International Association of Marine Aids to Navigation and Lighthouse Authorities

AISM Association Internationale de Signalisation Maritime IALA

IALA Recommendation V-128

On

Operational and Technical Performance Requirements for VTS Equipment

Edition 3.0

June 2007

Edition 1.0 – June 2004

Edition 1.1 – June 2005

Edition 2.0 – December 2005

20ter, rue Schnapper, 78100
Saint Germain en Laye, France
Telephone +33 1 34 51 70 01 Fax +33 1 34 51 82 05
e-mail: iala-aism@wanadoo.fr   Internet: www.iala-aism.org

Document Revisions

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 Annex 6 – Hydrological and Meteorological equipment	Annexes added as they are completed to ensure all aspects of VTS equipment are covered.
December 2005	Restructured to include operational performance requirements. Annex 2 amended to reflect new annex on operational performance requirements. Annex 6 renamed to Annex 5 Annex 1,3,4,6 added	Annexes 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 annexes harmonised, part of Annex 2 moved to new IALA Guideline (Establishment of Radar Services) Clarification of text, few sentences in annex 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.

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 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 Operational and Technical Performance Requirements for VTS as set out in the annexes to this recommendation as follows:

Annex 1 – Core Operational requirements for VTS

Annex 2 – Performance Requirements - Radar

Annex 3 – Performance Requirements - Automatic Identification System (AIS)

Annex 4 – Performance Requirements - Radiocommunications

Annex 5 – Performance Requirements - Hydrological and Meteorological

Annex 6 – Performance Requirements - Closed Circuit TV

Annex 7 – Performance Requirements - Direction Finding (DF) equipment. *(To be developed)*

Annex 8 – DGNSS and additional position related services equipment. *(To be developed)*

Annex 9 – Equipment for transfer of near real-time data between VTS centres. *(To be developed)*

RECOMMENDS that Competent Authorities providing Vessel Traffic Services take into consideration the appropriate Operational and Technical Performance Requirements contained in the Annexes to this recommendation when establishing appropriate standards for shore and offshore-based VTS.

* * *

Table of Contents

Annex 1

Core Operational Requirements for VTS

Table of Contents

1. INTRODUCTION

The purpose of this Annex is to give an overview of the core operational performance requirements for VTS including:

- Radar
- Automatic Identification System (AIS)
- Communications
- Closed Circuit TV (CCTV)
- Hydrometeo
- VTS Data System

Further details are given in Annexes 2 and onwards

Requirements of the VTS equipment may have a high impact on acquisition and life-cycle costs of a VTS and therefore the performance recommendations are divided into three different capabilities:

- **Basic** - applicable to VTS information service and, where applicable, navigational assistance service.
- **Standard** - applicable to all types of VTS as identified by IMO – information service, navigational assistance service and traffic organizational service – for areas with medium traffic density and/or without major navigational hazards.
- **Advanced** - applicable to VTS areas with high traffic density and/or specific major navigational hazards.

These capabilities may be used as applicable within a VTS, e.g. part of a VTS area may call for a Basic and another part may call for a Standard capability.

1.1 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

1.2 Supporting Documents

	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

2. VTS Radar Service

2.1 General

The performance requirements placed on the VTS radar service vary a great deal depending on traffic density, type of VTS, regional features and the VTS coverage area. Basic functions will be provided by the VTS Radar, enhanced functions may be provided by the VTS processing system. The purpose of this document is to describe the general performance requirements of the radar service. By meeting these general requirements, it is possible to provide the service required of the VTS radar equipment in the VTS coverage area.

The VTS Radar System should be capable of performing the functions shown in Table 2.1 These parameters will assist in the development of the traffic image.

Table 2.1 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

2.2 Characteristics of the Radar Target

The radar system's detection and measurement capacity depends on the characteristics of the radar and the target. These include the target's average reflective area and its oscillation in relation to the time and the measuring frequency used. The distributions of the target's reflective parts, the incidence angle and turning speed have a major impact on the power reflected back from the target.

The detection capacity required of the system is determined according to the type of service, traffic density and potential navigational hazards. Table 2.2 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,.

Table 2.2 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 m^2	1 m ASL
2	Inshore fishing vessels, sailing boats, speedboats and the like.			X		3 m^2	2 m ASL
3	Aids to Navigation with radar reflector.		X	X	4 m^2	10 m^2	3 m ASL
4	Small metal ships, fishing vessels, patrol vessels and the like.	X	X	X	40 m^2	100 m^2	5 m ASL
5	Coasters and the like.	X	X	X	400 m^2	1,000 m^2	8 m ASL
6	Large coasters, bulk carriers, cargo ships and the like.	X	X	X	4,000 m^2	10,000 m^2	12 m ASL
7	Container carriers, tankers etc.	X	X	X	40,000 m^2	100,000 m^2	18 m ASL

2.3 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.

2.4 Radar Accuracy and Discrimination

The measurement of accuracy and discrimination of the system is determined by the VTS authority based on Type of Capability. The recommendations for target separation for different types of capability are listed in Table 2.3.

Table 2.3 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	1.2°	1.3°	0.7°	0.8°	0.55°	0.6°
		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	≤0.7°		≤0.45°		≤0.40°	
	S-band	Angle between targets as seen from the radar	N/A		3.5°	4°	1.8°	2°
		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		≤2°		≤1.25°	

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.

2.5 Availability

The VTS authority should define the requirements for the availability of the radar service. The recommendations for availability are listed in Table 2.4 below. [a]

Table 2.4 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**.

2.6 Calculation

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

- by waterway model, or
- by radar site/ radar site combination model

[a] Reference IALA Guideline 1035 on Availability and Reliability of Aids to Navigation, December 2004

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.

3. AUTOMATIC IDENTIFICATION SYSTEM (AIS)

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.

3.1 Availability

The requirements for AIS availability is a matter for the VTS Authority to determine.

4. COMMUNICATIONS

Reliable communications are essential to deliver VTS services and coverage should be available throughout the VTS Area from one or communication technologies as listed below.

4.1 Very High Frequency (VHF)

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.

4.2 Long Distance Communication

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

4.3 Radio Direction Finder (RDF)

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 Table 4.1

Table 4.1 Bearing Accuracy

	Type of Capability		
	Basic	Standard	Advanced
Recommended Bearing Accuracy	$\leq \pm 2.5°$	$\leq \pm 1.5°$	$\leq \pm 1.0°$

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.

4.4 Communication with 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.

4.5 Availability

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

5. HYDROMETEO EQUIPMENT

It is essential that a VTS Centre has access to local Hydrometeo 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. Table 5.1 gives an indication of typical minimum accuracy requirements.

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

Table 5.1 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.

6. CLOSED CIRCUIT TV AS A VTS SENSOR (CCTV)

6.1 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.

6.2 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.

6.3 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.

6.4 Availability

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

7. VTS DATA SYSTEM

7.1 General

A VTS Data 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.

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

7.2 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.

7.3 Long Range Sensor Data

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 Figure 7.1. 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.

7.3.1 Availability

The requirements for Long Range Sensor data availability is a matter for the VTS Authority to determine.

7.4 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.

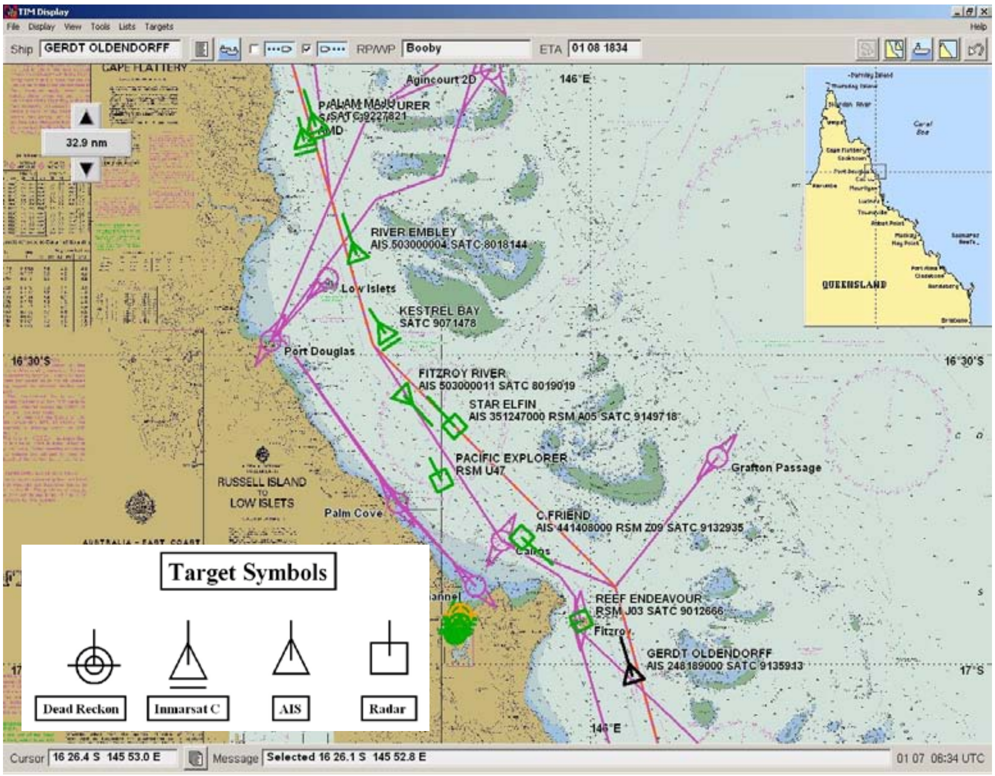


Figure 7.1 Long range image

7.5 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 Figure 7.2. This example is taken from the Baltic AIS Network which is integrated to the VTS system

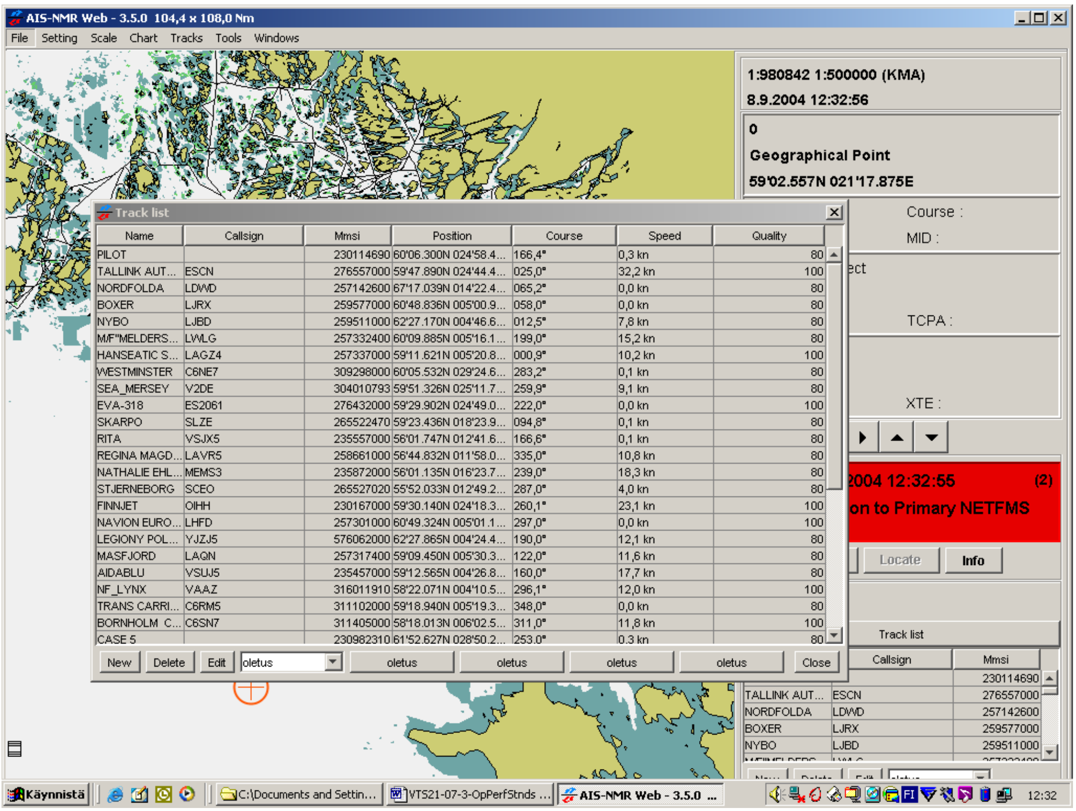


Figure 7.2 Example of List of Participating Vessels –Source: Archipelago VTS, FMA

8. 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; and
- Data from other sources if relevant.
- 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

Annex 2

Performance requirements - Radar

Table of Contents

1. Introduction

1.1 Background

Performance requirements for VTS radars are generally different to the requirements for marine navigational radars. VTS radars normally need to operate simultaneously on short and long range and this leads to dynamic requirements that far exceed those required onboard a ship.

Furthermore, weather related phenomena such as ducting will influence VTS radars more than ships' radars. This can have a significant influence on the performance – either positive or negative.

Good clutter suppression is needed for sea clutter and, in most parts of the world, for rain clutter as well. In addition, the need to see small targets in rough weather conditions is essential, especially if objectives include detection of targets for security purposes.

The introduction of AIS further develops VTS into a modern information system, and the presentation of radar information needs to follow the trend, putting new demands on the radar performance. Antenna side lobes and ghost targets (multiple reflections) may lead to false and dangerous results when radar returns and AIS plots are associated. High precision is therefore required to allow for unambiguous correlation of position obtained from two information sources.

1.2 Scope

The aim of this recommendation is to set generic performance requirements for Radar in VTS.

2. References

[1]	IEEE Std 686-1997	IEEE Standard Radar Definitions
[2]	Merrill I Skolnik	Introduction to Radar Systems, McGraw-HILL Higher Education, ISBN 0-07-290980-3
[3]	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.*
[4]	Ingo Harre	RCS in Radar Range Calculations for Maritime Targets. http://www.mar-it.de/Radar/RCS/RCS_18.pdf
[5]	IMO	Performance Standards for radar reflectors (latest edition)
[6]	International Telecommunications Union (ITU)	ITU-R SM.1541 Unwanted emissions in the out-of-band domain
[7]	International Telecommunications Union (ITU)	ITU-R SM.329-9 Spurious emissions
[8]	The International Organisation for Standardisation(ISO)	ISO 8729 Ships and marine technology – Marine radar reflectors
[9]	IALA	IALA 1056 Guideline for VTS radar service

3. Definitions and Clarifications

3.1 Definitions

For general terms used throughout this annex refer to:

- IEEE Std 686-1997 IEEE Standard Radar Definitions.

Specific terms are defined as follows:

- **Availability** is the probability that a system will perform its specified function when required.
- **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.
- **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 P_D** is the probability of detection at the output of a radar, subsequent to signal processing and plot extraction, but prior to tracking, and presentation.
- **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.
- **Track swap** is the transfer of a track identity (track label) to another track.

3.2 Software tools

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
AREPS	Advanced Refractive Effects Prediction System Space and Naval Warfare Systems Center, San Diego, http://sunspot.spawar.navy.mil.

3.3 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 isotrope
dBm	Decibel milliwatt
DF	Direction Finder
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
m^2	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)

P_D	Probability of Detection
P_{FA}	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
UTC	Universal Time Co-ordinated
UTM	Universal Transverse Mercator
VTS	Vessel Traffic Services
X-band	8.0 – 12.0 GHz
µs	microsecond
º	Degree
>	Greater than
≥	Greater than or equal to
≤	Less than or equal to

4. Functional Requirements

4.1 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.

4.2 Characteristics of Radar

In principle VTS radars typically function like ships radars, but they will in most cases need to operate simultaneously on short and long range, preferably without the need for operator adjustments.

Weather-related phenomena such as sea clutter and ducting will further influence shore-based radars more than ships' radars.

In addition, new challenges have developed over recent years, including:

- Introduction of new technologies, especially AIS, require the presentation of radar information to be sufficiently accurate to avoid ambiguity.
- Antenna side lobes and ghost targets (multiple reflections) may lead to false and dangerous results when radar returns and AIS plots are associated. High precision, low side lobe antennas and careful location of VTS radars is therefore required to allow for unambiguous correlation of position obtained from the two information sources.
- Offshore Renewable Energy developments, such as wind farms. VTS radars will normally not be dependent on Doppler shift and they are therefore not affected by the rotation of wind turbines, but the large towers may reflect radar signals resulting in false echoes. From a VTS Operator's perspective however, these false echoes are normally easy to distinguish. Shadowing may also present difficulties but the extent of this potential problem is currently not understood. Competent/VTS Authorities are therefore encouraged to enter into early discussions with Offshore Renewable Energy Developers in order to minimise any potential effects on VTS operations.
- Increasing demands to see small targets in rough weather, if objectives include detection of targets for security purposes.
- Requirement to reduce spurious / out of band emissions.

RF frequencies should comply with ITU Radio Regulations [6] [7] and national regulations. Otherwise it is suggested that the supplier decides on the most economical solution to meet the individual performance requirement, especially focussed on resolution, coverage and weather penetration.

4.2.1 Clutter and noise reduction facilities

Appropriate, clutter reduction facilities should be available to meet the performance criteria as defined per section 6.1.

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.

4.2.2 Dynamic characteristics

The dynamic range of the radar should, in normal weather and propagation conditions, detect and process the surface objects specified in Table 5.1 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. Table 4.1 refers.

Table 4.1 Typical target characteristics.

Target types		Typical characteristics at X-band		
		RCS	**Height**	**Fluctuations etc.**
1	Aids to Navigation without radar reflector.	Up to 1 m^2	1 - 4 m ASL	Rapidly fluctuating, highly dependent on sea characteristics.
2	Aids to Navigation with radar reflector.	10 – 100 m^2		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 m^2	1 – 2 m ASL	Rapidly fluctuating.
5	Small metal ships, fishing vessels, patrol vessels and other similar vessels.	10 – 100 m^2	2 - 4 m ASL	
6	Coasters and other similar vessels.	100 – 1000 m^2	6 - 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 – 10000 m^2	10 - 25 m ASL	
8	Container carriers, tankers and other similar vessels.	10000 – 1000000 m^2	15 - 40 m ASL	
9	Buildings, cranes. Stacks of containers and other large structures.	Up to 1000000 m^2	Depend on site	Insignificant.
10	Floating items, oil drums and other similar items. Birds, floating or flying.	Up to 1 m^2	0 to 0.5 m ASL	Rapidly fluctuating, highly dependent on sea characteristics.
11	Flocks of birds.	Up to 3 m^2	Sea level and up	Rapidly fluctuating, flight paths tend to be characteristic of given species in given areas of interest.

4.2.3 Antenna height

The figures below illustrate how the height of the antenna above the water line affects the maximum and minimum detection range performance.

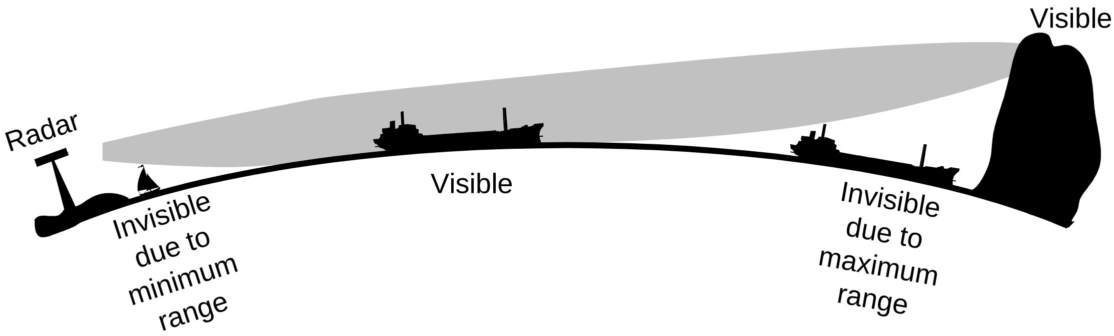


Figure 4.1 Target range and visibility

4.2.4 Plot Extraction

Plot extraction (see IALA Guideline 1056) should be automatic. The plot extraction process should be able to handle a minimum of plots per rotation (see Table 5.3).

4.2.5 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 P_D and P_{FA}.

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.

4.2.6 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 5.3) and to maintain tracks under certain conditions of P_D (Table 5.4) and $P_{FA} \leq 0.01$.

4.2.7 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.

4.3 Reliability and availability

The VTS authority should define the requirements for availability of radars for any given area in a VTS and thereby the requirements for reliability.

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".*
>
> *Availability = (service time - out of service time) / service time*

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 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**,

4.3.1 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 risk. 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.

4.4 Detection range and conditions

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 5.1 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 6.1;
- 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 6.1.

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.

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 6.1.

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 6.1.

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 6.1.

4.5 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.

5. Operational requirements

5.1 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 5.1 list the type of capability recommended per Annex 1 and corresponding target characteristics, to be used for the determination of detection performance.

Table 5.1 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 m^2	1 m ASL
2	Inshore fishing vessels, sailing boats, speedboats and the like.			X		3 m^2	2 m ASL
3	Aids to Navigation with radar reflector.		X	X	4 m^2	10 m^2	3 m ASL
4	Small metal ships, fishing vessels, patrol vessels and the like.	X	X	X	40 m^2	100 m^2	5 m ASL
5	Coasters and the like.	X	X	X	400 m^2	1,000 m^2	8 m ASL
6	Large coasters, bulk carriers, cargo ships and the like.	X	X	X	4,000 m^2	10,000 m^2	12 m ASL
7	Container carriers, tankers etc.	X	X	X	40,000 m^2	100,000 m^2	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

5.2 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 5.2 provides **examples** of point target characteristics suitable for the recommendation levels.

Table 5.2 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
In range		Long range applications (up to 20 nm coverage – littoral waters, offshore etc)	75 m	100m	60 m	75 m	50 m	60 m
In range		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	1.2^{o}	1.3^{o}	0.7^{o}	0.8^{o}	0.55^{o}	0.6^{o}
In azimuth	**X-band**	Or distance in meters, whichever is the greater	25 m	40 m	20 m	30 m	15 m	25 m
In azimuth	**X-band**	Corresponding –3 dB antenna horizontal beam width	$\leq 0.7^{o}$		$\leq 0.45^{o}$		$\leq 0.4^{o}$	
In azimuth	**S-band**	Angle between targets as seen from the radar	N/A		3.5^{o}	4^{o}	1.8^{o}	2^{o}
In azimuth	**S-band**	Or distance in meters, whichever is the greater	N/A		20 m	30 m	15 m	25 m
In azimuth	**S-band**	Corresponding –3 dB antenna horizontal beam width	N/A		$\leq 2^{o}$		$\leq 1.25^{o}$	

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

5.3 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 5.3 suggests values for each individual radar sensor in a system.

Table 5.3 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 [a]	≤ 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°

5.3.1 Track initiation and track maintenance

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

---

[a] 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.

Recommendation for the minimum radar P_D for track initiation is given in Table 5.4. For track maintenance a lower minimum radar P_D can apply, depending on the tracking principles used by the manufacturers.

Table 5.4 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		

5.3.2 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 5.3 and Table 8.1 are respected.

The maximum number of false tracks allowed is dependant 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.

5.3.3 Track loss

Track loss may occur as a result of $P_D < 1$ 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 5.3 and Table 5.4 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.

5.3.4Track 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.

5.4 Side lobe suppression

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

Table 5.5 provides characteristics suitable for the three Recommendation levels.

Table 5.5 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.

6. Radar configuration and installation

6.1 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).

It will typically 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.

Table 6.1 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					
				Basic recommendation		Standard recommendation		Advanced recommendation	
		RCS	Height	Clear	2 mm/h rain	Clear	4 mm/h rain	Clear	10 mm/h rain
20 m ASL	1	1 m^2	1 m ASL	N/A		N/A		5 NM Up to sea state 4	NIL
	2	3 m^2	2 m ASL	N/A		7 NM Up to sea state 3	4NM	7 NM Up to sea state 5	6 NM
	3	10 m^2	3 m ASL	7 NM Up to sea state 3	4 NM	8 NM Up to sea state 4	5NM	9 NM Up to sea state 6	7 NM
	4	100 m^2	5 m ASL	9 NM Up to sea state 4	8 NM	11 NM Up to sea state 5	9NM	12 NM Up to sea state 7	10 NM
	5	1000 m^2	8 m ASL	12 NM Up to sea state 5	10 NM	13 NM Up to sea state 6	11 NM	14 NM Up to sea state 8	13 NM
50 m ASL	1	1 m^2	1 m ASL	N/A		N/A		10 NM Up to sea state 4	NIL
	2	3 m^2	2 m ASL	N/A		10 NM Up to sea state 3	7 NM	12 NM Up to sea state 5	9 NM
	3	10 m^2	3 m ASL	10 NM Up to sea state 3	6 NM	12 NM Up to sea state 4	8 NM	14 NM Up to sea state 7	12 NM
	4	100 m^2	5 m ASL	13 NM Up to sea state 4	12 NM	15 NM Up to sea state 5	13 NM	17 NM Up to sea state 7	15 NM
	5	1000 m^2	8 m ASL	16 NM Up to sea state 5	15 NM	18 NM Up to sea state 6	17 NM	20 NM Up to sea state 8	18 NM
100 m ASL	1	1 m^2	1 m ASL	N/A		N/A		12 NM Up to sea state 4	NIL
	2	3 m^2	2 m ASL			13 NM Up to sea state 3	5 NM	16 NM Up to sea state 5	10 NM
	3	10 m^2	3 m ASL			17 NM Up to sea state 4	10 NM	18 NM Up to sea state 7	16 NM
	4	100 m^2	5 m ASL			20 NM Up to sea state 5	19 NM	22 NM Up to sea state 7	20 NM
	5	1000 m^2	8 m ASL			23 NM Up to sea state 6	22 NM	25 NM Up to sea state 8	23 NM

Note – Calculations in this table were performed using the software programme CARPET.

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 meet.

Table 6.2 Typical range performance, S-Band.

Antenna elevation	Target type	Modelled as fluctuating point target		Detection and tracking ranges for standard atmosphere and rain/sea state as indicated	
				Standard recommendation	
		RCS	Height	Clear	16 mm/h rain
20 m ASL	3	4 m^2	3 m ASL	4 NM	3 NM
				Up to sea state 4	
	4	40 m^2	5 m ASL	7 NM	5 NM
				Up to sea state 5	
	5	400 m^2	8 m ASL	10 NM	8 NM
				Up to sea state 6	
50 m ASL	3	4 m^2	3 m ASL	7 NM	4 NM
				Up to sea state 4	
	4	40 m^2	5 m ASL	11 NM	8 NM
				Up to sea state 5	
	5	400 m^2	8 m ASL	14 NM	13 NM
				Up to sea state 6	
100 m ASL	3	4 m^2	3 m ASL	10 NM	NIL
				Up to sea state 4	
	4	40 m^2	5 m ASL	14 NM	12 NM
				Up to sea state 5	
	5	400 m^2	8 m ASL	18 NM	19 NM
				Up to sea state 6	

Table 6.1 and Table 6.2 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.

6.1.1 Propagation 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.

For most parts of the world evaporation ducting tends to persist most of the time, giving extended range, especially for low mounted antennas. 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.

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

- Tropical climate;
- Dry and hot climate;

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.

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

6.2 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 6.1.

Table 6.3 Equipment standards and specification levels

Standard	Subject	Condition	Suggested limits versus equipment location					
			Conditioned[a] indoor, office or equipment room	Outdoor				
				Hot desert climate[b]	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						

6.3 Influence from Wind farms, Power cables and other like obstructions

The main influence from wind farms etc will typically be reflections.

The symmetrical lay out of wind farms may result in unwanted ghost echoes.

VTS radars will normally not be dependent on Doppler shift and they are therefore not affected by the rotation of wind turbines.

7. Interfacing

Methods for control of the radar, supply of information needed by the radar and methods for distribution of Radar Video should be described from the individual system supplier. Make sure that data transmission rates and bandwidths are sufficient.

---

[a] 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.

[b] May in addition require special considerations in respect to sun radiation, dust (sand storms) and severely corrosive atmosphere.

7.1 Track Data Output

Track data output is contained in track records. A track record should contain at least the following data:

- Track identification: an automatically generated integer or alphanumerical label;
- Current track date and time: from a common time reference;
- Current target position: Numerous formats: geographical (Latitude, Longitude), UTM (Northing, Easting), local (Range, Bearing);
- Current target speed: speed over ground
- Current target course: in degrees relative to North.

8. Back up and fall-back arrangements

8.1 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.

Table 8.1 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.

Table 8.1 Redundancy

<table>
<tr><th colspan="8">Availability and redundancy</th></tr>
<tr><td colspan="2" rowspan="2"></td><td colspan="6">Recommendation level</td></tr>
<tr><td colspan="2">Basic</td><td colspan="2">Standard</td><td colspan="2">Advanced</td></tr>
<tr><td colspan="2">Recommended availability for the individual radar site</td><td colspan="2">99 %</td><td colspan="2">99.7%</td><td colspan="2">99.9%</td></tr>
<tr><td colspan="2">Accessibility to site</td><td>Easy</td><td>Difficult</td><td>Easy</td><td>Difficult</td><td>Easy</td><td>Difficult</td></tr>
<tr><td rowspan="2">Redundancy typically required</td><td>Yes</td><td></td><td></td><td></td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>No</td><td>X</td><td>X</td><td>X</td><td></td><td></td><td></td></tr>
</table>

9. Safety precautions

Safety precautions should follow national and international standards as applicable for the individual installation.

This typically includes standards to protect personnel and equipment in relation to:

- Rotating machinery
- Radiation hazards
- Electrical shock
- Lightning strikes

It may also include warning lights at the radar towers for air traffic.

10. Marking and identification

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

Local or national legislation may require signposts etc.

11. Documentation

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

List of Figures

List of tables

Annex 3

Performance requirements for Automatic Identification System (AIS) in VTS

Table of Contents

1. 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.

1.1 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.

2. References

[1]	IMO MSC. 74(69), Annex 3	IMO Recommendation on Performance Standards for a Universal Shipborne Automatic Identification System (AIS)
[2]	SOLAS Convention	Chapter V Safety of Navigation, Regulation 19
[3]	ITU Radio Regulations	Appendix S18, Table of Transmitting Frequencies in the VHF Maritime Mobile Band
[4]	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

[5]	IEC Standard 61993 Part 2	Universal Shipborne Automatic Identification System (AIS) Operational and Performance Requirements, Methods of Testing and required Test Results.
[6]	IALA Technical Clarification	IALA Technical Clarifications of Recommendation ITU-R M.1371-1
[7]	IALA Recommendation A-124	IALA Recommendation on AIS Shore Stations and Networking Aspects Related to the AIS Service
[8]	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
[9]	Resolution A.953(23)	World-Wide Radionavigation System
[10]	Resolution A.688(17)	Code on Alarms and Indicators
[11]	Resolution MSC.39(63)	Adoption of amendments to the Code on Alarms and Indicators
[12]	IALA Recommendation V-125	IALA Recommendation on the Integration and Display of AIS and other information at a VTS Centre.

3. 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

4. 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.

4.1 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

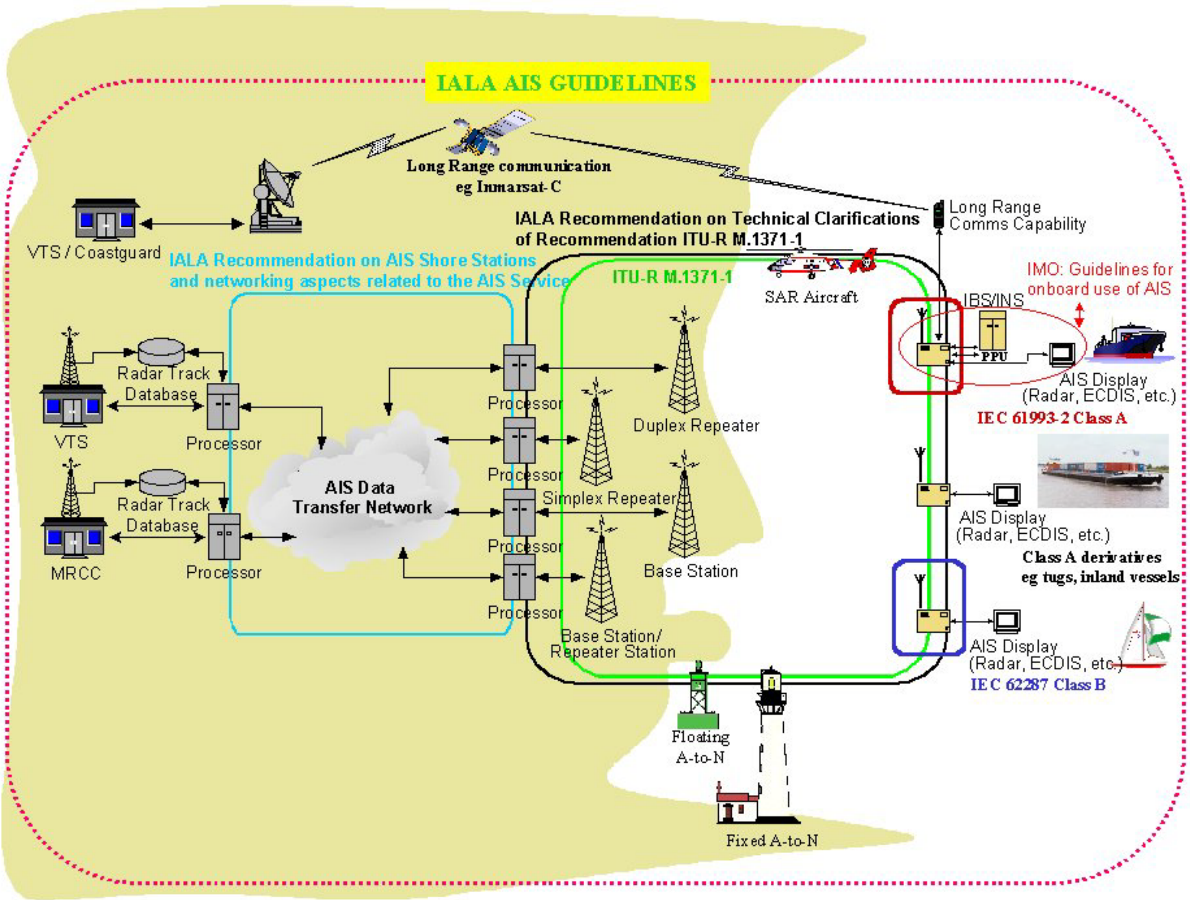
4.2 Objectives of AIS

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.



4.3 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.

5. Operational requirements

5.1 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.

a. 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.

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

c. 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.

5.2 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 can not currently respond to messages from virtual MMSIs.

5.3 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 onboard.

5.4 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.

5.5 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.

5.6 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.

5.7 Graphical presentation

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

5.7.1 Symbol usage

The IALA Guidelines on AIS include a description of the recommended AIS target symbols, but these were originally intended for the onboard 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 onboard 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.

5.7.2 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.

5.8 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.

6. Design and installation

6.1 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.

6.2 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

7. 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.

8. Documentation

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

Annex 4

Performance requirements for Radiocommunications in VTS

Table of Contents

1. 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.

1.1 BACKGROUND

The performance requirements placed on the radiocommunications service varies depending on traffic density, levels of VTS, special regional features and the coverage of the VTS area. The purpose of this document is to describe the general performance requirements of this service.

1.2 OBJECTIVES OF RADIOCOMMUNICATIONS EQUIPMENT

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.

2. REFERENCES

Relevant SOLAS requirements; SOLAS Chapter IV (Radiocommunications)

SOLAS Chapter V (Safety of Navigation) – Regulation 12

SOLAS Chapter V (Safety of Navigation) – Regulation 19

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;

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"

3. DEFINITIONS

As defined by ITU-R and IEC.

4. FUNCTIONAL REQUIREMENTS

4.1 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.

4.2 Malfunctions, warnings, alarms and indications

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

5. OPERATIONAL REQUIREMENTS

5.1 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.

5.2 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.

5.3 Availability

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

6. DESIGN AND INSTALLATION

6.1 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.

6.2 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.

6.3 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.

6.4 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.

6.5 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.

7. 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.

8. 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.

9. SAFETY PRECAUTIONS

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

10. DOCUMENTATION

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

Annex 5

Performance requirements for Hydrological and Meteorological Equipment in VTS

Table of Contents

1. 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.

1.1 Background

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.

1.2 Scope

The aim of Annex 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.

1.3 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.

2. References

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

IMO Resolution A.686(17)	Code on Alarms and Indicators (and MSC.39(63) Adoption of amendments to the Code on Alarms and Indicators)
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
IMO	SOLAS (i.e. Chapter V, Regulation 12)
IEC 529	Degrees of protection provided by enclosures (IP Code)
IEC 721-3-6	Classification of environmental conditions
IEC 60945	Maritime Navigation and Radiocommunication Equipment and Systems
WMO	International Meteorological Vocabulary
	Guide to Meteorological Instruments and methods of Observation
NMEA 0183	Standard for Marine Electronic Devices (IEC equivalent)

3. Definitions

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

3.1 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

4. Functional Requirements

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

4.1 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

4.2 Reliability

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

4.3 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.

5. 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.

5.1 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.

6. Design and Installation

Key aspects to design and installation include:

- Durability and resistance to environmental conditions
- Interference
- Power supply requirements /options
- Installation, and
- Maintenance

6.1 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.

6.2 Interference

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

6.3 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.

6.4 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"

6.5 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.

7. 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.

8. Backup Arrangements

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

9. Safety Precautions

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

10. Marking and Identification

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

11. Documentation

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

Annex 6

Performance requirements for Closed Circuit TV Service in VTS

Table of Contents

1. 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.

1.1 BACKGROUND

The performance requirements placed on the CCTV service varies depending on traffic density, levels of VTS, special regional features and the coverage of the VTS area. The purpose of this document is to describe the general performance requirements of these sensors.

1.2 OBJECTIVES OF CCTV EQUIPMENT

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.

2. REFERENCES

Electronics Industry Association (EIA) Recommended Standard RS-170

Relevant SOLAS requirements; SOLAS Chapter V (Safety of Navigation) as Regulation 12

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;

Resolutions with more specific requirements, such as:

NMEA 0183 – Standard for Marine Electronic Devices (IEC equivalent 60945)

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"

3. DEFINITIONS

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

4. FUNCTIONAL REQUIREMENTS

4.1 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.

4.2 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.

4.3 Malfunctions, warnings, alarms and indications

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

5. OPERATIONAL REQUIREMENTS

5.1 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).

5.2 Operational 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).

5.3 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.

5.4 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 ongoing 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).

5.5 Software requirements

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

5.6 Availability

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

6. DESIGN AND INSTALLATION

6.1 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.

6.2 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.

6.3 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.

6.4 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.

6.5 Maintenance

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

7. 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.

8. 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.

9. SAFETY PRECAUTIONS

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

10. MARKING AND IDENTIFICATION

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

11. DOCUMENTATION

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

****