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| IALA Guideline |

DraFT G1111-7

Producing Requirements for radio direction finders

Functionality and performance specifications

Working paper, output from VTS 51

Edition 1.0

Date (of approval by Council)

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

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| Date | Details | Approval |
|  | Edition 1.0  This document originates from IALA Guideline G1111 (ed 2015), which has been redeveloped as the G1111 series of guidelines concerning establishing functional & performance requirements for VTS Systems. Document revisions include document structure realignment and verification of currency and accuracy of the content. |  |
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# INTRODUCTION

This Guideline presents a common source of information to assist VTS authorities in the understanding of Radio Direction Finders (RDF), supporting the design of a radio direction finding service and its contribution to the VTS traffic image (situational awareness) as well as guidance of how the VTS Authority should specify the associated functional and performance requirements.

## General Terms

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 authority 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 reflect into 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

# DEFINITIONS

## General Terms

For general terms used throughout this section refer to ~~IEEE Std 686-1997 IEEE Standard Radar Definitions~~ ***(replace with appropriate references for series topic).***

## Specific Terms

Specific terms are defined as follows:

**Receiver Gain** - is the.

**Receiver Sensitivity** – typically

**Feeder Loss :** Built in Test Equipment

**Bearing accuracy**  - frequency modulation of the).

**Probability of Detection**

**EPIRB** .

## Specific IALA Definitions

**Specific Term in bold –** details in normal text. Include items specifically related to the series topic where IALA has additional clarifying details to common definition (if common definition exists. If no common definition exists, use the IALA definition on its own.)

* + 1. G1150 IALA guideline establishing, Planning & Implementing vts
    2. VTS Authority.

# References

1. Include references that are specific to the series topic.

# 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

*(If the above isn’t the consensus, then the text below is suggested for template purposes)*

**Specific acronym in bold –** full name in normal text. Include acronyms specific to the series topic.

# Operational Overview

This guideline considers application of RDF to VTS areas of responsibility. These areas may vary in the types of risks, vessels and their interactions, the required sensor ranges and the types of services.

Radio Direction Finders (RDF) are a sensor system that supports VTS and SAR operation by indicating the direction/bearing to a VHF transmitting station. Since a RDF only indicates the bearing of the transmitting station relative to the RDF sensor location, two or more appropriately located RDFs are needed to estimate the position of the transmitting station.

The necessary Functional and Performance requirements may differ throughout the geographical area of VTS responsibility. As such, setting the Functional and Performance Requirement should be align to the risks being mitigated and facilitate VTS operations.

VTS authorities should consider the need for an RDF system based on the type of traffic in the VTS area, such as

the presence of non-SOLAS class vessels and recreational vessels that do not carry an AIS transponder (assuming

the VTS is able to receive AIS data). The VTS Authority should assess the requirement for a RDF system based on

a risk assessment of these and other relevant factors. For example, RDF can be particularly effective in high volume transit areas or TSS where vessels are continuously reporting in to VTS Authorities even if the Operator only see a bearing line.

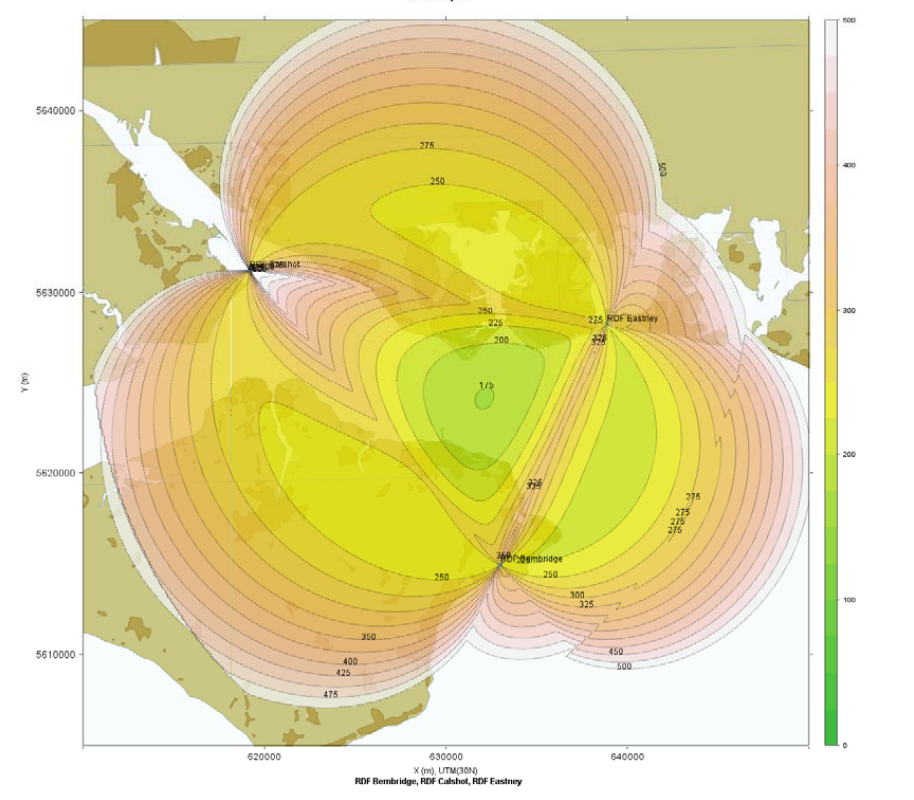
When a RDF system is assessed as being necessary, the VTS authorities should, at least, consider the following:

* the required RDF coverage area, based on:
* possible RDF location(s);
* waterway structure and navigational hazards;
* the types of ships to be detected;
* expected meteorological conditions.
* the required bearing accuracy;
* Presence of 3rd party sources of electrical and RF noise
* the required frequency range of the RDF equipment (this may e.g. include frequencies used for SAR);
* the number of simultaneously monitored VHF channels;
* other influencing factors, such as obstructions in the line of sight and the presence of potential reflective surfaces, which may reduce the performance of an RDF system.

## Areas of Coverage

The RDF coverage area needs to be consistent with the results of risk assessment and possible VTS responsibilities for SAR. Factors affecting the detection performance of RDF systems, including potential interference and propagation characteristics, should be taken into account as well as special local conditions, such as heavy rainfall.

In order to allow accurate identification in the main area of operation with two or more RDF stations, the bearing angles on target should cross close to 90º (the position accuracy with two or more RDF stations degrades very rapidly when the bearing angles do not cross at 90º; in the extreme cases of 0º and 180º crossing angles no position estimation is possible). This may pose significant restrictions on the potential locations of the RDF stations. The recommended method for determination of RDF coverage and range performance is a combination of site inspections and RDF system performance calculations. The diagram below Figure 15 provides an example of such a calculation.



The evaluation should include:

* calculation of VHF Radio Range based on RDF antenna height and minimal VHF antenna height on the target

of interest;

* calculation of all applicable losses (target’s VHF transceiver power, required RDF sensitivity, losses in VHF

cable etc.);

* evaluation of the effects from propagation conditions and obstructions; and
* influence of meteorological conditions.

The calculations may be supplemented by comparison and/or validation test.

## Bearing Accuracy

One of the most important performance parameters of the Radio Direction Finder system is the bearing accuracy.

Besides the technical characteristics of the RDF equipment, many other factors may significantly reduce the

bearing accuracy in real conditions. Therefore, the following aspects should be taken into account when

assessing bearing accuracy:

* the specified RDF equipment bearing accuracy
* the environment of the RDF antenna;

Multipath signal propagation, caused by reflections from surrounding objects, can significantly deteriorate the bearing accuracy.

* the received signal strength. Low received signal levels may significantly reduce the bearing accuracy. Major factors affecting received signal strength are:
  + distance to the target;
  + RDF receiver(s) sensitivity, antenna gain and feed losses;
  + weather conditions;
  + output power and duration of transmitted signal.
* the delay between signal detection and output for presentation should be no more than 3 seconds.

The main cause of this delay is the internal processing of the received signal within the RDF system to achieve declared accuracy.

In order to achieve the best possible performance, proper calibration is essential and will mitigate against the

adverse effects of some of the factors listed above.

The recommended bearing accuracy depends upon the functional requirements for each particular VTS area and the reason for jncluding a RDF as a sensor. Suppliers can provide specifications for each model but typically vary between ≤ 5˚ and ≤ 2˚ however accuracy continues to evolve.



## Frequency Range

Since the main purpose of RDF is detection of VHF communication devices, the frequency range of RDF should, at

least, correspond to the frequencies used for marine VHF communications. Additionally, support for standard

SAR frequencies 406 Mhz for EPIRB transmissions and 121.5 Mhz for homing for civilian beacons (and 243 Mhz for military) may be required if the VTS Authority has a responsibility for SAR operations.

## Number of Simultaneously Monitored VHF Channels

RDF may support simultaneous or almost simultaneous reception on multiple VHF frequencies. This can be

achieved using one or several VHF receivers (typically 4-8).

The single-receiver RDF can be switched to any VHF channel at any time. This can be done manually or

automatically (when the RDF receiver scans a pre-defined list of VHF channels).

There may also be a need to monitor several VHF channels at the same time. For example, SAR channels and VHF

channel 16 may be required to be monitored simultaneously, while all other VHF working channels are monitored

selectively. In such a situation, the use of a multiple-receiver RDF is required.

## Algorythms

In terms of the mathematical algorythm used in DF systems, manufactures typically use the principles of amplitude comparison or phase comparison and each have their own characteristics for all applications.

* + 1. Doppler

Uses the doppler shift induced by a received signal and measuring the phase relationship across a number of elements in a DF receiver aerial.

* + 1. Correlative interferometry

Uses phase difference from signals received across a number of elements within the DF receiver aerial

* + 1. Watson-watt (or adcock)

This method measures the phase difference between across pairs of aerials

# Producing Functional and Performance requirements

The requirements should be based on the high level approach described in IALA Guideline G1150 Establishing, Planning and Implementing VTS ed Dec 2020.

. This included that the feasibility study on risk should specify the risks within interested area and the means to address or mitigate such risks.

## VHF Channel Management

There are two types of RDF systems available on the market:

* RDF systems with a single-channel receiver;
* RDF systems with a multi-channel receiver.

RDF systems with a multi-channel receiver may simultaneously receive and process multiple frequencies. Which

RDF system is appropriate for the VTS Authority should be determined from the operational requirements.

Single-channel receiver RDF systems should, as a minimum, include:

* remotely controlled selection of VHF channel;
* automatic channel scan function from a pre-defined list of working channels;
* if relevant, prioritization of SAR channels in scanning mode.

Multi-channel receiver RDF systems should, as a minimum, include:

* remotely controlled selection of VHF channels for each receiver;
* automatic channel scan function from a pre-defined list of working channels for one or more receivers;
* simultaneous output of detected bearings for all receivers.

## SAR Functionality

Where VTS authorities have SAR responsibilities, additional functionality of RDF equipment may be required, such

as:

* detection of devices transmitting on SAR frequencies;
* automatic filtering of Emergency Location Transponder (ELT) tones of Man-Overboard EPIRB devices;
* receiving and decoding of COSPAS/SARSAT signals.

## Man Overboard EPIRB Detection Capabilities

This capability ensures detection of specific standardized ELT codes transmitted by EPIRB devices. It minimizes the probability of false alarms, caused by spurious transmissions on SAR frequencies.

## COSPAS/SARSAT Detection and Decoding

This capability ensures reception and decoding of digital data transmitted by COSPAS/SARSAT radio beacons. Received data contains the identification number and the measured geographic coordinates of the radio beacon, which can be used for SAR planning.

# AccePtance of VTS RDF Systems

## The 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 detailed acceptance criteria should form part of the agreed site and factory acceptance testing regime.