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| IALA Guideline |

DraFT G1111-2

Producing Requirements for Voice communications

Functions, Performance And radar specifIC AcceptANce

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# INTRODUCTION

Radio communication equipment is typically integrated into VTS applications to provide the VTSO with a real-time means of disseminating information from the traffic image to VTS participants to support safe navigation of the VTS area.

The intent of this Guideline is

* To be a common source of information on VTS Voice Communication systems.
* To provide detailed information about functional and performance requirements regarding voice communication in VTS systems

## The IALA G1111 guideline series

This Guideline is one of the G1111 series of guideline documents. The purpose of the G1111 series is to assist the VTS Provider in preparing the definition, specification, establishment, operation, and upgrades of a VTS system. The documents address the relationship between the operational requirements and VTS system performance (technical) requirements and how these requirements affect system design and sub system requirements.

The G1111 series of guideline documents present system design, sensors, communications, processing, and acceptance, without inferring priority. The guideline documents are numbered and titled as follows:

* G1111 Establishing Functional & Performance Requirements for VTS Systems
* 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 and VDES
* 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

A VTS system primarily comprises three elements: an IT platform, software functionality and a suite of communication devices and sensors. The Communication devices and sensors are each covered by the new Guidelines G.1111-2 to G.1111-8.

# DEFINITIONS

## General Terms

|  |  |  |
| --- | --- | --- |
| **VTS System** | – | within the G.1111 guidelines, the VTS System is the VTS software, hardware, communications and sensors. This excludes personnel and procedures. |
| **VTS Equipment** | – | within the G.1111 guidelines, VTS Equipment refers to the individual items of software, hardware, communications and sensors, which make up the VTS System. |
| **VTS User** | - | within the G.1111 guidelines, VTS User is defined as someone with either an operational, technical, or administrative need to use or access the VTS System. |

## Specific Terms

Specific terms in this document are defined as follows:

* **ATIS ;**  Automatic Transmitter Identification System in use in certain European inland waters . At the end of transmission an ATIS code is transmitted as identification, resulting in displaying the ships call sign on the VHF UI.
* **ATEX ;** ATmosphères EXplosibles; A European Guideline for area’s with danger for explosions under atmospheric circumstances
* **Simplex ;**  communication is done via one frequency ,. Both transmitter and receiver use the same frequency.
* **Duplex ;** communication is done via 2 different frequencys enabling bi-directional communication **.**
* **Directional antenna** ; a directional antenna is an antenna which radiates or receives greater power in specific directions
* **Omni-directional antenna ;** an omnidirectional antenna is a class of antenna’s which radiates power equally in all directions.
* **Antenna Gain** ; it is a relative measure of an antenna's ability to direct or concentrate radio frequency energy in a particular pattern or direction. This measurement is typically measured in dBi (Decibels relative to an isotropic radiator) or in dBd (Decibels relative to a dipole radiator). However in most marine VHF antenna specifications it is simply stated as dB gain.
* **Digital Selective Calling (DSC);** is a standard for transmitting pre-defined digital messages via the [medium-frequency](https://en.wikipedia.org/wiki/Medium-frequency) (MF), [high-frequency](https://en.wikipedia.org/wiki/High-frequency) (HF) and [very-high-frequency](https://en.wikipedia.org/wiki/Marine_VHF_radio) (VHF) maritime radio systems. It is also a part of the [Global Maritime Distress Safety System](https://en.wikipedia.org/wiki/Global_Maritime_Distress_Safety_System) (GMDSS)

## Specific IALA Definitions

# References

1. Convention on Safety of Life at Sea (SOLAS) Chapter IV (Radio Communications).
2. Convention on Safety of Life at Sea (SOLAS) Chapter V (Safety of Navigation) – Regulation 12.
3. Convention on Safety of Life at Sea (SOLAS) Chapter V (Safety of Navigation) – Regulation 19.
4. IMO Resolution A.694(17) - General Requirements for Shipborne Radio Equipment forming Part of the Global Maritime Distress and Safety System (GMDSS) and for Electronic Navigational Aids.
5. IALA World Maritime Radio Communications Plan.
6. IEC 60945 - Maritime navigation and radio communication equipment and systems - General requirements, methods of testing and required test results.
7. IEC 61162 - Digital Interfaces for Navigation Equipment within a Ship.
8. ETSI EN301 929-2 v1.2.1 - Electromagnetic compatibility and radio spectrum matters (ERM): VHF transmitters and receivers as Coast Stations for GMDSS and other applications in the maritime mobile service.
9. ITU-R M.493-15 - Digital selective-calling system for use in the maritime mobile service.
10. ITU-R M.541-9 - Operational procedures for the use of Digital Selective Calling equipment in the Maritime Mobile Service.
11. ITU-R M.689-2 - International maritime VHF radiotelephone system with automatic facilities based on DSC signalling format.
12. ITU-R M.1082-1 - International maritime MF/HF radiotelephone system with automatic facilities based on DSC signalling format.
13. ITU-R M.1084-5 – Interim solutions for improved efficiency in the use of the band 156-174 MHz by stations in the maritime mobile service.
14. ITU-R M.1842-1 - Characteristics of VHF radio systems and equipment for the exchange of data and electronic mail in the maritime mobile service.
15. [*"Recommendation M.541: Operational procedures for the use of digital selective-calling equipment in the maritime mobile service"*](https://www.itu.int/rec/R-REC-M.541/en). [*International Telecommunication Union*](https://en.wikipedia.org/wiki/International_Telecommunication_Union). 2015.
16. [Very high frequency - Wikipedia](https://nl.wikipedia.org/wiki/Very_high_frequency)
17. IMO Resolution A.801(19) – Provision of Radio Services for the GMDSS.

# Abbreviations

Please refer to IALA G.1111 Establishing Functional and Performance Requirements for VTS systems for an extensive list of abbreviations and acronyms covering the entire G1111 series

GMDSS General Maritime Distress and Safety System

MMSI Maritime Mobile System Identifier

# Operational considirations

## Operational Areas/OVERVIEW

Communication is an essential part of a VTS system. It is the means by which a VTS operator can provide essential navigation advice to visiting vessels for the purpose of improving navigational safety and efficiency. Therefore, a VTS Provider should ensure that the VTS communication system enables VTS Operators to easily call the correct vessel and correctly identify an incoming caller, over clear voice communication channels. The VTS Provider should clearly identify the area over which voice communication is required and the operating ranges for the types/ sizes of vessel that will be participating in the VTS. In addition, the VTS Provider should specify the required voice communication channels, the operational functionality that will be used and the sites where it is possible to install equipment.

As specified in ITU R M.689-2 [Ref: 12], the use of Digital Selective Calling (DSC) may be included within the voice communication system as a means of improving efficiency.

As provided in IALA Guideline G1150, implementing a VTS is a five stage process. The first phase (Initiation) includes the need for a feasibility study to assess risks, operational feasibility, legality, technical capability, budget and timing. The VTS Provider will need to conduct and apply these process to his defined VTS Area to determine the precise Operational Requirements for the VTS design and procurement, including the voice communication operational requirements.

A VTS is typically implemented in three situations, as follows:

* Ports and Port Approaches
* Coastal VTS (such as a managed Traffic Separation Scheme)
* Inland VTS

## Port and Port Approaches

The port approach area is usually within the 12NM zone but may extend beyond. Due to the nature of a port approach, and the activities that take place, it is likely that a high volume of VHF communication may take place in the port approach area. The VTS Provider may consider that some operations, such as bunkering, may be assigned a specific channel in order to keep other channels clear for navigation and VTS related communication.

The port area typically consists of confined waters. Traffic includes sea-going vessels, allied services vessels and, possibly, inland waterway vessels and leisure craft. Due to VTS workload a port may be divided into sectors with a separate VTS Operator responsible for each defined sector. In such circumstances, a radio plan may define specific radio channels for use in the each of the sectors.

The required VHF range is usually very limited, but might be obstructed or mirrored, even if only temporarily, by cranes, moored or passing vessels, cargo, and buildings. For this reason, special attention should be given to VHF antenna siting.

## Coastal VTS

A Coastal VTS may be established to manage vessel traffic through a traffic separation scheme or when in transit passage through an international strait, to assist vessels in navigating specific obstacles (such as bridges) or to guide vessels safely through marine protected areas. In such cases, VTS Operators will be in communication with all visiting vessels to ensure that they are aware of the prevailing regulations and to ensure that they have provided the necessary pre-arrival information. A radio plan may be published to simplify communication with vessels approaching from different directions by allocating specific channel to vessels based on their direction of approach. However different approaches (e.g. based upon workload) may occur.

Some Coastal VTS that are in busy areas involving a high volume of voice communication are recommended to consider the use of MMSI based calling using channel 70 (DSC) to increase communication efficiency.

## Inland Waterway

Inland waterways, such as rivers and canals, are confined waters that may be used by a large variety of vessels, ranging from sea-going vessels to recreational vessels. Locks, bridges, and waterway intersections may be present that might require special attention from VTS-operators. VHF communication with locks, bridges may be outside VTS responsibility.

The Inland Waterways VTS Operator will be required to manage all types of vessel that use the waterway, from commercial ships to leisure vessels. Due to the confined nature of inland waterways, fast and correct identification of calling vessels is essential. Systems such as the ATIS system (used on European Inland Waterways) transmit the vessel identity digitally within the VHF voice call in order to provide easy access to vessel identity information for the VTS Operator. Such systems could be considered for use on other inland waterway systems.

## Coverage

Typically voice communication for VTS operations can be achieved using the Maritime VHF-band and VHF DSC, and most of the VTS-systems are only implemented for Area A1.

However VTS Providers may choose to implement extended coverage based on the sea area’s defined by the GMDSS.

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 communication satellites (in practice this means INMARSAT and Iridium)

Inmarsat covers the area between 70°North and 70°South and Iridium is global.

* 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).

Area A4 may be covered by HF communication or by satellite services with global coverage

### Very High Frequency (VHF)

The Maritime VHF band comprises a number of channels within the frequency range of 156 MHz to 162.025 MHz. These are mainly used for voice communication except channel 70 (DSC) and the channels allocated specifically for AIS. The VTS Authority may require VHF Channels to be designated / licensed by the National Radio Authority for specific types of operations (e.g. Coast Station Radio License). Specific channels are determined to provide safety watch, DSC and VTS information.

The VHF equipment should comply with national and international regulations, particularly with the Master Plan of shore-based facilities for GMDSS. The use of simplex and duplex channels as well as 25 kHz channels can be used in accordance with the appropriate ITU-R and national regulations. Additionally 12.5 kHz channels are also allowed under Appendix 18 of the Radio Regulations in accordance with ITU-R M.1084 **Fout! Verwijzingsbron niet gevonden.**.

As it evolves, e-Navigation will enable greater use of data communication between ship and shore. Such data communication between ship and shore or ship to ship can be implemented within the VHF Marine Band in accordance with ITU-R M.1842-1 **Fout! Verwijzingsbron niet gevonden.**. Following the introduction of this regulation, it is anticipated thatthe VDES digital infrastructure over Maritime VHF will become available. However, it should be noted that certain duplex channels in the maritime VHF band may be converted to the VDES data service and will therefore be no longer available for voice communication.

### Medium and High Frequency (MF and HF)

MF and HF may be used on a regional basis where medium and long range communication is required. The VTS Provider may require specific channels to be designated by the National Radio Authority for specific types of operations. The equipment should comply with national and international regulations.

### Satellite Communications

Exceptionally, communication via satellite may be required, depending on the service provided by the VTS.

### Emergency Situations

GMDSS is a suite of communication services that are intended to enable any vessel in distress to call for assistance. As identified in section 5 above, it includes VHF, HF and MF voice communication frequencies as well as DSC frequencies across these bands. VTS Providers should consider whether to include additional frequency bands in order to assist in emergency situations. In addition, consideration should be given to the inclusion of facilities for voice communication in the VHF Air Band (108MHz – 137MHz) in order to coordinate with Search & Rescue Assets such as helicopters.

# Producing Functional and Performance requirements

## Functional and Performance Requirement Overview

Operational Requirements outline the user needs. Technical, functional and performance requirements define the equipment used, what the equipment can do and how it needs to perform. VTS Providers should avoid being too prescriptive regarding the technical requirements of the Voice Communication System to enable innovative solutions to be offered.

In general, radio equipment that is designed for use on board a ship should not be used in a VTS. Such radios are set up for ship use and therefore, when using a duplex channel, a ship radio at a VTS would use the same frequency for transmission as a ship and the same frequency for reception. This could result in transmissions not being received. VTS Radio Communication equipment should be designed and configured for Coast Station operation.

Functional requirements are the operational facilities provided by the communication equipment and their user interface. Voice Communication functionality will probably be implemented in software and therefore the user interface and facilities may vary from one supplier to another, even if using the same physical hardware. Therefore functional requirements should be about coverage, the number of (simplex/duplex) channels required for each VTS-centre, availability per VTS working position, recording facilities etc. Also fall-back/backup facilities may be part of functional requirements as well as extensibility.

Performance requirements relate to the operational capability of the communications equipment and its ability to deliver the performance that is defined within the Operational requirements. Achieving defined performance requirements may require one or more coastal radio sites and where multiple sites are necessary, additional functional requirements may need to be specified in ordere.g. to achieve best signal selection/retransmission and maintenance.

## Functional Requirements

VTS Centres require a means of clear and easy to use voice communication for interacting with ships. Within the VHF band, the VTS Centre will require the availability of a number of radio channels relative to the number of ship movements and the size of the VTS area. The functionality requested should reflect its intended operational use so a clear definition is essential. E.g. a VTS Provider should confirm whether specific voice channels are to be continuously monitored or whether a particular receiver might scan a number of channels to search for calls.

Built-in test features should include monitoring of functions and performance.

### User Interface

VTS Providers should give careful consideration to ensure that the user interface of the voice communication system eases to use so that it eases operator workload and does not cause complications. Sometimes mistakes in voice communication are a factor in maritime accidents and so the voice communication system needs to present the VTS Operator with an unambiguous status display to enable an accurate and efficient communication.

The User Interface should provide easy identification of incoming calls and provide a simple means of channel selection.

It is common for modern Voice Communication Systems to use a touch screen display for presenting the status of all radio equipment and to enable channel and radio selection. The status display should clearly present the current operational status of each item of radio equipment with clear indication of incoming calls and when a device is transmitting. The Operator Display should also be able to provide facilities for the handling and transmission of DSC messages.

The Voice Communication System Status Display could include:

* Channel selection facilities
* Easy push-to-talk functionality
* Squelch control
* Visual transmit indication
* Visual receive indication
* Signal strength indication (where available)
* Indication of VHF station receiving best signal, and selection of proper VHF station
* Capable of displaying DSC messages
* Capability to send DSC messages
* Where applicable display ATIS code
* System status information (e.g. warnings, alarms)
* Replay facilities

The voice communication user interface may be implemented using some or all of the following components: :

* Graphical presentation (typically a touch screen display).
* Microphone
* Loudspeaker
* Hand switch (PTT)
* Foot switch (PTT)
* Headset

The User Interface should allow easy switching between connected devices

### Incoming Call management (Multiple Radio Coast Stations)

Where a VTS System comprises multiple radio Coast Station sites, an incoming call from a vessel may be received by more than one coastal radio site. This can be confusing for a VTS Operator as the Status Display may indicate that two (or more) adjacent sites have received an incoming call. In fact, it is only a single vessel making the call. There are a number of ways that such situations can be overcome:

1. Automatic selection of best audio quality. When a call is received the system automatically routes the best quality audio signal (based on Signal Strength Indication) to the VTS Operator. This ensures that the VTS Operator receives the best quality audio for communication with the incoming vessel. The site with the best Signal Strength may also be selected (automatic) for transmission (from VTS to ship).
2. Adjacent Station Channel Muting.  When the VTSO transmits from a coastal site there is a highly probability that the transmitted signal will be received by the VHF Receivers at an adjacent VHF site as well as by the ship.  This is especially true when omnidirectional aerials are used.  To the VTSO, this will appear to be another incoming call at the adjacent station but in reality it is the result of his own transmission.  Adjacent Station Channel Muting will mute the receivers at the adjacent station on the channel used for transmission to avoid this potential confusion.

### Noise Suppression

Clear voice communication is essential to VTS operations and so the user interface of the voice communication system should include functionality for reducing low level background noise (typically known as Squelch).

### Digital Selective Calling (DSC)

DSC provides additional facilities that can improve the effectiveness of VHF voice communication [Ref:12]. DSC initiated calls (using commands transmitted on VHF Channel 70) can be addressed to a ship by using its MMSI. This means that the VTSO can be certain that the call can only be answered by the correct vessel. In addition, a DSC call can make the radio equipment on the bridge of a ship produce an acoustic alarm. In certain situations, this can be useful for alerting an unresponsive crew.

Other DSC facilities, including receipt of GMDSS DSC emergency calls can be managed through an effective DSC interface.

### Recording and Replay

The Voice Communication System shall record all conversations time synchronised with the traffic image recording. At least 30 days (G1111-1) of recordings shall be maintained on the system and available for playback.

The replay of a recorded conversation by a VTS Operator shall be possible at any time. A clear indication should be given that a replay is active.

## Performance Requirements

The VTS Provider should ensure that the VTS radio communication provides adequate coverage for the VTS area. VHF radio communication is generally dependent upon the line-of-sight between the VTS VHF antenna site and the ship VHF antenna.

Clearly defining the area where voice communication coverage is required is the first step in establishing the performance requirements of the voice communication system. In addition, it is also necessary to understand the types of vessel that will be involved in communication with the VTS at various ranges. Large vessels such as VLCCs normally have their communication antenna on a mast on the roof of the bridge. In such cases, the antenna may be at a height of 30m above sea level whereas a fishing vessel may have communication antenna at heights of 10m above sea level and therefore communication would be possible with the VLCC at a greater range than for a fishing vessel. Therefore, the voice communication coverage area should be determined based on the maximum communication range required for communication with the smallest size of participating vessel.

## Installation Considerations

### Site Considerations

Appropriate and available sites for the installation of Voice Communication equipment need to be specified. A voice communication site will need facilities for the installation of antenna equipment in an elevated position. This may be achieved through the provision of a communications tower or a multi sensor tower that also hosts other equipment. It should be noted that where multiple antenna installations are required at a single location, there must be appropriate vertical separation between antennas. The site should also provide space to house rack mounted equipment, preferably in a temperature controlled environment.

The following should also be taken in account when establishing coastal radio sites:

* Lightning protection
* Wind load on antennas
* Ice build up
* Maintenance Access

Externally installed electronic equipment should be in an appropriate environmental enclosure. IEC requirements should be applied as far as relevant. In addition to the requirements of IMO Resolution A.694(17), the siting and installation of radio communication equipment should make provision for accessibility, maintenance and repair. Also provisions regarding logging and monitoring should be taken into account.

### Antenna Arrangements

A typical marine VHF antenna is designed with vertical polarization. This means that the best performance from the antenna will be achieved when the antenna is mounted perfectly vertical. Any angle beyond vertical will lessen the performance of the antenna.

It should be noted that multiple radio transmitters can be combined and operate through the same antenna. The result of this action is that the output power of connected radio equipment will be reduced. Therefore the use of a combiner will compromise transmission coverage performance. For example, the use of two radios transmitting through a single antenna will result in a 50% reduction in output power.

Antenna can be configured as Transmit / Receive Antenna or as single function antenna. A single function (Receive) antenna can be split to the receive connection on all voice communication base station equipment. Where there are multiple radios on a single site, a single function (receive) antenna should be installed at the highest location so that it has the best chance to receive weaker signals from small vessels at long range. Transmit antenna would then be installed at lower positions on the tower (to maintain the appropriate vertical separation). Whilst they will be lower and potentially suffer a loss of range performance, a single transmitter transmitting through a single antenna will transit at its full power output.

Separate transmit and receive antennas can result in the transmitted signal being detected by the receive antenna at the same site. In such circumstances, it is necessary to mute the receiver while the VTSO is transmitting so that the feedback does not confuse the operator into believing that another incoming vessel has called the station. For VTS Areas with multiple VHF sites, it is also possible that a transmission by the VTSO from one station can be received by an adjacent radio site and would appear like an incoming call. It is preferable that, when transmitting on a particular channel, that the Receivers at local and adjacent radio sites should be muted on the transmitting channel to avoid such confusion.

Local legislation/regulations considering antenna height and transmission power, as well as practical considerations like availability of sites for installation will lead to an antenna plan. Use of omni-directional antenna’s vs. directional antenna’s may be part of this process.

VHF range on inland waterways is often limited by obstructions along the banks of a meandering river. Local legislations may restrict antenna-height and transmission power.

In areas with ATEX restrictions requirements to reduce transmit power (both ships as well as VHF-site’s) may apply.

### Interference

Radio communications equipment complies with applicable international standards and regulations - see IEC 60945 **Fout! Verwijzingsbron niet gevonden.**, which covers the general requirements for navigation and radio equipment and includes interference. The avoidance of interference is essential, therefore equipment should be installed in accordance with manufacturer’s instructions and monitored to ensure that instances of interference are investigated and rectified.

Special attention should be given during the design stage to ensure electromagnetic compatibility (EMC) of radio communication equipment used. Frequency spectrum (i.e. VHF working channels), used for VTS radio communication, must be agreed with the national radio licensing authority.

### Power Supply

IEC requirements should be applied as far as relevant. In remote locations, authorities should consider the use of renewable power sources (e.g. solar panels or wind turbines, in combination with batteries) as an alternative to diesel generators. In addition, uninterruptible power supplies could be considered as a backup to the primary power supply.

### Site Selection and Installation

Consideration should be given to the power output of the radio system at the antenna instead of the power output at the radio equipment. Note that, where multiple transceivers are combined and/or filtered through to a single antenna, the effective radiated power could be reduced significantly.

Care must also be taken that proper separation is maintained when co-locating antenna sites .

Sites for radio communication equipment should be selected based upon optimizing the coverage of the VTS area and the ability to provide the required services e.g. telecommunication links and access. Considerations include availability of electrical power, physical security of the site, housing and possible co-location with existing infrastructure.

### VTS Centre Layout

Special attention should be given to equipment in a situation with multiple VTSO’s in a same room. Voice communication from one VTS Operator may disturb the work of another. Assessing the acoustic properties of the proposed VTS Centre may be appropriate and assist in the design of acoustic barriers to enable multiple operators to work side by side undisturbed.

### Networking

If the VTS area of responsibility is located within the VHF range of a VTS control centre it is possible to enable VHF communication with standard VHF transceiver equipment. This might be similar to shipborne equipment, but then taking into account the difference in the duplex channel frequency. This will be more or less typical for small VTS system.

However large VTS system, covering area’s far away from the VTS-centre, require more advanced and distributed VHF solutions. In these situations VTS authorities are currently making, more and more, use of Internet Protocol (IP) technology such as VoIP solutions on radio sites and internal communications. This allows for a more efficient use of infrastructure, more flexibility and optimised system design.

VTS radio communication interfaces ashore may be vendor-specific. An exception is VoIP (Voice over IP) which is standardised by industry and the Internet Engineering Task Force (IETF). Within VoIP several implementations have been defined e.g. RTP H.323, ED-137 (Air Traffic) and SIP(Telephony). Interface standards will thus be dependent on the requirements of the VTS Provider and the equipment being installed.

However, work within the IALA e-NAV committee and other organisations aim for open systems architecture with associated international standards, which may be adopted as developed.

This allows for a more efficient use of infrastructure, more flexibility and optimised system design. VoIP technology (especially when applied for VTS radio communications) is very sensitive to delays in the IP network. Excessive delays may cause significant degradation of VHF communication quality. Additional challenges include the need to use the IP packet 'Quality of Service' (QoS) functionality by the IP network to minimize negative effects such as latency and jitter.

### Redundancy and Fall-Back Arrangements

Redundancy facilities can be provided by duplicating radio communication equipment and through the provision of multiple VTS Operator workstation facilities. In the event of an equipment failure, the quick availability of a hot standby unit will enable normal operations to continue without downtime.

Fall-back arrangements, via a business continuity plan, should be considered such as handing over operations to another VTS.

# Annex A Further Antenna Considerations

This annex is descriptive and intended to supplement previous sections in this document and introduce the reader to common VHF topics .

The selection of antenna parameters (height, gain, side lobes, polarisation etc.) for a given installation is key to the resulting VHF performance. VTS authorities are, however, advised to avoid specifying detailed antenna characteristics, in favour of identifying and should preferably specify operational requirements such as:

* coverage area and range performance based on need and risk assessments
* Requested level of communication and typical ship types
* need for overlapping and redundant coverage.

The identified operational requirements will allow the radar vendor some flexibility to achieve the best solution within the given constraints and considering cost and location options.

## Maximum detection range

VHF signals propagate in a direct line .The reach of VHF signals basically limited to the line of sight. Due to the curving of the earth surface it is limited, and its limitation is highly determined by the height of the antenna’s (sending and receiving antenna). The formula below can be used for a calculation of the antenna reach , or vice versa calculating which antenna height should be used to achieve a certain reach



h1

h2

S(h1,h2) = 3,57 \* (√h1 +  √ h2 )

In which :

S = maximum line of sight in kilometers

h1 = antenna height station 1 in meters

h2 = antenna height station 2 in meters

Source [Very high frequency - Wikipedia](https://nl.wikipedia.org/wiki/Very_high_frequency)

## Antenna gain



Figure xx illustrates the effect of antenna gain in association to coverage.

A typical marine VHF antenna is designed with vertical polarization. This means that the best performance from your antenna will be had when your antenna is mounted perfectly vertical. Any angle beyond vertical will lessen the performance of the radio signal.

A set-up point may be either a single VHF location , or a location for multiple transmitters/receivers on different frequencies.

In case of multiple transmitters/receivers thoughts have to be given on combining transmitters on 1 antenna or not. E.g. in the case of 2 simplex channels with different antenna’s on 1 set-up point there might be a risk of receiving the transmitting signal from one antenna on the other antenna (full power). Use of 1 combined antenna will prevent this risk. This highly dependent on frequency spacing between the 2 (or more) frequencies. This is only possible with duplex channels and separate transmitter and receiver equipment.

A set-up with multiple transmitters/receivers on 1 location will usually lead to antenna combiners/ splitters and or filters. Also the type of antenna’s and/or antenna gain will be part of design.

Type of antenna’s might be :

* + Directional
  + Omni-directional

The antenna-gain is an indication for its use , in general terms

* + High antenna gain (e.g. 9 dB) ; suitable for long distance
  + Low antenna gain (e.g. 3dB) ; suitable for short distance coverage

## Environmental Influence

Obstructions, e.g., topography, buildings and other man-made structures may block or reflect radio signals. Other transmitters and sources of electromagnetic radiation may cause interference.

Inland and harbour VTS will often require special considerations as the number of structures, their density and their close ranges can create very complex distortions. Additional care should be taken to assess and mitigate effects caused by natural and man-made structures such as bridges, buildings, riverbanks, sheet metal pilings, and steep bends.

Also meteorological and hydrological conditions may impact VHF performance. Area’s of high air pressure may have an influence on the coverage (increased) of the VHF signals .

Sun bursts may also have an effect on the transmission of radio signals and this effect may be more significant during night time them day time.

* 1. VHF Setup
     1. Simplex communication

Simplex communication channels use a single frequency. Therefore it is necessary that a transmission has to be completed before another transmission can commence in order to avoid garbled communication.. Conversation on a simplex channel is one-to-many. All ships on that frequency hear each other and can talk to each other. Inter-ship communication is possible.

* + 1. Duplex communication

Duplex communication channels use 2 frequencies enabling both parties to transmit at the same time with clear reception by the other party Inter-ship communication is not possible, communication is more or less one-to-one. If communication with a VTS centre takes place via a duplex channel, the communication from the VTS centre will be heard by all ships. Intership communication can be made possible if retransmission is enabled. Enabling/disabling may be activated by an operator action.

* + 1. Diversity /BSS (Best Signal Selection)

Is used in systems with multiple transmitters, separated from each other, on the same frequency. The audio signal from the receiver which gives the best signal strength, is switched to the speakers. Selection is based upon the RSSI -value. When replying the receiver with best signal strength is selected for transmission. This implies that the VTS will receive all transmissions in the area being covered by all receivers, but when answering, the VTS will not be heard by ships out of range from the selected transmitter.

Since only 1 transmitter is selected for transmitting no issues will occur in ‘overlap’ area’s.

Depending on how the VHF system is set up it can also transmit similary via all channels. This makes transmission audible on all ships in the area. Measure’s against garbled communication in overlap area’s have to be taken.

1. VHF Acceptance
   1. Acceptance of VTS communication Systems

IALA Guideline 1111-9 Acceptance Framework of VTS System provide general acceptance steps and key area of considerations related to acceptance of VTS System and VTS Equipment.

The VHF voice communication systems could be tested to evaluate the fulfilment of the specific requirements in the agreed requirements according to Test Plan and Test Procedure.

It might also be desirable to verify the availability and include (part off) an annual cycle in the acceptance process to ensure good long-term operation.

* 1. Test Metodology
     1. VHF Functions and other features

The verification of Operator Functions, Operational outputs can normally be made as functional tests, whereas verification of Transmitting power, SWR, phase measurements etc. can be performed as technical measurements.

* + 1. VHF Coverage

The continuous coverage of the VTS can be checked utilising of targets of opportunity which aligns to the requirement. This may be complemented by use of controlled targets (handhelds of shore as well as ships) determining the maximum range of transmitting/receiving for specific frequencies.

1. Development

Digital Private Mobile Radio (dPMR), is a [common air interface](https://en.wikipedia.org/wiki/Common_Air_Interface) for digital mobile communications. dPMR is an open, non-proprietary standard that was developed by the [European Telecommunications Standards Institute](https://en.wikipedia.org/wiki/European_Telecommunications_Standards_Institute) (ETSI) and published under the reference ETSI TS 102 658.

A simplified version of the dPMR protocol intended for licence-free applications was also published by ETSI under the reference TS 102 490.

The major advantage is the ability to use 4 voice channels in the same spectrum that currently allows only one. This was the initial driving criteria as the implementation of VDES means that the number of channels available for voice is reduced.

There are extra features within dPMR and the question is which one will be implemented. Depending on decisions made by IMO, ITU and proposals by IALA there could be some features added now done within the GMDSS branch. Two good features will be a full identification number (MMSI) embedded in the signal and a position report. These data with the data on shore and ship from radar and AIS could give a fuller 'situational awareness' picture.

dPMR requires a 6.25 kHz channel.



dPMR equipment complies with the relevant European standard ETSI EN 301 166 as well as the FCC emission mask applicable for operation in the US.

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* + 1. dPMR functionality

dPMR446 is license free, and equipment is capable of voice, data and voice+data modes of operation.

This means that dPMR446 can provide voice calls, text messaging ([SMS](https://en.wikipedia.org/wiki/SMS)), status and embedded data such as GPS position etc.

This technology is covered by ETSI standard TS102 490.

* + 1. dPMR Mode 1

This is the peer to peer mode of dPMR (without repeaters or infrastructure) but without the limitations of the licence-free counterpart. It can operate all typical licensed PMR frequency bands and without the RF power limits of dPMR446. As well as offering voice and data, dPMR446 Mode 1 also supports combined voice+data so it is possible to embed data into a voice call or automatically append it at the end of a call. It is part of the ETSI standard TS102 658

* + 1. dPMR Mode 2

dPMR Mode 2 is the licensed conventional PMR version and operations include repeaters and other infrastructure. This brings extra functionality such as analogue or digital network interfaces which can be IP based. Inclusion of repeaters and base stations means that wide area coverage is possible even more so when multiple repeaters are used. Such multiple repeaters can be managed by dynamic channel selection or they can be part of a co-channel wide area network.

* + 1. dPMR Mode 3

dPMR Mode 3 is also part of the ETSI TS102 658 standard, and can offer multichannel, multisite trunked radio networks. This ensures optimum use of spectrum and optimum density of radio traffic.