# RADIO DIRECTION FINDERs

## Introduction

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

RDF can be used to correlate a VHF transmission with a particular target thereby identifying the target in question. This is particularly useful if the target does not have AIS and cannot be identified otherwise.

Another use of RDF is to estimate the position of a transmitting station that is not detected otherwise, e.g. because of its small size.

RDF is not suitable for continuous tracking since it can only estimate a position while the target is actually transmitting.

## Operational Requirements

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.

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 declared VTS level of capability and possible responsibilities for SAR;
* the required bearing accuracy;
* 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.

### RDF Coverage Area

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. Figure 16 provides an example of such a calculation.



1. Estimated Position Accuracy of a RDF Configuration

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;
* 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 - typically specified for 'near to ideal' conditions;
* 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.



### 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 (121.5 MHz, 243 MHz and 406 MHz) 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.

## Functional Requirements

### 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, prioritisation 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.

## Design, Installation and Maintenance Considerations

The RDF systems should be specified taking the considerations in Section 1 into account. This should also consider maintenance access, lightning protection and wind load on antennas. The build-up of ice in some climates should also be a consideration.

### Antenna Installation

RDF antenna installation requires careful consideration, especially with regard to the site. The following aspects should be considered:

* the RDF antenna should be placed on a very stable support to avoid any rotation or torque as this directly affects RDF bearing accuracy;
* the antenna height should be sufficient for detection of VHF transmissions from the targets of interest across the coverage area;
* the presence of objects and geographic features that might cause reflections or the blocking of signals;
* rotating or moving objects (like radar antennas and PTZ CCTV) should be a safe distance from the RDF antenna (refer to the manufacturer’s instructions).

### Lightning Protection

Typically, a RDF antenna is placed on the very top of a mast, so special attention should be paid to lightning protection of the structure. It should provide adequate lightning protection without causing reflections and/or obstruction of the incoming VHF signals.

### Calibration

Calibration should be performed according to the manufacturer’s instructions and should be revisited if there are significant changes to the equipment and/or environment.

### Built-In Test and Diagnostics

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