IALA

IALA GUIDELINE

G1111
ESTABLISHING FUNCTIONAL AND PERFORMANCE REQUIREMENTS FOR VTS SYSTEMS AND EQUIPMENT

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DOCUMENT REVISION

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

Date	Details	Approval
May 2015	First issue (edition 1.0) of Guideline 1111 on "Preparation of Operational and Technical Performance Requirements for VTS systems". Originated from IALA Recommendation V-128, edition 3. Annex from former Recommendation changed to Guideline and revised to include additional considerations, new technologies and emerging technologies. Additionally, consistency has been improved and duplications were removed.	Council 60
January 2022	Edition 1.1 - Editorial corrections published January 2022, in alignment with IMO Resolution A.1158(32) Guidelines for Vessel Traffic Services.	Council 74
December 2022	Edition 2.0 - Due to the comprehensive content of G1111 (115 pages), the document was split into one guideline and nine sub-guidelines and reviewed to describe the establishment of the functional requirements better. Title changed to "Establishing Functional and Performance Requirements for VTS Systems and Equipment"	Council 76

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1. INTRODUCTION

This Guideline presents a common source of information to assist competent authorities and VTS providers in the preparation and establishment of functional and performance requirements for VTS systems. Tailoring is required to capture the specific and relevant performance requirements from the generic information included within this document. The Guideline should not be used as a specification without such tailoring.

References and definitions applicable to the separate sections are included in the sections where appropriate.

This Guideline is associated with Recommendation R0128 VTS Systems and Equipment [1], a normative provision of IALA Standard S1040 Vessel Traffic Services (VTS). To demonstrate compliance with the Recommendation, the provisions of this Guideline should be taken into account.

1.1. PURPOSE

This Guideline is one of the *G1111* series of guideline documents. The purpose of the *G1111* series is to assist the competent authority for VTS and the VTS provider in preparing the definition, specification, establishment, technical operation and upgrades of a VTS system. The documents address the relationship between the functional requirements and VTS system performance (technical) requirements and how these reflect into system design and sub system requirements.

1.2. G1111 GUIDELINE SERIES

The G1111 series of guideline documents present system design, sensors, communications, processing, and acceptance, without inferring priority. New sub-guidelines can be introduced to the *G1111* series in future. The guideline documents are numbered and titled as follows:

- G1111 Establishing Functional and Performance Requirements for VTS Systems and Equipment
- G1111-1 Producing Requirements for the Core VTS System
- G1111-2 Producing Requirements for Voice Communications
- G1111-3 Producing Requirements for RADAR
- G1111-4 Producing Requirements for AIS
- G1111-5 Producing Requirements for Environment Monitoring Systems
- G1111-6 Producing Requirements for Electro Optical Systems
- G1111-7 Producing Requirements for Radio Direction Finders
- G1111-8 Producing Requirements for Long Range Sensors
- G1111-9 Framework for Acceptance of VTS Systems and Equipment

2. ESTABLISHING THE FUNCTIONAL AND PERFORMANCE REQUIREMENTS FOR A VTS SYSTEM AND EQUIPMENT

IALA Guideline *G1150 Establishing, Planning and Implementing VTS [2]* advises on the planning and implementation of a VTS related to the definition of operational, functional, performance and acceptance requirements of a VTS system. These requirements should be:

- derived from a business case and feasibility study in the initiating phase; and
- defined in the planning phase of the overall VTS project before the procurement of the VTS system.

The competent authority for VTS and/or the VTS provider should establish operational, functional and performance requirements and acceptance plan for a VTS system at the same time as they establish their procurement plan. These requirements should form the basis for the entire system lifecycle, its definition and its acceptance following implementation.

The *G1111* Guideline Series provide generic guidance for all potential equipment and sensors that may be used in designing a VTS system. The guidance is not prescriptive, and the capabilities required may vary between VTS, VTS area and VTS sectors or even specific parts of a VTS area or sector. VTS capability should be linked to a risk assessment which will identify the degree of mitigation expected of a VTS, together with other mitigation measures, in addressing a specific hazard or hazards. The extent of risk mitigation will be determined by a number of factors that include the equipment fit, equipment capability, local geography and operator authorization/training. This Guideline focuses on an overview of the key areas for consideration related to the establishment of a VTS system.

IALA sub-guidelines *G1111-1* to *G1111-8* provide specific guidance on initiating and planning functional and performance requirements and implementing VTS systems and equipment, based on operational requirements.

Acceptance steps are typically conducted on the proposed or implemented VTS to ensure compliance with the requirements. These acceptance steps are discussed in *G1111-9 Framework for Acceptance of VTS Systems and Equipment*.

2.1. PROJECT PLANNING

IALA Guideline *G1150* recommends a project management approach to ensure that major deliverables, assumptions and constraints are clearly documented when planning and implementing a VTS. This will assist in defining the scope of the VTS, its goals and objectives that need to be met. Project management is considered as a discipline with the purpose to achieve specific goals and objectives by planning, organizing, motivating, and controlling resources.

Relevant international guidance prepared and published by appropriate international organizations regarding project management should be considered, or, where there are national requirements for project management, these should be used.

2.1.1. PROJECT MANAGEMENT STEPS

Project management is undertaken in different steps in order to improve control and quality. Guideline *G1150* provides an overview of the five project management phases and the key areas for consideration as they relate to VTS:

- Initiating
- Planning
- Implementing
- Controlling
- Closing

It is noted that before completing each stage to define functional and performance requirements, these results could be re-evaluated by risk assessment and cost benefit analysis. The core practice in the planning phase is finalising the requirements. This involves combining the relevant operational requirements with the functional and performance requirements, without unintentionally restricting flexibility in the implementation.

It is important to write well-structured, individual requirement statements within the published requirements documentation.

Note that, for the implementation phase, several possible technical solutions may be identified to achieve the defined requirements and each of these solutions may have different strengths and weaknesses. Scoring systems to address the most critical aspects of the operational requirements may need to be considered when preparing a procurement plan.

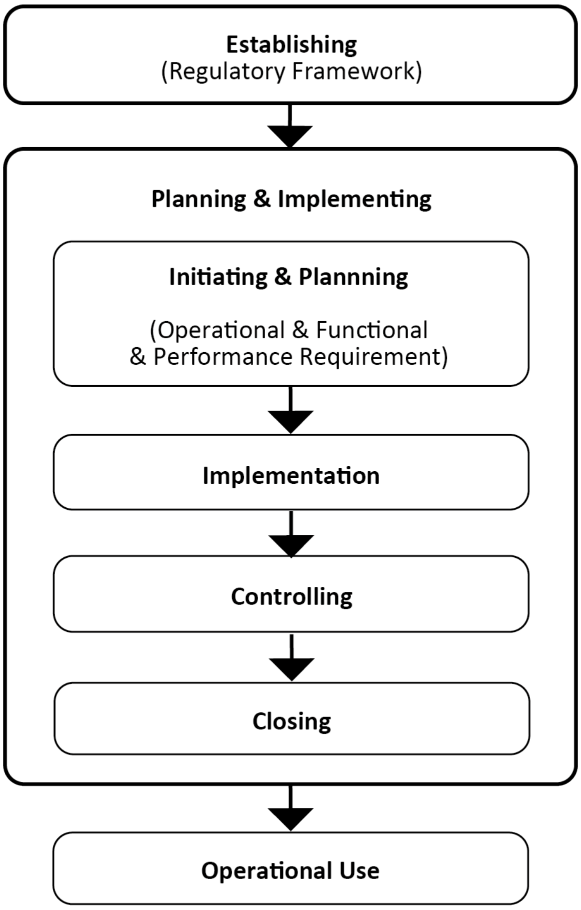

Figure 1 Project management steps in establishing VTS systems

2.2. SECURITY REQUIREMENTS

The security requirements needed to derive the functional and performance requirements should include, but not be limited to:

- Physical security of the VTS Centre and remote sites
- Cyber security
- Business continuity, availability, reliability and disaster recovery

2.3. OPERATIONAL REQUIREMENTS

The operational requirements needed to derive the functional and performance requirements should include, but not be limited to:

- Delineating the VTS area and, if appropriate, VTS sub-areas or sectors
- Types and sizes of ships required or expected to participate in the VTS
- Navigational hazards and traffic patterns
- Human/machine interface and human factors, including health and safety issues
- Tasks to be performed by VTS operators and/or supervisors
- Operational procedures, including communication, staffing level and operating hours of the VTS
- Information sharing and co-operation with external stakeholders
- Legal framework

2.4. DERIVING FUNCTIONAL AND PERFORMANCE REQUIREMENTS

The functional and performance requirements for a VTS system should be derived from the operational requirements. This may be an iterative process, which can be aligned with the phases of Guideline *G1150*.

In order to define functional and performance requirements, the operational requirements may be grouped into:

- communications
- situational awareness
- recording and playback
- reliability and availability

The grouping of operational requirements facilitates the creation of functional and performance requirements, for example, divided into:

- voice and data communication
- the VTS Centre, sites, sensors and processing
- recording and replay, including post situational analysis
- redundancy and resilience

Deriving system concepts may involve various mathematical, functional and simulation models to visualize different characteristics of the system. Models to consider might include, but not be limited to:

- Radio communications coverage
- Sensor coverage
- Communications network infrastructure
- Data architecture and interfaces
- Reliability and availability, including any redundancy options
- Lifecycle costs

The models could assist in establishing the relationship between the system concepts, associated functional and performance requirements and operational requirements. Feasibility studies (site surveys, equipment trials etc.) may also be appropriate to reduce technical risks which may otherwise not be apparent until implementation.

Additional functional and performance requirements may come from, but not be limited to:

- Environmental considerations
- Legal obligations
- Ergonomic issues
- Safety (other than navigational safety)
- Security requirements, e.g., physical security, personnel security, cyber security incl. software updates during operation
- Operational business rules or operational procedures

3. IMPLEMENTATION CONSIDERATIONS

VTS system implementations may require consideration of the following:

- VTS system function and performance including, but not limited to :
  - Off-the-shelf solution or customized solution
  - Sensor and radio coverage, including overlapping coverage
  - Equipment redundancy
  - Communications routes
  - External Interfaces
  - Electromagnetic issues (EMI/EMC)
- VTS system sustainability including, but not limited to:
  - Lifecycle planning, including environmental impact and sustainability in the choice of materials, power consumptions etc.
  - Maintenance of the VTS system and equipment
- Environmental constraints and impacts such as wind, influence from the sea, precipitation and possibly ice
- Locational and infrastructure design should include but not be limited to:
  - VTS Centre location(s)
  - Available land and suitability of sensor sites
  - Existing infrastructure such as power and data lines
  - Selection of installation sites with due respect to neighbours
  - Security and site access
- Rules and regulations, for example:
  - Applicable rules and regulations, i.e. required licenses (transmission, building etc.)
  - Business rules

- Organization, for example:
  - Administrative functions and roles
  - Authorization levels

Any VTS system should, as a minimum, be equipped with means to build a VTS traffic image as well as providing reliable communications.

The system architecture of a VTS system should carefully consider issues such as, but not be limited to:

- Network requirements (bandwidth, latency etc.)
- Redundant data paths
- Data integrity
- Security requirements, e.g., physical security, cyber security
- Data storage
- Reporting and recording requirements
- Maintenance of the VTS System and its equipment

In addition, the system architecture should have built-in flexibility for future upgrades and have the capability to be maintained without impacting routine VTS operations.

During the development of the system architecture, comprehensive site surveys should be performed, including but not limited to the above considerations. Involvement of relevant stakeholders in the site survey early in the process adds value and ensures awareness of the potential risks (e.g., design and performance).

3.1. AVAILABILITY AND RELIABILITY

The VTS provider should define an overall availability and reliability target for the VTS system, including the elements to be considered based on the risk assessment results. The relationship between downtime and availability figures is given by Table 1.

Table 1 Relationship between downtime and availability

Availability				
Annual downtime	87.6 hours	24 hours	8 hours	4 hours
Corresponding Availability	99%	99.7%	99.9%	99.95%

The VTS provider can decide whether individual sub-systems are critical or non-critical. Non-critical sub-systems may be excluded from the overall system availability requirement.

Note that multiple means of communications and overlapping sensor coverage will increase overall availability. Such a solution may result in reduced requirements for the availability of each item of equipment individually.

Scheduled maintenance activities may be included in availability figures.

Also note that required spare parts should be readily available, to ensure the shortest time to repair. Therefore, VTS providers should plan for sufficient spare parts and service arrangements, or business continuation plans in order to meet the availability criteria.

The VTS system availability may be improved by the following redundancy measures:

- by duplicating hardware and/or by using externally hosted VTS system and equipment - in duplicated hardware systems, hand-over procedures from active to stand-by equipment should be considered;
- by siting sensors such as radio and radar aerials to provide partial overlapping coverage; and
- by facilitating gradual reduction of capabilities in individual VTS Equipment.

3.2. RECORDING, ARCHIVING AND REPLAY

Within legal limitations, provision should be made for secure storage, retrieval and presentation of VTS data so the relevant historical data can be easily recalled and played back.

The data retention period should allow for the full retrieval of data post-incident/accident, in compliance with national requirements and those of the investigation procedures.

Stored and archived data should include, but not be limited to:

- VTS traffic image
- Sensor data
- Voice communication
- Other relevant information

It may also include (within legal limitations):

- Internal VTS personnel conversations inside the VTS centre
- VTS personnel activities
- Technical and maintenance requirements, e.g., logging, failure tracking, long term failure statistics and analysis, system performance monitoring and improvement

The data should be recorded automatically and be capable of replay without impact to on-going VTS operations. Synchronization of information is recommended for replay.

Data security should always be considered especially when providing online storage. Long term archiving may be considered for traffic statistics, risks evaluation, strategic planning etc.

3.3. OTHER CONSIDERATIONS

3.3.1. ENVIRONMENTAL CONSIDERATIONS

The VTS provider should specify the local environmental conditions for VTS system performance, design and outdoor installations.

3.3.2. EQUIPMENT SHELTERS

A shelter can provide a protective environment with characteristics that depend on the location and design of the shelter. In situations where contained equipment is reliant on the environment created by the shelter, the shelter facilities (e.g., cooling or heating) may become critical to the achieved availability of the equipment.

3.3.3. LIGHTNING PROTECTION

Lightning protection is often subject to national or local legislation taking into account local conditions, severity, earth conductivity, power grid constraints etc. The guidance from country to country differs depending on lightning strike frequency and severity. As a consequence, requirements for the number and type of lightning arrestors, the number of earthing points and the minimum cross sectional area of conductors vary to suit local conditions.

The general principles include:

- Lightning arrestors and/or conductors should be positioned higher than other equipment and be designed to protect the entire installation.
- Separate down conductor(s) on the exterior of buildings should not be connected to metal parts of buildings such as steel reinforcements, handrails and antenna masts.
- Safety grounding of equipment should be kept separate from lightning protection.
- Potential equalization should be achieved in earth and never at the top of the equipment. See Guideline *G1012 The Protection of Lighthouses and Other Aids to Navigation against Damage from Lightning* for further information.
- Warning lights.

High structures, such as RADAR towers, may require warning lights for air traffic. Some light arrangements may also be disturbing to both vessel traffic, the general public and to birds and animals. It is therefore recommended to consult local authorities for specific requirements or restrictions in the area.

3.3.4. SITE AND EQUIPMENT ACCESS

As part of the selection of a VTS system location, the VTS provider should analyse the need for site access for installation and maintenance. Fencing and other protective means against illegal intrusion may also be needed in many cases.

3.3.5. ELECTRICAL POWER

The VTS system could require a reliable source of electrical power, which could include a backup power source such as an Uninterruptable Power Supply (UPS) and/or generator.

Renewable sources should be used where appropriate.

3.3.6. SAFETY AND SECURITY PRECAUTIONS

For each location, the VTS provider should implement safety and security requirements in accordance with relevant legislation.

Safety requirements should, at least, consider but are not limited to:

- safety procedures, such as instructions to personnel performing maintenance;
- personnel protection equipment for working at heights;
- lone working on remote sites;
- safety switches to isolate equipment and to stop rotating antennas;
- precautions regarding electromagnetic radiation, rotating machinery and electrical shock, railings on masts etc.; and
- protection of the general public.

Security requirements should, at least, consider:

- physical restrictions, e.g., fences, locks, motion sensors, monitoring (CCTV); and
- access procedures, i.e., restrictions imposed by ISPS.

3.3.7. EQUIPMENT PRESERVATION AND MONITORING

The VTS provider should also consider the following:

- fire detection and (remote) alarms;
- automated fire extinguishers;

* remote monitoring of site status (power, fuel, temperature, site environmental conditions etc.); and
* remote monitoring of equipment status.

3.3.8. MARKING AND IDENTIFICATION

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

Legislation may require additional marking or identification, signposts etc.

3.3.9. DOCUMENTATION

The VTS provider should specify deliverable documentation to accompany the VTS equipment, which should be available for appropriate personnel. As a minimum, documentation should include:

* operating instructions;
* maintenance instructions (preventive and corrective) inclusive of procedures and spare parts catalogue;
* safety information (e.g., regarding radiation, electrical safety and rotating machinery);
* certificates and permissions as required by relevant legislation;
* test procedures, test certificates; and
* "As built" documentation comprising drawings, equipment configurations, software versions, etc.

3.3.10. EQUIPMENT STANDARDS AND APPROVALS

Legal requirements for equipment standards and approval (or statements of conformity) vary from country to country. It is the responsibility of the VTS provider to ensure compliance to local, regional and international standards. The VTS Provider should state any applicable standards as part of the acquisition process.

VTS providers should ensure that all appropriate standards and approvals for their VTS area have been considered. Typical standards and approvals may include the following:

* Electrical Safety
* Mechanical Safety
* Radiation Safety
* Electromagnetic Compatibility
* Radio Spectrum licensing
* Hazardous / Chemical Substances

4. DEFINITIONS

The following definitions apply within this document and in all the G1111 series of guideline documents:

VTS system	–	the VTS system is the VTS software, hardware, communications and sensors. This excludes personnel and procedures.
VTS equipment	–	VTS equipment refers to the individual items of software, hardware, communications and sensors, which make up the VTS system.
VTS user	-	VTS user is defined as someone with either an operational, technical, or administrative need to use or access the VTS system.

The other definitions of terms used in this Guideline can be found in the International Dictionary of Marine Aids to Navigation (IALA Dictionary) and were checked as correct at the time of going to print. Where conflict arises, the IALA Dictionary should be considered as the authoritative source of definitions used in IALA documents.

5. ABBREVIATIONS

º	Degree
>	Greater than
≤	Less than or equal to
≥	Greater than or equal to
%	percent
µs	microsecond
AIS	Automatic Identification System
AREPS	Advanced Refractive Effects Prediction System
ASL	Above Sea Level
AtoN	Marine Aid(s) to Navigation
BITE	Built In Test Equipment
BoM	Bureau of Meteorology (Australia)
C	Celsius
CARPET	Computer Aided Radar Performance Evaluation Tool
CCTV	Closed-Circuit Television
CE	Conformité Européenne
CHC	Canadian Hurricane Centre
Circ.	Circular (IMO)
COG	Course over Ground
COSPAS	Cosmicheskaya Sistema Poiska Avariynyh Sudov (Russian; Space System for the Search of Vessels in Distress)
COSPAS/ SARSAT	Search and Rescue Satellite-Aided Tracking
CPA	Closest Point of Approach
CPHC	Central Pacific Hurricane Centre
CS	Coastal Surveillance
CW	Continuous Wave
dB	decibel
dB(A)	A-weighted decibel
dBi	decibel isotropic
DF	Direction Finder
DSC	Digital Selective Calling
DSF	Decision Support Function
DST	Decision Support Tool
D-GNSS	Differential GNSS
EC	European Commission
ECC	Electronic Communications Committee

ECDIS	Electronic Chart Display and Information System
ECS	Electronic Chart System
EIA	Electronics Industry Association
ELT	Emergency Location Transmitter
EMC	Electromagnetic Compatibility
EMF	ElectroMagnetic Force (EU Directive)
EMI	Electromagnetic Interference
ENC	Electronic Navigation Chart
EO	Electro-Optical
EOS	Electro-Optical Sensor
EPIRB	Emergency Position Indicating Radio Beacon
ERC	European Research Council
ETA	Estimated Time of Arrival
ETSI	European Telecommunications Standards Institute
EU	European Union
FAT	Factory Acceptance Test
FATDMA	Fixed-Access Time-Division Multiple Access
FCA	Functional Configuration Audit
FMCW	Frequency Modulated Continuous Wave
FMS	Fiji Meteorological Service
FoV	Field of View
GHz	gigahertz
GIT	Georgia Institute of Technology
GMDSS	Global Maritime Distress and Safety System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
h/hr	hour
HDF	Hierarchical Data Format
HF	High Frequency (3–30 MHz radio frequency range (band))
HMI	Human / Machine Interface
hPa	hectoPascal
hydro/meteo	hydrological/meteorological
ICNIRP	International Commission on Non-Ionizing Radiation Protection
ID	Identification
IDC	International Data Centre (for LRIT)
IEC	International Electro-Technical Commission
IEEE	The Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IHO	International Hydrographic Organization
IMD	Indian Meteorological Department
IMO	International Maritime Organization
IOC	Intergovernmental Oceanographic Commission

IP	Ingress Protection
IP	Internet Protocol
IR	InfraRed
ISO	International Organization for Standardization
IT	Information Technology
ITU	International Telecommunication Union
ITU-R	International Telecommunication Union-Radiocommunication
JMA	Japan Meteorological Agency
JTWC	Joint Typhoon Warning Center
Ka-band	26.4 – 40 GHz (radar band)
kg	kilogram
kHz	kilohertz
km/h	kilometres per hour
KPI	Key Performance Indicator(s)
Ku-band	12.0 – 18.0 GHz (radar band)
kW	kilowatt
LRIT	Long Range Identification and Tracking
LVD	Low Voltage Directive (EU)
m	metre
m/s	metres per second
m2	square metre
m3	cubic metre
MF	Medium Frequency (300 kHz and 3000 kHz radio frequency range (band))
MFR	Météo France
MHz	MegaHertz
MIL-STD	Military Standard (US)
MKD	Minimum Keyboard and Display
mm/hr	millimetre per hour
MMSI	Maritime Mobile Service Identity
MPA	Marine Protected Area(s)
MPEG	Moving Pictures Expert Group
MSC	Maritime Safety Committee (IMO)
MSI	Maritime Safety Information
MTBF	Mean Time Between Failure
MTI	Moving Target Indication
N	The radio refractivity index
N/A	Not applicable
NAVTEX	Navigational Telex
NHC	National Hurricane Centre
NIMA	National Imagery and Mapping Agency
NM	nautical mile
NTIA	National Telecommunications and Information Administration

OFTA	Office of the Telecommunications Authority
OJ	Official Journal of the European Union
PC	Personal Computer
PCA	Physical Configuration Audit
PD	Probability of Detection
PFA	Probability of False Alarm
PRF	Pulse Repetition Frequency
PSLR	Peak Side Lobe Ratio
PSS	Practical Salinity Scale
PSSA	Particularly Sensitive Sea Area(s)
PTZ	Pan, Tilt, Zoom
QoS	Quality of Service
RACON	Radar beacon
RADAR	Radio Detection and Ranging
RCS	Radar Cross Section
REACH	Registration, Evaluation, Authorization and Restriction of Chemical substances
RF	Radio Frequency
RDF	Radio Direction Finder
RH	Relative Humidity
RMS	Root Mean Squared
RoHS	Reduction of Hazardous Substances
R&TTE	Radio and Telecommunications Terminal Equipment
SAIS	Satellite AIS
SAR	Search and Rescue
SARSAT	Satellite-based Synthetic Aperture Radar
SART	Search and Rescue Transponder
SAT	Site Acceptance Test
S-band	2.0 – 4.0 GHz (Note: military designation is F-band)
SLA	Service-Level Agreement
SN	Safety of Navigation (IMO)
SOG	Speed over Ground
SOLAS	Safety of Life at Sea
SPA	Special Protected Area(s)
SS	Sea State
STC	Sensitivity-Time Control
STD./std.	Standard
S-57	Transfer Standard for Digital Hydrographic Data (IHO)
S-100	Geospatial Information Registry (IHO)
S-101	IHO ENC Product Specification
TCPA	Time to Closest Point of Approach
TDMA	Time-Division Multiple Access
UPS	Uninterruptable Power Supply

US	United States (of America)
UV	Ultraviolet (light)
VDL	VHF Data Link
VHF	Very High Frequency
VoIP	Voice over Internet Protocol
VTMIS	Vessel Traffic Management and Information System
VTS	Vessel Traffic Service or Vessel Traffic Services (dependent on context)
VTSO	Vessel Traffic Services Operator
W	watt
WGS84	World Geodetic System 1984 (Reference coordinate system used by GPS)
WMO	World Meteorological Organization
X-band	8.0 – 12.0 GHz (Note: military designation is I-band)
XML	Extensible Mark-up Language

6. REFERENCES

[1] IALA. Recommendation R0128 VTS Systems and Equipment (V-128).

[2] IALA. Guideline G1150 Establishing, Planning and Implementing a VTS.

[3] IALA. Guideline G1012 The Protection of Lighthouses and Other Aids to Navigation against Damage from Lightning.