. Separate calculations for high and low risk are required, providing both exist within the coverage area. Individual waterway availability calculations are then averaged to produce one figure for each waterway risk category. If desired, a figure for each waterway may be reported.

Radar site availability model: In this model, administrations must define which radar sites serve low risk waterways and which serve high risk waterways. The overall availability is calculated by averaging the availability of the associated individual radar sites as illustrated in the examples below.

Example 1: An Advanced site receives complete radar coverage. For example, a VTS area having two radar sites where at Radar site A the availability was 99% and Radar site B’s availability was 99,7%, but both radar sites suffered coincidental outages during 0,1% of the period. Although neither radar site individually met the availability target the combined availability was 99.9% and met the performance goal achieved.

Example 2: A Basic site receives coverage from radar site A (as above) covering a low risk waterway. Radar site C, adjacent to radar site A, provides completely overlapping coverage to the low risk waterway portion served by radar site A. Radar site C’s performance was 99%, but neither unusable period (of radar sites A and C) coincided. The low risk waterway covered by radar site A received usable signals for 100% of the time.

While these two distinctly different situations have different availability requirements based upon the level of risk, the concept of availability remains consistent – the minimum requirement is met for the coverage area.

Note: Higher availability percentage targets may be applicable to more critical parts of the VTS area. Risk assessment may support lower availability percentage targets in less critical areas.

# Marking and identification

All equipment should be marked with manufacturer name, type and serial number.

Local or national legislation may require signposts etc.

National and/or local regulations may require the posting of signs to notify the public that they are under surveillance.

# Documentation

Documentation should be provided in accordance with the IALA VTS Manual.

# SAFETY PRECAUTIONS

No specific safety requirements in addition to resolution A. 694(17).

1. PERFORMANCE REQUIREMENTS – RADAR
2. Introduction

The purpose of this Annex is to support VTS authorities and integrators in the selection of radar sensors for new and existing VTS systems. The radar solution to a given VTS application may consist of one or more networked radar sensors. Unlike other applications, VTS radars normally need to operate simultaneously on short and long range and this leads to receiver dynamic range requirements that far exceed, for example, those required on board a ship. However, in some cases a marine navigational radar may fulfil requirements in a VTS area with low complexity or as a gap filler within a radar sensor network.

Weather-related phenomena pose significant challenges to the design and specification of radar sensors. Ducting, for example, may influence VTS radars more than ships’ radars. Additionally, more effective clutter suppression for sea, rain and land may be required than that normally associated with a conventional shipboard radar.

Specific security objectives also introduce particular challenges to the radar sensor where there could be a need to detect small targets in heavy clutter conditions or where small versus large target discrimination is essential.

The use of multi-sensor integration, including radar, AIS and other sensors, imposes additional demands on radar sensor performance and accuracy. False and inaccurate information from the radar, when improperly associated with information from other radars or sensors, may lead to increased risks to safe navigation and security-related decisions. Such false and inaccurate information can arise from antenna side lobes, time side lobes, doppler side lobes, ghost targets (multiple reflections), range ambiguous returns and inappropriate data processing. Appropriate assessment of data integrity and accuracy from the radar sensor(s) is a vital requirement arising from the overall VTS solution.

1. References
2. IEEE Std 686-1997 IEEE Standard Radar Definitions
3. Merrill I Skolnik Introduction to Radar Systems, McGraw-Hill Higher Education, ISBN 0-07-290980-3
4. P.D.L. Williams, H.D, Cramp and Kay Curtis Experimental study of the radar cross section of maritime targets, ELECTRONIC CIRCUITS AND SYSTEMS, July 1978. Vol 2. No 4.
5. Ingo Harre RCS in Radar Range Calculations for Maritime Targets. http://www.mar-it.de/Radar/RCS/RCS\_18.pdf
6. IMO Performance Standards for radar reflectors (latest edition)
7. International Telecommunications Union (ITU) ITU-R SM.1541 Unwanted emissions in the out-of-band domain
8. International Telecommunications Union (ITU) ITU-R SM.329-9 Spurious emissions
9. The International Organisation for Standardisation( ISO) ISO 8729 Ships and marine technology – Marine radar reflectors
10. IALA IALA Guideline No. 1056 for VTS radar service
    1. Software tools
       1. CARPET

Computer Aided Radar Performance Tool

TNO (Toegepast Natuurkundig Onderzoek) Physics and Electronics Laboratory, P.O.Box 96864, 2509 JG The Hague, Netherlands, http://www.tno.nl

* + 1. AREPS

Advanced Refractive Effects Prediction System

Space and Naval Warfare Systems Center, San Diego, http://sunspot.spawar.navy.mil.

1. Definitions and Clarifications
   1. Definitions

For general terms used throughout this annex refer to:

* IEEE Std 686-1997 IEEE Standard Radar Definitions.

Specific terms are defined as follows:

* Antenna Side Lobes
* Availability is the probability that a system will perform its specified function when required.
* Blind Spots
* Chirp
* Coherence
* Doppler
* Doppler Side Lobes
* FMCW
* Ghost Target
* Noise figure
* Normal weather and propagation conditions are the conditions persisting 99% - 99.9 % of the time as defined by the individual VTS authority. The rest of the time is considered having adverse weather and propagation conditions.
* Polarisation of a radar signal is determined by the orientation of the electrical field. In the case of circular polarisation the field rotates left or right.
* Pulse
* Pulse Compression
* Radar as referred to in this document relates to all aspects of the radar from sensor through to the presentation of radar to the VTS operator.
* Radar Cross Section
* Radar PD is the probability of detection at the output of a radar, subsequent to signal processing and plot extraction, but prior to tracking, and presentation.
* Radar PFA is the probability of false alarm at the output of a radar
* Range ambiguous returns
* Reliability is the probability that a system, when it is available performs a specified function without failure under given conditions for a given period of time.
* Sea characteristics include wave/swell height, direction and speed of waves/swell and distance between waves/swell.
* Squint is the angular difference between the axis of antenna rotation and a selected geometrical axis.
* Target fluctuations
* Track swap is the transfer of a track identity (track label) to another track
* Time Side Lobes.
  1. Abbreviations

AIS Automatic Identification System

AREPS Advanced Refractive Effects Prediction System

ASL Above Sea Level

CARPET Computer Aided Radar Performance Evaluation Tool

CW Continuous Wave

dB DeciBel

dBi DeciBel isotropic

dBm DeciBel milliWatt

DF Direction Finder

FMCW

FTC Fast Time Constant

GHz GigaHertz

GIT Georgia Institute of Technology

GPS Global Positioning System

IALA International Association of Marine Aids to Navigation and Lighthouse Authorities

ICAO International Civil Aviation Organization

IEC International Electro-Technical Commission

IEEE The Institute of Electrical and Electronic Engineers

IMO International Maritime Organisation

ITU International Telecommunication Union

kHz kiloHertz

Ku-band 12.0 – 18.0 GHz

kW kiloWatt

LNFE Low Noise Front End

m metre

m2 square metre

MDS Minimum Detectable Signal

MHz MegaHertz

mm/h millimetre per hour

m/s metre/second

MSC Maritime Safety Committee

MTBF Mean Time Between Failure

MTTR Mean Time to Repair

N/A Not applicable

NM Nautical Mile (also nmi)

PD Probability of Detection

PFA Probability of False Alarm

PRF Pulse Repetition Frequency

PW Pulse Width

R Range

RCS Radar Cross Section

RF Radio Frequency

S-band 2.0 – 4.0 GHz (NB military designation is F-band)

UTC Universal Time Co-ordinated

UTM Universal Transverse Mercator

VTS Vessel Traffic Services

X-band 8.0 – 12.0 GHz (NB military designation is I-band)

µs microsecond

º Degree

> Greater than

≥ Greater than or equal to

≤ Less than or equal to

1. Target Detection and Target Measurement Process

The target detection and target measurement process is so complex that full appreciation requires in depth knowledge of radar target characteristics and behaviour, the surrounding environment and the radar technologies applied. This document provides an overview of the major considerations in the translation of the Operational Requirements (VTS) into Technical Specifications (radar sensor(s)).

* 2. Characteristics of the Radar Target

The main characteristics of VTS radar targets are defined by their height above sea level, their radar cross section (RCS) and the fluctuations in RCS.

Table 4 lists these typical characteristics for targets relevant to VTS, based on [3]

* + 1. Radar Cross Section

A target may be observed when transmitted radio energy is reflected back from the target to the receiver. The amount of energy reflected is directly proportional to the radar cross section of the target.

Formally, the RCS is defined as the ratio between the power [in W] scattered by the target back towards the radar receiver and the power density [in W/m2] hitting the target. Thus RCS is measured in m2 and has the dimensions of an area.

Note that there is no simple relationship between the physical size of the target and the RCS. The reflected energy depends on several factors, such as the radar operating frequency or frequencies, the angle of incidence of the radio waves, target speed, material and geometry.

The RCS of a target can fluctuate severely as a result of target movements and environmental effects with consequences on the display of related target information.

1. Typical target characteristics

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Target types** | | **Typical characteristics at X-band** | | |
| **RCS** | **Height** | **Fluctuations etc.** |
| 1 | Aids to Navigation without radar reflector. | Up to 1 m2 | 1 to 4 m ASL | Rapidly fluctuating, highly dependent on sea characteristics. |
| 2 | Aids to Navigation with radar reflector. | 10 – 100 m2 | Rapidly fluctuating, wind and currents may tilt to blind angles and lobing may cause reflectors to be in blind spots. |
| 3 | Small open boat, fibreglass, wood or rubber with outboard motor and at least 2 persons onboard, small speedboat, small fishing vessels or small sailing boats. | 0.5 – 5 m2 | 0.5 to 1 m ASL | Rapidly fluctuating may be hidden behind waves up to 50 % of the time.  Slow moving targets tend to lie lower in the water than fast moving ones and therefore RCS visible to the radar tends to increase with speed. |
| 4 | Inshore fishing vessels, sailing boats and speedboats, equipped with radar reflector of good quality. | 3 – 10 m2 | 1 to 2 m ASL | Rapidly fluctuating. |
| 5 | Small metal ships, fishing vessels, patrol vessels and other similar vessels. | 10 – 100 m2 | 2 to 4 m ASL |
| 6 | Coasters and other similar vessels. | 100 – 1000 m2 | 6 to 10 m ASL | RCS is highly dependent on aspect angle of the individual vessel. Rate of fluctuations is typically moderate. |
| 7 | Large coasters, Bulk carriers, cargo ships and other similar vessels. | 1000 – 10,000 m2 | 10 to 25 m ASL |
| 8 | Container carriers, tankers and other similar vessels. | 10,000 – 1,000,000 m2 | 15 to 40 m ASL |
| 9 | Buildings, cranes. Stacks of containers and other large structures. | Up to 1,000,000 m2 | Depends on site | Insignificant. |
| 10 | Floating items, oil drums and other similar items. Birds, floating or flying. | Up to 1 m2 | 0 to 0.5 m ASL | Rapidly fluctuating, highly dependent on sea characteristics. |
| 11 | Flocks of birds. | Up to 3 m2 | Sea level and up | Rapidly fluctuating, flight paths tend to be characteristic of given species in given areas of interest. |
| 12 | Jet Skis and other personal water craft | Up to 0.5 m2 | 0 to 1 m ASL | Rapidly fluctuating but virtually independent of aspect angle |
| 13 | Wind turbines (onshore and offshore) |  |  | TBA |

* 1. ???

The above table may contain target information which some users might view as clutter (land etc). Modern warship design seeks to minimise RCS and as a result the above figures cannot be related to such vessels.

* + 1. Influence from Wind farms

Wind turbines produce large static target-like returns, which, from a VTS Operator’s perspective, are normally easy to distinguish from vessel traffic. The complex return from a wind turbine is made up of two key elements: the tower and generator housing (offering a large static zero-doppler RCS) and the rotating blades of the turbine (offering a complex spread of non-zero-doppler RCS that can vary with wind direction and speed). This complex return will be seen as a large static target by conventional pulse radar whereas FMCW and coherent radars using doppler processing will see a complex target spread across the doppler domain. Solid state radar technology (with or without doppler processing) using pulse compression techniques may suffer reduced detectability due to time side lobes associated with these large static returns.

The symmetrical lay out of off-shore wind farms may in addition result in unwanted ghost echoes. The mechanisms can be analysed, and mitigation measures may include radar positioning and the use of multiple sensors to cover affected areas.

Illustration to be added

1. Title required
   * 1. Influence from bridges, power lines, oil rigs and other like obstructions

Bridges, power line pylons and off-shore structures produce large static target-like returns, which, from a VTS Operator’s perspective, are normally easy to distinguish from vessel traffic. Solid state radar technology (with or without doppler processing) using pulse compression techniques may suffer reduced detectability due to time side lobes associated with these large static returns.

* + 1. Characteristics of the Environment

The main characteristics of the environment affecting radar operation are defined by atmospheric conditions affecting propagation, precipitation and the characteristics of the sea and land surfaces.

* 1. Propagation conditions

The density of the atmosphere is not uniform with altitude, and gradients results in bending of the radio waves. Water in the atmosphere is the primary contributor to this, but temperature and pressure gradients will also affect.

The temperature and humidity gradients in the air above the sea surface cause the radar beam to be bent up or down - in most cases down - and to follow the earth’s curvature to some extent, thereby elongating the range for potential target detection. This condition is known as super refraction, or ducting.

Insert figure from www radartutorial.eu

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Main effects are that:

* The air in contact with the ocean’s surface is saturated with water vapour. In clear conditions, the air is not usually saturated a few meters above the surface, so there is a decrease of water vapour pressure from the surface to an altitude, typically 5 – 30 meters above the surface. Such a change in the moisture distribution without an accompanying temperature change, forms a so-called evaporation duct, leading to extended radar range, especially for low mounted antennas.
* Surface based ducts
* Elevated ducts
* Ducting can be strong and form trapping layer(s), resulting in wave-guide like duct (s),

Inset illustration of surface based and elevated duct.

1. Title required
   * + 1. Evaporation ducting

For most parts of the world evaporation ducting tends to persist in all clear weather conditions, giving extended range. The effect will give average improvement in detection performance and may therefore be very useful in respect to security applications, if required. The effect is usually not stable enough to be calculated in safety applications

Tropical climate will present radars for extensive layers of evaporation ducting, typically increasing the amount of incoming noise and thereby affecting performance if not properly considered in the system design.

Arctic climate ….

* + - 1. Surface based and elevated ducting
      2. Trapping layers
      3. Special concerns for dry, hot desert areas of the world

Dry and hot climate as that existing in desert areas may result in layered atmospheric conditions, potentially with severe impact on radar performance.

* + 1. Precipitation
    2. Sea surface conditions
    3. Land surface conditions
  1. 1Characteristics of the Radar

VTS radars could be of the following types:

* Pulse Radar (usually Magnetron based)
* Pulse Compression radar (usually Solid State)
* Frequency Modulated Continuous Wave, FMCW (usually Solid State)

A general explanation of each radar type follows

* + 1. Pulse Radar

A pulse radar transmits high peak power RF pulses (10 to 50 kilowatt) for very short duration (50 to 500 nano seconds). The transmission is made with a pulse repetition frequency (PRF) of typically 1000 to 4000 pulses per second. Upon reception, the returned signal is amplified, demodulated and processed.

Main characteristics include:

* It is a well-known and proven technology
* Increased pulse duration translates into longer-range detection, but poorer range resolution and less ability to penetrate adverse weather conditions.
* The need for periodic Magnetron replacement
* Fixed transmission frequency(ies)
* Requires for transmission wide frequency band(s)

Additional challenges include:

* The need to reduce out of band transmissions. Note that ITU requirements for shipborne radar are less stringent than for land based radar.
  + 1. Pulse Compression radar

A pulse compression radar transmits low peak power modulated chirps (up to 200 watts and eventually higher) with a duration of up to 100 micro seconds. The transmission is made with a chirp repetition frequency of typically 1000 to 20000 chirps per second. Upon reception, the returned signal is amplified, pulse-compressed and processed

The energy in the chirp of a pulse compression radar is comparable to the energy emitted in a pulse from a magnetron radar. The longer chirps are converted into short pulses upon reception by the process of pulse compression; therefore high range resolution can be maintained at all ranges and at all times.

Main characteristics include:

* It is based on well-known and proven principles, but the high power at high frequency solid state amplifier technology relies on recent developments;
* No need for Magnetron replacement due to solid state power amplifier, reducing the need for periodic maintenance;
* Increased ability to penetrate adverse weather conditions facilitating smaller target detection or reducing constraints on the antenna design;
* Transmission frequencies can be programmed, which adds flexibility;
* Cleaner spectrum, which means that are fewer emissions outside the allocated frequency band(s).

Additional challenges include:

* The need for sophisticated interference rejection due to the longer chirps transmitted
* The need for simultaneous short and long range detection increases complexity
* High power solid state amplifiers operate with large currents, requiring careful design to obtain high reliability
* By nature the pulse compression radar creates so-called time side lobes. Minimising the effect from such sidelobes, requires sophisticated techniques, alternatively sidelobe suppression may imply reduced detectability for small targets in the vicinity of larger targets
  + 1. Frequency Modulated Continuous Wave

Frequency modulated continuous wave radar transmits low peak power, continuous wave forms (typically up to 1 watt, occasionally up to 50 watts). The wave forms are repeated with a typical rate of 500 to 2000 per second. Upon reception, the returned signal is amplified, compressed and processed

The total amount of energy transmitted from frequency modulated continuous wave radar is often very low comparable to the energy emitted in a pulse from a magnetron radar, reducing range detection capabilities. On reception, the signals are amplified and the wave forms are converted into pulses, therefore high range resolution can be maintained at all ranges.

Main characteristics include:

* It is based on well-known and proven principles
* No need for Magnetron replacement due to solid state power amplifier, reducing the need for periodic maintenance.
* The ability to detect from very short range
* Transmission frequencies can be programmed, which adds flexibility
* Cleaner spectrum, which means that are fewer emissions outside the allocated frequency band(s)

Additional challenges include:

* Dynamic limitations restrict the ability to handle small and large target simultaneously. This also affects long range detection
* Target revisit rate is low compared to typical VTS target kinematics
* The need for sophisticated interference rejection, even more than for pulse compression radars
* By nature FMCW creates so-called time side lobes. Suppressing the sidelobes may reduce detectability of small targets in the vicinity of larger targets
* Careful waveform design is required to minimize problems arising from range errors associated with target doppler and resolution of range ambiguities.

11.5.4 Doppler Processing

In principle, all above radar types can be supplemented by doppler processing. This may include a doppler filter bank, giving the radial velocity of received signals or rejection of non moving targets or targets with certain radial velocity by MTI techniques.

Main characteristics include:

* It is based on well-known and proven principles
* Increased visibility of small targets of interest, when sufficiently separated in radial velocity, from clutter.
* Waveform designs can be used to optimize the radar performance in a given application.

Additional challenges include:

* The processing and detection algorithms need to recognize operational need regarding targets with zero speed or targets only moving tangentially.
* Improved detection in clutter is only possible for targets having radial speeds sufficiently different from that of stationary and moving clutter.
* Additional complexity is added and coherent transmit waveforms or alternative techniques are essential to support doppler processing. Therefore, the magnetron based radar is not immediately suitable.
  1. System aspects

The achieved performance of a radar installation can be significantly affected by balanced selection of key components, transmitter, receiver, antenna, signal processing and extraction of information.

* + 1. Transmitter

For all radar types, the average power has an influence on the detection range, however unnecessarily high average power will result in larger amounts of unwanted information (e.g. sea clutter) conflicting with targets of interest. The peak power (not FMCW) is less critical and high peak power may result in higher losses in the transmission lines of the radar.

VTS applications typically require improved range resolution and more effective weather penetration, compared to ships’ navigation radars. This infers a transmitter design with short pulses or pulse compression.

* + 1. Receiver

The receiver sensitivity (often expressed by the receiver noise figure) is one of the main factors with respect to detection of small distant targets in clear weather. The noise figure may be expressed in different terms such as ‘Low Noise Front End (LNFE) noise figure’ and ‘overall noise figure’, making it difficult to compare radars from different vendors.

A better expression for receiver sensitivity is the Minimum Detectable Signal (MDS); however,

this is not ideal either as it may be difficult to measure this figure in a reliable manner.

The dynamic characteristics are very important, especially if operational conditions require:

* Simultaneous detection of targets on short and long range;
* Supply of signals for more than one display with different range settings;
* Simultaneous supply of signals for different operational roles;
* Supply of signals for automatic video processing and automatic tracking.

Minimum detectable signals at the receiver input and processed onwards lie typically at -90 to -105 dBm in VTS applications, or may be as low as -115 dBm for security applications.

Very large targets at close range are, however, not fully within the beam at short range, limiting

the input at the receiver to about + 10 dBm for the typical case.

Consequently, the overall dynamic range needed for the individual radar for a VTS application is typically between 100 and 125 dB.

* + 1. Dynamic characteristics

Graph to be added, remember influence from propagation

1. Title required

The dynamic range of the radar should, in normal weather and propagation conditions, detect and process the surface objects specified in Table 15.2 within the VTS area. This should be done, while avoiding distortion such as:

* Pulse stretch – resulting in any significant disturbance of the radar image or the tracking performance;
* Masking of small targets by larger targets (except if shaded);
* Masking of small targets by the effects of time side lobes (in the case of pulse compression or CW radars).

In addition maximum target sizes and target fluctuations for targets of interest should be considered. Error! Reference source not found. refers.

* + 1. Signal Processing
       1. Clutter and noise reduction facilities

Appropriate, clutter reduction facilities should be available to meet the performance criteria as defined per section 15.5.

This will typically include:

* White noise suppression;
* Sea clutter suppression;
* Rain penetration and volume clutter suppression; and in some cases;
* Adaptation to varying propagation conditions.

The features should preferably be automatic for systems requiring standard or advanced specifications.

* + 1. Antenna
       1. Antenna design
       2. Antenna height

Figure 6 illustrates how the height of the antenna above the water line affects the maximum and minimum detection range performance.



1. Target range & visibility
   * 1. Extraction of information
     2. System losses
2. Functional requirements

The detection capacity required of the system is determined according to the type of service, traffic density and potential navigational hazards. Error! Reference source not found. below describes the typical reflection features and type of capability requirements of VTS targets. The table illustrates typical target parameters, including reflection characteristics, and identifies the detection capabilities required for differing types of targets.

Following assessment of the type of targets required to be detected, which may differ within the VTS area, the table identifies the type of capability required and defines typical characteristics for use in setting performance standards.

When selecting a radar system the system should be designed in such a way that the defined target types can be detected and tracked reliably in the required area covered by the VTS service in visibility conditions, at precipitation rates at sea states and in propagation conditions relevant for the individual radar site.

Note that Radar Cross Section and height of the radar cross section varies substantial with aspect ratio and physical details for the individual target within each category. The figures in table 2.2 are conservative, recommended values for the type of targets listed,

1. Target Reflection Features and Type of Capability recommended

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| TARGET | | Type of Capability | | | Design Requirements | | |
| Basic | Standard | Advanced | Radar cross section | | Height of Target |
| S-band | X-band |
| 1 | Aids to Navigation etc. –without radar reflector. Small open boats, fibreglass, wood or rubber with outboard motor and at least 4 meters long, small speedboats, small fishing vessels, small sailing boats and the like. |  |  | X |  | 1 m2 | 1 m ASL |
| 2 | Inshore fishing vessels, sailing boats, speedboats and the like. |  |  | X |  | 3 m2 | 2 m ASL |
| 3 | Aids to Navigation with radar reflector. |  | X | X | 4 m2 | 10 m2 | 3 m ASL |
| 4 | Small metal ships, fishing vessels, patrol vessels and the like. | X | X | X | 40 m2 | 100 m2 | 5 m ASL |
| 5 | Coasters and the like. | X | X | X | 400 m2 | 1,000 m2 | 8 m ASL |
| 6 | Large coasters, bulk carriers, cargo ships and the like. | X | X | X | 4,000 m2 | 10,000 m2 | 12 m ASL |
| 7 | Container carriers, tankers etc. | X | X | X | 40,000 m2 | 100,000 m2 | 18 m ASL |

* 1. General requirements

The output from a radar should include radar image and track data. The radar facilities provided for VTS should comply with the minimum performance requirements defined by this document.

The individual VTS authority should ensure that the selected system architecture, the equipment, the network capacity, etc. is capable of meeting the performance requirements.

Radar functions should be designed and implemented to optimise performance and minimize operator workload to the level practical. Ideally, only basic functions such as start and stop should be controllable by operators and it is recommended to make adaptation to changing weather conditions, etc. automatic.

* 1. Objects to be detected

The radar in a VTS should be capable of detecting and tracking all types of surface objects defined by the VTS authority in weather conditions normal for the individual site.

Table 6 lists the type of capability recommended in APPENDIX 1 and corresponding target characteristics, to be used for the determination of detection performance.

1. Target Reflection characteristics and Type of Capability

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| TARGET | | Type of Capability | | | Design Requirements | | |
| Basic | Standard | Advanced | Radar cross section | | Height of Target |
| S-Band | X-Band |
| 1 | Aids to Navigation etc. –without radar reflector. Small open boats, fibreglass, wood or rubber with outboard motor and at least 4 meters long, small speedboats, small fishing vessels, small sailing boats and the like. |  |  | X |  | 1 m2 | 1 m ASL |
| 2 | Inshore fishing vessels, sailing boats, speedboats and the like. |  |  | X |  | 3 m2 | 2 m ASL |
| 3 | Aids to Navigation with radar reflector. |  | X | X | 4 m2 | 10 m2 | 3 m ASL |
| 4 | Small metal ships, fishing vessels, patrol vessels and the like. | X | X | X | 40 m2 | 100 m2 | 5 m ASL |
| 5 | Coasters and the like. | X | X | X | 400 m2 | 1,000 m2 | 8 m ASL |
| 6 | Large coasters, bulk carriers, cargo ships and the like. | X | X | X | 4,000 m2 | 10,000 m2 | 12 m ASL |
| 7 | Container carriers, tankers etc. | X | X | X | 40,000 m2 | 100,000 m2 | 18 m ASL |

In addition any special object of interest should be specified separately.

Refer to [9] for guidelines regarding radar target characteristics and radar range performance

* 1. Target Discrimination

In normal weather and propagation conditions, surface objects within the VTS area should be separated in presentation, and individually tracked without track swap, at any applicable target speed when they are positioned apart and with distances as defined by the individual VTS authority.

Table 7 provides examples of point target characteristics suitable for the recommendation levels.

1. Target Separation and Accuracy

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Radar accuracy and physical separation between small point targets for discrimination in display and tracking | | | Type of Capability | | | | | | |
| Basic | | Standard | | | Advanced | |
| Display | Tracking | Display | Tracking | | Display | Tracking |
| **In range** | | Short range applications (<5 nm coverage – include waterways, harbours etc) | 25 m | 40 m | 20 m | 30 m | | 15 m | 25 m |
| Long range applications (up to 20 nm coverage – littoral waters, offshore etc) | 75 m | 100m | 60 m | 75 m | | 50 m | 60 m |
| Very long range applications (>20 nm coverage) | N/A | | 100 m | 125 m | | 80 m | 100 m |
| **In azimuth** | **X-band** | Angle between targets as seen from the radar | 1.2o | 1.3o | 0.7o | 0.8o | | 0.55o | 0.6o |
| Or distance in meters, whichever is the greater | 25 m | 40 m | 20 m | 30 m | | 15 m | 25 m |
| Corresponding –3 dB antenna horizontal beam width | ≤0.7o | | ≤0.45o | | | ≤0.4o | |
| **S-band** | Angle between targets as seen from the radar | N/A | | 3.5o | | 4o | 1.8o | 2o |
| Or distance in meters, whichever is the greater | N/A | | 20 m | | 30 m | 15 m | 25 m |
| Corresponding –3 dB antenna horizontal beam width | N/A | | ≤2o | | | ≤1.25o | |

For larger (non-point) targets the definition of separation is highly dependent on aspect angles, pulse stretch etc. Proper transmitter and receiver characteristics, rather than specification of absolute separation, will ensure proper separation of such targets.

The system should be designed in such a way that the defined radar accuracy and discrimination can be achieved in the entire area(s) covered by the VTS service. In long measuring distances, the impact of the height and type of antenna on the measuring accuracy and resolution should be taken into account. The system should also be capable of displaying and tracking all targets of interest simultaneously in normal conditions without the need for manual adjustments by the operator.

* 1. Detection range and conditions

Performance should, in all cases, be evaluated assuming standard atmospheric conditions.

Ducting may occur almost anywhere, and all systems should be designed to eliminate adverse effects from this.

The influence from adverse propagation effects should be analysed in detail for areas of the world having:

* Tropical climate;
* Dry and hot climate;

The requirements for radar coverage and range performance should be determined by the VTS authority under the weather and propagation conditions normal for the individual site.

In normal weather and propagation conditions the surface objects specified in Table 6 and within the VTS area should be:

* Clearly displayed from a defined minimum horizontal range (e.g. 50m) from the antenna position to the maximum detection range determined in accordance with section 15.5;
* Tracked stably from a defined minimum horizontal range (e.g.100 metres) from the antenna position to the maximum detection range determined in accordance with section 15.5.
* The equipment should give a clear indication and tracking of targets at such specified ranges.
* Note that excessive antenna heights may increase the above minimum values or require dedicated vertical radiation patterns (inverse cosecant square) to be used for the antenna. Displacing the radar could also avoid such lack of coverage.
  + 1. Poor Visibility

The radar detection range (or radar visibility) will normally not be affected by poor visual visibility caused by haze, fog or smog. Performance requirements in such conditions should be based on the clear weather values stated in Table 8.

* + 1. Performance in sea clutter

The requirements to detect targets in higher sea states should be defined individually depending on normal site conditions. “Normal conditions” are typically defined as those existing 99 – 99.9 % of the time. Typical values of what is possible with technology on the market at the time of making this recommendation are stated in Table 8.

* + 1. Rain penetration and performance in volume clutter

The ability to detect targets in precipitation should be defined for the individual VTS system by the VTS authority on the basis of statistical information about normal local weather conditions including the:

* Frequency of precipitation
* Density of precipitation
* Size of rain cells etc.

Such data is normally available from local meteorological services.

The detection range may be reduced by up to 25% as a result of precipitation, based on the amount of normal precipitation identified for the area. This assumes that volume clutter (rain clutter) has been suppressed to obtain acceptable false alarm rates.In many cases precipitation is not uniform and it may be desirable to specify performance in precipitation showers typical for the individual site.

Alternatively, a simpler method of averaging the precipitation may be to assume that the precipitation is uniform. Typical values for this method, and assuming technology available at the time of writing this recommendation, have been used in Table 8.

* 1. Determination of range performance

The recommended method for determination of radar coverage and range performance is a combination of site inspections and radar system performance calculations, made by experts with a sound operational and technical knowledge about the subject.

Objectives may be:

* To determine if a given radar configuration is sufficient. This can for example be in relation to extension of a VTS;
* In relation to new or updated radar configurations, to set the technical requirements to a given VTS area, determine the number of radars; define the position(s) etc.

Where the first normally is a straight forward process and the second can be a demanding process with several iterations.

In both cases the calculation of performance should be focussed on the smallest targets of interest in poor weather conditions.

Note that it may be beneficial to subdivide a VTS into areas with different capabilities (Basic - Standard – Advanced).

Typically, it will not be possible to encounter for all variables and calculations are therefore made on the basis of a simplified model of the targets and the environment based on statistical information.

1. Typical range performance, X-Band

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Antenna elevation** | **Target type** | **Modelled as fluctuating point target** | | **Detection and tracking ranges for standard atmosphere and rain/sea state as indicated** | | | | | |
| **RCS** | **Height** | **Basic recommendation** | | **Standard recommendation** | | **Advanced recommendation** | |
| **Clear** | **2 mm/h rain** | **Clear** | **4 mm/h rain** | **Clear** | **10 mm/h rain** |
| **20 m ASL** | 1 | 1 m2 | 1 m ASL | N/A | | N/A | | 5 NM | NIL |
| Up to sea state 4 | |
| 2 | 3 m2 | 2 m ASL | N/A | | 7 NM | 4NM | 7 NM | 6 NM |
| Up to sea state 3 | | Up to sea state 5 | |
| 3 | 10 m2 | 3 m ASL | 7 NM | 4 NM | 8 NM | 5NM | 9 NM | 7 NM |
| Up to sea state 3 | | Up to sea state 4 | | Up to sea state 6 | |
| 4 | 100 m2 | 5 m ASL | 9 NM | 8 NM | 11 NM | 9NM | 12 NM | 10 NM |
| Up to sea state 4 | | Up to sea state 5 | | Up to sea state 7 | |
| 5 | 1000 m2 | 8 m ASL | 12 NM | 10 NM | 13 NM | 11 NM | 14 NM | 13 NM |
| Up to sea state 5 | | Up to sea state 6 | | Up to sea state 8 | |
| **50 m ASL** | 1 | 1 m2 | 1 m ASL | N/A | | N/A | | 10 NM | NIL |
| Up to sea state 4 | |
| 2 | 3 m2 | 2 m ASL | N/A | | 10 NM | 7 NM | 12 NM | 9 NM |
| Up to sea state 3 | | Up to sea state 5 | |
| 3 | 10 m2 | 3 m ASL | 10 NM | 6 NM | 12 NM | 8 NM | 14 NM | 12 NM |
| Up to sea state 3 | | Up to sea state 4 | | Up to sea state 7 | |
| 4 | 100 m2 | 5 m ASL | 13 NM | 12 NM | 15 NM | 13 NM | 17 NM | 15 NM |
| Up to sea state 4 | | Up to sea state 5 | | Up to sea state 7 | |
| 5 | 1000 m2 | 8 m ASL | 16 NM | 15 NM | 18 NM | 17 NM | 20 NM | 18 NM |
| Up to sea state 5 | | Up to sea state 6 | | Up to sea state 8 | |
| **100 m ASL** | 1 | 1 m2 | 1 m ASL | N/A | | N/A | | 12 NM | NIL |
| Up to sea state 4 | |
| 2 | 3 m2 | 2 m ASL | 13 NM | 5 NM | 16 NM | 10 NM |
| Up to sea state 3 | | Up to sea state 5 | |
| 3 | 10 m2 | 3 m ASL | 17 NM | 10 NM | 18  NM | 16 NM |
| Up to sea state 4 | | Up to sea state 7 | |
| 4 | 100 m2 | 5 m ASL | 20 NM | 19 NM | 22 NM | 20 NM |
| Up to sea state 5 | | Up to sea state 7 | |
| 5 | 1000 m2 | 8 m ASL | 23 NM | 22 NM | 25 NM | 23 NM |
| Up to sea state 6 | | Up to sea state 8 | |

It is important to understand the limitations and tolerances this entails. All applicable losses should be included in the calculations.

The probability of detection and false alarm rates used for calculations should comply with that required to meet the operational performance required for the individual VTS radar as determined per Annex 1 of this document.

The false alarms taken into account in the calculations should include unwanted information from noise and clutter, as presented to the operator or to the tracker (after signal processing), but not signals from other unwanted objects.

Single scan probability of detection values for VTS applications will generally lie in the range from 0.7 to 0.9

It is normally desirable not to have noise and clutter spikes presented to the operator in each scan. Therefore, optimal false alarm rates for VTS applications normally lie in the range from 10-4 to 10-5 for the radar video display.

The individual supplier may decide to use different values for the tracking, on condition that the tracking requirements are met.

1. Typical range performance, S-Band

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Antenna elevation** | **Target type** | **Modeled as fluctuating point target** | | **Detection and tracking ranges for standard atmosphere and rain/sea state as indicated** | |
| **RCS** | **Height** | **Standard recommendation** | |
| **Clear** | **16 mm/h rain** |
| **20 m ASL** | 3 | 4 m2 | 3 m ASL | 4 NM | 3 NM |
| Up to sea state 4 | |
| 4 | 40 m2 | 5 m ASL | 7 NM | 5 NM |
| Up to sea state 5 | |
| 5 | 400 m2 | 8 m ASL | 10 NM | 8 NM |
| Up to sea state 6 | |
| **50 m ASL** | 3 | 4 m2 | 3 m ASL | 7 NM | 4 NM |
| Up to sea state 4 | |
| 4 | 40 m2 | 5 m ASL | 11 NM | 8 NM |
| Up to sea state 5 | |
| 5 | 400 m2 | 8 m ASL | 14 NM | 13 NM |
| Up to sea state 6 | |
| **100 m ASL** | 3 | 4 m2 | 3 m ASL | 10 NM | NIL |
| Up to sea state 4 | |
| 4 | 40 m2 | 5 m ASL | 14 NM | 12 NM |
| Up to sea state 5 | |
| 5 | 400 m2 | 8 m ASL | 18 NM | 19 NM |
| Up to sea state 6 | |

Table 8 and Table 9 give examples of calculated range performance typical for the three recommendation levels. Note that the rain intensity and sea states are increased with increased specification level.

* 1. Side lobe suppression

Antenna side lobes should be sufficiently low to avoid false targets, especially false targets far from the antenna main lobe.

Table 10 provides characteristics suitable for the three Recommendation levels.

1. Side lobe suppression

|  |  |  |  |
| --- | --- | --- | --- |
| **Antenna side lobe suppression** | **Recommendation level** | | |
| **Basic** | **Standard** | **Advanced** |
| Minimum first side lobe level suppression | 26 dB | 27 dB | 28 dB |
| Increasing to, at angles +/- 10° or more outside the main lobe. | 33 dB | 34 dB | 35 dB |

In the case of pulse compression or continuous wave (CW) radars, time side lobes should also be evaluated.

* 1. Radar Detection Performance and Disturbances

Factors disturbing and restricting the performance of radar systems include noise as well as interference and clutter signals from various sources. Each radar site should be designed and equipped with devices to reduce the adverse effects of rain and sea clutter and enhance the probability of target detection per scan. The radar should also be designed and installed so as to eliminate to the maximum extent possible, false echoes caused by side lobes or reflections from nearby structures. When selecting a radar system and the measuring frequency, regional special conditions such as heavy rainfall should be taken into account.

There are several technological solutions available to raise the performance of the radar system to the required level. Most typical solutions include higher average transmission power, larger antennas, circular polarization, reducing the receiver noise, sector blanking and more effective processing and filtering of the transmitted and received signal.

* 1. Built-in test features

Built-in test features should include monitoring of functions and performance. It is recommended that results are made accessible for remote monitoring, especially for radars installed in locations that are difficult to access.

1. Radar configuration and installation
2. PERFORMANCE REQUIREMENTS FOR AUTOMATIC IDENTIFICATION SYSTEM (AIS) IN VTS
3. Introduction

AIS is intended to enhance safety of life at sea, the safety and efficiency of navigation, and the protection of the marine environment. In addition, AIS may contribute to maritime security. SOLAS Regulation V/19 requires that AIS exchange data ship-to-ship and with shore-based facilities. Therefore, the purpose of AIS is to help identify vessels; assist in target tracking; simplify information exchange (i. e. reduce ship reporting using radiotelephony); and provide additional information to assist situational awareness. In general, data received via AIS will improve the quality of the information available to the VTSO or OOW. AIS is a useful source of supplementary information to that derived from other navigational systems and sensors, including radar.

* 1. Description of AIS as a VTS sensor

Automatic Identification System (AIS) is a system that makes it possible to monitor and track ships from suitably equipped ships, and shore stations. AIS transmissions consist of bursts of digital data ‘packets’ from individual stations, according to a pre-determined time sequence. AIS data consists of shipboard information such as position, time, course over ground (COG), speed over ground (SOG), heading, etc. AIS uses a broadcast and interrogation technology that operates ship-to-ship and ship-to-shore and includes limited communication capabilities.

Shore stations receive the same information from AIS equipped ships within VHF range. .

The International Maritime Organization (IMO) has established carriage requirements for merchant ships. The International Telecommunication Union (ITU) has defined the technical characteristics and ratified the global frequencies. In addition, the International Electrotechnical Commission (IEC) has developed methods for testing AIS for global interoperability.

AIS makes navigation safer by enhancing situational awareness and increases the possibility of detecting other ships, even if they are behind a bend in a channel or river or behind an island in an archipelago. AIS also solves the problem inherent with radars, by detecting smaller craft, fitted with AIS, in sea and rain clutter.

1. References
2. IMO MSC. 74(69), Annex 3 IMO Recommendation on Performance Standards for a Universal Shipborne Automatic Identification System (AIS)
3. SOLAS Convention Chapter V Safety of Navigation, Regulation 19
4. ITU Radio Regulations Appendix S18, Table of Transmitting Frequencies in the VHF Maritime Mobile Band
5. ITU-R M.1371-1 ITU Recommendation on the Technical Characteristics for a Universal Shipborne Automatic Identification System (AIS) Using Time Division Multiple Access in the Maritime Mobile Band
6. IEC Standard 61993 Part 2 Universal Shipborne Automatic Identification System (AIS) Operational and Performance Requirements, Methods of Testing and required Test Results.
7. IALA Technical Clarification IALA Technical Clarifications of Recommendation ITU-R M.1371-1
8. IALA Recommendation A-124 IALA Recommendation on AIS Shore Stations and Networking Aspects Related to the AIS Service
9. Resolution A.694(17) General Requirements for Shipborne Radio Equipment forming Part of the Global Maritime Distress and Safety System (GMDSS) and for Electronic Navigational Aids
10. Resolution A.953(23) World-Wide Radionavigation System
11. Resolution A.688(17) Code on Alarms and Indicators
12. Resolution MSC.39(63) Adoption of amendments to the Code on Alarms and Indicators
13. IALA Recommendation V-125 IALA Recommendation on the Integration and Display of AIS and other information at a VTS Centre.
14. Definitions

AIS Automatic Identification System

ASM AIS Service Management

BSC Base Station Controller

FATDMA Fixed Access Time Division Multiple Access

LSS Logical Shore Station

OOW Officer of the Watch

PSS Physical Shore Station

SOTDMA Self Organising Time Division Multiple Access

VTSO Vessel Traffic Services Operator

1. Functional requirements

For VTS purposes, an AIS service provides AIS information from one or several base stations to users. In addition to vessel data, an AIS service provides status on AIS equipment and management functions for the control of the AIS network. The AIS Service may consist of one or more PSS or AIS Networks, or a combination of both.

* 1. Application

These performance requirements are for the use of AIS in a Vessel Traffic Service (VTS). AIS should improve the safety of navigation by assisting in the efficient navigation of ships, protection of the environment, and operation of VTS, by satisfying the following functional requirements:

* in a ship-to-ship mode for collision avoidance
* as a means for littoral States to obtain information about a ship and its cargo, and
* as a VTS tool, i.e. ship-to-shore (traffic management)

AIS should provide ships and competent authorities, information from the ship, automatically and with the required accuracy and frequency, to facilitate accurate tracking.

Mandating AIS carriage and establishing a service to receive, process and distribute the AIS signals received from vessels enhances safety and security and improves the ability to manage traffic.

Some shore facilities may need to act on the information, others may need to monitor AIS and maintain an information database. For these reasons, a nationwide or regional network may be set up.

The service should also be capable of information exchange and distribution among several users ashore and afloat. Government agencies, allied services and commercial maritime interests may have justifiable needs for AIS data.

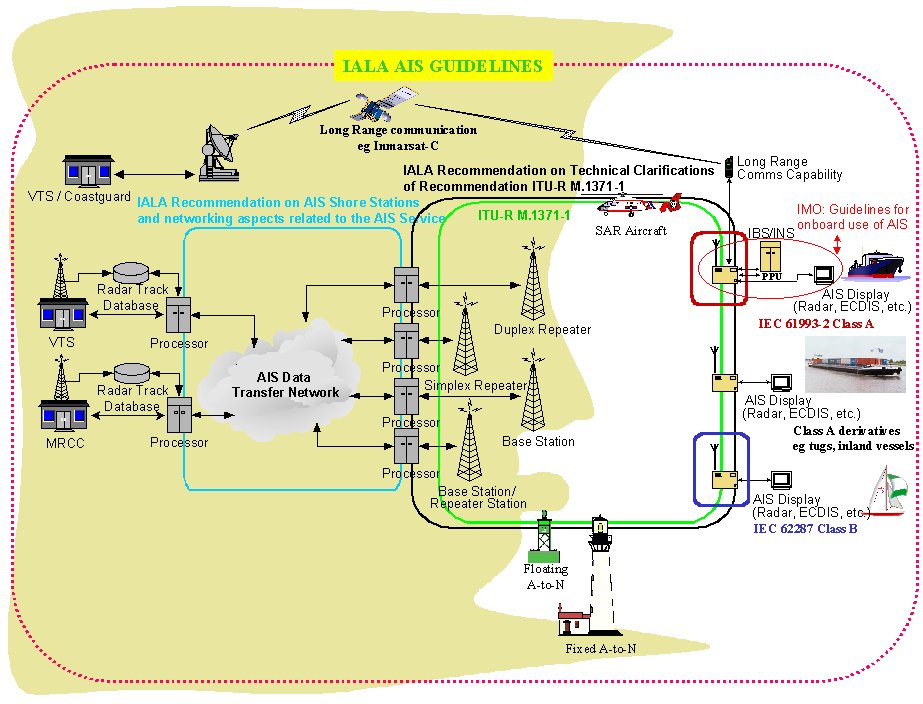
In order for VTS to take full advantage of AIS, access to the capabilities of an AIS Base Station is required. This access should preferably be through an AIS service. With this access, the VTS may change the reporting rate or AIS channel, send short safety-related messages, or perform other functions as necessary

* 1. Objectives of AIS

AIS shall:

* provide information automatically to appropriately equipped shore stations, other ships and aircraft, including the ship’s identity, type, position, course, speed, navigational status and other safety-related information;
* receive automatically such information from similarly fitted ships;
* monitor and track ships;
* exchange data with shore based facilities;
* assist in ensuring the highest possible level of safety and efficiency for vessel traffic in the designated area.

The requirements should not be applied to cases where international agreements, rules or standards provide for the protection of navigational information. AIS should be operated taking into account the guidelines developed by the International Maritime Organization.



1. Title required
   1. Equipment

AIS equipment is described in detail in IALA Recommendation A-124 on Automatic Identification System (AIS) Shore Station and networking aspects relating to the AIS Service.

1. Operational requirements
   1. General requirements

The AIS service should provide timely, relevant and accurate information to users to support the decision-making processes of a VTS. The AIS service may also support port operations by providing information to appropriate shore facilities. It provides automatic vessel position reports and movement information as it is received at remote sites throughout the service area. In support of incident response, the AIS service, in conjunction with the port authority, can provide information about traffic and the corresponding situational information. Utilizing the AIS Service, the VTS will monitor safety and security zone boundaries that are established in connection with an incident. The AIS service also provides information to allied services to support their tasks.

* + 1. AIS information needs of the VTS.

Basic information needs for vessel tracking and port security related missions are:

1. Up-to-date knowledge regarding the route to be transited.
2. Timely, relevant, and accurate information about vessels within the area that might affect safety, security, or the decision making of the VTSO.
3. Timely information about emergency and environmental conditions that might affect safety or the decision making of the VTSO.
4. Where required, the transmission of relevant information to the mariner in a manner that does not distract from the task at hand, particularly in narrow, confined channels where there is heavy traffic.

AIS, as well as existing aids to navigation and tools, pilotage systems, navigation management systems, and regulations provide information to the mariner but these systems require integrity monitoring to ensure the information they impart is accurate.

* + 1. Integrated Operations.

Where applicable, AIS should support regional Vessel Traffic Services between adjoining VTS Centres.

* + 1. Incident Analysis Support.

The AIS service should support incident response and analysis.

1. Immediately after notification of an incident, the AIS service should alert vessels in or planning to enter the area of concern with particulars of the incident.
2. The AIS service may provide for review of supporting information and events that occurred before, during, and after an incident. Otherwise, the VTS should have the ability to support recording and replay of AIS data.
   1. Use of virtual MMSI for VTS communication

Addressing of AIS units is accomplished via the Maritime Mobile Service Identity (MMSI). Every base station will have a unique MMSI number. However, when a VTS is operating several AIS Base Stations, it can present a single address, known as a virtual MMSI number. This will enable the ships to send and receive AIS messages in the VTS area using only one MMSI regardless of the number of base stations in use.

This functionality has to be supported through the AIS Network. However, shipboard AIS units cannot currently respond to messages from virtual MMSIs.

* 1. Short safety-related messages

Short safety-related messages are free format text messages. They can be addressed either to a specified destination (MMSI) or broadcast to all ships in the area. Their content should be relevant to the safety of navigation, e.g. an iceberg sighted or a buoy not on station. Such messages can contain a maximum of 158-162 characters. Although unregulated, these messages should be kept as short as possible.

Cautionary note: The VTSO should not assume that all short safety-related messages have been read on board.

* 1. Use of binary messages for data exchange

IMO has selected seven binary messages, as shown below, to be used as a trial set. The intention is to use this set for a period of 4 years (May 2004-May 2008) with no change.

The messages are:

* meteorological and hydrological data
* dangerous cargo indication
* fairway closed
* tidal window
* extended ship static and voyage related data.
* number of persons on board
* pseudo-AIS targets.

For further details, see IMO SN/Circ.236, dated 28 May 2004, Guidance on the Application of AIS Binary Messages.

* 1. Use of the VTS Targets message

One of the IMO approved binary messages is for broadcast pseudo AIS targets. This contains information on non-AIS targets derived by means other than AIS. Typically these will be targets that are tracked by a VTS-system based on radars. Sometimes the VTS Targets message is also referred to as VTS Footprint.

The AIS message for VTS Targets can be filled with information for a maximum of 7 targets. At present, IMO restricts this to a maximum of 4. Each target comprises:

* Target id (MMSI, IMO number or Callsign)
* Latitude
* Longitude
* Course (COG)
* Speed (SOG)
* UTC time stamp

A VTS Targets message can either be sent as an addressed message to one target or as a broadcast message to all targets that are inside the VHF coverage area of one or more shore stations (i.e., PSS).

For additional information, refer to IMO SN Circ/236 – Guidance on the application of AIS Binary messages.

* 1. Assigned Mode

VTS may use the AIS Service capability to change the reporting mode (from autonomous to assigned mode, for example) of selected shipboard AIS units. This will enable the ship station to operate according to a specific transmission schedule, as determined by a competent authority.

* 1. Graphical presentation

In the VTS Centre, AIS-data is usually viewed on an electronic chart, either separately or combined with the radar data.

* + 1. Symbol usage

The IALA Guidelines on AIS include a description of the recommended AIS target symbols, but these were originally intended for the on board ECDIS/ECS systems. As the guidelines point out, the given symbols are not necessarily adequate in the VTS context. The main difference is that a VTS-operator may prefer a much wider range of information than is necessary on board a ship. For example traffic management may necessitate the use of symbols which depict different types and sizes of vessels. Further it may be necessary to show which vessel have pilots embarked, and which do not.

* + 1. Interaction with radar tracks

A target that is tracked by radar and also carries an AIS transponder may be displayed with one symbol based on a fusion of the dynamic information received from the two sensor types. The user may have the option to display the input from each sensor with two different symbols. It should also be possible to identify which sensor(s) are used to derive the target position.

* 1. Data Validity

The validity of AIS data received from ships is dependent on the proper installation of AIS, correctly interfaced and functioning ship’s equipment, and correct manual input of static and voyage-related data.

Until further regulations dictate stricter data accuracy requirements in the AIS mobile units, caution has to be taken when using AIS data for processing.

VTS may contribute AIS service data to government agencies, allied services and commercial maritime interests. This determination will be made by the relevant Competent Authority.

1. Design and installation
   1. Transmission Layer

AIS is an unencrypted broadcast system and as such, its data is accessible to anyone with a suitable receiver. National regulations may regulate the use of AIS frequencies. AIS may be susceptible to interference from adjacent channels. Due consideration should be given to frequency allocations adjacent to AIS channels to avoid possible service disruption.

19.2 Coverage aspects

In general, AIS design coverage ranges should approximate VHF voice communication ranges. However, actual vessel traffic density or geographic considerations (i.e., mountains or other VHF occlusions) may determine the need for additional base stations

When estimating the size of the operational coverage (operational cell) for shore facilities, an important consideration is the traffic load – number of mobile AIS stations within the area.

For example, calculations in one port have indicated that an AIS Base Station could accommodate less than 300 active AIS units.

For further information, please refer to IALA GUIDELINES ON THE AUTOMATIC IDENTIFICATION SYSTEM (AIS) Volume 1, Part II – Technical Issues, Edition 1.1

1. Interfacing

The VTS will select features of the AIS network it requires via the AIS Service. These features are the Basic AIS Services defined in IALA Recommendation A-124.

Class B

Limited base stations

1. PERFORMANCE REQUIREMENTS FOR HYDROLOGICAL AND METEOROLOGICAL EQUIPMENT IN VTS
2. Introduction

The environmental systems in a VTS, also referred to as the hydrological / meteorological (hydro/meteo) systems, include sensors and readouts of various meterological or hydrographical variables. Typical meteo variables are those provided by weather stations and include air temperature and humidity, wind velocity and direction, and visibility. In certain locations, hydro variables such as tidal level, and current direction and velocity may be required. This data may be obtained through sensors or available in tables/databases from national authorities. Sensors providing this data, usually located at remote sites, communicate the variables to a Vessel Traffic Services Centre (VTS centre) via a telecommunications link. At the VTS centre, graphical and/or numeric information is presented for use by the operators.

* 1. Scope

The aim of Appendix 5 of this recommendation is to:

* identify functional and operational requirements for hydrographical and meteorological equipment in VTS; and
* provide guidance on design and installation of such equipment.
  1. Objectives of Hydrological / Meteorological Equipment

Hydrological and meteorological information may be integrated into VTS applications to provide the operator a real-time assessment of the environmental situation in the VTS area of responsibility. Information collected from this equipment can be provided to ships to assist in assessing the waterway conditions.

A number of countries operate tide gauges and current meters to assist the prediction of tidal heights and streams or for the broadcast of real-time information to shipping. The Intergovernmental Oceanographic Commission (IOC) is responsible for co-ordinating the Global Sea Level Observing System (GLOSS) program to establish global and regional networks of sea level stations for providing essential information for international oceanographic research programmes. GLOSS operates under the Global Ocean Observing System (GOOS) http://ioc.unesco.org/goos. IALA supports and encourages participation in the GLOSS program.

1. References

There are many applicable IMO, IEC, WMO and other requirements. These include, but are not limited to:

1. IMO Resolution A.686(17) Code on Alarms and Indicators (and MSC.39(63) Adoption of amendments to the Code on Alarms and Indicators)
2. IMO Resolution A.694(17) General Requirements for Shipborne Radio Equipment forming Part of the Global Maritime Distress and Safety System (GMDSS) and for Electronic Navigational Aids
3. IMO SOLAS (i.e. Chapter V, Regulation 12)
4. IEC 529 Degrees of protection provided by enclosures (IP Code)
5. IEC 721-3-6 Classification of environmental conditions
6. IEC 60945 Maritime Navigation and Radiocommunication Equipment and Systems
7. WMO International Meteorological Vocabulary
8. Guide to Meteorological Instruments and methods of Observation
9. NMEA 0183 Standard for Marine Electronic Devices (IEC equivalent)
10. Definitions

For general terms used throughout this document refer to the World Meteorological Organization (WMO).

* 1. Abbreviations

GLOSS Global Sea Level Observing System

GOOS Global Ocean Observing System

IALA International Association of Marine Aids to Navigation and Lighthouse Authorities

IEC International Electro-Technical Commission

IMO International Maritime Organisation

IOC International Oceanographic Commission

IP Ingress Protection

NMEA National Marine Electronics Association

WMO World Meteorological Organization

XML Extensible Mark-up Language

* 1. Hydro/Meteo Equipment

1. Functional Requirements

Briefly stated, the functional requirements state what the system should be able to do, the functions it should perform.

* 1. Sensors

For hydro/meteo systems within a VTS, the measurement sensors should be installed and located according to recommendations from a VTS authority in consultation with hydrologist/meteorologist(s). The Sensor identification and location should be provided.

The measurements/sensors may include:

* Wind speed / Wind direction / Wind gust
* Air temperature / Relative humidity
* Precipitation
* Barometric Pressure (atmospheric pressure)
* Visibility
* Water temperature / Water level / Salinity
* Height of tide
* Current speed (may be required at various depths)
* Current direction (may be required at various depths)
* Wave height / direction
* Ice coverage / thickness
* Ice coverage
* Salinity

It is essential that a VTS Centre has access to local Hydro/meteo information relevant to the VTS Area(s) and can, if required by the VTS Authority, disseminate this to their users and allied services.

Where a VTS Authority determines a need to establish their own monitoring stations, it should be noted that the individual VTS Authorities should determine the accuracy and availability requirements for each VTS Centre, as these will be based on individual circumstances. Error! Reference source not found. gives an indication of typical minimum accuracy requirements.

Note: The target availability should be as proscribed by IMO A.915(22).

1. Indication of typical minimum accuracy

| **Parameter** | **Minimum Accuracy** |
| --- | --- |
| Height of Tide | ≤ ± 0.10 m |
| Rate of Tidal Stream/ Current | ≤ ± 0.5 knots |
| Direction of Tidal Stream/Current | ≤ ± 10 Degrees |
| Wave height | ≤ ± 10% of the height |
| Wave Direction | ≤ ± 20 Degrees |
| Wind speed | ≤ ± 1m per sec |
| Wind Direction | ≤ ± 10 Degrees |
| Visibility | ≤ ± 10% of the distance |
| Air Temperature | ≤ ± 1**0**C |
| Air Humidity | ≤ ± 5 % |
| Air Pressure | ≤ ± 2 hPa |
| Sea Surface Temperature | ≤ ± 1**0**C |

The VTS Authority should specify the time periods over which the various data parameters should be updated and may be averaged, if required, as these factors will depend upon the local circumstances pertaining to the VTS Centre.

* 1. Reliability

The reliability, accuracy, range, resolution, and units of the measurements should satisfy the minimum requirements as determined by WMO.

* 1. Malfunctions and Indicators

As a minimum, malfunctions, warnings, alarms and indicators should respond to the requirements of IMO Resolution A.686(17) and MSC.Circ.39(63). Additional requirements may be required, depending on the individual type / purpose of sensor.

1. Operational Requirements

Briefly stated, operational requirements are qualitative and quantitative parameters that specify the desired capabilities of a system and serve as a basis for determining operational effectiveness.

Operational Requirements may include ergonomics, operational controls and information presentation. Due to the varied nature of hydrological and meteorological equipment in VTS, it is not possible to specify ergonomic or operational control requirements.

* 1. Information Presentation

The results of the measurements should be transmitted in WMO standard units and displayed in user-selectable format.

The measurements should be available to the VTS operators through an integrated display or separate instruments. Data may be presented numerically and/or graphically. A log of the latest 24 hour measurements should be available to the VTS operators either numerically or graphically.

1. Design and Installation

Key aspects to design and installation include:

* Durability and resistance to environmental conditions;
* Interference;
* Power supply requirements /options;
* Installation; and
* Maintenance.
  1. Durability and Resistance to Environmental conditions

Electronics installed externally should be in an environmental enclosure. IEC requirements for environmental conditions should be applied as practicable.

* 1. Interference

These sensors are industrial equipment and therefore comply with applicable international standards and regulations. IEC requirements (IEC 60945) refer.

* 1. Power Supply Requirements / Options

Relevant IEC requirements should be applied. In remote locations, due to the low power consumption of hydro/meteo sensors, authorities should consider use of alternative power (e.g. solar panels, wind vanes, etc.), in lieu of generators, when commercial power is not available.

* 1. Installation

Requirements concerning the installation of sensors, wiring and the arrangement of the equipment providing hydro/meteo information to the VTS centre should be determined. Operational requirements will determine where sensors are to be located and how many are required. Sites for sensors should be selected based upon optimizing data relevant to the VTS. Other considerations include:

* availability of power,
* protection against vandalism,
* housing, and collocation with existing VTS, AtoN, or other suitable infrastructure

Relevant IEC requirements should be applied. For example:

* IEC 529 "Degrees of protection provided by enclosures (IP Code)"
* IEC 721-3-6 "Classification of environmental conditions, Part 3: Classification of groups of environmental parameters and their severities; Ship environment"
* IEC 60945 "Maritime navigation and radiocommunication equipment and systems - General requirements, methods of testing and required test results"
  1. Maintenance

Possible requirements, in addition to IMO Assembly Resolution A.694(17) concerning maintenance, should be determined. Citing considerations for sensors should include maintenance, repair, and accessibility requirements.

* 1. Interfacing

The data to be interfaced for the hydro/meteo service are described under ‘Functional Requirements / Sensors’.

For the interfacing of hydro/meteo services to VTS equipment, several different standards are in use. Among those standards, the Standard for Marine Electronic Devices, NMEA 0183, has been applied for these applications. In addition, the WMO has developed an interface standard for hydro/meteo applications.

For the interface between a VTS and its users, hydro/meteo data should follow standardized data exchange formats, e.g., XML. (In addition, a time stamp and source should be provided.

1. Backup Arrangements

Depending on the individual type of the equipment, requirements concerning back-up and fall-back arrangements should be determined.

1. Safety Precautions

Depending on the individual type of the equipment, requirements in addition to IMO Resolution A.694(17) should be determined.

1. PERFORMANCE REQUIREMENTS FOR ELECTRO-OPTICAL EQUIPMENT IN VTS
2. INTRODUCTION

CCTV information may be integrated into VTS applications to provide the operator a real-time assessment of the situation in the VTS area of responsibility. Information collected from this equipment can be provided to ships to assist in assessing the waterway conditions.

1. REFERENCES
2. Electronics Industry Association (EIA) Recommended Standard RS-170
3. Relevant SOLAS requirements; SOLAS Chapter V (Safety of Navigation) as Regulation 12
4. General resolutions, such as resolution A.694(17) - General Requirements for Shipborne Radio Equipment forming Part of the Global Maritime Distress and Safety System (GMDSS) and for Electronic Navigational Aids;
5. Resolutions with more specific requirements, such as:
6. NMEA 0183 – Standard for Marine Electronic Devices (IEC equivalent 60945)
7. IEC 529 "Degrees of protection provided by enclosures (IP Code)"
8. IEC 721-3-6 "Classification of environmental conditions, Part 3: Classification of groups of environmental parameters and their severities; Ship environment"
9. IEC 60945 "Maritime navigation and radiocommunication equipment and systems - General requirements, methods of testing and required test results"
10. DEFINITIONS

As defined by Electronics Industry Association (EIA), Motion Picture Experts Group (MPEG) and Joint Photographic Experts Group (JPEG).

1. FUNCTIONAL REQUIREMENTS
   1. Characteristics of the CCTV

Cameras may be used as a more cost effective solution to radar or in conjunction with radar as an additional sensor, depending on the level of risk. CCTV may be effective in a limited area not covered by other sensors or provide supplemental information with other sensors (e.g. identification).

The camera may be capable of automatically tracking a vessel selected by the VTS Operator. In addition, there should be the possibility for the VTS Operator to manually de-select any acquired target and manually select another target and/or area, in order for the VTS Operator to perform specified monitoring tasks, such as pilot embarkation and disembarkation.

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.

VTS authorities should consider the need for low-light level, infrared, colour, intensified and laser-gated low light level, as well as digital image processing and video compression of CCTV installations.

Characteristics to be considered with regard to CCTV installations include resolution, focus uniformity, shading, lag/image retention, spectral sensitivity, blooming, and light sensitivity.

* 1. Reliability, accuracy, range, and resolution

The reliability, accuracy, range, and resolution should satisfy the minimum requirements of the VTS and as determined by EIA and MPEG.

* 1. Malfunctions, warnings, alarms and indications

Refer to relevant requirements of Resolution A. 686(17) and Resolution MSC.39(63).

1. OPERATIONAL REQUIREMENTS
   1. Ergonomics

Regarding CCTV controls, one should consider the VTSO position and the use of the CCTV. It is desirable for the CCTV to be controlled from a single operator position (e.g. touch screen, mouse click, and joystick for CCTV slewing and automatic tracking).

* 1. 3Operational controls

The camera may be controllable manually in pan, tilt, and zoom modes. The extent of this control will be dependent on geography of the waterway, camera installation site, etc. Camera housings are generally equipped with means for keeping the lens operational (e.g. heaters, lens wipers, protective coating, and washers).

* 1. Detection Performance

Depending upon the circumstances, cameras should allow the VTSO to identify the type and possibly the name of the vessels concerned.

The type of vessel should be capable of being identified normally at a minimum range of 3 nm from the camera location, but this will depend on the individual circumstances, including local topography. The identity of a vessel by shape, colour and other features should be capable of being determined normally at a minimum range of 1 nm, but again this will depend on the individual circumstances. These ranges are based on a nominal visibility in excess of 10 nm.

* 1. Recording and Replaying of Data

The data should be recorded automatically and capable of being replayed, if required by the VTS Authority. Replay of CCTV should not interfere with on-going operations. This may require a separate display system for playback. The VTS Authority must determine the quality of recording and playback (e.g., frames per second, resolution, period).

* 1. Software requirements

The software requirements for CCTV are a matter for the VTS Authority to determine.

* 1. Availability

The requirements for the availability of CCTV are a matter for the VTS Authority to determine.

1. DESIGN AND INSTALLATION
   1. Durability and resistance to environmental conditions

Electronics installed externally should be in an environmental enclosure. As regards environmental conditions, the IEC requirements should be applied as far as relevant.

* 1. Interference

CCTV equipment is industrial equipment and therefore complies with applicable international standards and regulations. Refer to the IEC requirements (IEC 60945) as far as relevant.

* 1. Power supply

IEC requirements should be applied as far as relevant. In remote locations, authorities should consider use of alternative power (e.g. solar panels, wind vanes, etc.) in addition to generators and/or uninterruptible power supplies.

* 1. Site selection and Installation

Requirements concerning the installation of CCTVs, wiring and the arrangement of the equipment in the VTS Centre should be determined. Operational requirements will determine where CCTVs are to be located and how many are required. Sites for CCTVs should be selected based upon optimizing the views of areas relevant to the VTS. Other considerations include:

Note: Special care must be given to the stability of the camera mounting and preventing glare from direct sunlight. It may be appropriate to consider the use of software to mitigate unavoidable vibration.

* 1. Maintenance

Requirements in addition to IMO Resolution A.694(17) concerning maintenance should be determined if necessary.

1. INTERFACING

For the interfacing of CCTV services to VTS equipment, several different standards are in use e.g. EIA, MPEG, JPEG. A time stamp and source should be provided for recording and playback purposes.

1. BACK-UP AND FALL-BACK ARRANGEMENTS

Redundant cameras of the same type are not normally installed in VTS. However, different camera types may be collocated and can provide backup.

1. SAFETY PRECAUTIONS

No specific safety requirements in addition to resolution A.694(17).

* 1. ????
  2. CLOSED CIRCUIT TV AS A VTS SENSOR (CCTV)
     1. General

The performance requirements of a CCTV service vary depending on traffic density, type of VTS service, special regional features, coverage of the VTS area and the intended use.

VTS Authorities should consider the need for low-light level, colour, intensified and laser-gated low-light level, as well as digital image processing and video compression of CCTV installations.

* + 1. Detection Performance of CCTV Cameras

Depending upon the circumstances, cameras should be capable of identifying the type and possibly the name of the vessels concerned.

The CCTV should enable identification of the type of vessel at a minimum range of 3 nm from the camera location, but this will depend on the individual circumstances, including local topography. The identity of a vessel by shape, colour and other features should be capable of being determined normally at a minimum range of 1 nm, but again this will depend on the individual circumstances. These ranges are based on where the nominal visibility is in excess of 10 nm. Image quality and update/refresh rates should meet these requirements.

* + 1. Characteristics of the CCTV

Cameras may be used either in low traffic density areas where this is a more cost effective solution to radar or in conjunction with radar as an additional sensor, depending on the level of risk.

The camera should be capable of automatically tracking a vessel manually selected by the VTS Operator via the VTS Screen, if required by the VTS Authority. In addition, there should be the possibility for the VTS Operator to manually de-select the automatically acquired target and manually select another target and/ or area of the acquired target, in order for the VTS Operator to perform specified monitoring tasks, such as pilot embarkation/disembarkation.

Where more than one camera is installed to cover a VTS area it is desirable for the output from both to be fused together to provide one composite picture.

* + 1. Availability

The requirements for the availability of CCTV are a matter for the VTS Authority to determine.

The requirements for AIS availability are

1. PERFORMANCE REQUIREMENTS FOR RADIO DIRECTION FINDERS IN VTS
2. INTRODUCTION

A number of VTS Authorities require RDF receivers to identify the target of a transmitting vessel on VTS display. This may be used to correlate with the radar target.

In order to ensure accurate identification on the VTS display the use of two or more separate RDF bearing stations are required. Bearing angles on the target should be as close to 90º as possible. The recommended bearing accuracy for the types of capability are provided in Error! Reference source not found.

1. Bearing Accuracy

|  |  |  |  |
| --- | --- | --- | --- |
|  | Type of Capability | | |
| Basic | Standard | Advanced |
| Recommended Bearing Accuracy | ≤ ± 2.5º | ≤ ± 1.5º | ≤ ± 1.0º |

All bearings should be automatically displayed on the VTS display when the signal has been received after a delay of no more than 3 seconds. The bearings should remain visible on the VTS display as long as the vessel is transmitting a signal. The VTS operator should have the ability to suppress RDF information on the VTS display.

It is foreseen that this requirement may decrease as AIS usage by VTS Authorities increases, but will not become obsolete as, depending on the circumstances, AIS information may not always be available.

RDF is not suitable of being used for continuous tracking.

1. Performance requirements for Long Range sensors in VTS
2. Long Range Sensors

Where AIS, radar and Long Range Sensor Data (e.g. LRIT positional data) are utilised they should be fused and presented to the VTSO as one unambiguous target as shown in Error! Reference source not found.. However, the VTS Operator should have the ability to choose whether to display the information on a sensor basis. That is, whether individual targets are to be displayed using the AIS derived data, the radar derived data, or the LRIT derived data only, or from all three subjects to track fusion in accordance with the requirements of the VTS Authority.

If Long Range Sensor Data information shows differences when compared to other sources, VTSOs should use appropriate procedures and evaluate the obtained information and where applicable advise the vessel immediately.

* 1. Statellite AIS

1. PERFORMANCE REQUIREMENTS FOR COMMUNICATIONS IN VTS
2. INTRODUCTION

Radiocommunications equipment is typically integrated into VTS applications to provide the operator a real-time assessment of the situation in the VTS area of responsibility as well as a means to deliver timely services to VTS participants. Information collected and disseminated via this equipment can assist in assembling the traffic image and in supporting safe navigation of the VTS area.

1. REFERENCES
2. Relevant SOLAS requirements; SOLAS Chapter IV (Radiocommunications)
3. SOLAS Chapter V (Safety of Navigation) – Regulation 12
4. SOLAS Chapter V (Safety of Navigation) – Regulation 19
5. Resolution A.694(17) - General Requirements for Shipborne Radio Equipment forming Part of the Global Maritime Distress and Safety System (GMDSS) and for Electronic Navigational Aids;
6. IEC 529 "Degrees of protection provided by enclosures (IP Code)"
7. IEC 721-3-6 "Classification of environmental conditions, Part 3: Classification of groups of environmental parameters and their severities; Ship environment"
8. IEC 60945 "Maritime navigation and radiocommunication equipment and systems - General requirements, methods of testing and required test results"
9. DEFINITIONS

As defined by ITU-R and IEC.

1. FUNCTIONAL REQUIREMENTS
   1. Characteristics of Radiocommunications equipment

Radiocommunication is the central ingredient in the operation of VTS. Radiocommunications links are used to collect position, safety, and general information from shipboard personnel and remote sensing devices. These links are also the primary means through which services are delivered to VTS participants. Components of the VTS radiocommunications equipment may include:

Very High Frequency (VHF) voice radio - It is common for the VTS to have its own independent VHF network for their use within specifically designated VHF Channels. This network may comprise of one or more VHF Channels in different sectors of the VTS Area. The VTS Authority may require specific VHF Channels to be designated by the National Radio Authority for specific types of operations. The VHF equipment must comply with national and international regulations.

Medium Frequency (MF) and High Frequency (HF) voice and data – MF and HF may be used on a regional basis where long range communication is required. The VTS Authority may require specific channels to be designated by the National Radio Authority for specific types of operations. The equipment must comply with national and international regulations.

Radio Direction Finding (RDF) - VTS Authorities may use RDF receivers to determine which vessels may be transmitting. In order to ensure accurate identification, the use of two or more separate RDF bearing stations is required. All bearings should be automatically displayed on the VTSO display. The bearings should remain visible at least as long as the vessel is transmitting a signal. The use of RDF may decrease as AIS usage by VTS Authorities increases. However, RDF is unlikely to become obsolete as, depending on national requirements, some vessels may not be equipped with AIS. RDF is not suitable for continuous tracking.

Automatic Identification System (AIS) – See other IALA documents on this equipment (Recommendations A-123, A-124, A-126 and IALA Guidelines 1029 and 1030 on Operational and Technical aspects of AIS)

The shipborne equipment must meet the functional requirements of the relevant IMO performance standards and the ITU-R Radio Regulations.

* 1. Malfunctions, warnings, alarms and indications

Refer to relevant requirements of Resolution A.686(17) and Resolution MSC.39(63).

1. OPERATIONAL REQUIREMENTS
   1. Radiocommunications Coverage

VTS Radiocommunications shall be in accordance with ITU-R Radio Regulations. Depending upon the circumstances, radiocommunication equipment should be capable of receiving signals from appropriately equipped ships. VHF voice radio reception is dependent upon the line-of-sight distance between VTS receive site and the ship antenna heights. This is also true with AIS, although there are performance differences between VHF voice radio and AIS. As a minimum, the radiocommunications range should facilitate VTS ship communications before the ship enters a VTS area of responsibility.

* 1. Recording and Playback of Data

Radiocommunications data should be recorded automatically and capable of being replayed onto a separate replay system, if required by the VTS Authority. A time stamp and source should be provided for recording and synchronised playback purposes.

* 1. Availability

The requirements for the availability of radiocommunications equipment are a matter for the VTS Authority to determine.

1. DESIGN AND INSTALLATION
   1. Durability and resistance to environmental conditions

Electronics installed externally should be in an environmental enclosure. As regards environmental conditions, the IEC requirements should be applied as far as relevant.

* 1. Interference

Radiocommunications equipment is industrial equipment and therefore complies with applicable international standards and regulations. Refer to the IEC requirements (IEC 60945) as far as relevant. Care must be taken when selecting antenna sites that adjacent equipment does not interfere with, nor is interfered with, VTS radiocommunications equipment. Radiocommunications shall be in accordance with ITU-R Radio Regulations and national regulations.

* 1. Power supply

IEC requirements should be applied as far as relevant. In remote locations, authorities should consider use of alternative power (e.g., solar panels, wind vanes, etc.) in addition to generators and/or uninterruptible power supplies.

* 1. Site selection and Installation

Requirements concerning the installation of radiocommunciation equipment, wiring and the arrangement of the equipment in the VTS Centre and in remote sites should be determined. Operational requirements will determine where radiocommunications transceivers and antennas are to be located and how many are required. Sites for radiocommunications equipment should be selected based upon optimizing the coverage of the VTS area. Care must be taken when co-locating antenna sites that proper separation is maintained to avoid interference. To avoid channel saturation, consideration should be given to subdividing the VTS area into communications sectors based upon channel use with adjacent sectors using separate channels. Other considerations include availability of power, protection against vandalism, housing, and collocation with existing VTS, AtoN, or other suitable infrastructure.

45.5 Maintenance

In addition to the requirements of IMO Assembly Resolution A.694(17), siting considerations for radiocommunications equipment should address maintenance, repair, and accessibility requirements.

46 INTERFACING

For the interfacing of radiocommunications services to VTS equipment, several different standards are in use, including the 4-wire E&M standard.

For the interface between a VTS and its users, VHF voice is the standard practice. AIS data communications should follow ITU-R Rec. M.1371-1 and IALA A-124.

47 BACK-UP AND FALL-BACK ARRANGEMENTS

The provision of redundant radiocommunications equipment is recommended. Additionally, consideration should be given to an emergency mobile communications capability as a means to re-establish communications capabilities.

1. Communications between Shore and Ship
   1. General

Reliable ship-to-shore and shore-to-ship communications are essential to deliver VTS services and should be available throughout the VTS Area from one or more communication means as listed below.

* 1. Short-Range Voice Communications

The VTS Authority should utilise dedicated working VHF Channels designated by the National Radio Authority for specific types of operations. In addition, one or more VHF Channels may be utilised in different sectors of the VTS Area.

It is common for the VTS to have its own independent VHF network, for the use within specifically designated VHF Channels.

The VHF equipment must comply with national and international regulations.

* 1. Short-Range Messaging

AIS has the ability to send safety-related messages (messages 12 and 14) from ship to shore and shore to ship. Where appropriate, it can be used to reduce the burden of voice communications, provided proper communication procedures are in place to acknowledge receipt of the message.

* 1. Long-Range Communications

In the case where a VTS Authority requires long distance voice communications or messaging, such as pre-arrival information, any available communication systems, such as INMARSAT or Iridium, should be used and therefore an independent network is not required.

1. PERFORMANCE REQUIREMENTS FOR DATA PROCESSING AND DISPLAY IN VTS
2. Introduction

Where both AIS and radar data are available they should be fused and presented to the VTSO as one unambiguous target using best available target data. However, the VTS Operator should have the ability to choose whether to display the information on a sensor basis. That is, whether individual targets are to be displayed using the AIS derived data only or the radar derived data only or from both subject to track fusion in accordance with the requirements of the VTS Authority.

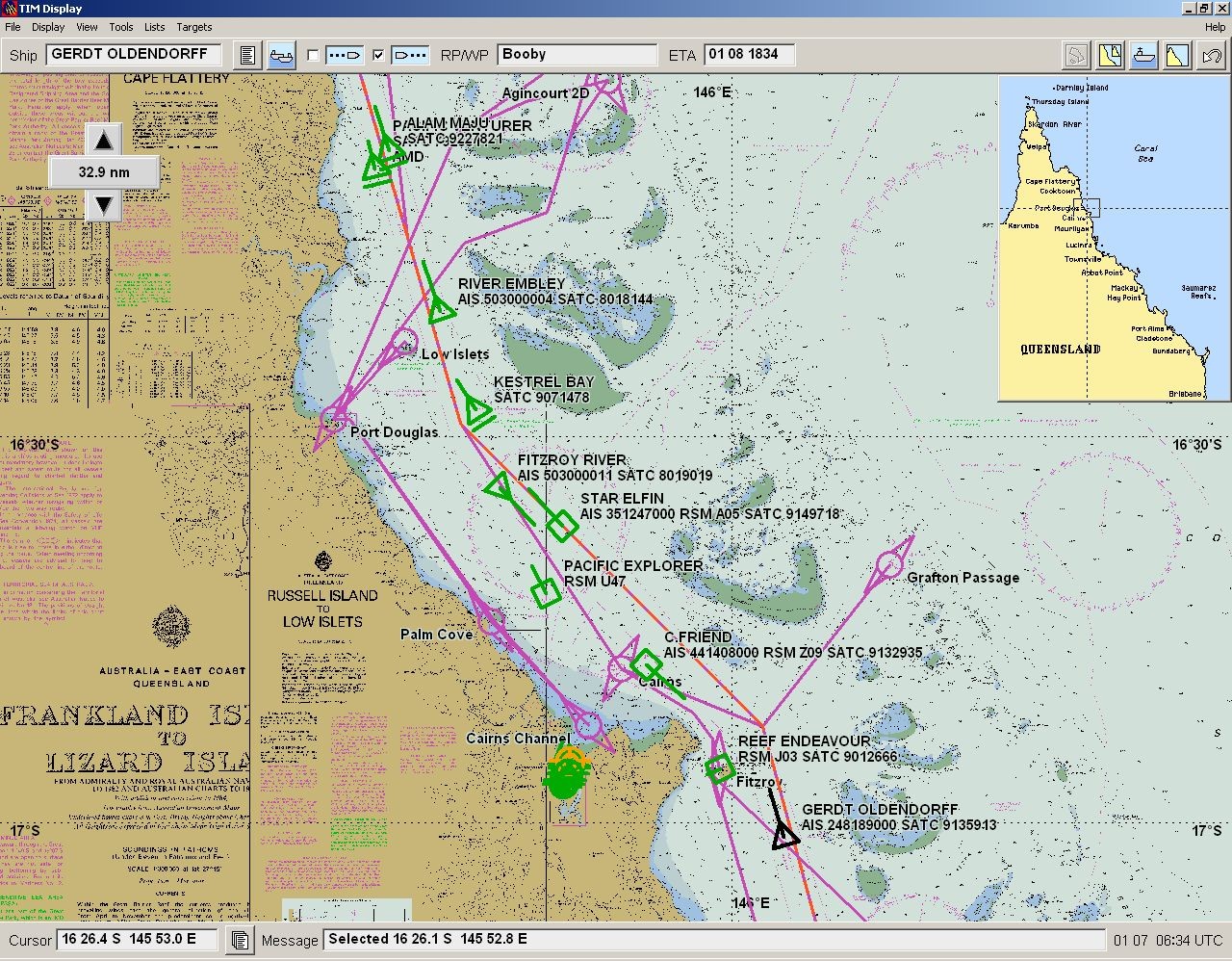
If AIS information shows differences when compared to other sources, VTSOs should use appropriate procedures and evaluate the obtained information and where applicable advise the vessel immediately.

1. Control of Displayed Information

To ensure the best possible traffic image is maintained the duty VTSO should have the capability to select the primary target source being displayed for individual vessels or all vessels. For example, selecting the radar target for a vessel with a faulty AIS unit or the AIS network is unreliable.

1. Emergency Situations

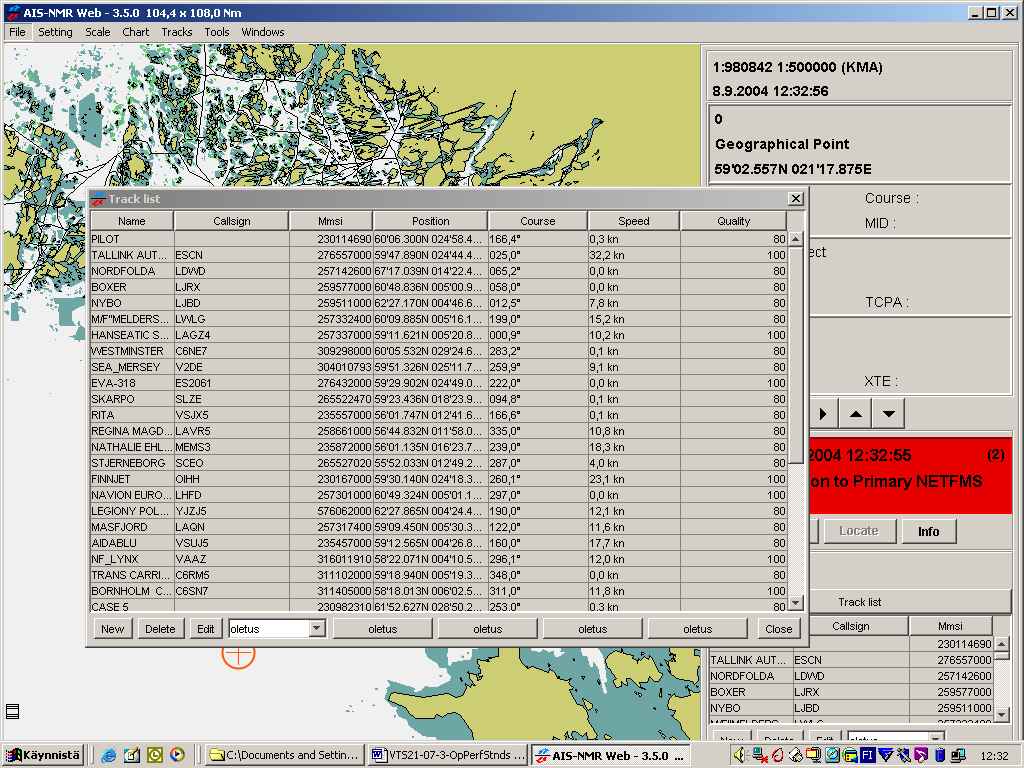
To optimize the operations of the VTS Centre the data information should be easily transferred to another location capable of maintaining the VTS service in the event of an emergency situation resulting in temporary closure of the VTS Centre.



1. Long Range Image
2. List of Participating Vessels

The list of participating vessels should include static information and dynamic information concerning the vessel, for example Vessels Name, Call Sign, IMO Number, MMSI, ETA, ETD, Draft, Course, Speed and Position, if required.

An example of a typical list is shown in Error! Reference source not found. This example is taken from the Baltic AIS Network which is integrated to the VTS system



1. Example of List of Participating Vessels –Source: Archipelago VTS, FMA
   1. Plot Extraction

Plot extraction (see IALA Guideline No. 1056) should be automatic. The plot extraction process should be able to handle a minimum of plots per rotation (see Table 55.1).

* 1. Track Initiation

Track initiation should be automatic, automatic except in selected areas, automatic in selected areas, or manual depending on the concept of operations.

In **automatic track initiation modes**, all plots in a scan should be considered potential targets. Some of the plots will be associated with previously established tracks, while the remaining plots should be considered as candidates for new tracks, i.e. tentative tracks.

Tentative tracks will become confirmed tracks if plots from consecutive scans “fit into the picture” within reasonable physical manoeuvrability limits, otherwise the tentative tracks are discarded.

The tracking system should be able to handle at least a certain number of tentative tracks and to initiate tracks and eventually to confirm tracks under certain conditions of PD and PFA.

It should also be possible to initiate a track manually. In manual track initiation a plot on the radar display is selected by the operator using a graphical tool. When selected this plot should form the starting point for a tentative track which eventually should be confirmed or discarded, as in the automatic case described above.

* 1. Maintaining Track

If automatically or manually created tentative tracks persist over a certain length of time the tracks should be promoted to confirmed tracks. Confirmed tracks should be shown on the display. The tracking system should be able to handle at least a certain number of confirmed tracks (Table 55.1) and to maintain tracks under certain conditions of PD (Table 55.2) and PFA ≤ 0.01.

* 1. Track Termination

If a confirmed track either moves outside a user defined maximum range, into a user defined non-tracking area, if the quality of the track falls below a predefined minimum, 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 the operator should receive a warning as defined by the VTS Authority.

49.5 Plot extraction and tracking performance

The requirements in respect of plot extraction and tracking should be defined by the individual VTS authority, on the basis of local conditions, number of radar sensors in a system etc. Table 55.1 suggests values for each individual radar sensor in a system.

1. Radar tracking performance parameters.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Plot Extraction and Tracking Performance for each individual radar in a system** | | | | |
| **Parameter** | | **Recommendation level** | | |
| **Basic** | **Standard** | **Advanced** |
| Number of plots per antenna rotation | | ≥ 1000 | ≥ 2500 | ≥ 5000 |
| Number of confirmed tracks | | ≥ 100 | ≥ 200 | ≥ 300 |
| Time for confirmation of tentative track | | ≤ 1 minutes | | |
| Time from track confirmation to achievement of specified accuracy | | ≤ 2 minutes | | |
| Time from data loss to automatic track termination | | ≥ 1 minutes | | |
| Speed of tracked objects | | ≤ 50 knots | | ≤70 knots |
| Turn rate of tracked objects | | ≤ 10°/second | | ≤ 20°/second |
| Accuracy in track position | Range [[2]](#footnote-2) | ≤ 0.75 % of range covered by the individual radar or 10m + selected pulse length, whichever is the greater | | ≤ 0.5 % of range covered or 5m + pulse length |
| Bearing a | ≤ 1°, X-band  ≤ 2°, S-band | | ≤ 0.5°, X-band  ≤ 1°, S-band |
| Accuracy of track data | Speed a | ≤ 2 knots | ≤ 1 knot | ≤ 1 knot |
| Course a | ≤ 5° | ≤ 2° | ≤ 2° |

* 1. Track initiation and track maintenance

The radar PD should be adapted to the role of the VTS. The automatic track initiation and track maintenance is optimised accordingly.

Recommendation for the minimum radar PD for track initiation is given in Table 55.2. For track maintenance a lower minimum radar PD can apply, depending on the tracking principles used by the manufacturers.

1. Track initiation

|  |  |  |  |
| --- | --- | --- | --- |
| **Minimum radar** PD for track initiation | | | |
| **Priority of the VTS** | **Recommendation level** | | |
| **Basic** | **Standard** | **Advanced** |
| Surveillance and/or traffic monitoring | 0.9 | 0.8 | 0.7 |
| Safety | 0.9 | | |

* 1. False tracks

False tracks may appear as a result of noise, clutter (including wakes) and ghost echoes. However, the number should not be significant if the recommended values given in Table 55.1 and Error! Reference source not found. are respected.

The maximum number of false tracks allowed is dependent on role of the VTS. False tracks should be avoided in safety critical areas and occasionally accepted in areas where surveillance and traffic monitoring is the priority.

There is a trade-off between the time for confirmation of tentative track and the number of false tracks. A longer confirmation time implies less false tracks and it should be possible to balance this trade-off in the setup of the VTS.

* 1. Track loss

Track loss may occur as a result of PD < 1 in combination with targets manoeuvring, especially in the vicinity of obstructions such as bridges.

A level generally accepted is that each operator should correct up to one track loss per hour in all areas where the recommended values given in Table 55.1 and Table 55.2 are respected.

The VTS authority should address critical areas, such as the vicinity of bridges, and explain expectations to tracking to allow VTS suppliers to make solutions accordingly.

* 1. Track swap

Swapping of track identity may occur as a result of targets moving close together or even merging for a period of time, especially if targets are overtaking with small difference in speed and course.

A simple method of manual correction should be employed.

In the case of AIS information being available for the radar track(s) in question, automatic correction should be performed.

The problem may also be addressed by implementing operational procedures to separate targets or to prevent overtaking in critical areas.

1. PERFORMANCE REQUIREMENTS FOR EXTERNAL INFORMATION EXCHANGE IN VTS

4. External Information Exchange
   1. Between the VTS System and other VTS Systems/National Centres
   2. Between the VTS System and Allied Services

VTS Centres should be equipped with the ability to communicate with relevant allied services by the use of reliable communication networks. It is recommended that VTS Centres should be equipped with a digital switched network, with caller identification.

2. TEST AND ACCEPTANCE CRITERIA
3. Equipment standards and specification levels

International, and in some cases national standards, apply for radar and associated equipment. Common standards and suggested specification levels are listed in Table 15.5.

1. Equipment standards and specification levels

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Standard | Subject | Condition | Suggested limits versus equipment location | | | | | |
| Conditioned[[3]](#footnote-3) indoor, office or equipment room | Outdoor | | | | |
| Hot desert climate[[4]](#footnote-4) | Tropical climate | Subtropical climate | Temperate climate | Arctic climate |
| IEC 68-2 | Dry Heat | Function | 40°C | 60°C | 55°C | 50°C | | |
|  | Cold | Function | 10°C | 0°C | | - 25°C | | -40°C |
|  |  | Storage | - 25°C | | | | | -40°C |
| IEC 529 | Protection | Storage and function | IP 20 | IP 54 | | | | |
| IEC 950, UL, CSA | Safety | Storage and function | Refer to standards | | | | | |
| ITU-R SM.1541 | Unwanted emissions in the out-of-band domain | Function | Refer to standards, same values apply worldwide independent on climate | | | | | |
| ITU-R SM.329-9 | Spurious emissions | Function |

1. Reference IALA Guideline 1035 on Availability and Reliability of Aids to Navigation, December 2004 [↑](#footnote-ref-1)
2. Within one standard deviation (Gaussian distribution) when sailing on a straight course. Note that verification may require simulated tracks or other methods due to the fact that it may be impossible to direct a test target to sail with sufficient accuracy. [↑](#footnote-ref-2)
3. Air conditioned, ventilated or heated to temperatures between 15°C and 30°C and with less than 90 % humidity. If these levels cannot be met, requirements, including a reasonable margin, should change accordingly. [↑](#footnote-ref-3)
4. May in addition require special considerations in respect to sun radiation, dust (sand storms) and severely corrosive atmosphere. [↑](#footnote-ref-4)