PRODUCT DESCRIPTION
FOR
DIRECTION FINDING SYSTEM (DF)

TS00220

December 2020

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FORWARD

HAYSYS is pleased to present, within this document, the details of its Direction Finding (DF) System. The system has been designed specifically for fixed ground installation at both civil and military airports.

POINT OF CONTACT

Enquiries regarding the content of this document should be addressed to the Managing Director:

HAYSYS Limited
Pembroke House
Spring Meadow Business Park
Spring Meadow Road
Rumney
Cardiff
United Kingdom
CF3 2ES

Tel: +44 (0)2920 020871
Fax: +44 (0)2920 735949
E-mail: jhayden@haysys.co.uk

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Author

Signature	Name	Position/Organisation	Date
	J. Hayden	Managing Director	

Approved on behalf of HAYSYS Limited

Signature	Name	Position/Organisation	Date
	N. Lloyd	Project Engineer	

Quality Approval

Signature	Name	Position/Organisation	Date
	J. Hayden	Quality Manager	

III. ABBREVIATIONS

Abbreviation	Meaning
AF	Audio Frequency
AM	Amplitude Modulation
ATC	Air Traffic Controller
BIT	Built-In Test
BITE	Built-In Test Equipment
COTS	Commercial off the Shelf
DF	Direction Finding
DSP	Digital Signal Processing
EC	European Council
EU	European Union
FM	Frequency Modulation
FPGA	Field Programmable Gate Array
GIS	Geographical Information System
HMI	Human Machine Interface
ICAO	International Civil Aviation Organisation
IP	Internet Protocol
LOB	Line of Bearing
LPS	Lightning Protection System
MHz	Mega Hertz
OEM	Original Equipment Manufacturer
PoE	Power over Ethernet
RSS	Received signal Strength
UHF	Ultra-High frequency
VHF	Very-High Frequency
VPN	Virtual Private Network

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1 INTRODUCTION

This document provides the detail of the DF Technical Solution offered by HAYSYS Limited, predominantly for fixed site Airport installations.

HAYSYS offer a unique and innovative DF solution through the use of both Commercial-Off-The-Shelf (COTS) equipment and equipment designed specifically for Direction Finding (DF) applications in an Air Traffic Control (ATC) environment.

The unique flexibility of the DF solution in terms of the display equipment and number of simultaneous monitored, or concurrent frequency channels, provide the customer with a level of system re-configuration capability and future-proofing for a system with a minimum design life of 15 years.

Some of the key features of the DF solution are:

a. Class A (±2°) Direction Finder
b. Wide Aperture 16-element VHF or UHF Pseudo Doppler Shift commutated Antenna
c. HAYSYS Ltd are the Original Equipment Manufacturers (OEM) for most key equipment's.
d. Inter-equipment communications using TCP/IP (Ethernet), including to the Antenna
e. Highly cost-effective solution.
f. Effective Human Machine Interface (HMI) using touch screen technology
g. Extensive system information and spatial awareness detail provided to the user
h. User configuration including layered vector mapping, raster mapping or bitmap images
i. Continuous monitoring and alarm functions at the display units
j. Up to 15 display units can be networked in a single system
k. Up to 32 EDF Processors on a single antenna system.
l. System Configuration from Display Units
m. Full Multi-Channel DF System with channel changes from the Display Units
n. System based on modularised equipment providing increased flexibility.

The HAYSYS DF System has been designed using the very latest digital technology, including Field Programmable Gate Arrays (FPGA) and synthesised processors that guarantee the system to be resilient to component obsolescence and ensure that the system design life is extended well beyond conventional systems based on older technology.

Software maintenance is also guaranteed as all software supplied for the system is designed in-house.

2 EU REGULATIONS CONTROLS ON DUAL USE EQUIPMENT – EU 388/2012

Dual-use items are goods, software, technology, documents and diagrams which can be used for both civil and military applications. They can range from raw materials to components and complete systems, such as aluminium alloys, bearings, or lasers. They could also be items used in the production or development of military goods, such as machine tools, chemical manufacturing equipment and computers.

Council Regulation (EU) No 388/2012 amends Council Regulation (EC) No 428/2009 and contains the latest version of the EU Dual-Use List of controlled items.

2.1 The Control Lists

UK goods are controlled and are listed on one of the UK Strategic Export Control Lists (https://www.gov.uk/guidance/uk-strategic-export-control-lists-the-consolidated-list-of-strategic-military-and-dual-useitems).

2.2 Control Categories

The following Control Categories are included:

0 - nuclear materials

1 - materials, chemicals, 'micro-organisms' and 'toxins'

2 - materials processing

3 - electronics

4 - computers

5 - telecommunications and information security

6 - sensors and lasers

7 - navigation and avionics

8 - marine

9 - aerospace and propulsion

Direction Finding Systems are only mentioned in Category 5 and 7, from the above list.

2.3 Category 5 - TELECOMMUNICATIONS AND "INFORMATION SECURITY"

5A1 Systems, Equipment and Components

5A001

e. Radio direction finding equipment operating at frequencies above 30 MHz and having both of the following, and specially designed components therefor:

1. "Instantaneous bandwidth" of 10 MHz or more; and

2. Capable of finding a Line Of Bearing (LOB) to non-cooperating radio transmitters with a signal duration of less than 1 ms;

THE HAYSYS DIRECTION FINDING EQUIPMENT DOES OPERATE AT FREQUENCIES ABOVE 30MHZ BUT IS NOT CAPABLE OF EITHER ITEM 1. OR 2. OF THE ABOVE LIST. THEREFORE, THE HAYSYS VDF SYSTEM IS NOT REGARDED AS A DUAL-USE ITEM UNDER THIS CATEGORY.

2.4 Category 7 - NAVIGATION AND AVIONICS

7A Systems, Equipment and Components

7A115 Passive sensors for determining bearing to specific electromagnetic source (direction finding equipment) or terrain characteristics, designed or modified for use in space launch vehicles specified in 9A004 or sounding rockets specified in 9A104.

Note: 7A115 includes sensors for the following equipment:

a. Terrain contour mapping equipment;

b. Imaging sensor equipment (both active and passive);

c. Passive interferometer equipment.

THE HAYSYS DIRECTION FINDING EQUIPMENT HAS NOT BEEN DESIGNED FOR USE IN SPACE LAUNCH VEHICLES AND DOES INCLUDE ANY SENSORS FROM THE LIST ABOVE. THEREFORE, THE HAYSYS VDF SYSTEM IS NOT REGARDED AS A DUAL-USE ITEM UNDER THIS CATEGORY.

3 GENERAL

3.1 Doppler Principle - Theory of operation

Sixteen omni directional antennas are arranged in a circular array and are connected to an RF combining or "summer" circuit. The summer combines the antenna signals in a way which simulates the continuous rotation of a single antenna element about the axis of symmetry of the antenna array.

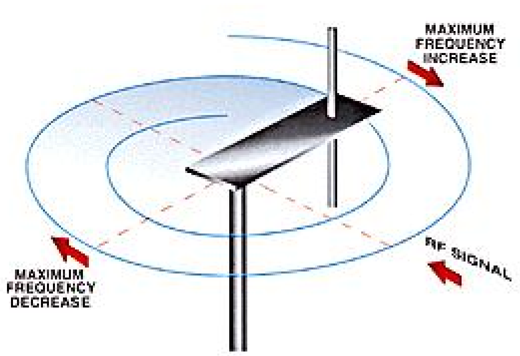

Figure 1 - Doppler principle

In the simplified figure, Figure 1, a single antenna element is shown rotating in a circular path. As the element approaches the incoming RF wavefront, a frequency increase occurs, and when the element travels in the same direction as the wavefront, the frequency decreases. This up-down frequency shift or modulation occurs at the rotational frequency of the antenna.

Applying the modulated RF signal to the input of a narrow band receiver produces a component in its audio output at the antenna rotation frequency (sometimes called the commutation or sweep frequency). This tone is superimposed on the normal audio output and the phase of the tone (relative to the synchronising reference used to commutate the antenna) is the bearing angle. The EDF processor processes this audio signal to calculate (resolve) the bearing angle.

The overall DF system solution is modular in design and consists of a number of equipment's. These equipment's are now detailed in the following sections.

4 OVERVIEW OF THE SYSTEM EQUIPMENT SET

The equipment set consists of a complete DF path, from the Antenna right through to the Display unit.

The following equipment list comprises the key DF equipment's. Other items have not been included, but are still required, in this list (e.g., Antenna masts, fixings, cables etc.), for clarity purposes.

a. Antenna System
b. RF Splitter
c. Synchronisation Pulse Distributor
d. DF Receiver (1 receiver per simultaneous channel to be monitored)
e. EDF Processor (1 EDF per simultaneous channel to be monitored)
f. Communications Modem (if required)
g. Ethernet switches
h. Display Unit
i. Test Oscillator (if required)

Figure 2 below, shows the various elements of the DF solution along with its connectivity.

As detailed in section 4.10 each of the monitored frequency channels can be selected from the display positions. All information between the main DF building (Antenna location) and the display unit sites is over standard MODEM (Ethernet) equipment.

4.1 Overall System Context

This section summarises the key features of the system that provides the ATC Controller with total confidence that assists with the creation of situational awareness of the surrounding Air Traffic.

a. Single Antenna system that enables multiple frequency channels to be monitored truly concurrently, including the emergency distress frequency of 121.5 MHz. The Antenna is a 16-element wide aperture precision di-pole array. With the Antenna being a Wide Aperture type, along with a ground-breaking digital algorithm in the EDF Processor, resilience to reflections, caused by surrounding objects, is provided. The Antenna also includes sophisticated Built-In Test Equipment (BITE). The commutation of the received carrier signal produces a Doppler shift which produces a frequency modulation in the received Audio Frequency (AF).

b. Each Communications Receiver is Multi-Channel with the ability to monitor any frequency channel in the Aeronautical VHF band in accordance with the International Civil Aviation Organisation (ICAO) Annex 10 requirements. Available frequency steps include 25kHz and 8.33kHz. Control of the receivers is via standard Ethernet. Up to 32 Receivers can be installed per frequency band (VHF or UHF).

c. The EDF Processor is the heart of the DF system and in addition to processing the received AF signals that have been modulated by the electronically commutated Antenna, to produce the bearing data; the EDF Processor also continually monitors the complete system for equipment or communication errors. Any errors trigger both audible and visual alarms at all connected displays. All communications between the Display systems and the other system elements are routed through the EDF Processor. The EDF Processor contains advanced DSP Algorithms that provide the superior accuracy. Up to 32 EDF Processors can be installed in a single system, allowing up to 32 frequency channels to be monitored concurrently.

d. The DF Display System – A highly intuitive touch screen display that provides unprecedented control over the system functionality. In addition to a standard Compass Rose display, the displays can be configured to display bearing vectors on various formats of geographical maps, including both raster and vector map formats that allow layers of information to be selected and added (such as major roads, water ways, forested areas etc.). The display system also contains the engineering functions necessary for the configuration of the system (password protected). The engineering functions also include the ability to configure what functionality is available to the ATC Operator. The displays also provide the alarm (both visual and audible) indications as well as system test facilities such as Test Oscillators and full Antenna testing. Up to 15 Display positions, each displaying up to 4 frequency channels, can be installed into a single system.

e. The reference Test Oscillators are positioned at know bearings around the DF Antenna up to a maximum of 100m away. The unit contains all the required RF and control electronics along with the VHF antenna. The unit is powered and controlled over a single CAT 5 cable and uses the Power over Ethernet (PoE) protocol to derive its power and control.

f. The complete DF System is configured as a private Ethernet network with the Antenna, Receivers, EDF Processors, Test Oscillators, Ethernet switches and Display systems all having assigned Internet Protocol (IP) addresses. The network can have as many Ethernet switches as required but the one at the Antenna site (whether local or remote to the tower) is required to have standard PoE ports for the connectivity to the Test Oscillators.

The complete DF System is shown diagrammatically in Figure 2. The design of the HAYSYS DF System provides a level of modularity and should additional frequency channels be required to be monitored concurrently then only an additional Receiver/EDF Processor pair is required for each concurrently monitored frequency.

Up to 32 concurrently (without scanning) monitored frequency channels can be monitored from the one Antenna and with the ability to connect up to 15 display systems to a single EDF Processor, the HAYSYS DF System offers a high level of modularity and system expansion capability to provide the level of future proofing required for a system that has a 15 year plus installed life.

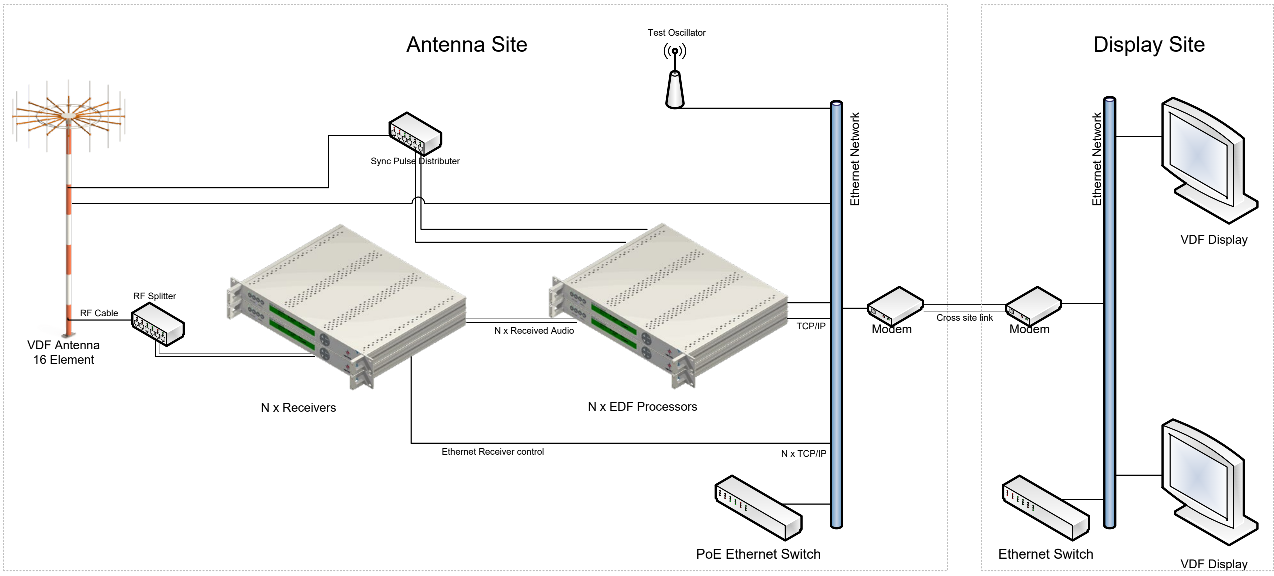

Figure 2 - DF System (2-channel example)

The HAYSYS DF System is a professional grade system designed specifically for the ATC Market and application. The system achieves a Class A accuracy (±2°) and has an instrument accuracy of < ± 1°.

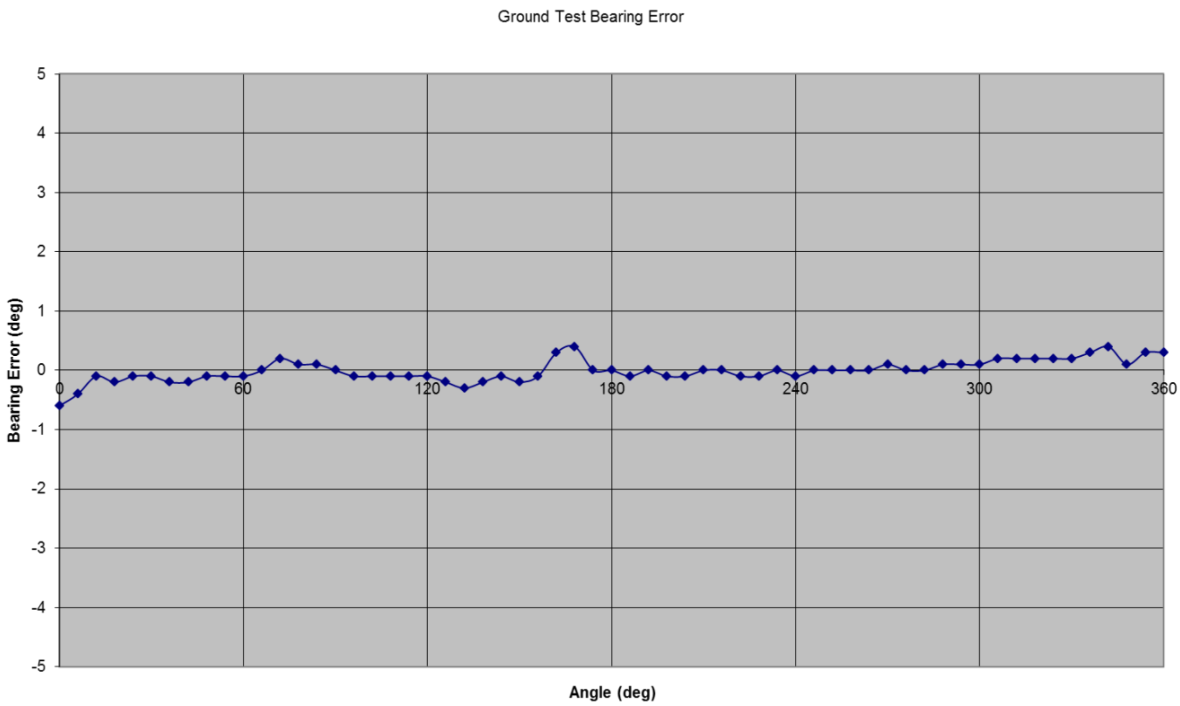

Figure 3 - DF System Instrument Accuracy

Figure 3 - DF System Instrument Accuracy, shows the results from accuracy testing conducted with a ground-based transmitter.

4.2 System Installation

HAYSYS has the capability to deliver truly turn-key projects including the following aspects:

a. VDF System Installation
b. Shelter provisions, designed specifically for the HAYSYS DF System, including Air Conditioning
c. HAYSYS designed, Tilt-Over Antenna Mast
d. Civil Works – Foundation design and installation, Shelter Installations, Existing Building renovations
e. Cross-site cabling installation, including Fibre Optic cabling
f. Lightning Protection

Figure 4 - VDF Shelter Installation at Cambridge Airport, UK.

4.3 DF Antenna System

The HAYSYS designed VHF antenna system is a sixteen-element wide aperture array which uses the pseudo-doppler principle to determine the direction of the transmission source. The diameter of the Antenna is 3m and weighs 45Kgs. The diameter of the Antenna is such that it makes it a Wide Aperture type, in that the diameter is greater than one wavelength at the lowest frequency of use (117.975MHz – wavelength of 2.543m).

The antenna is powered over ethernet (PoE) and provides sync pulses to the EDF Processors in order to resolve the bearings for each channel. The combined / summed RF output of the antenna elements is passed into the receiver(s). The VHF Antenna is shown in Figure 5. The antenna also has a built-in internal oscillator which enables the calibration and testing of the whole system without the risk of unwanted signals and reflections.

The Antenna has been designed to withstand wind speeds up to 100 mph and is constructed from anodised Aluminium, which is then powder coated. All fixings and bolts used in its construction are Stainless Steel, all to ensure the maximum protection against corrosion. The Antenna is also designed with a fibre glass mast, that includes a Stainless-Steel tilt-over assembly, for ease of maintenance by a single person.

Depending on location, the Antenna is usually situated on a 3-meter mast with at least one ICAO approved automatic LED Obstruction light. The mast is manufactured from Glass Reenforced plastic and can be tilted over, for ease of maintenance.

All connectors and cabling are enclosed within the mast, providing maximum protection from the environment.

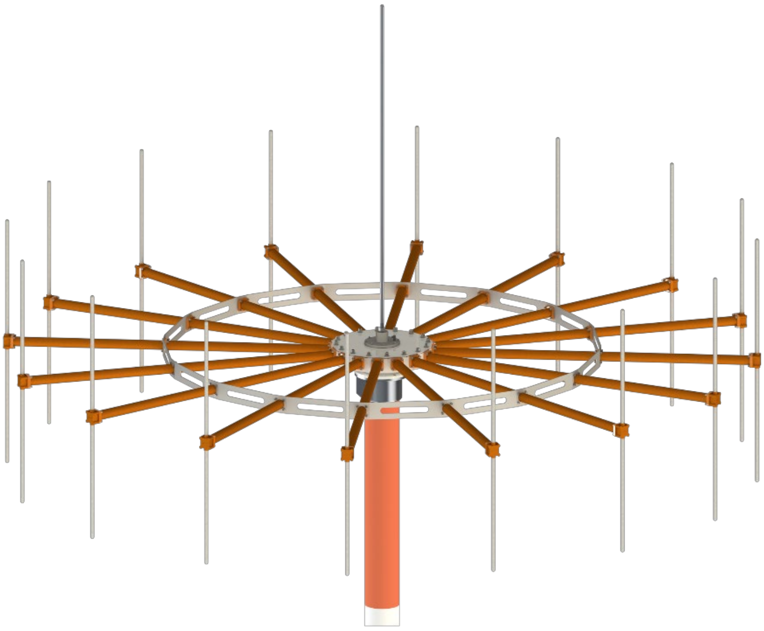

Figure 5 – 16-Element VHF Antenna (with Lightning Rod)

As shown in Figure 5 above, the Antenna can be fitted with an Air Terminal (Lightning Rod), providing lightning protection to IEC 62305.

4.4 Synchronisation Pulse Distributor

The Sync Pulse Distributer is a passive 19" Rack Mounted equipment that allows the differential digital sync pulses from the antenna to be distributed to all EDFs in the same band. With the Antenna generating the Synchronisation Pulses, the EDF Processors and Receivers, within the system, are all the same and can be interchanged with ease. This system architecture eliminates single points of failure within the EDF Processor and Receiver sub-system.

Figure 6 – Sync Pulse Distributor Front Panel

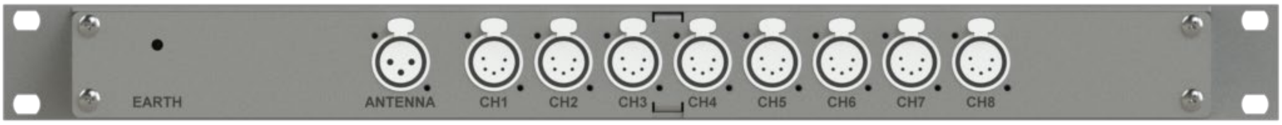

Figure 7 – Sync Pulse Distributor Rear Panel

Each of the Sync Pulse outputs are connected as an input, to the system EDF Processors and controls the timing of the system channels.

4.5 RF Splitter

The VHF and UHF RF Splitters are active equipment's which allows the RF signal from the antenna to be split to all receivers in the same band with near zero losses or distortion. Any unused outputs should be terminated with a 50Ω BNC RF terminating plug to ensure correct impedance matching and operation of the system.

The Front panel as shown in Figure 8 has an LED to indicate when it is powered. The connections to the unit are on the back panel as shown in Figure 9.

Figure 8 – RF Splitter Front Panel

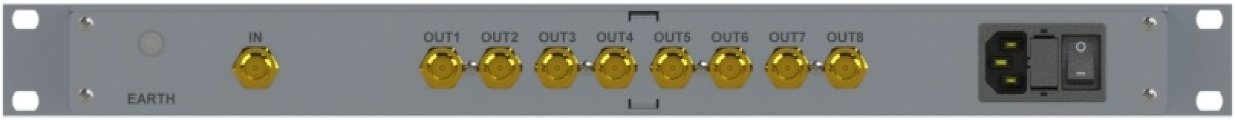

Figure 9 – RF Splitter Rear Panel

As the splitter is an active splitter, the signal levels presented at each of the outputs are the same as the output level from the connected Antenna. Each output of the splitter is connected to the RF input of each of the system Communications Receivers.

4.6 Communications Receiver

The HAYSYS Communications Receiver is a multi-channel receiver that although can be used as a standard receiver; it has been designed specifically for the HAYSYS DF System and as such integrates perfectly, covering both the VHF Channels and the UHF Channels.

It has a standard 19" sub-rack form factor with a height of 1U (44.45mm/1.75 inches). It can be remotely controlled via Ethernet or operated locally using the front panel menu system. In a multi receiver installation, each receiver can be assigned a name that appears on the front panel display to assist in the identification of the unit.

Figure 10 - Communications Receiver

Some of the key specifications for the receiver are as follows:

a. Multiple Modes – AM, FM, WFM, USB, LSB and CW

b. Operating Temperature Range of 0°C to +50°C.

c. Frequency Stability of less than 1ppm

d. Sensitivity of less than 0.35µV

e. Selectivity of less than 10kHz/-6dB

Since the HAYSYS DF System is based upon the Doppler shift effect produced by the commutation of the Antenna, the Receiver is normally set to FM mode of operation since it is the frequency shift component of the received AF that the EDF Processor operates on to resolve the bearing data. This then allows the DF System to operate on any carrier received, including an AM modulated carrier. A further benefit of the FM mode of operation is that the sensitivity is four times better than that when operating in AM mode.

Figure 11 - Receiver Front Panel

As shown in Figure 11 - Receiver Front Panel, the receiver can be controlled and configured locally from the four button Menu system. When integrated in the DF System, any changes made locally to the receiver are immediately communicated to all Display positions.

The front panel also includes four 'favourite' buttons (F1 to F4) that can be programmed from the front panel to any menu item. The front panel also displays the Received Signal Strength (RSS) indication (a range from 0 to 9) that is also communicated to the Display to indicate the distance to the aircraft.

All connections to/from the receiver are made from the rear panel using standard connectors, with the impedance of the RF connector being 50Ω.

The HAYSYS Communications Receiver is also available powered from 24V D.C.

4.7 EDF Processor

As can be seen from Figure 12 - EDF Processor, The EDF Processor has the same form factor as the Communications Receiver. The front panel also looks very similar and also has similar functionality in terms of the menu system.

Just as with the Receiver, the EDF Processor can be controlled either locally, using the menu system, or remotely at the Display Systems over the DF Network.

The EDF processor uses Digital Signal Processing (DSP) algorithms in an embedded processor. These algorithms provide superior signal detection and bearing angle measurement.

The EDF Processor has been designed to work specifically with the HAYSYS Antenna System and provides the derived bearing information from the audio input from the Communication Receiver. Each EDF Processor within the system is synchronised to the Antenna, as part of the ground-breaking algorithm, providing highly accurate bearing information, resilient to RF reflections.

The EDF Processor has also been designed to be independent of any other EDF Processor within the system, providing a high level of system fault tolerance in a multi-channel system.

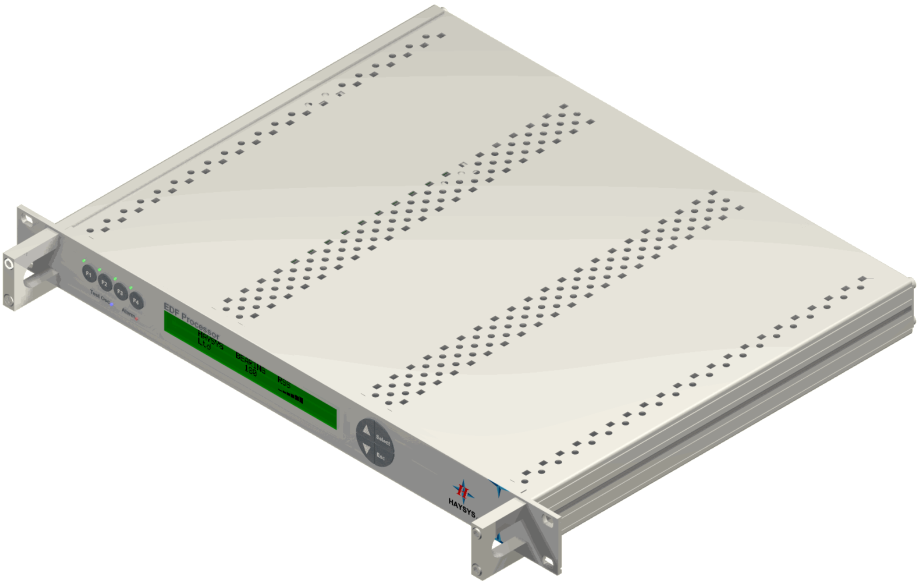

Figure 12 - EDF Processor

The EDF Processor can provide an updated bearing at a configurable rate of between 50ms and 1500ms. The default rate being 250ms. The EDF Processor also controls the sweep rate of the Antenna that is again configurable with a default value of 500Hz.

Figure 13 - EDF Processor Front Panel

As with the Receiver front panel, the EDF Processor front panel also contains 4 favourite buttons, that can be programmed by the system maintainers in order to navigate the front panel menu with ease.

All connections are made from the rear panel and the EDF Processor is available powered from 24V D.C.

4.8 Test Oscillator

The DF system is able to operate a test oscillator located at given bearings incident to the main DF antenna for the purposes of equipment testing and confidence checking.

The Test Oscillator is a multi-channel low power transmitter that is mounted on a suitable non-metallic mast approximately 80m from the DF antenna at a known bearing. The frequency channel of the Test Oscillator is set by the display position and follows the frequency channel that has been selected prior to operating the Test Oscillator. The test oscillator has a frequency range of 118MHz to 137MHz.

Activating the Test Oscillator will result in a DF bearing and trace being displayed on the display software. The displayed bearing can be confirmed to be the correct value and provide the operator with confidence that the complete system is operational and accurate. During testing the resulting Test Oscillator bearing is checked against programmed bearing limits and if in error an alarm displayed.

The Test Oscillator unit is self-contained and contains an integral antenna and is controlled and powered over a single CAT5e PoE Ethernet connection simplifying the installation. The Test Oscillator unit is shown below:

Figure 14 – Test Oscillator Unit (Pole Mounted)

4.9 System Ethernet Network

The installed DF System forms a complete private Ethernet network with communications between all equipments using the TCP/IP protocol. Each equipment within the system has a dedicated IP address and controlled through the system Ethernet Switch. For systems where the display positions are remote from the DF Antenna site a second Ethernet switch is provided, with an appropriate communications link between the two switches.

4.10 DF Display Positions

The DF Display application provides the resolved DF vector display in relation to an underlying map of the local area surrounding the DF Antenna installation. Furthermore, additional functionality for the system is also included, allowing the display of both the received bearing information and all alarm messages. The application runs under Microsoft Windows® operating system.

The DF Display application also allows the facility to display additional information as display layers that can be turned on and off by the user. Such layers could be alternative map displays that provide different map information. Other layers could include user defined layers such as place names as shown or even local emergency contact numbers.

Each display position can display up to 4 monitored frequency channels at the same time. One of these frequency channels can be allocated to the 'Guard' frequency (121.5 MHz on VHF or 243.0 MHz on UHF).

The versatility of the HAYSYS DF system allows additional fully functional display positions to be installed anywhere on the installed site where access to the DF system Ethernet network is available. This includes the Ethernet switch installed at the antenna site and at the tower. The display position installed at the antenna site could be enabled to have all the maintainers' functionality directly available.

Should the DF network be available to the maintainers desktop Windows PC at their office, the DF display software can be installed on this PC and they could have the fully functional display, including all the maintenance facilities, at their fingertips.

Figure 15 - DF Display Application – shown as Raster display

As shown above, the resolved bearing is displayed as a line drawn on the map from the origin (the DF Antenna), at an angle corresponding to the resolved bearing data.

The frequency to be monitored is selected by means of the touch screen buttons as displayed in the button section of the screen. The selected button changes colour when activated.

Other buttons include the 'TO' button that operates the local test oscillator, the 'RCL' button that recalls the last bearing on the selected frequency channel and the 'QTE/QDM/QUJ/QDE' buttons that selects the orientation of the bearing data displayed on the vector line and for true or magnetic bearings.

The map display is a fully functional Geographical Information System (GIS) and is geo-referenced, with the Latitude and Longitude co-ordinates of the mouse position, appearing to the right of the on-screen buttons.

A further map facility is also provides where maps can be displayed in a Vector format such as the ESRI® Shape files as shown in Figure 16 - DF Display, Vector Map display. The benefit of the vector maps over the raster maps is that the vector maps come with map overlays such as land masses, waterways etc. These overlays can be turned on/off at will to provide the exact level of detail required by the controller.

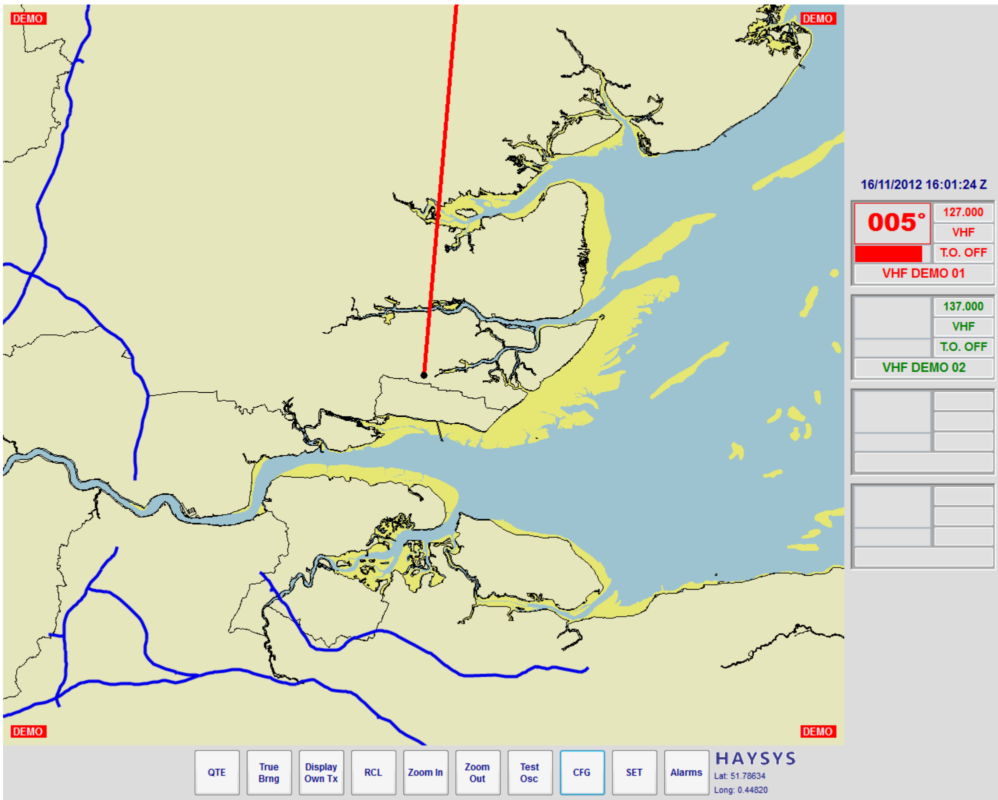

Figure 16 - DF Display, Vector Map display

Furthermore, the vector format map displays much better when closely zoomed in as there is no pixilation of the map detail.

The vector map display provides total flexibility with the controller/maintainer able to define the content used for each of the overlays.

Each of the system displays can also be configured to display only a simple Compass Rose bearing display, as shown in Figure 17 below.

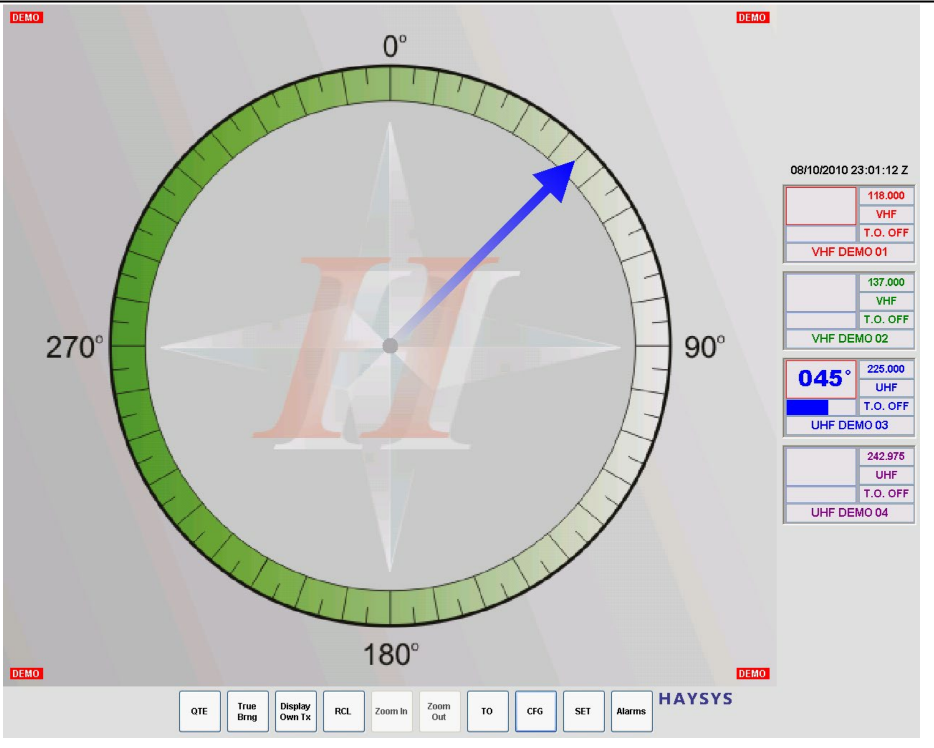

Figure 17 - DF Display Application – shown as Vector (Compass) display

The Compass Rose display offers a more conventional and simpler vector display, should the user prefer it.

The bezel shown in the Compass display also shows the status of the system by changing colour as follows:

a. Green - No alarms
b. Red - Alarm condition or new alarm
c. Amber - Acknowledged alarm
d. Blue - Alarm condition that has cleared without acknowledgement

This colour scheme provides the operator with an instant and effective indication of the system health.

As shown in Figure 15, Figure 16 and Figure 17 above, each of the display units can be configured by the user to display the bearing lines using raster mapping, vector (compass) display or vector mapping display. The Vector mapping display provides the ability to add/remove map layers that contain graphical information such as Boundary lines, urban areas, Airports, Bridges etc. as shown below.

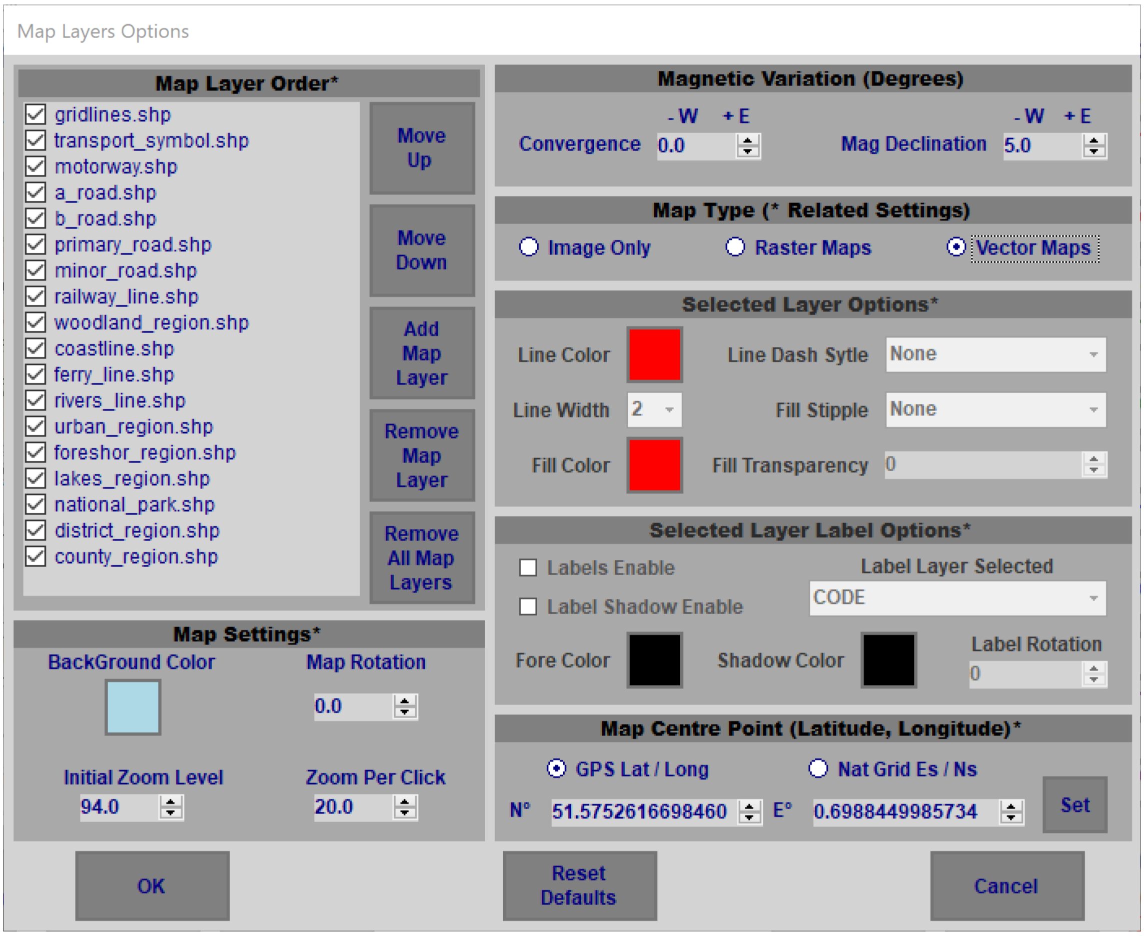

Figure 18 - DF Display, Map Layer Options

4.10.1 QDM, QDR, QTE and QUJ

Each of display positions offer functionality that is independent of other display positions. One such function is the orientation of the display bearing. Figure 19 below shows QTE orientation is being displayed with no magnetic variation added, i.e. a True Bearing. That is, the digital numerical bearing is displaying the bearing value to the transmission.

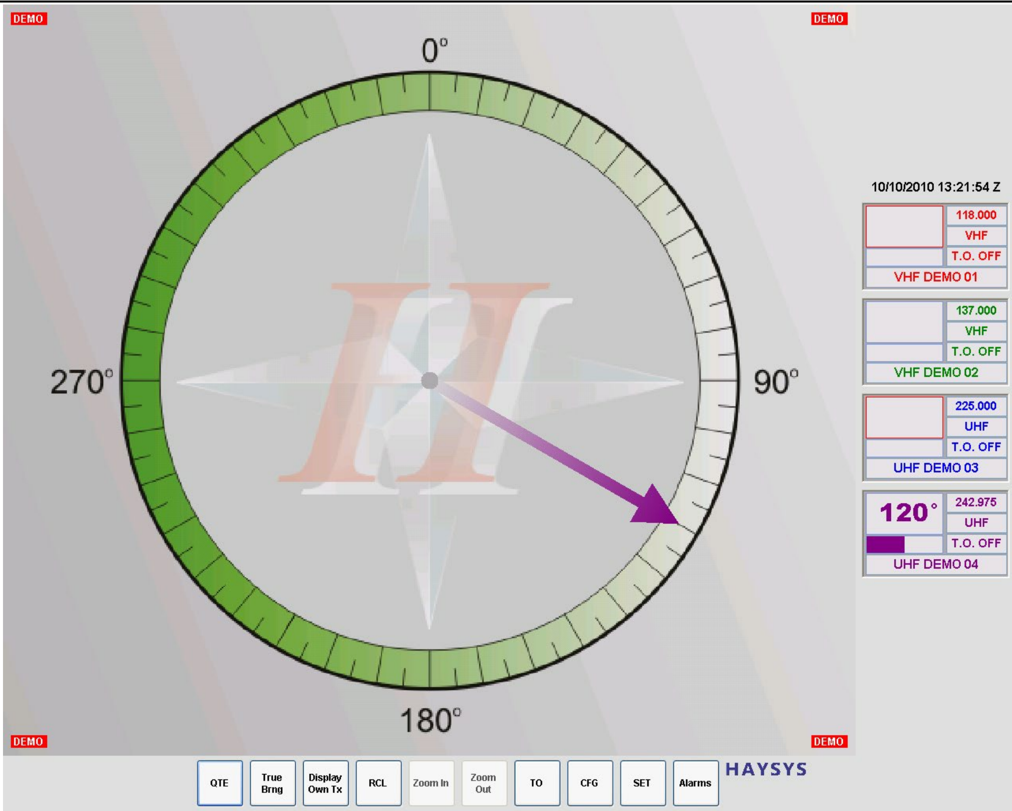

Figure 19 - Compass display showing QTE bearings

If the operator presses the QTE button the button turns green and its label is changed to QDM along with the 'True Brng' turning green with its label changing to 'Mag Brng' as shown in Figure 20 below. Notice the reversed pointer and 180° plus 3° added to the bearing value. The value shown is the heading the aircraft should be on to reach the DF antenna. The 3° being the magnetic variation setting.

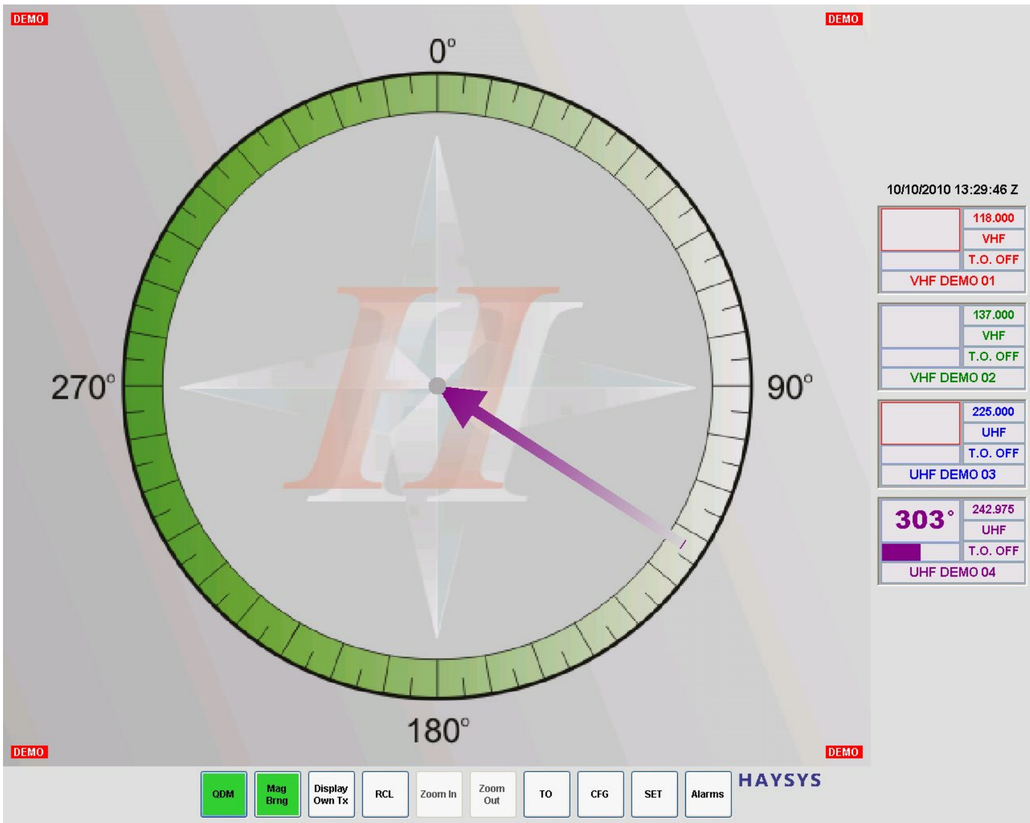

Figure 20 - Compass Display showing QDM bearing

The ‘Mag Brng’ button can be deselected which will remove the magnetic variation and result in the QDM button changing to QUJ.

Finally if the ‘Mag Brng’ button is selected while the orientation button is showing QTE, its label will change to QDR.

4.10.2 System Configuration

The ATC controller can make a number of changes to each display (if enabled to do so), through the Application Configuration screen by pressing the CFG button. This brings up the Application Configuration screen as shown below.

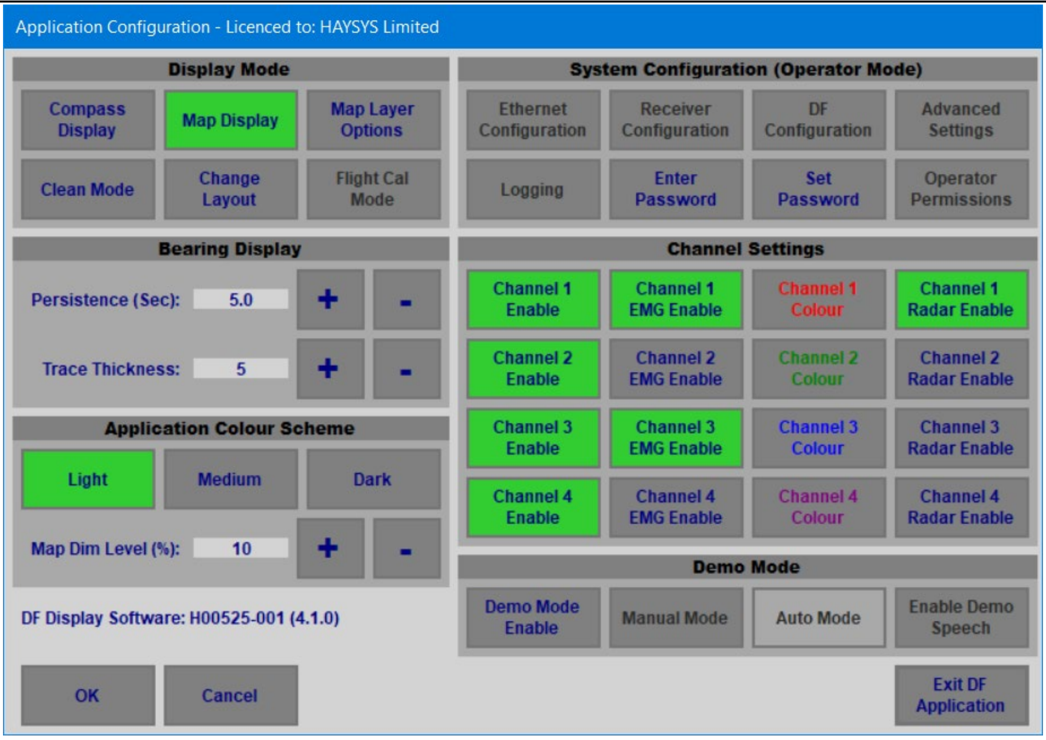

Figure 21 - Application Configuration

From this screen the operator could have full control over the look and feel of the display including:

a. Enabling the display of up to four channels on the one screen
b. Selection of which channels are capable of the 'one-touch' guard frequency change.
c. Display persistence
d. Vector and bearing colour scheme, including the dim level of the map display and vector line thickness.
e. Type of display, i.e. Compass Display, Map Display, Type of Map display including geo coordinated raster mapping and vector mapping.
f. Layers to be displayed on the vector mapping.
g. Operation of a DEMO mode including recorded aircraft calls.
h. Which channel is sent to the connected RADAR Display

This screen also provides a substantial level of functionality to the system maintainers under password protection including:

a. Configuration of the DF Ethernet network
b. Receiver Configuration
c. EDF Configuration
d. System Logs
e. Control over ATC Controller functionality
f. Advanced Settings

4.10.3 Bearing display persistence

The bearing display persistence at each of the display positions is an adjustable setting independent of the other display positions and can be accessed by the operator under the 'CFG' button. The adjustment is from 1 second upwards.

4.10.4 Last Bearing Recall

Each display position has the ability to recall the last received bearing for the channels being displayed, by pressing and holding the 'RCL' button. The recalled bearings are displayed as a dashed lines as seen below.

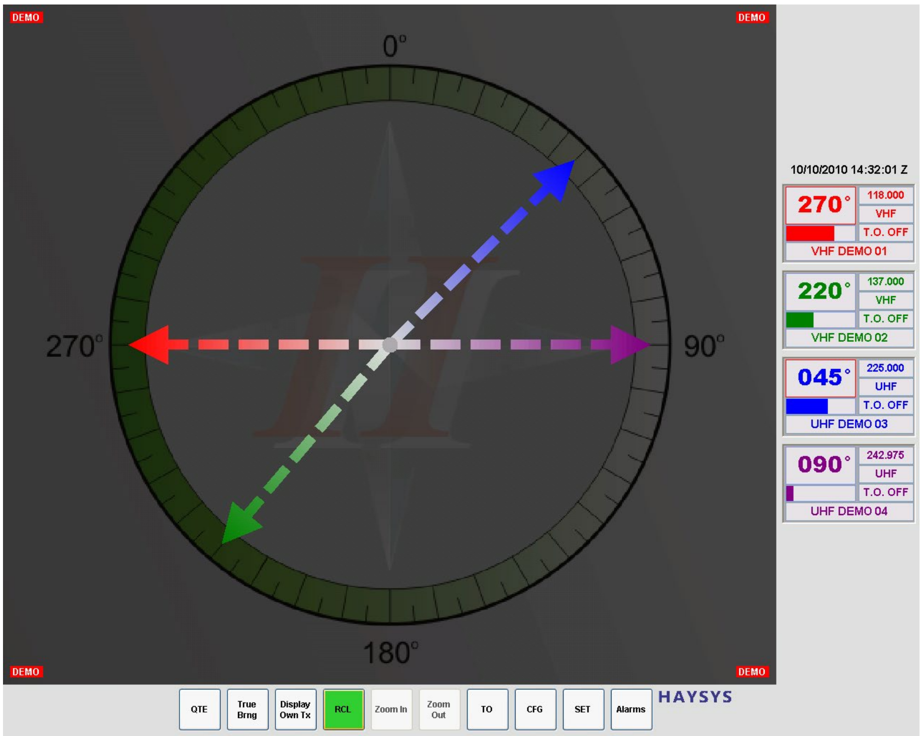

Figure 22 - Bearing Recall function

Figure 22 also shows the display with the Map/Compass display dimmed to highlight the vector lines seen. A very useful display function.

4.10.5 Magnetic Variation settings

The HAYSYS DF display provides the maintainer/ATC operator with the facility to set the magnetic variation in terms of both Convergence and Magnetic Declamation – both to an accuracy of 0.1°. This setting is easily accessed through the map display options under the 'CFG' button.

4.10.6 Map Dim Level

As mentioned above the ATC Controller can adjust the dim level of the map display from with the application configuration screen

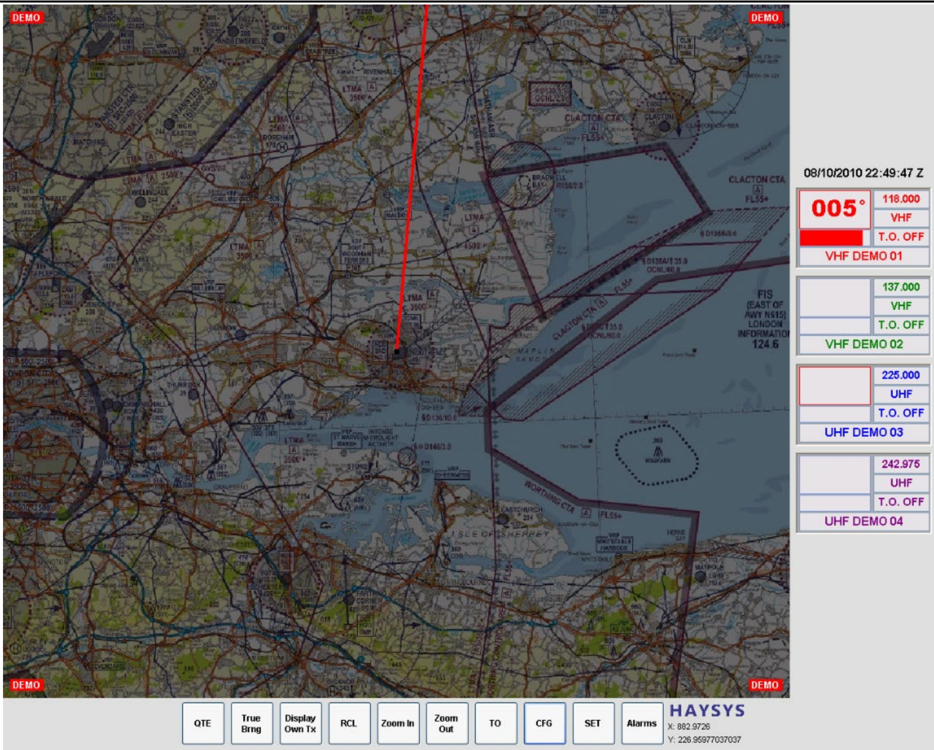

Figure 23 - Map Dim Level

With the map dim level increased, the bearing vector lines become more pronounced and easier to see on a graphically busy screen as shown in Figure 23 above. It can additionally be dimmed in darkened ambient conditions.

4.10.7 Display position colour scheme

Each of the DF display positions, in addition to the map dimming, can be set to a particular colour scheme; Light, Medium and Dark.

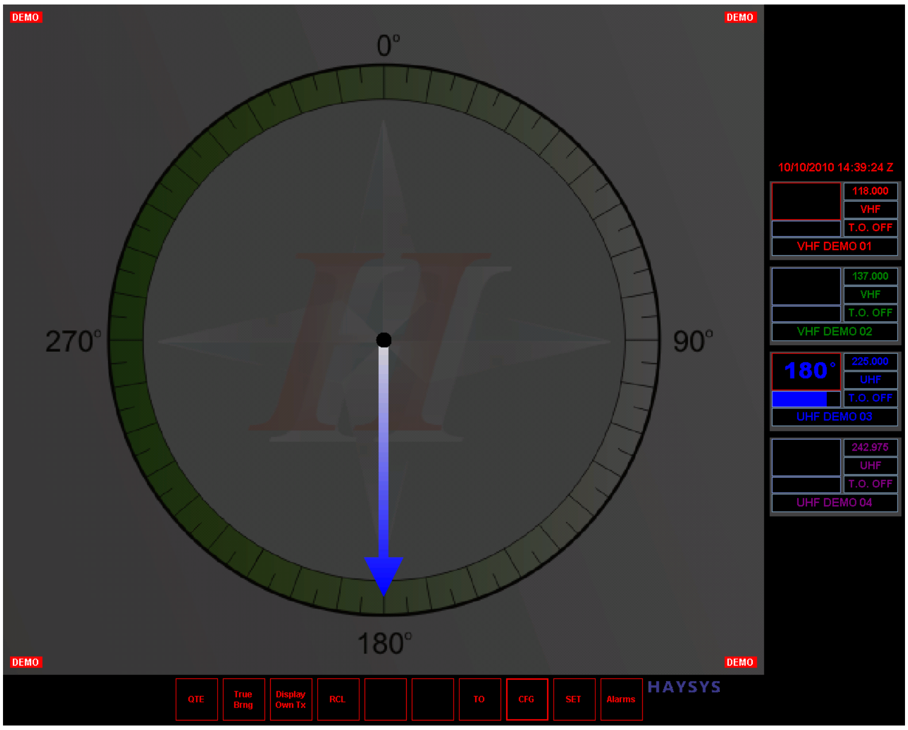

Figure 24 - Compass Display with dark colour scheme

Figure 24 above shows the Compass display with the map dimmed and the 'Dark' colour scheme selected.

This then has the effect of adjusting the brightness of the display and is in addition to the screens own brightness and contrast adjustments.

4.10.8 Received Signal Strength (RSS)

In addition to the bearing information, the display also provides an indication of the Received Signal Strength (RSS) shown as a 10-step progress bar directly underneath the numerical bearing for the channel.

The RSS provides the controller with a little bit more information that adds to their spatial awareness picture.

4.10.9 Frequency Selection

The frequency of any of the channels can be selected by firstly pressing the SET button and then selecting the frequency desired from one of the preset buttons as shown in Figure 25 below.

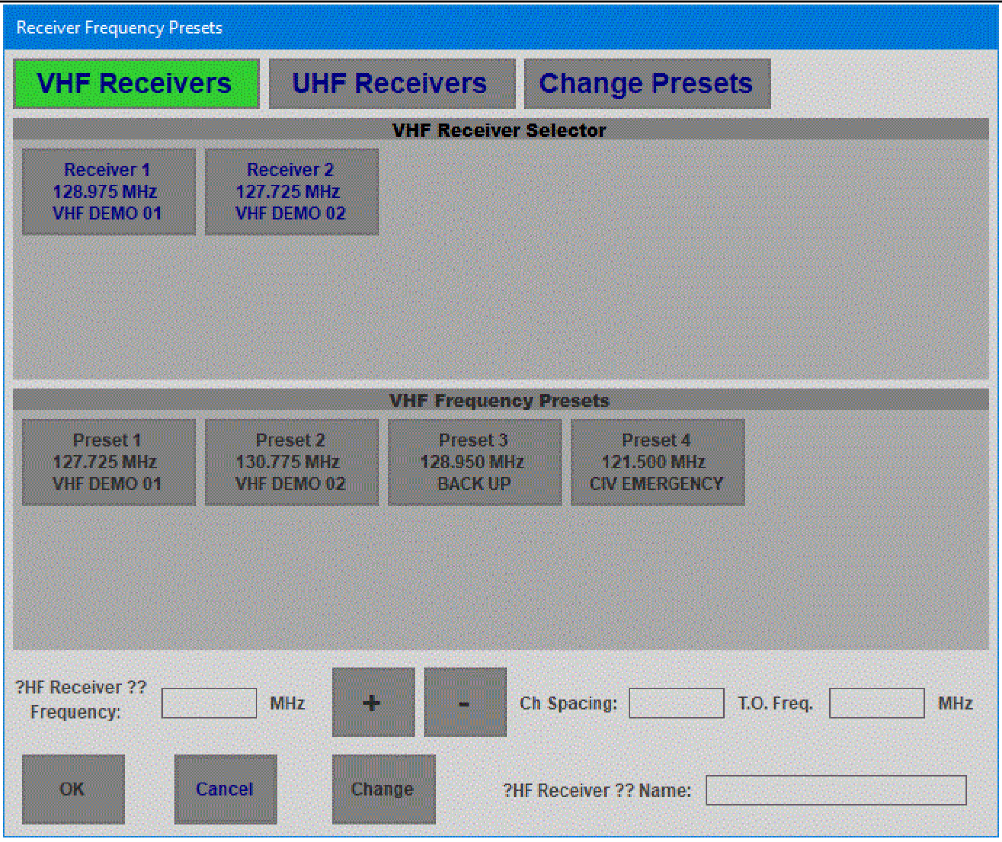

Figure 25 - Frequency Selection

Should the required frequency preset not be available, then one of the preset frequencies can be modified by selecting the preset, entering the required frequency, channel spacing etc. and then pressing the CHANGE button. The name given to the channel can also be entered here and will appear on the front panels of the receivers and its associated EDF Processor.

4.10.10 Display own Tx Function

Another function includes the Display own Tx function (sometimes known as Tx Bar), where the operator can select to view the bearing generated from their transmissions to the aircraft or not. For this function, if disabled, no bearing is displayed on the display screen. However, the transmission bearing is still resolved and can be tested against known bearing limits for the site of the test transmitters. When enabled this effectively makes the station transmitters look like Test Oscillators and the accuracy of the system is tested every time the controller speaks to an aircraft.

4.11 External Interfaces – RADAR Displays

The DF System also includes interfaces to other external systems. These include RADAR display systems, such as the Cobham RDS 1600 Display and their replacement display system. The system also interfaces, as standard, to the Thales TopSky system. These systems allow the bearing vector to be superimposed directly onto the RADAR display, bisecting the target (aircraft) that is transmitting.

4.12 Auto-Triangulation

With the HAYSYS DF System being designed using the latest state-of-the-art technology, including GIS mapping and Ethernet connectivity, multiple DF Systems at different locations can be networked together to release the systems Auto-Triangulation functionality as standard. This will allow any DF System to also provide an accurate position, in addition to the direction of the aircraft.

Furthermore, the HAYSYS Auto-Triangulation System allows additional displays to be added at central locations that provide Distress and Diversion capability, particularly on the distress frequencies 121.500 MHz (VHF) and 243MHz (UHF).

4.13 DFConnectAnywhere©

A further advantage of the HAYSYS DF System being networked, is that this releases the DFConnectAnywhere© functionality. Using a suitably secure Virtual Private Network (VPN), a high level of remote maintenance, testing and configuration of any of the DF Systems on the network can be achieved from either a single dedicated position or from any Airport with the HAYSYS DF System installed.

4.14 System Testing Facilities

The DF System has been designed specifically for the Air Traffic Management sector and as such is highly reliable and includes constant system monitoring using techniques such as 'heartbeats' form the equipment to confirm equipment operation. Most system faults are detected and reported by the system without any user intervention. The system also includes the provision of a reference Test Oscillator (see section 4.8) that coupled with the Transmitter testing and Antenna Test Facility, provides ultimate confidence that the system is fault free and calibrated.

4.14.1 Antenna Testing

In addition to the Built-In Testing (BIT), the display positions can also operate an automatic Antenna Test procedure, that can be initiated by the maintainer. The maintainer-initiated test provides more detailed information of testing activity and should the testing result in a failure, provides the detail of which dipole in the array has failed the testing.

4.15 Antenna Lightening Protection

If required, HAYSYS can design and implement a Lightening Protection System (LPS) to IEC 62305. This will include the provision of Antenna Grounding arrangement such that the ground resistance is reduced to less than 10Ω. The LPS will also include the required connectivity to ensure equipotential bonding.

4.15.1 Surge Arrestors

As with the LPS described above, all surge protection devices are selected to provide protection and are compliant with IEC 62305. All Surge Protection devices are installed in a Surge Protection assembly housing that includes a common earth bar that all devices are connected to. All cables entering the building are immediately passed through the Surge Protection Assembly.

4.16 Antenna location

Figure 26 below shows the general recommendation provided by the UK CAA for the physical safeguarding of DF Antennas. The recommendation is that no objects should be within 120m of the antenna and then height restrictions after this on a 2˚ slope out to a distance of 450m.

The latest Wide Aperture Antenna, offered by HAYSYS Limited, is proven to reduce the impact of RF reflections on the VDF Bearings derived from calling aircraft.

UK CAA, CAP670 - GEN02.24 RECOMMENDATION

VHF Direction Finder

Ground level safeguarding of circle radius 120 m centred on aid, and 2% (1:50) slope from ground level at aid out to 450 m radially.

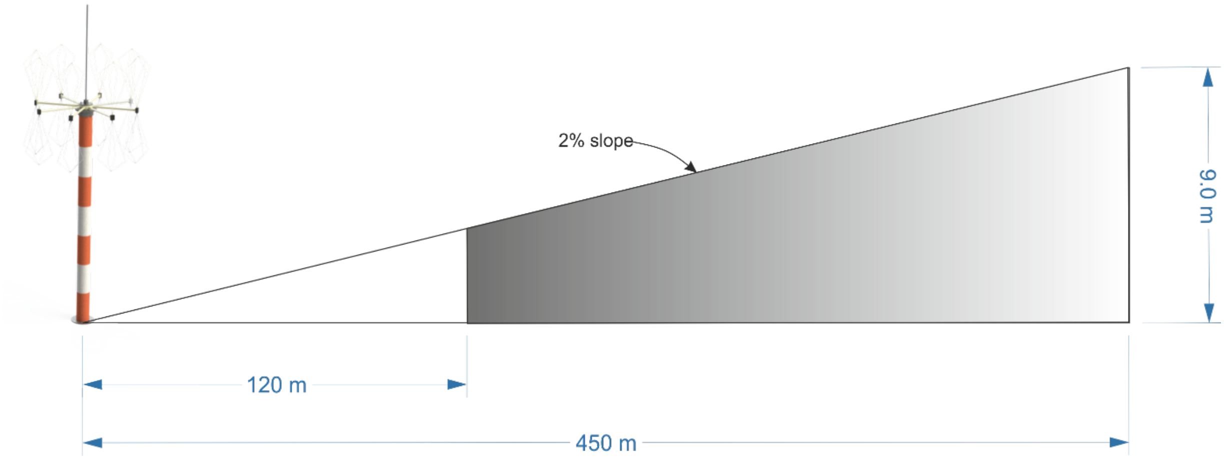

Figure 26 - DF Antenna, Physical Safeguarding

5 WARRANTY

HAYSYS is pleased to offer its standard warranty of 24 months for all delivered items. The terms of our warranty are as follows:

a. All costs for labour and materials are included.
b. Access to our Customer Support, either via the telephone helpdesk or Support portal is included
c. Shipping costs for the return of either the repaired or replacement item, to the customer is included
d. Costs for shipping the failed item to HAYSYS are excluded
e. All failed items will be repaired/replaced within 30 days of its receipt

For additional support during the Warranty period please see our support option.

Should the customer wish a HAYSYS engineer to provide on-site assistance, then this would be provided using the rates agreed with the customer.

6 TECHNICAL SPECIFICATIONS

6.1 General

The technical specifications for the DF system equipment's are shown below.

6.2 Power Requirements

The DF system assemblies are all powered from 240V AC with 24V DC versions available. Units with automatic failover are also available upon request.

6.3 Antenna System

General	Wide-aperture, 16-element dipole arrays
Signal Polarisation	Vertical
Operating Band	118 MHz to 137 MHz (VHF Antenna)
	225 MHz to 400 MHz (UHF Antenna)
Operating Temperature Range	-50°C to +100°C
Elevation	Operates at up to 45° vertical angle of arrival
Wind speeds	Resists speeds of up to 200 km/hr
Weight	40 Kgs
Connection	RF - N-Type connector
	Ethernet and Sync Pulse connections - RJ45 connectors

6.4 DF Receiver (Aeronautical Band)

VHF Frequency Range	118 MHz to 137 MHz
UHF Frequency Range	225 MHz to 400 MHz
	(Other frequency ranges are optional)
Channel Spacing	25 kHz and 8.33 kHz
Operating Temperature Range	-20°C to +55°C
Frequency Error	≤± 3 ppm
Modulation Type	Frequency Modulation (FM) or Amplitude Modulation (AM)
Sensitivity	≤ 1 µV
Image Rejection	≥ 100 dB
IF Rejection	≥ 100 dB

Size	Standard 1U 19" Rack

6.5 EDF Processor

Commutation Frequency	500 Hz
Bearing Accuracy	<±2° (CAP 670 Class A)
Bearing Resolution	0.1º
DF Sensitivity	-126 dBm
DF Response time	<150ms
Sampling Rate	250ms
Audio input	0.01 to 0.6 VRMS
Operating Temperature Range	-20°C to +55°C
Size	Standard 1U 19" Rack
Weight	4Kgs
Interfaces	1 x Ethernet Interface
	1x I/O Interface
	1x Sync Pulse Input
	1 x Audio input

6.6 Test Oscillator

Multichannel in VHF and UHF Aeronautical Band (other bands available).

8.33 and 25 kHz Channel Spacing

Programmable Power output -9 to 0 dBm

Powered by Power over Ethernet (PoE) to IEEE 802.3af standard

Water Resistant to IP65

Dimensions 65 x 120 x 40mm

6.7 Display Unit

Monitor	10" TFT LCD Touch Screen Display (other sizes are available)
PC Base Unit	Dell or similar