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| IALA Guideline |

1???

AccEptance of VTS SYSTEMS

Edition 1.0

Document date

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

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| Date | Page / Section Revised | Requirement for Revision |
| month/year approved by Council | aaaaa | aaaaaa |
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|  |  |  |
|  |  |  |

0. Preamble 6

1. INTRODUCTION 7

1.1. definition 7

1.2. References 7

2. AIMS AND OBJECTIVES 8

3. VERIFICATION AND VALIDATION PROCESS 9

3.1. Management of the process 9

3.1.1. Strategic Planning 9

3.1.2. agreement on the requirement acceptance criteria 9

3.1.3. Verification and Validation Methods 9

3.1.4. Establishment of Acceptance Test Plan (ATP) 10

3.2. Process Model 11

3.2.1. System Element verification 13

3.2.2. System Integration 13

3.2.3. System verification 13

3.2.4. Validation Process prior to installation and Factory Acceptance Test (FAT) 13

3.2.5. Installation and setting to work 14

3.2.6. On site System Validation Process and Site Acceptance Test (SAT) 14

4. VTS SYSTEM Verification and Validation 16

4.1. Introduction 16

4.2. Verification and validation of Functional and Performance Requirements 16

4.3. Verification items 16

4.4. Validation items 16

5. On-Site AccePtance 18

5.1. Introduction 18

5.2. Pre-conditions before site installation and testing can commence 18

5.3. Test Execution 18

5.4. Formal registration, approval/non-approval of test outcomes 18

6. Radar Validation ANNEX 19

6.1. Design verification and Type approvals 19

6.2. FACTORY ACCEPTANCE 19

6.2.1. Functional verification 19

6.3. Site Acceptance of the Individual Radar Sensor 20

6.3.1. Inspections 20

6.3.2. Functional verification 20

6.3.3. Assessment of Influencing Factors 20

6.3.3.1. Shadowing and Multipath 20

6.3.3.2. Interference 21

6.3.3.3. Clutter suppression 21

6.3.3.4. Birds (floating or flying), suppression 21

6.3.4. Performance Measurement 21

6.3.4.1. Dynamic Requirements 21

6.3.4.2. Side lobes 22

6.3.4.3. Positional Accuracy 22

6.3.4.4. Target separation 22

6.3.4.5. Range detection 23

6.3.5. Overall Radar service 24

6.3.5.1. Functional verification 24

6.3.6. Radar coverage 24

6.3.6.1. Overall coverage 24

6.3.7. Determination of target RCS 25

6.3.8. in operation testing (not sure if this is needed specifically for radar) 28

7. Communications ANNEX 29

7.1. INTRODUCTION 29

7.2. AIMS AND OBJECTIVES 29

7.3. VERIFICATION & VALIDATION 29

7.3.1. Elements Verifications 29

7.3.2. Integration Verification 29

7.3.3. Validation Process Prior to installation 29

7.3.4. Validation Process on site 30

8. AUTOMATIC IDENTIFICATION SYSTEM ANNEX 31

8.1. INTRODUCTION 31

8.2. VERIFICATION ITEMS 31

8.3. VALIDATION ITEMS 31

9. ENVIRONMENTAL MONITORING ANNEX 34

10. ELECTRO-OPTICAL SYSTEMS ANNEX 35

11. RADIO DIRECTION FINDERS ANNEX 36

12. LONG RANGE SENSORS ANNEX 37

13. RADIO COMMUNICATIONS ANNEX 38

13.1. requirements 38

13.2. Verification items 39

13.3. Validation items 39

14. DATA PROCESSING 41

14.1. Recording, Archiving and Replay 42

15. VTS HUMAN / MACHINE INTERFACE ANNEX 43

16. RADIO COMMUNICATIONS ANNEX 44

Introduction 44

Purpose and Objectives 44

Standards and References 44

Design, Installation and Maintenance 44

Radio Communications Coverage 44

Recording and playback of data 45

System Malfunctions, Warnings, Alarms and Indications 45

17. DECISION SUPPORT ANNEX 46

18. EXTERNAL INFORMATION EXCHANGE ANNEX 47

18.1. (Example Heading level 2) 67

18.1.1. (Example heading level 3) 67

18.1.1.1. (Example heading level 4) 67

19. OVERVIEW (Example Heading level 1) 68

19.1. TABLES 68

20. FIGURES 69

21. DEFINITIONS 70

22. ACRONYMS 71

23. REFERENCES 72

List of Tables

Table 1 Example of a table with the significant information in the first column 68

Table 2 Example of a table with the significant information in the first row 68

Table 3 Example of a table with coloured rows 68

Table 4 Example table 78

List of Figures

Figure 1 Example figure 69

Figure 2 Another example figure 69

List of Equations

Equation 1 Geographical range 67

Equation 2 Theory of Special Relativity 67

# Preamble

At present, this document is a collection of information collected and processed during VTS-41, VTS-42, VTS-43 and VTS 44 to be brought forward to the next working period.

It is by no means representing the expected final outcome of the work to either update G1111 with further information on the acceptance of VTS systems or to make a separate guideline on the subject.

Part of the discussions at VTS-44 included a possible update of the structure to comprise numerous separate guidelines to the following scheme:

**Guidelines to be written:**

1. Overall process description guideline
   * High level (functional / nonfunctional)
   * Technology independent
   * Acceptance of overall system

**Technological dependent guidelines**

1. Radar
2. EOS
3. (Radio) Communications
4. Environmental monitoring
5. Human / Machine interface
6. Data processing
7. Decision support
8. External information exchange
9. IT aspects

Template structure for each guideline:

1. INTRODUCTION

1.1. definition

1.2. References

2. AIMS AND OBJECTIVES

3. VERIFICATION AND VALIDATION METHODS

3.1. <Technology> Element verification

3.2. <Technology> Integration Verification

3.3. <Technology> Validation Process prior to installation

3.4. <Technology> Validation Process on site

The below chapters comprised the collection of work up to and including VTS 42, yet to be subdivided into separate guidelines.

# INTRODUCTION

To be developed.

## definition

**Definition of Verification according to ISO:9000-2005 §3.8.4**

Confirmation, through the provision of objective evidence , that specified requirements have been fulfilled

Note 1 to entry: The term “verified” is used to designate the corresponding status.

Note 2 to entry: Confirmation can comprise activities such as

* performing alternative calculations,
* comparing a new design specification (3.7.3) with a similar proven design specification,
* undertaking tests (3.8.3) and demonstrations, and
* reviewing documents prior to issue.

**Definition of Validation according to ISO:9000-2005 §3.8.5**

Confirmation, through the provision of objective evidence (3.8.1), that the requirements (3.1.2) for a specific intended use or application have been fulfilled

Note 1 to entry: The term “validated” is used to designate the corresponding status.

Note 2 to entry: The use conditions for validation can be real or simulated.

Missing definitions in G1111

Area masking

Sector Blanking

Sector Transmission

## References

|  |  |  |
| --- | --- | --- |
| [1] | IALA Recommendation V-119 | The Implementation of Vessel Traffic Services |
| [2] | IALA Recommendation V-128 | Preparation of Operational and Technical  Performance Requirements for VTS Systems |
| [3] | IALA Guideline 1111 | Preparation of Operational and Technical Performance Requirements for VTS Systems |
| [4] | ISO 15288:2008 | Systems and Software Engineering – System life cycle processes |
| [5] | INCOSE-TP-2003-002-03.2.2 | INCOSE Systems Engineering Handbook. A Guide for System Life Cycle Processes and Activities, Ver. 3.2.2 October 2011. |

# AIMS AND OBJECTIVES

This guideline presents a common source of information to assist in the operational and technical acceptance of VTS systems.

The aim of this document is to provide a framework for validating and accepting a VTS System or a subsystem. In addition the document provides guidance on the methodology to be used.

This can be broken down in the following objectives:

* create a common understanding between the party accepting the (sub)system and the party delivering the (sub)system.
* describe (best practises) procedures/activities involved in defining tests and their expected output.

These processes demonstrate that the VTS (sub) System is working according to the agreed specifications.

The outcome of these processes/activities should lead to the acceptance of the VTS (sub) System.

# VERIFICATION AND VALIDATION PROCESS

This section explains the verification and validation process, the planning, the different phases and methods considered by IALA as a reference for the subsequent sections of the document.

This process aims to verify the compliance of the VTS system prior to operation against the contractual requirements through a structured model.

## Management of the process

### Strategic Planning

It is recommended to include a strategic plan for the validation and verification in the contractual document. Indeed the effort shall be adapted to system complexity and criticality.

The VTS system acceptance strategic plan may include how acceptance will be organized including the logistic, content and test order in each step, dependencies between process steps, key milestones to reach before proceeding to next stage/phase as well as a link to contractual acceptance.

### agreement on the requirement acceptance criteria

The requirements describe the operational scenarios, use cases, technical functions and performance of the system.

Requirements should:

* be uniquely identifiable
* have an acceptance criterion

A guidance principle for requirements is to describe them in a SMART (Specific Measurable Achievable Relevant Timebound) way. However this may not be possible for every requirement and, if so, contracting parties have to agree upon the acceptance criteria for these specific requirements.

Before the acceptance process can start the contracting parties should agree on the set of requirements to be validated, the verification and validation methods, and how to deal with non-compliance.

### Verification and Validation Methods

The basic verification and validation methods adopted by IALA, applicable to the VTS system or its different elements and relevant in the different phase of the V model, are as follow:

* Inspection (I): An examination of the item against applicable documentation to confirm compliance with requirements. Inspection is used to verify properties best determined by examination and observation (e.g. paint color, weight, physical dimensions, etc.).
* Similarity (S): Similarity is most appropriate where a design is being modified or is very similar to an existing verified system. When verifying by similarity, a common scenario is to perform an analysis to ensure the design and operational environment is similar enough to claim similarity.
* Analysis (A): Use of analytical data or simulations under defined conditions to show theoretical compliance. Analysis (including simulation) is used where verifying to realistic conditions cannot be achieved or is not cost-effective and when such means establish that the appropriate requirement, specification, or derived requirement is met by the proposed solution.
* Demonstration (D): A qualitative exhibition of functional performance, usually accomplished with no or minimal instrumentation. Demonstration (a set of verification activities with system stimuli selected by the system developer) may be used to show that the system or subsystem response to stimuli is suitable. Demonstration may also be appropriate when requirements or specifications are given in statistical terms (e.g. mean time to repair, average power consumption, etc.).
* Test (T): An action by which the operability, supportability, or performance capability of an item is verified when subjected to controlled conditions that are real or simulated. These verifications often use special test equipment or instrumentation to obtain very accurate quantitative data for analysis.
* Operational Trial (O): A period of time by which the system performance and reliability has to be proven according to Operational Procedure and reliability requirement.
* Certification (C): Written assurance that the product has been developed and can perform its assigned functions in accordance with legal or industrial standards. The development reviews and verification results form the basis for certification; however, outside authorities, without direction as to how the requirements are to be verified, typically perform certification (e.g. CE certification, UL certification, etc.)

The verification and validation cost generally increase when going down through the methods listed above, but also provides increased confidence that the requirement is actually met. The methods therefore involve balancing the most cost-effective mix of adequate testing against minimizing the risk of not meeting a requirement. Inadequate verification postpones problems to the validation phase, where costs for implementing needed changes to remedy the possible non-conformance is typically much larger.

For the validation, it is not sufficient to indicate the validation method. It is also needed to document *how* the stakeholder requirements shall be validated, and which validation activities the customer shall witness. As an example, there is a big difference if a requirement shall be tested with targets of opportunity or if the customer presupposes calibrated and certified targets, as the latter is much more expensive in both cost and schedule.

### Establishment of Acceptance Test Plan (ATP)

Goals:

* Agreement on acceptance criteria
* Agreement on verification and validation methods
* Agreement on planning and major milestones (e.g. FAT & SAT)
* Take into consideration the logistical aspects (e.g. resources, possible dependencies, documentation, …)
* Address non-compliance

The Acceptance Test Plan (ATP) is a collection of tests, analysis, and acceptance criteria that allows demonstrating that the system met contractual requirements. It shall describe the Validation methods for each requirement and the process phase in which these tests or analysis shall be conducted.

The Contractor, in cooperation with the Customer, may be responsible for the creation of the ATP which should be agreed on prior to the commencement of the acceptance testing. The ATP scope shall cover the complete system that forms the overall deliverable.

For each stage of acceptance testing, the Contractor shall issue a test procedure based on the agreed acceptance methods and procedures captured in the ATP. Test procedures should demonstrate compliance to the contractual requirements.

This test procedure shall include requirements for any systems, tools, software or resources needed to enable validation of the system under test. It should also include an agreed test protocol which consist of a list of requirements and corresponding verification tests, with their measurements and expected results, to demonstrate compliance.

At each stage of acceptance, the test report should at least include:

* Tested requirement(s)
* Configuration details;
* Date of the test;
* Who performed the test;
* The outcome of the test such as pass/fail, measurements, or findings.

Upon successful completion of the acceptance activities, described in the ATP, the system is considered ready for operational use.

## Process Model

Due to the complexity of the verification and validation process, the process may be broken down to several levels (see Figure 1 ):

* Component level (equipment or software);
* Sub-system level (functional assembly of components such as Communication system, AIS system, Radar system, …);
* VTS system level

VTS System

Level

Sub System

Level

Component

level

Design process / Customer requirement

Validation & verification process

VTS System

Design

Sub System

Design

Component

Design

Component

Validation &

verification

Ref to section 6

Sub System

Validation &

Verification

Ref to section 5

VTS System

Validation &

Verification

Ref to section 4

Figure 1: Verification process breakdown into levels

Verification and validation processes may be carried out at each level. Figure 2 illustrates how this may be done through a Generic Project Life-cycle Model called the V-model in System Engineering terms. This generic process is described in the remainder of this section. It must be noted that not all of the described process steps may be applicable to a specific level and thus the process steps may be adapted to each level. The procedures specific to each level are detailed in section 4, 5 and 6.

It should also be noted that a project often experience iterations between the phases as described in IALA guideline 1111 [3].

Implementation

Project Definition

System Design

Detailed Design

Test & Qualification

Implementation

System Architecture

Integration

(Tender)

Operational

Requirements

(Offered)

System

Requirements

System Element Requirements

Implementation

System Element Verification

System Integration

System Verification

System Element Design

Production

Installation & Training

System

Validation prior to installation

Installation &

Setting to work

On Site

System

Validation

IOT

SAT

FAT

Figure 2: V model

This paragraph describes the different phases of the verification and validation process.

### System Element verification

Goal:

* Evidence that individual system elements are compliant to the requirements

The purpose of System Element Verification is to verify the function and performance compliance of each system component. The Contractor usually performs this phase before or during implementation. This is typically done in the form of compliance statements, also stating the used validation methods. However, the Customer may want to witness and/or approve part of the process, such as:

* Type approval of individual equipment, as required by law in individual countries;
* Individual Hardware and Software specific verification tests;
* Verification of elements prior to delivery in the form of Factory Acceptance Tests;

### System Integration

Goal:

* Assemble system elements according to its intended functions

This phase is not a verification process as such, but rather aims to assemble system elements according to the defined architecture.

### System verification

Goal:

* Verify that the integrated system is performing according to system requirements

The extent of verification is highly dependent on the system complexity and Customer specific requirement. Part of this process step is the verification of the interaction between system elements.

### Validation Process prior to installation and Factory Acceptance Test (FAT)

Goal:

* Verify prior to installation that the functions and performance of the system are in accordance to the contractual requirement, in contractor or component vendor premises.

The conduction of this phase is the contractor responsibility and usually prepares for the Factory Acceptance Tests

Reasons for testing in factory:

* Controlled environment to perform a test
* Cheaper
* Easier
* Quick
* More precise
* Repeatable
* Availability of specific equipment
* Possibility of destructive testing
* More complete testing possible

The Factory Acceptance Test demonstrates, prior to shipping and as far as agreed, that the system conform to contractual specifications. The Customer may elect to attend or to be represented at the FAT.

The FAT will normally include Functional and Performance testing to agreed procedures.

Personnel conducting the test should be familiar with set-up and operation of the system in test. The Customer’s representative(s), if in attendance, should be appropriately qualified to accept the system and understand issues that may arise during the testing. Safety Instructions should be noted.

The outcome of a FAT should be recorded in a test report or certificate. These typically include:

* References to project name, customer, software revisions, hardware revisions, parts and serial numbers etc.;
* List of instruments and their calibration status;
* Functional test results including verification of safety measures;
* Performance test results;
* Signatories.

After the FAT, the contractor should ensure that any issues that arise are addressed.

### Installation and setting to work

Goal:

* To install system and be ready for on site testing.

Prior to the installation, the Supplier and Customer should agree that preparatory work, such as civil works and structures, is satisfactorily completed.

Part of this process step is the visual inspection of the installation on site of the system.

### On site System Validation Process and Site Acceptance Test (SAT)

Goal:

* Provide objective evidence that the system operates according to the specified requirements, thereby achieving its intended use in its intended operational environment.

After installation and setting-to-work, the SAT should take place. The purpose of the SAT is to confirm full operational and functional compliance.

Reasons for testing on site:

* Interaction with other systems
* Interaction with present infrastructure
* representative environment (e.g. geography)

This process performs a comparative assessment and confirms that the Customer requirements are correctly fulfilled. The validation process may cover the following validation examples depending on type of system:

* Operational tests
* Functional tests
* In-operation test (determining that availability, maintainability criteria etc. are meet)
* All supporting documentation is available;

Ideally, the SAT should not repeat the tests done at FAT.

The outcome of a SAT should be recorded in a test report or certificate. These typically include:

* References to project name, customer, software revisions, hardware revisions, parts and serial numbers etc.;
* List of instruments and their calibration status;
* Functional test results including verification of safety measures;
* Performance test results;
* Open issues and corrective actions
* Signatures.

During the SAT, the Customer and the Contractor should discuss any open issues and agree on appropriate corrective actions to be taken towards acceptance.

# VTS SYSTEM Verification and Validation

## Introduction

VTS System verification and validation is the top-most level of the whole process. After finalisation, the VTS System is demonstrated to comply with the customer requirements.

During the system-level V&V, the identified system-level requirements need to be demonstrated. The VTS sub-system-level and equipment-level requirements are assumed to have been demonstrated during the respective SATs and FATs.

Some system-level tests are identified in the annexes, describing the sub-systems in detail. Depending on the customer requirements, additional system-level tests may be appropriate.

## Verification and validation of Functional and Performance Requirements

* It is recommended to base verification on measured performance data using real targets/objects.
* Measurements, made from a live situation, should be analyzed taking into account the (possibly substantial) influence from the environment such as sea state, weather and propagation.
* It may be necessary to introduce simulated data to demonstrate system performance limits or to test alerting.
* Include statement about involving end-users?

## Verification items

* The customer may verify that the following documents have been issued:
  + Equipment test reports and compliance certificates
  + Sub-system test and calibration reports.
  + VTS System documentation such as design documents, operational and maintenance manuals.
* It is recommended that customer personnel, witnessing or taking part in the testing procedures, have been appropriately trained using the system.
* Availability and Reliability requirements
  + This type of requirements is, in general, time-consuming to test. Especially with high-availability figures, it takes a long time to collect statistically significant results. Also, VTS Systems usually have fallback/mitigation functions and redundant configurations to ensure continued operation when equipment or even complete sub-systems fail. In general, this means these requirements are not addressed during the VTS System level V&V.
  + It is suggested, after completion of the VTS System V&V, to agree upon a defect liability period in which the system is operational. During this period, no changes in configuration should be made, except to correct observed problems, and a record should be kept of any issues. At the end of the defect liability period, customer and contractor agree whether the VTS System is fit for operational use.

## Validation items

Validation items are largely defined by the specific sub-systems that make up the VTS system under test. In addition, there may be specific customer requirements.

As an example, requirements that generally need to be validated at system-level are

* Adequate coverage of the VTS area by sensors and communication means
* The quality of the traffic image
* The overall performance of the VTS System

# On-Site AccePtance

## Introduction

The purpose of this section is to support the customer in the validation and verification of a sub-system on-site.

On-site V&V should demonstrate the proper functioning of the sub-system after installation and addresses those requirements that can only be tested in the operational environment. It takes into account the outcome of the FAT and demonstrates that the installed sub-system complies with applicable regulations and the agreed requirements. On-site V&V may include inspections, functional checks and performance measurements.

In general, site acceptance testing comprises VTS sub-systems using different technologies and competent persons for the respective system.

## Pre-conditions before site installation and testing can commence

Before the on-site V&V can start, it should be checked whether items like

* + Site access
  + Construction works
  + Power (grid / non-grid / backup)
  + Environmental conditioning
  + Network connections
  + Safety measures
  + Lightning protection
  + Security

are sufficiently completed to able to commence testing.

## Test Execution

The items to be tested include

* + Physical Configuration Audit
  + Inspection of workmanship and regulatory compliance
  + Test of the equipment and sub-system installation
  + Test of sub-system integration, including networking
  + Setting to work, parameter adaptation and tuning
  + Operational performance tests

## Formal registration, approval/non-approval of test outcomes

It is recommended to register the test outcomes

* + For each sub-system individually
  + For the complete site, i.e. all the sub-systems, that make up the site

Based on the formal outcome of the tests, it should be agreed whether the VTS System level V&V can start.

# Radar Validation ANNEX

Be sure not to repeat descriptions from G1111

Address customer witnessing (or not) in general document

Define the term Contractual requirements relative to the V model

Mention quality assurance during production – on system level

Prior to SAT, the system shall be installed and set up in a state ready for operation.

Design verification and Type approvals …………………..

The purpose of this section is to support Competent and VTS authorities in the validation of radar performance and its contribution to the VTS traffic image (situational awareness) for:

* The overall Radar Service
* The individual Radar Sensor

This is typically performed by the combination of Design Verification, Type Approvals, Factory Acceptance Tests and Site Acceptance Tests where the FAT typically will focus on detailed functional tests and measurements of Technical Specifications (e.g. Transmitted power, pulse characteristics and antenna data) for the individual equipment.

The SAT shall demonstrate that the Radar Service complies with the Contractual requirements under operational conditions. This includes inspections, functional checks, measurements, and performance validation for the individual Radar Sensor as well at the overall Radar Service.

Also note that the installed radar performance should be assessed relative to that contracted and expected from site surveys. Some factors cannot be measured in absolute terms but require assessment by experienced and well educated technicians and/or operators.

## Design verification and Type approvals

From 1111…

## FACTORY ACCEPTANCE

The FAT is an verification of functionally and specifications, typically performed on sub-system or unit level ant not affected by environmental conditions. The radar specific content typically includes the following items:

### Functional verification

With the radar(s) in operational state, verify that functions and characteristics are compliant to Contractual requirements, such as:

* Safety functions
* Transmitted power
* Receiver sensitivity
* Transmitted and received waveform characteristics (e.g. time side lobes for pulse compression radars, pulse rise/fall/stretch for pulse radars)
* Antenna characteristics (e.g. gain, beam width, azimuth side lobes)
* Power consumption
* Test and monitoring functions

## Site Acceptance of the Individual Radar Sensor

Describe the SAT process – that we cannot expect it to be over and done with in one go – requires observations through extended time period due to the influence of weather conditions

### Inspections

Move the following to higher level

Verify that all equipment is installed and connected in accordance with the applicable installation documentation and good workmanship practice, in particular check that:

* there are no visible physical defects
* all units are connected to protective ground
* a lightning protection system has been implemented

Radar Sensor specific inspections include i.e.:

* check of the installation, that waveguides are connected properly, routed without sharp bends/dents and properly connected to grounding systems
* dehydration of waveguides
* lightning protection of antennas and waveguides
* safety (man aloft) switching

### Functional verification

Radar Sensor functional verification, with the radar(s) in operational state, include i.e:

* radar video is available and updated within the required rate
* control and monitoring interfaces (incl. redundancy if applicable) function as intended
* the safety switch functions work as intended
* the (built in) test and monitoring equipment is working according to contractual requirements, provides the intended information and does not display any errors
* site specific setup (position, update rate, transmission sectors, area masking etc.) has been completed
* that the video alignment in range and azimuth is correct. The test should be performed on at least two clearly visible point targets at known positions differing in, at least, azimuth.

### Assessment of Influencing Factors

#### Shadowing and Multipath

The assessment of influencing factors should include an evaluation of the radar performance in respect to shadowing and multipath effects taking constraints imposed by the individual Radar Sensor site into consideration.

Looking at the radar video, possibly at increased intensity to have surface clutter presented, observe that shadowing caused by large buildings, ships and other structures corresponds to line of sight without additional masking of coverage.

Reflections or multipath effects causing ghost echoes may be challenging to evaluate as such echoes easily are mistaken for real targets. The suppression, e.g. by masking of track initiation, may be a task requiring long term observations, use of AIS information etc.

Ghost targets caused by multipath reflections from moving vessels is of special concern as they often behave as real moving targets. Mitigation of such effects for the individual Radar Sensor may not be possible, but multi sensor correlation on System level can be a solution.

Illustration

Windfarms ….

Illustration

#### Interference

During SAT it should be verified that interference from other radars, including those on ships, is efficiently eliminated. Observe that “running rabbits” and other form of strokes are efficiently removed by enabling of the interference suppression

Illustration

#### Clutter suppression

Assessment of the clutter suppression features requires observations over time in order to evaluate their effect in a variety of weather situations, and their influence on detection performance.

The rain and sea clutter suppression should be validated against contractual requirements. This should be done under weather conditions normal for the location and the time of year.

Observe that good discrimination between target echoes and clutter is maintained with changing weather while at the same time avoiding false targets. In order to ensure optimum sensitivity, it should be considered to leave the settings such that a small sprinkle of clutter remains visible.

Testing during extreme events is normally not practical and should be avoided. Such conditions are normally covered by analysis during the design phase of a system.

During operation, iterative configurations of the clutter suppression might be necessary.

#### Birds (floating or flying), suppression

### Performance Measurement

Should behaviour before and after processing be discussed ?

#### Dynamic Requirements

Fulfilling of dynamic requirements can be verified by observation of known targets including the ability to detect

* small targets at their maximum required detection range
* large targets at the minimum range of the Radar coverage
* small targets in front of (in range) or besides (in azimuth) large targets at any range.

To be further developed

Receiver linearity to be known from design validation or FAT measurements – need to know for the follow on subjects

#### Side lobes

Azimuth side lobe characteristics of the antenna will be known from FAT, however, structures within the beamforming region of the antenna may increase the side lobe level at the individual site. Intense echoes of point targets in the coverage can be used to make onsite verification.

illustration

Range (time) side lobe characteristics (for pulse compression radars) will normaly be known from the design verification of the radar. Like for the azimuth side lobes, intense echoes of point targets in the coverage can be used to make onsite verification.

illustration

Time side lobes should not be mistaken from reflections in WG

illustration

Should a discussion on Doppler side lobes be included ?

#### Positional Accuracy

Verification of radar video positional accuracy in range and bearing should be performed using at least two fixed point targets within the coverage area, and at different bearings, more than 90 degrees apart. Preferably, one of the targets should be within a range of 2 nautical miles and the other between 30 % and 70 % of the radar coverage range. AtoNs on fixed foundations (not floating and held in position by chain) are typical good for the purpose. Fixed point structures such as broadcasting towers with precisely known geographical position may also be utilised.

Make illustration of where on the return to measure, leading edge on pulse radar, centre of gravity on pulse compression radar

For the range verification, please notice that the speed of light in the atmosphere differs from that in vacuum and hence the former should be used.

Targets with AIS are a good tool to further confirm positional accuracy within the coverage area. However, notice that AIS transponder installations often suffer from poor installation resulting in positional inaccuracies, therefore expect deviations.

#### Target separation

Verification of range and azimuth separation can be done using 1 out of 3 methods.

1. The preferred, by one fixed and one movable equal sized point targets (refletors) on land, e.g. a beach or flat paved area
2. Calculate on the basis of measured characteristic, being antenna pattern and transmitted pulse characteristics, the first compensated for any processing effects and the later compensated for any pulse stretch in the receiver chain
3. The most difficult, using point reflectors floating on the sea.

Do not use distributed targets such as ships as the radar characteristic of those typically are composed from several individual reflections and no be reproducible

To be further developed

#### Range detection

False alarms, propagation to be included in discussion

The validation of the range detection performance shall determine the detection of targets from minimum to maximum of the radar coverage range.

Use of targets of opportunity, AtoNs and Vessels in area, can give initial indication of range performance; however, this will not give quantitative and reproducible verification. It is therefore recommended to perform range detection tests using one or more test vessels with predetermined RCS, and at selected bearings (at least two) in the area of interest.

The RCS can be determined from paragraph 6.3.7

The planned sailing routes should preferably be radially and with free line of sight, from close to the radar to at least 10% beyond the calculated detection range. At the same time, safety of navigation must be obeyed.

The test must be performed within specified weather conditions for detection of the types of targets used. Theoretical ranges for the controlled target(s) used, and in actual weather conditions, must be determined (e.g. using CARPET models).

***Example of test sequence***

Illustration to be added

Observe radar (and tracking if applicable) performance from radar display, and:

1. Ask the test target to sail along the pre-planed trajectory. Ask the target to make a manoeuvre for each 1-2 nautical miles in order to evaluate radar echoes as a function of aspect ratio.
2. Observe and record (note, make screen captures or record live) the echo updates for the targets.
3. Continue the test until the target reaches a position that is 10% beyond calculated detection range or until video plots are seen in less than 3 out of 10 scans on the radar display, whichever situation occurs first.
4. Repeat the test when targets are sailing inbound.
5. Repeat steps 1)-4) for other selected bearings.

Acceptance criteria, e.g. for 90% probability of detection is that the target is seen in 9 out of 10 scans. However, allow for disturbances, e.g. loss of detection due to a larger vessel passing between the radar and the test target.

The obtained results can be used to benchmark simulation tools (based on the models used by CARPET) which in turn can be used to predict radar detection performance under different weather conditions.

### Overall Radar service

#### Functional verification

Radar Service functional verification include i.e.:

* data from all Radar Sensors is available and all Radar Sensors are functioning
* the overall positional accuracy and the alignment between the video, plots and tracks from the Radar Sensor(s) and the underlying charts.
* the transmission sector(S) and area masking has been set up correctly, e.g. that the Area Masking correspond to the actual land and sea.

### Radar coverage

Validation of the radar coverage may be divided into two parts, one part entails validating the overall coverage of the VTS system while the other part is concerned with validating the range detection performance.

#### Overall coverage

Validation of the radar coverage, ranging from that of individual radar sensors to that of the total VTS system, can be done using several hours of recordings of video and/or tracking information of targets of opportunity. An example of such a recording is shown in Figure 6‑1.



Figure 6‑1: Example of a video recording lasting several hours showing snail tracks of the vessel traffic (find better picture)

Validation of coverage outside normal shipping routes can be done using a test vessel covering additional areas of interest.

### Determination of target RCS

Short introduction to RCS, two possibilities of target choice to be added: uncalibrated vs calibrated

RCS must be known………………

Using uncalibrated targets

Most targets of interest for VTS will have AIS position and identification. This information, together with the target characteristics provided in table 9 of the IALA guideline 1111, can be used to obtain a rough estimate of the vessel RCS which in turn can be used in the validation of the radar detection performance.

However, this method can never lead to precise results as the RCS of such targets may vary drastically depending on the aspect angle as illustrated in *Figure 6‑2*.



*Figure 6‑2: The RCS as a function of the aspect angle for two different vessels. Both vessels are approximately 4000 GRT. Note that the scale is logarithmic and readings range from approximately 1 thousand square meters to 10 million square meters.*

Using calibrated targets

Radar receiver must be calibrated

The most accurate results on radar performance are obtained using calibrated targets, however, it is not practical to move e.g. radar reflectors at sea and it is therefore necessary to measure the RCS of vessels used for test against a reference reflector prior to any testing.

The selection of test targets should at least include the smallest type of test vessels mentioned in tender requirements (see tables 9 and 10 in ref [3]). (somewhere, discuss the importance of knowing the relation between RCS and target type)

Using very small targets such as rubber or wooden boats require radars meeting the IALA advanced recommendations. For non-metallic targets, circular polarisation will not work.

The calibration must be performed in calm weather with a low sea state.

A reliable choice of reference reflector is a metallic sphere floating on the sea surface on an air-filled tube (see Figure 6‑3).

Figure 6‑3 Example of a reference target: a metallic sphere on top of an air-filled tube floating on the sea surface.

The RCS, , of such a metallic sphere can be calculated according to

(insert reference)

where is the radius of the sphere. Note that the above equation is independent of the radar frequency and is valid in the regime where the radar wavelength is much smaller that the sphere radius. As an example, the radius of the sphere shown in Figure 6‑3 is 0.35 meters corresponding to an RCS of 0.4 square meters.

It is essential that the sphere is positioned close to the sea surface. If the sphere is elevated significantly, the measurements will be compromised due to lobing, that is interference between the direct echo signal and that reflected off of the sea surface

Note that the response of reference targets is polarisation dependent (typically calibrated in the horizontal plane) and the target calibration plane must match that of the antenna polarisation.

A prerequisite for the calibration is that the radar receiver characteristics are known.

Calibration procedure

The target to be calibrated and the reference reflector must be placed within a short distance from the radar, preferably at 0.5 to 1 nautical mile and in any case at less than 2 nautical miles. Additionally, the test area must be within free line of sight and distant from larger objects.

Illustrate/describe test setup

Request the controlled target(s) to move into the decided test position, carrying the reference target and:

1. Place the reference target with its floating support on the surface of the water.
2. Let the controlled target move 50-100 meters away from the test target, until clear separation is obtained on the radar display
3. Adjust the radar gain to obtain a clean picture of the test spot, with the test and reference targets clearly visible, and stable in the water, both in azimuth and range. Make sure that any automatic gain adjustment is disabled such that the gain will remain constant throughout the calibration procedure
4. Record the intensity of the reference target echo during at least 30 consecutive scans. Calculate the average value and variance of the echo intensity
5. Ask the controlled target to point its stern towards the radar (see Figure 6‑4)
6. Record the intensity of the controlled target echo during at least 30 consecutive scans. Calculate the average value and variance of the target intensity
7. Let the controlled target change its aspect angle in steps of 45 degrees (see Figure 6‑4), and after each change of aspect angle, repeat the measurement in 6). The last measurement is performed with the controlled target seen from astern
8. Let the controlled target move along a circular path centred at the reference target and with a radius of approximately 100 meters, and for each antenna scan, record the intensity of the controlled target echo



Figure 6‑4 Target angle relative to the radar antenna

If the values of the recorded intensities are on a logarithmic scale (in dB), the echo intensities must be transformed into the linear domain before averaging.

In order to determine the correct RCS, the receiver characteristics must be taken into account. (describe better)

When watching the echoes, note that real targets seldom follow the (simplified) mathematical models used by radar performance evaluation tools. This is particularly the case if very small, especially non-metallic, targets are used. Proper judgement of system performance does therefore require vast experience.

### in operation testing (not sure if this is needed specifically for radar)

Eg to validate availability – to be moved to system level

# Communications ANNEX

## INTRODUCTION

Radio communication equipment is useful for VTS Authorities and as a reminder; G1111 has produced guidance for the installation of the VTS infrastructure.

This document seeks to verify and validate the requirements.

## AIMS AND OBJECTIVES

The objective of this document is to provide methods to VTS authorities in the verification and validation of radio communication equipment performance.

## VERIFICATION & VALIDATION

We have defined the verification and validation processes in the following sections under Elements Verifications, Integration Verification, Validation Process Prior to installation and Validation Process on site.

### Elements Verifications

The elements to be verified and validate includes

* Radio Communications
* RDF
* AIS

### Integration Verification

VTS communication equipment may be located at remote sites and hence there is a need to verify its integration to the operating system of the VTS Centre. The competent and VTS authorities have to verify the following:

* The VTS Centre is able to remotely control and monitor the radio sites
* The link between the VTS Centre and the remote radio sites is operational

### Validation Process Prior to installation

Various aspects of the VTS site have to be taken into consideration to ensure that the site is suitable. The following validation processes are recommended:

At the moment, there is a list of items to check. In the next session, the processes will have to be defined.

* To check that the design of the system take into consideration the performance of the various components (e.g coaxial cables, antenna gain, SWR) for optimal performance.
* To carry out an Electro Magnetic Interference (EMI) test to ensure that there would not be unnecessary interference
* To ensure that the frequency is within the authorized limits by the local regulatory authority
* To conduct a spectrum analysis on the frequency to be used to ensure that its good
* Define the criterions for the calibration of the RDF (RDF)
* To check that the VHF Data Link has adequate slots for the additional loading (AIS)

### Validation Process on site

The VTS site should meet the operational requirements of the VTS Centre and there is a need to validate its capabilities. The following processes are recommended for validation.

At the moment, there is a list of items to check. In the next session, the processes will have to be defined.

* To ensure each equipment/components are installed properly and operational
* To conduct coverage test to verify the coverage (e.g. DSC, VHF Comms, Ch 16, lost messages for AIS)
* To check that the radio parameters (e.g. transmit power, receiver sensitivity) is optimized for the coverage area
* To check that the communications is operational (e.g. VTS operator at VTS centre able to communicate with vessels)
* To ensure that there is adequate lightning protection for the system
* To check that the joints between equipment/components are properly insulated and waterproof
* To verify that the radios for the VTS centre are configured properly according to the assigned frequencies
* To ensure that there is adequate backup power supply for the system
* The recording and playback should be tested and verified to be working according to the requirements
* To verify that the list of alarms and triggers are functioning as per required by the VTS Centre
* To verify that the fastening device to secure the antennas are appropriate taking into consideration the environmental conditions (e.g. wind load).
* To verify that the backup and fail back arrangements are functional
* To verify that the criterions are fulfilled
* To check the accuracy (e.g. bearing accuracy should be as what was stated in the requirements) and reliability of the system in real conditions. (RDF)
* To verify that the RDF is able to detect and locate transmission in the required frequency range (RDF)
* To verify that the RDF is able to simultaneously or near simultaneously monitor the required number of channels. (RDF)

# AUTOMATIC IDENTIFICATION SYSTEM ANNEX

## INTRODUCTION

The purpose of this section is to support Competent and VTS authorities in the validating AIS performance, AIS service and its contribution to the VTS traffic image (situational awareness).

The operational requirements to validate are describe in G1111 (§3.3)

Note that the validation procedure as to be adapted to the contractual requirement and in particular depend from available Physical Equipment (AIS base station; AIS limited base station; AIS receiver; AIS repeater; AIS Aid to Navigation (AtoN)).

## VERIFICATION ITEMS

The Competent and VTS authorities may verify that the following documents have been issued:

* AIS equipment test sheet issued by the AIS equipment manufacturer.
* AIS equipment compliance certificate issued by the AIS manufacturer including international standard (XXXX) and national or reginal regulation (CE Certificate)
* An MMSI number attribution issued by the appropriate national authority (Radio Communications or Broadcast Authority in most countries). Note that when several AIS base stations cover a large VTS Area, each base station can be given the same virtual MMSI.
* License has been attributed for every AIS base station by the appropriate national authority (Radio Communications or Broadcast Authority in most countries).
* Every AIS base station has a MMSI (Maritime Mobile Service Identity).
* Configuration document stating at the minimum that:

The correct MMSI number has been configure for each AIS equipment

If there is two base stations in and AIS Cell 30NM x 30 NM, one of the AIS base stations within a cell is configured to transmit its Fixed Access TDMA (FATDMA) information on one of the AIS VHF frequencies and the other base station is configured to transmit its FATDMA information on the other AIS VHF frequency.

## VALIDATION ITEMS

|  |  |  |  |
| --- | --- | --- | --- |
| G1111 | Scope | Procedure | Expected Result |
| 3.5 Operational Requirement | Check the AIS Coverage: | Check AIS track position report and information on the traffic image.  A cooperative vessel, with a verified AIS | All vessels equipped with an AIS transponder within the expected coverage area are displayed.  Cooperative vessel is tracked in the complete coverage area.  Note that weather condition, AIS network overload or specific consideration may affect the coverage ref to G1111 §3.7 for more information |
| 3.6.1.1 Target Tracking | Check that Vessel Position Report are available for VTSO |  | AIS tracks are display in the traffic image at the correct position  AIS information including the ship’s identity, ship type, position, course and speed over ground, navigational status and other safety related information are available.  The portrayal of the AIS tracks is consistent with the information received from the vessel (label, heading, outline size, …) |
| 3.6.1.2 Aids to Navigation | Check that AIS AtoN Report are available for VTSO AIS |  | AIS AtoNs are display in the traffic image at the correct position.  AIS AtoNs information including identity, type and other transmitted information are available |
| 3.6.1.3 Voyage-Related Data | Check that voyage, ETA and cargo are available to VTSO  Voyage, ETA and cargo are part of the standard AIS transmissions at 6 minutes intervals or on request. | Due to the absence of any commonly agreed procedure to update this data, it may not be present, be outdated or simply incorrect.  Consequently, the verification of this information shall be done with a cooperative vessel for which |  |
| 3.6.2 Information Exchange between VTS and Mariner |  | Coopering Vessel equipped with AIS shall be identified prior to the test |  |
| 3.6.2.1 Text Messaging | Check that VTSO and Mariner can exchange text message | Broadcast a message to all vessels fitted with AIS.  Acknowledge through VHF the good reception of AIS message | Vessel officer confirm the reception of the AIS message on its will appear on the Minimum Keyboard Display (MKD) of the on board AIS system |
|  |  | Send a message to specific vessels fitted with AIS.  Acknowledge through VHF the good reception of AIS message | Vessel officer confirm the reception of the AIS message on its will appear on the Minimum Keyboard Display (MKD) of the on board AIS system |
|  |  | Request to the Vessel Officer to send an AIS message to VTS. (It may be necessary to communicate the VTS MMSI number to the Vessel Officer). | VTSO is notify that an AIS message is received and can read the send message. |
| 3.6.2.2 Binary Messaging | Verify that the relevant “global” or “regional” binary messaging can be exchanged with mariners |  |  |
| 3.6.2.3 Aids to Navigation | AIS base stations, as part of a VTS System, can be configured to broadcast synthetic and/or virtual aids to Navigation (AtoN). |  |  |
| 3.6.3 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. |  |  |

# ENVIRONMENTAL MONITORING ANNEX

4.1 Introduction 64

4.2 Definitions and References 64

4.2.1 Definitions 64

4.2.2 References 64

4.3 Characteristics of Environmental Sensors in VTS 65

4.4 Operational Requirements 65

4.4.1 Information Presentation 65

4.4.2 Malfunctions and Indicators 65

4.4.3 Accuracy 65

4.5 Functional Requirements 66

4.6 Design, Installation and Maintenance Considerations 67

4.6.1 Suitability to Meet Range, Accuracy and Update Rate Requirements 67

4.6.2 Location within the VTS Area and its Approaches 67

4.6.3 Durability and Resistance to Environmental Conditions 67

4.6.4 Interference 67

4.6.5 Power Supply Requirements / Options 67

4.6.6 Installation 67

4.6.7 Maintenance 68

4.6.8 Interfacing 68

4.6.9 Backup Arrangements 68

4.6.10 Safety Precautions 68

# ELECTRO-OPTICAL SYSTEMS ANNEX

5.1 Introduction 69

5.2 Definitions and References 69

5.2.1 Definitions 69

5.2.2 References 69

5.3 Characteristics 69

5.4 Operational Requirements 70

5.4.1 Sensor Site Selection 70

5.4.2 Sensor Selection 70

5.4.3 Detection, Recognition and Identification 70

5.4.4 Recording and Replay 71

5.5 Functional Requirements 71

5.5.1 Pan, Tilt and Zoom 71

5.5.2 Precision and Repeatability 71

5.5.3 Auto Focus 71

5.5.4 Image Processing 71

5.5.5 Configuration 72

5.6 Design, Installation and Maintenance Considerations 72

5.6.1 Durability and Resistance to Environmental Conditions 72

5.6.2 Data Communications 72

5.6.3 Maintenance 72

# RADIO DIRECTION FINDERS ANNEX

6.1 Introduction 74

6.2 Operational Requirements 74

6.2.1 RDF Coverage Area 74

6.2.2 Bearing Accuracy 75

6.2.3 Frequency Range 76

6.2.4 Number of Simultaneously Monitored VHF Channels 76

6.3 Functional Requirements 76

6.3.1 VHF Channel Management 76

6.3.2 SAR Functionality 77

6.3.3 Man Overboard EPIRB Detection Capabilities 77

6.3.4 COSPAS/SARSAT Detection and Decoding 77

6.4 Design, Installation and Maintenance Considerations 77

6.4.1 Antenna Installation 77

6.4.2 Lightning Protection 77

6.4.3 Calibration 77

6.4.4 Built-In Test and Diagnostics 77

# LONG RANGE SENSORS ANNEX

7.1 Introduction 78

7.2 Long Range Identification and Tracking (LRIT) 78

7.3 Satellite AIS 78

7.4 HF Radar 79

7.5 Synthetic Aperture Radar (SARSAT) 79

# RADIO COMMUNICATIONS ANNEX

The purpose of this section is to support Competent and VTS authorities in the validating of radio communications, its performance parameters and its contribution to the VTS traffic image (situational awareness) and in supporting safe navigation of the VTS area.

## requirements

In 1111, do not repeat, advise on the most important specifics, such s EMC, keep on high level

The operational requirements to validate are the following:

* Collect position, safety, and general information from shipboard personnel and remote sensing devices ;
* the radio infrastructure guarantee the coverage in line with the area (A1, A2, A3, or A4) ;
* enable voice communications, data services and potentially video applications ;
* the radio communications range should facilitate VTS ship communications before the ship enters a VTS area of responsibility ;
* provide facility to automatically record radio communications and play back.

The functional requirements to validate are the following:

* Shipborne equipment should meet the functional requirements of the relevant IMO performance standards and the ITU‐R Radio Regulations ;
* Shore based equipment should also conform to the appropriate local technical standards ;
* Routine calls using DSC can be initiated by the VTS in order to direct a VHF call to a specific vessel through MMSI based addressing ;
* Distress calls use DSC system
* Power supply :
  + Spare solutions for supplying power (diesel generators, batteries, solar panels, wind turbines)
  + uninterruptible power supplies
* Site selection:
  + electrical power
  + physical security of the site
  + housing and possible re-location with existing infrastructure
  + Optimization of the coverage
* Environmental conditions – Weather elements
  + Electronic devices must be adapted from weather conditions : temperature, humidity and wind
  + wind load on antennas
  + lightning protection
  + maintenance access
  + Build-up of ice should also be a consideration
* Interference
  + Healthy requirements
  + Frequency spectrum must be agreed with the national radio licensing authority
  + Equipment should be installed in accordance with manufactorer's instruction and monitored
* Interfacing / Network
  + Compatibility of equipments with systems
* Development and innovations
  + Network card should be implemented in transmitters
* Back-up radio equipment
  + Radio equipment should be duplicated : availability assessment
* Shore stations
  + Power must be checked on antenna
* Antenna:
  + The resistance of the tower must be taken in consideration in the choice of antenna (wind conditions, weight)
  + orientation of antenna
  + Antenna directivity diagram
* Rack

## Verification items

* Power supply
  + Power supply test sheet issued by the equipment manufacturer
  + Power supply compliance certificate issued by the AIS manufacturer including local standard.
* Site location
  + Avoid channel saturation by subdividing the VTS area
  + Evaluate the impacts on human beings.
* Interference
  + Certificate…
  + Check if there is no neighboorhood station that can interfere the signal
* Interfacing / Network
  + Check the possibility of linking the equipment to the VTS authority network
* Shore stations / Radio signal
  + Check the Frequency band : VHF, MHF…

## Validation items

* Power supply must be available as long as possible : need alternative solutions as as batteries
  + Check the electrical wiring
  + Check the voltage of each power supply in respect of local standards
  + Check the activation time of spare power supply if main power is interrupted
* Environmental conditions – Weather elements - Electronic devices must be adapted from weather conditions
  + temperature, humidity and wind must be checked on site
* Shore stations / Radio signal
  + Measurements
    - Tx frequency
    - Rx frequency
    - Transmitters – ratio directed power / reflected power
    - Transmitters – Demodulation
    - Transmitters – Distorsion
    - Receivers – Sensitivity for squelch on
    - Receivers – Sensitivity for squelch off
    - Receiver – Scope 50 % full scale
    - Receiver – Listening on receiver loud speaker
* Antenna
  + Adaptation measurement for each antenna
* Interference: Frequency spectrum must be agreed with the national radio licensing authority
  + Study by the radio authority to validate the agreement
  + Check the frequency spectrum with tools like spectrum analyzer
* Interference: other tests to measure the efficience of the signal
  + Decoupling measurements between antennas
  + Harmonics measurements
* Development and innovations
  + voip: test:
    - Latency
    - Jitter
    - Quality of Service QoS
* Rack
  + Racks must be located in protected housing where tests must be done:
    - Power supply
    - Ambiant temperature
    - Humidity

# DATA PROCESSING

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

The validation shall focus on Operational Requirements of a recognized up-to-date traffic image, rather than Technical Specifications, using the principles of target racking and data fusion. Additionally, it introduces the issues of managing various types of information required within and outside the VTS.

the trade-off between a higher target detection probability, a larger initiation delay or a larger false target rate,needs to be taken into account.

It is recommended that the VTS Authority should specify the Operational and associated Validation

Requirements rather than Technical Specifications of Data processing

The operational requirements may be determined by:

* the Tracking and Data Fusion of the VTS system;
* the Tracking and Data Fusion sections consider sensor data from various sources including:

 Radar sensors;

 Adjacent VTS area or other agency tracks;

 AIS and Satellite AIS;

 LRIT;

 Electro-Optical Systems (EOS);

* Extracted plots include the following attributes:

 Time of measurement;

 Measured position (Cartesian or polar) and positional uncertainty;

 Originating sensor

* In addition, the plots attributes include:

 Identity;

 Radial (Doppler) speed;

 Physical extent of the plot;

 Signal strength

* Determination of environmental capabilities and constraints;
* Determination of ; the required probability of target detection and minimum acceptable latency in weather and propagation conditions normal for the VTS area
* Target separation and positional accuracy
* Update rate
* The required positional accuracy of the track and other associated track information (identity, target type, COG, SOG, manoeuvre etc.).

## Recording, Archiving and Replay

* Technical acceptance of Recording, Archiving and Replay will typically consist of functional tests in combination with validation of archive capacity.

# VTS HUMAN / MACHINE INTERFACE ANNEX

10.1 Introduction 97

10.2 Definitions and References 97

10.2.1 Definitions 97

10.2.2 References 97

10.3 Characteristics of User Interface 97

10.4 Operational Requirements 97

10.4.1 Traffic Image and Information Display 98

10.4.2 Environmental Information 99

10.4.3 Decision Support Presentation 99

10.4.4 Electro-Optical Sensor Data Display and Control 99

10.5 Functional Requirements 99

10.5.1 System Status and Control 99

# RADIO COMMUNICATIONS ANNEX

## Introduction

Radio communication equipment is typically integrated into VTS applications to provide the VTSO with 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.

## Purpose and Objectives

The purpose of this section is to support Competent and VTS authorities in the validation of Radio Communication System performance, supporting the design of the Radio Communication System and its contribution to the VTS traffic image (situational awareness).

The objectives of this validation will be to ensure the VTS system fulfills the following radio communication related objectives:

* Conforms to relevant local and international standards;
* Achieves design, installation and maintenance requirements;
* Achieves required radio communications coverage;
* Achieves required recording and playback of data;
* Demonstrates and displays required system malfunctions, warnings, alarms and indications

## Standards and References

Standards and references as per G1111 and customer supplied.

## Design, Installation and Maintenance

To be detailed – using G1111 as basis.

## Radio Communications Coverage

Validation of Radio Communication equipment to guarantee required coverage should be based upon the following:

* Area A1 - Within range of VHF coast stations with continuous DSC (digital selection calling) alerting available (about 20-30 nautical miles);
* Area A2 - Beyond area A1, but within range of MF coastal stations with continuous DSC alerting available (about 100 nautical miles);
* Area A3 - Beyond the first two areas, but within coverage of geostationary maritime communication satellites (in practice this means INMARSAT). This covers the area between roughly 70°N and 70°S
* Area A4 - The remaining sea areas. The most important of these is the sea around the North Pole (the area around the South Pole is mostly land). Geostationary satellites, which are positioned above the equator, cannot reach this far.

## Recording and playback of data

Recording and replay of radio communications should be validated to ensure that all designated radios record data as per recording and replay guidelines in G1111 and customer requirements.

## System Malfunctions, Warnings, Alarms and Indications

From the system verification tables all radio communication system malfunctions, warnings, alarms and indications should be defined.

Where system malfunctions, warnings, alarms and indications can be raised via controlled means or by triggers of opportunity, these should be validated to ensure adequate performance.

# DECISION SUPPORT ANNEX

11.1 Introduction 102

11.2 Definitions and references 102

11.2.1 Definitions 102

11.2.2 References 102

11.3 Characteristics of Decision Support Tools 102

11.4 Operational Requirements 103

11.4.1 Collision Avoidance 103

11.4.2 Anchor Watch 103

11.4.3 Grounding Avoidance 103

11.4.4 Air Draught Clearance 104

11.4.5 Sailing Plan Compliance 104

11.4.6 Area related 104

11.4.7 Speed Limitations 104

11.4.8 Incident or Accident Management 104

# EXTERNAL INFORMATION EXCHANGE ANNEX

12.1 Introduction 105

12.2 Definitions and References 105

12.2.1 Definitions 105

12.2.2 References 105

12.3 Characteristics of External Information Exchange in VTS 105

12.4 Data Management Considerations 106

12.4.1 Suitability for Purpose 106

12.4.2 Access to Information 107

12.4.3 Data Security and Confidentiality 107

12.4.4 Legal Limitations 107

12.4.5 Data Integrity 107

12.4.6 Data Models 108

12.4.7 Architecture of Sharing 108

12.4.8 Storage 108

12.4.9 Communication Links

1. G1111 reference Matrix

*Separate annexes may need to be developed for subsystems*

|  |  |  |  |
| --- | --- | --- | --- |
| G1111 | Scope | Procedure | Expected Result |
| Technical Requirements |  |  |  |
| Tender approval | Check if the tender comply with country law | Review the tender documents and ensure that it comply with law and regulations | the tender match with all documents |
| Contract approval | Check the contact validity | Verify compliance with contractual documents and include all SAT and FAT Procedures | Validated contract |
| Type approval | Check if the type of the sensors is comply with the tender and country law | Review the tender documents and ensure that the sensor comply with documents | All sensors match with the tender documents |
| Qualified Person | Find the trained and Qualified Person | Proceed the FAT & SAT by the Qualified Person | Test done |
| Software/Hardware Version/Model | Check HW/SW Version / Model | Compare with contractual documents |  |
| Specifications | Check technical characteristics of the equipment | Fulfillment of the minimum requirements |  |
| Fall back mode | Check Fall back mode |  |  |
| Availability | Check the redundancy that get the desired Availability | Ensure that the availability not less than the requirement | High Availability |
| Latency | Check latency | measure the time from a sensor first gathering data relating to a target, to the time the corresponding data is presented to the user | Acceptable Latency Level |
| Coverage | Check that the coverage meet the requirements | Check overlapping sensors coverage | Full coverage |
| Bit error rate BER | Check BER | Check that the BER is below the acceptable level | Low BER |
| Signal to Noise ratio SNR | Ensure that the measured SNR give the required quality of service QOS | measurement of the power of a return from a target vs. the local sensor noise around the location of the target | High SNR |
| Sensors correlation | Check the correlation between sensors | Ensure that the correlation is done between Sensors | done |
| Operational Requirements |  |  |  |
| Sensors Sensitivity | Check sensors sensitivity | Measure the minimum received signal from all sensors |  |
| Calibration of all sensors | Check the calibration procedures for all sensor | accurately calibrate various sensors to the common reference system | Calibration certificate issued |
| Reliability | Check Reliability | Check the maintenance Procedures and spare parts list |  |
| The probability of target detection | Check the target detection rate |  | there is a trade-off between a higher target detection probability, a larger initiation delay or a larger false target rate. |
| The probability of false alarm | Check the false alarm rate |  | there is a trade-off between a higher target detection probability, a larger initiation  delay or a larger false target rate. |
| Sensors Accuracy | Check that sensor measurements have accepted accuracy | estimate of a target position and speed vector, measurements |  |
| The time stamping | Check The time stamping | The time stamping of sensor data, accurately reflecting the time of observation and measurement, is essential to enable the correct and accurate traffic image to be established and maintained |  |
| Track Validation | Check the Track Validation | Tracks should be validated against the possibility that they are, or have become, false tracks. Assessment of track quality and erratic track update behaviour may be considered as techniques to provide validation. | operational requirements regarding the detection of small targets may result in an increase in the probability of false tracks. |
| Track Data Output | The output of track data to other VTS sub-systems such as the display of the established traffic image to the VTSO | Track information, which might be required for display to the VTSO, includes:   Current location;   Vessel Identity;   Speed and course over ground;   Track history;   Contributing sensors (and lack of updates i.e. coasting);   Associating plot data;   Destination and ETA;   Passage plan;   Cargo;   Crew and passenger details. |  |

Table 18‑1 provides a specification, validation and verification template for VTS systems following the structure of IALA guideline 1111 providing compliance matrix intended for use at time of proposal as well as verification and validation matrix intended to be filled out during acceptance tests of the delivered solution.

The VTS authority might adapt the table to the individual requirements whereas proponents offering VTS solution not in any way shall modify the tables by editing text, deleting or adding a line. Only the fields marked as SoC (Statement of Compliance) and Clarification shall be completed as part of the proposal work

For compliance statements there are 4 types of fields:

1. Heading: section heading, no responses required
2. Information: informative text to provide further clarification – no responses required
3. Implicit: A requirement which is further subdivided into “children requirements. All children requirements must be complied to, in order to fully comply to an implicit requirement. A “partially comply” can be responded if one or more children requirements are not compliant
4. Requirement: a mandatory requirement associated with a single “shall” statement

Requirements shall be answered with one and only one of the following text:

1. C: “Comply” - the requirement is fully met by the proposed system, with no need for modification (COTS).
2. WC: “Will Comply” the requirement is not currently met by a COTS system baseline SW/HW but will do so after development or modification.
3. WPC: “Will Partially Comply” - the requirement will partially do so after modification. The proponent must explain in detail the required modification(s), how it will improve the system and where it will meet and not meet the requirement.
4. PC: “Partially Comply” - The current COTS baseline does not fully meet the requirement. Clarification is required.
5. NC: “Not Compliant” - The current COTS baseline does not meet the requirement and cannot be migrated to the PC, WPC or WC state in the near future.

Verification and validation shall follow the requirements set by the VTS-authority using the following methods:

* *Inspection (I):* An examination of the item against applicable documentation to confirm compliance with requirements.
* *Similarity (S):* Similarity is most appropriate where a design is being modified or is very similar to an existing verified system.
* *Analysis (A):* Use of analytical data or simulations under defined conditions to show theoretical compliance.
* *Demonstration (D):* A qualitative exhibition of functional performance, usually accomplished with no or minimal instrumentation.
* *Test (T):* An action by which the operability, supportability, or performance capability of an item is verified when subjected to controlled conditions that are real or simulated.
* *Certification (C):* Written assurance that the product has been developed and can perform its assigned functions in accordance with legal or industrial standards. The development reviews and verification results form the basis for certification; however, outside authorities, without direction as to how the requirements are to be verified, typically perform certification(e.g. CE certification, UL certification, etc.)

Where

|  |  |  |  |
| --- | --- | --- | --- |
| G1111 | Scope | Procedure | Expected Result |
| Technical Requirements |  |  |  |
| Tender approval | Check if the tender comply with country law | Review the tender documents and ensure that it comply with law and regulations | the tender match with all documents |
| Contract approval | Check the contact validity | Verify compliance with contractual documents and include all SAT and FAT Procedures | Validated contract |
| Type approval | Check if the type of the sensors is comply with the tender and country law | Review the tender documents and ensure that the sensor comply with documents | All sensors match with the tender documents |
| Qualified Person | Find the trained and Qualified Person | Proceed the FAT & SAT by the Qualified Person | Test done |
| Software/Hardware Version/Model | Check HW/SW Version / Model | Compare with contractual documents |  |
| Specifications | Check technical characteristics of the equipment | Fulfillment of the minimum requirements |  |
| Fall back mode | Check Fall back mode |  |  |
| Availability | Check the redundancy that get the desired Availability | Ensure that the availability not less than the requirement | High Availability |
| Latency | Check latency | measure the time from a sensor first gathering data relating to a target, to the time the corresponding data is presented to the user | Acceptable Latency Level |
| Coverage | Check that the coverage meet the requirements | Check overlapping sensors coverage | Full coverage |
| Bit error rate BER | Check BER | Check that the BER is below the acceptable level | Low BER |
| Signal to Noise ratio SNR | Ensure that the measured SNR give the required quality of service QOS | measurement of the power of a return from a target vs. the local sensor noise around the location of the target | High SNR |
| Sensors correlation | Check the correlation between sensors | Ensure that the correlation is done between Sensors | done |
| Operational Requirements |  |  |  |
| Sensors Sensitivity | Check sensors sensitivity | Measure the minimum received signal from all sensors |  |
| Calibration of all sensors | Check the calibration procedures for all sensor | accurately calibrate various sensors to the common reference system | Calibration certificate issued |
| Reliability | Check Reliability | Check the maintenance Procedures and spare parts list |  |
| The probability of target detection | Check the target detection rate |  | there is a trade-off between a higher target detection probability, a larger initiation delay or a larger false target rate. |
| The probability of false alarm | Check the false alarm rate |  | there is a trade-off between a higher target detection probability, a larger initiation  delay or a larger false target rate. |
| Sensors Accuracy | Check that sensor measurements have accepted accuracy | estimate of a target position and speed vector, measurements |  |
| The time stamping | Check The time stamping | The time stamping of sensor data, accurately reflecting the time of observation and measurement, is essential to enable the correct and accurate traffic image to be established and maintained |  |
| Track Validation | Check the Track Validation | Tracks should be validated against the possibility that they are, or have become, false tracks. Assessment of track quality and erratic track update behaviour may be considered as techniques to provide validation. | operational requirements regarding the detection of small targets may result in an increase in the probability of false tracks. |
| Track Data Output | The output of track data to other VTS sub-systems such as the display of the established traffic image to the VTSO | Track information, which might be required for display to the VTSO, includes:   Current location;   Vessel Identity;   Speed and course over ground;   Track history;   Contributing sensors (and lack of updates i.e. coasting);   Associating plot data;   Destination and ETA;   Passage plan;   Cargo;   Crew and passenger details. |  |

Table 18‑1 also suggest methods and appropriate stage,

* during design,
* as part of Factory Acceptance Test ,
* as part of Site Acceptance T
* or as part of In Operation Test

|  |  |  |  |
| --- | --- | --- | --- |
| G1111 | Scope | Procedure | Expected Result |
| Technical Requirements |  |  |  |
| Tender approval | Check if the tender comply with country law | Review the tender documents and ensure that it comply with law and regulations | the tender match with all documents |
| Contract approval | Check the contact validity | Verify compliance with contractual documents and include all SAT and FAT Procedures | Validated contract |
| Type approval | Check if the type of the sensors is comply with the tender and country law | Review the tender documents and ensure that the sensor comply with documents | All sensors match with the tender documents |
| Qualified Person | Find the trained and Qualified Person | Proceed the FAT & SAT by the Qualified Person | Test done |
| Software/Hardware Version/Model | Check HW/SW Version / Model | Compare with contractual documents |  |
| Specifications | Check technical characteristics of the equipment | Fulfillment of the minimum requirements |  |
| Fall back mode | Check Fall back mode |  |  |
| Availability | Check the redundancy that get the desired Availability | Ensure that the availability not less than the requirement | High Availability |
| Latency | Check latency | measure the time from a sensor first gathering data relating to a target, to the time the corresponding data is presented to the user | Acceptable Latency Level |
| Coverage | Check that the coverage meet the requirements | Check overlapping sensors coverage | Full coverage |
| Bit error rate BER | Check BER | Check that the BER is below the acceptable level | Low BER |
| Signal to Noise ratio SNR | Ensure that the measured SNR give the required quality of service QOS | measurement of the power of a return from a target vs. the local sensor noise around the location of the target | High SNR |
| Sensors correlation | Check the correlation between sensors | Ensure that the correlation is done between Sensors | done |
| Operational Requirements |  |  |  |
| Sensors Sensitivity | Check sensors sensitivity | Measure the minimum received signal from all sensors |  |
| Calibration of all sensors | Check the calibration procedures for all sensor | accurately calibrate various sensors to the common reference system | Calibration certificate issued |
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| The probability of false alarm | Check the false alarm rate |  | there is a trade-off between a higher target detection probability, a larger initiation  delay or a larger false target rate. |
| Sensors Accuracy | Check that sensor measurements have accepted accuracy | estimate of a target position and speed vector, measurements |  |
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Table 18‑1 Specification, verification and validation template for VTS systems

| **Item** | Description | Requirements | G1111 Reference | Compliance Statement *(Contractual agreement - shall this be included?)* | | Verification and Validation of delivered solution | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **SoC** | **Clarification** | **Test method** | **Milestone** | **Procedure** | **Expected results per contractual requirements** | **Result incl. reference to reporting & description of possible corrective actions** |
| 1 | **INTRODUCTION** | **Heading** |  | **N/A** |  |  |  |  |  |  |
| 1.1 | **Scope** | **Heading** |  | **N/A** |  |  |  |  |  |  |
|  | This document covers the technical requirements for the delivery and associated life cycle support of …… | Information |  |  |  |  |  |  |  |  |
| 1.3 | **Core Requirements** | **Heading** |  | **N/A** |  |  |  |  |  |  |
| 1.3 | **Operational Requirements** | **Heading** | **1.3** | **N/A** |  |  |  |  |  |  |
| 1.3.1 | The VTS area, (VTS sub-areas) (and sectors) are delineated …. | Information |  |  |  |  |  |  |  |  |
| 1.3.2 | The of services to be provided include (INS, TOS, NAS) | Information |  |  |  |  |  |  |  |  |
| 1.3.3 | Types and sizes of vessels expected to participate in the VTS include: | Information |  |  |  |  |  |  |  |  |
| 1.3.4 | Navigational Hazards and traffic patterns are described in ….. | Information |  |  |  |  |  |  |  |  |
| 1.3.5 | Human factors including health and safety issues include ….. | Information |  |  |  |  |  |  |  |  |
| 1.3.6 | Tasks to be performed by System users include…. | Information |  |  |  |  |  |  |  |  |
| 1.3.7 | Refer to ……. For operational procedures, staffing level and operating hours of the VTS | Information |  |  |  |  |  |  |  |  |
| 1.3.8 | Co-operation with external stakeholders will include ……. | Information |  |  |  |  |  |  |  |  |
| 1.3.9 | Refer to ….. for information about physical security of the VTS Centre and remote sites *(possible classified documentation)* | Information |  |  |  |  |  |  |  |  |
| 1.3.10 | Refer to ….. for information on Business continuity, availability, reliability and disaster recovery | Information |  |  |  |  |  |  |  |  |
| 1.3.11 | The Legal framework is described by ….. | Information |  |  |  |  |  |  |  |  |
| 1.3 | **Technical Implementation** | **Heading** | **1.3** | **N/A** |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
| 1.4.1 | **Availability and Reliability** | **Heading** | **1.4.1** | **N/A** |  |  |  |  |  |  |
|  | Note that multiple means of communications and multiple sources of sensor information may result in reduced requirements for the availability of each item of equipment individually. | Information |  | N/A |  |  |  |  |  |  |
|  | Overall System Availability shall be XX.X % | Requirement |  |  |  | Analysis during design | FAT |  |  |  |
| Measurement | IOT |  |  |  |
|  | Individual sensor a… | Requirement |  |  |  |  |  |  |  |  |
|  | Individual sensor b… | Requirement |  |  |  |  |  |  |  |  |
|  | Communication …. | Requirement |  |  |  |  |  |  |  |  |
|  | Etc. | Requirement |  |  |  |  |  |  |  |  |
| 1.4.2 | **Recording, Archiving and Replay** | **Heading** | **1.4.2** | **N/A** |  |  |  |  |  |  |
| 1.4.2.1 | Stored and archived data shall include:   * ….. | Requirement |  |  |  |  |  |  |  |  |
| 1.4.2.1 | Storage capacity shall be for a minimum of \_\_ days | Requirement |  |  |  |  |  |  |  |  |
| 1.4.2.1 | Data shall be recorded automatically and be capable of replay without impact to on-going VTS operations. | Requirement |  |  |  |  |  |  |  |  |
|  | Information shall be synchronised of for replay | Requirement |  |  |  |  |  |  |  |  |
| 1.4.3 | Design, Installation & Maintenance | **Heading** | **1.4.3** |  |  |  |  |  |  |  |
| 1.4.3.1 | **Climatic Categories for outdoor installations** | **Heading** |  | **N/A** |  |  |  |  |  |  |
|  | The outdoor installations will be subject to  “Basic”, “Hot”, “Cold” “Severe Cold” /  “Coastal/Ocean”, “hot dry”, “hot humid” climate condition *(delete as appropriate)* | Information | 1.4.3.1 | N/A |  |  |  |  |  |  |
|  |  | Requirement |  |  |  |  |  |  |  |  |
| 1.4.3.2 | **Wind Considerations** | **Heading** | **1.4.3.2** | **N/A** |  |  |  |  |  |  |
|  |  | Information |  |  |  |  |  |  |  |  |
|  |  | Requirement |  |  |  |  |  |  |  |  |
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| 1.4.3.3 | **Special Considerations** | **Heading** | **1.4.3.2** | **N/A** |  |  |  |  |  |  |
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To be discuss if it is relevant to have compliance & Verification and Validation in separated rows – or make 2 tables – also should we make separate annexes for each type of subsystem.

## (Example Heading level 2)

Body text



1. Geographical range

Where:

Rg is the geographical range (nautical miles) (alternatively NM)

ho is the elevation of observer’s eye (metres) (alternatively m)

Hm is the elevation of the mark (metres) (alternatively m)

### (Example heading level 3)

Body text.

1. Theory of Special Relativity

Where:

E is the kinetic energy (Joules) (alternatively J)

m is the mass (kilograms) (alternatively Kg)

c is the speed of light (metres/second) (alternatively m/s)

#### (Example heading level 4)

Body text.

# OVERVIEW (Example Heading level 1)[[1]](#footnote-1)

Body text. Bullets have only one sentence. Anything further needs to appear in the relevant 'bullet text' style.

* Bullet 1:
* Bullet 1:
* Bullet 1.

## TABLES

Body text

1. Example of a table with the significant information in the first column

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| Table heading | Table text |
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| Table heading | Table text |
| Table heading | Table text |

1. Example of a table with the significant information in the first row[[2]](#footnote-2)

|  |  |  |
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| **Table heading** | Table heading | Table heading |
| Table text | Table text | Table text |
| Table text | Table text | Table text |
| Table text | Table text | Table text |
| Table text | Table text | Table text |

1. Example of a table with coloured rows

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| Table heading | Table heading | Table heading |
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**Note:** Colours for text and cell shading need to be selected from the permitted palette (see ANNEX G)

# FIGURES



1. Example figure



1. Another example figure

# DEFINITIONS

The definition of terms used in this Guideline can be found in the International Dictionary of Marine Aids to Navigation (IALA Dictionary) at <http://www.iala-aism.org/wiki/dictionary.Acronyms>

# ACRONYMS

IMO International Maritime Organization (Acronym style)

# REFERENCES

1. Abcd
2. Efgh
4. EXAMPLE OF AN ANNEX – LANDSCAPE

| **Item** | Description | Requirements | G1111 Reference | Compliance Statement *(Contractual agreement - shall this be included?)* | | Verification and Validation of delivered solution | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **SoC** | **Clarification** | **Test method** | **Milestone** | **Procedure** | **Expected results per contractual requirements** | **Result incl. reference to reporting & description of possible corrective actions** |
| 1 | **INTRODUCTION** | **Heading** |  | **N/A** |  |  |  |  |  |  |
| 1.1 | **Scope** | **Heading** |  | **N/A** |  |  |  |  |  |  |
|  | This document covers the technical requirements for the delivery and associated life cycle support of …… | Information |  |  |  |  |  |  |  |  |
| 1.3 | **Core Requirements** | **Heading** |  | **N/A** |  |  |  |  |  |  |
| 1.3 | **Operational Requirements** | **Heading** | **1.3** | **N/A** |  |  |  |  |  |  |
| 1.3.1 | The VTS area, (VTS sub-areas) (and sectors) are delineated …. | Information |  |  |  |  |  |  |  |  |
| 1.3.2 | The of services to be provided include (INS, TOS, NAS) | Information |  |  |  |  |  |  |  |  |
| 1.3.3 | Types and sizes of vessels expected to participate in the VTS include: | Information |  |  |  |  |  |  |  |  |
| 1.3.4 | Navigational Hazards and traffic patterns are described in ….. | Information |  |  |  |  |  |  |  |  |
| 1.3.5 | Human factors including health and safety issues include ….. | Information |  |  |  |  |  |  |  |  |
| 1.3.6 | Tasks to be performed by System users include…. | Information |  |  |  |  |  |  |  |  |
| 1.3.7 | Refer to ……. For operational procedures, staffing level and operating hours of the VTS | Information |  |  |  |  |  |  |  |  |
| 1.3.8 | Co-operation with external stakeholders will include ……. | Information |  |  |  |  |  |  |  |  |
| 1.3.9 | Refer to ….. for information about physical security of the VTS Centre and remote sites *(possible classified documentation)* | Information |  |  |  |  |  |  |  |  |
| 1.3.10 | Refer to ….. for information on Business continuity, availability, reliability and disaster recovery | Information |  |  |  |  |  |  |  |  |
| 1.3.11 | The Legal framework is described by ….. | Information |  |  |  |  |  |  |  |  |
| 1.3 | **Technical Implementation** | **Heading** | **1.3** | **N/A** |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
| 1.4.1 | **Availability and Reliability** | **Heading** | **1.4.1** | **N/A** |  |  |  |  |  |  |
|  | Note that multiple means of communications and multiple sources of sensor information may result in reduced requirements for the availability of each item of equipment individually. | Information |  | N/A |  |  |  |  |  |  |
|  | Overall System Availability shall be XX.X % | Requirement |  |  |  | Analysis during design | FAT |  |  |  |
| Measurement | IOT |  |  |  |
|  | Individual sensor a… | Requirement |  |  |  |  |  |  |  |  |
|  | Individual sensor b… | Requirement |  |  |  |  |  |  |  |  |
|  | Communication …. | Requirement |  |  |  |  |  |  |  |  |
|  | Etc. | Requirement |  |  |  |  |  |  |  |  |
| 1.4.2 | **Recording, Archiving and Replay** | **Heading** | **1.4.2** | **N/A** |  |  |  |  |  |  |
| 1.4.2.1 | Stored and archived data shall include:   * ….. | Requirement |  |  |  |  |  |  |  |  |
| 1.4.2.1 | Storage capacity shall be for a minimum of \_\_ days | Requirement |  |  |  |  |  |  |  |  |
| 1.4.2.1 | Data shall be recorded automatically and be capable of replay without impact to on-going VTS operations. | Requirement |  |  |  |  |  |  |  |  |
|  | Information shall be synchronised of for replay | Requirement |  |  |  |  |  |  |  |  |
| 1.4.3 | Design, Installation & Maintenance | **Heading** | **1.4.3** |  |  |  |  |  |  |  |
| 1.4.3.1 | **Climatic Categories for outdoor installations** | **Heading** |  | **N/A** |  |  |  |  |  |  |
|  | The outdoor installations will be subject to  “Basic”, “Hot”, “Cold” “Severe Cold” /  “Coastal/Ocean”, “hot dry”, “hot humid” climate condition *(delete as appropriate)* | Information | 1.4.3.1 | N/A |  |  |  |  |  |  |
|  |  | Requirement |  |  |  |  |  |  |  |  |
| 1.4.3.2 | **Wind Considerations** | **Heading** | **1.4.3.2** | **N/A** |  |  |  |  |  |  |
|  |  | Information |  |  |  |  |  |  |  |  |
|  |  | Requirement |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
| 1.4.3.3 | **Special Considerations** | **Heading** | **1.4.3.2** | **N/A** |  |  |  |  |  |  |
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1. example of ANNEX heading level 1

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* + - 1. Example of Annex heading level 4

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1. Example table

| No | Title/Topic | IMO References | Requirements | Possible Audit Questions | Remarks |
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| 1 | Table text | Table text | Table text | Table text | Table text |
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1. EXAMPLE OF AN APPENDIX TITLE
2. APPENDIX HEADING 1

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* + 1. APPENDIX HEADING 3

Body text

* + - 1. Appendix Heading 4

Body text

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

Body text.

* 1. Example of ANNEX HEADING Level 2

Body text

* + 1. Example of annex heading level 3

Body text

* + - 1. Example of Annex heading level 4

Body text

1. PERMITTED COLOUR PALETTE



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

Corporate colours

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

- dark blue

- white

- yellow

- gradient blue

**Primary and secondary colours**

The primary colours are to be applied in complement

with the corporate colours.

This second level of colours gives rhythm and helps

to segment our publications.

The secondary colours are used to highlight

information, titles in a minor proportion only.

**Note: Corporate colours are not shown**

Recommendations

Model Courses

Guidelines

1. Example footnote [↑](#footnote-ref-1)
2. Example of footnote [↑](#footnote-ref-2)