User Manual

RT-1000 Multichannel General System Description

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Note

The manufacturer reserves the right to make modifications at any time and without previous information of the here described product.

Content

1 General Information

The RT-1000 Multichannel system is a direction finder (DF), which is designed for air traffic control (ATC) and for vessel traffic service (VTS) applications. The system is based on the very successful standard RT-1000 A and RT-1000 C Doppler direction finder, whose main components are applied in the multichannel system. In applications where more than 2 simultaneously bearing channels are required, the RT-1000 Multichannel is the solution with best cost-performance ratio. The flexible design enables system adaptation to almost all applications. It is realised by using a couple of different standard components, which may be combined and configured individually. The system can cover up to 24 simultaneous DF-Channels. The software “DF-Commander” may display the bearing information and control the system. Through various user interfaces, the DF can be integrated in other systems.

Note:
The RT-1000 Multichannel is not to be used as a voice communication receiver for aeronautical mobile communication services.

Note:
The DF channels typically will be connected to a display system (e.g. PC software) through a data network. The maximum reaction time between the start of a signal reception and completed output of averaged bearing values is 260 ms. This value has to be taken into account for network transfer and display of bearing data to maintain the 500 ms delay limit defined by DF certification rules.

2 System Block Diagram

The RT-1000 Multichannel system is separated in three main parts. The antenna inclusive the line protection box is installed outdoors. The antenna mast allows the changing of azimuth of the antenna in exact 10° steps which provides a very convenient testing of the direction finder only from one position on the field. Furthermore the mast provides a tilting mechanism which is also very useful for the antenna installation, cleaning and maintenance issues.
The antenna is connected to the shelter with a coaxial cable for receiving the RF-Signal and the cable for antenna control which conducts the necessary signals to provide the Doppler modulation.

Further processing of RF-Signal occurs in the shelter inside the DF-Cabinet. First, the RF-Signal is distributed to all installed DF-Channels by the RF-Splitter. Then DF-Channels undertake the real signal processing. As an output, every DF-Channel provides an already computed bearing data via the RS-232 protocol. This data is collected by a MOXA Nport device, which actually represents the DF Control System, and transmitted via LAN to different remote stations.

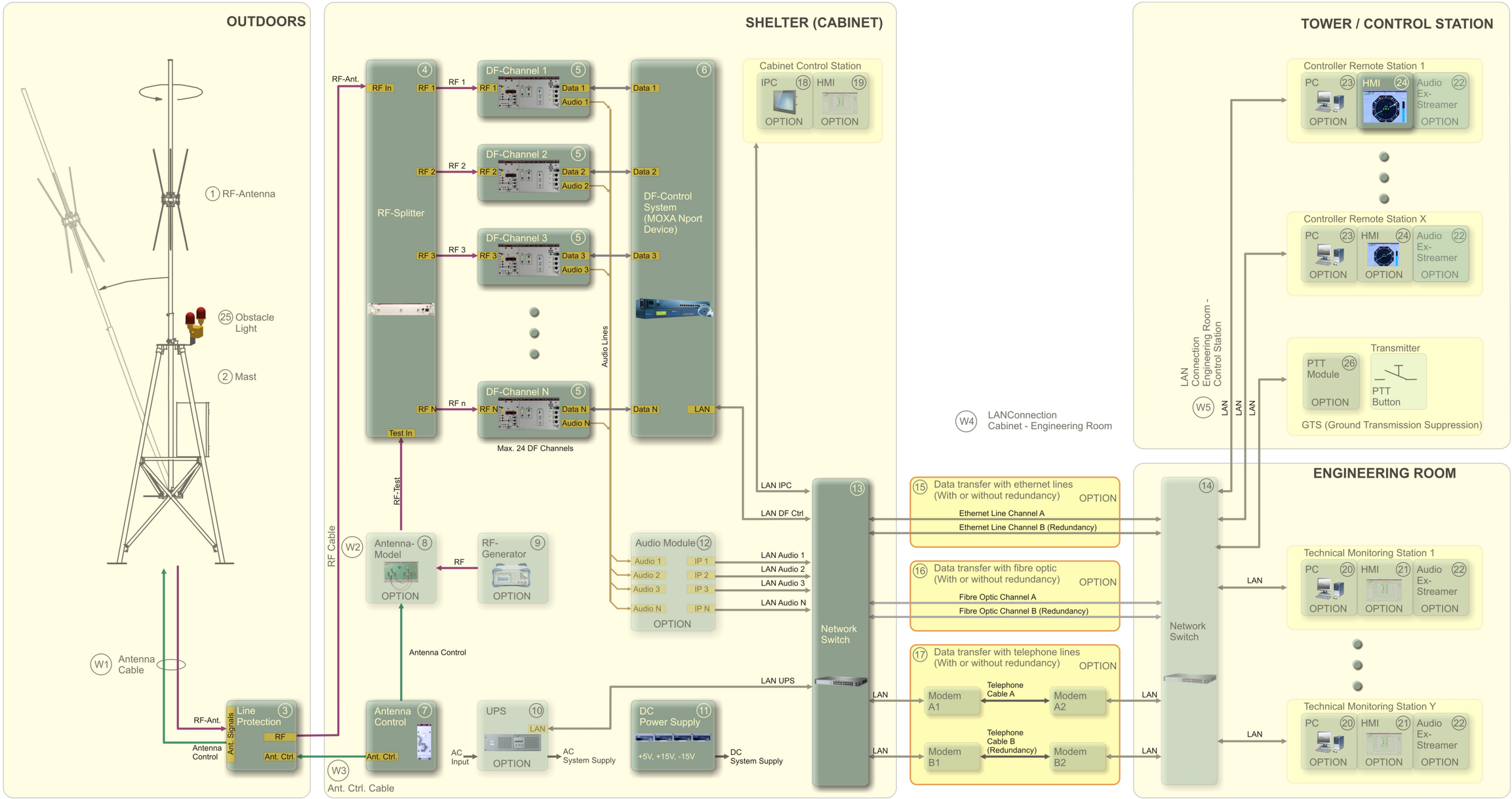
Remote stations represent in general a PC with HMI-Software “DF-Commander”, which not only provides the visualizing of bearing, but also have the possibility to monitor the function of all DF-Channels connected.
Remote stations can be integrated in a control tower, engineering room and in the cabinet with different options of “DF-Commander”. If the transmission of audio is required, the

installation of Audio Module and appropriate Ex-Streamer devices at control stations is necessary.

As an option the RT-1000 Multichannel system allows its system testing using RF-Generator and the Antenna Model. In this case, the RF-Generator simulates the electromagnetic field which comes to the antenna and the Antenna Model simulates the RF-Antenna itself. So these two options allow the complete testing of all system parameters during the normal operation without disconnecting the antenna from the direction finder.

Further, the uninterrupted power supply (UPS) can be purchased as an option.

RT-1000 Multichannel System Block Diagram



The way of data transfer between the shelter (cabinet) and the engineering room or tower depends on customer requirements and the type of laid data lines on the field. RHOTHETA provides three main solutions to transfer the data from shelter to the tower: The data transfer using Ethernet lines, the data transfer using the fibre optic lines and the data transfer via telephone cables using modems. All three solutions can be extended with a second data line to provide the redundancy and data transfer reliability.

3 Component Description

System Components		
Nr.	**Component**	**Description**
1	RF-Antenna	The RF-Antenna is a very robust Doppler antenna with four dipole elements and lightning protection rod in the middle. Due to customer requirements the antenna can be optimized for ATC or VTS applications in order to provide the maximum system sensitivity.
2	Mast	The mast is used for the antenna installation, system testing and maintenance. It offers the mechanism to turn the antenna in exact steps of 10° in order to enable the DF System testing from only one transmitter position on a field (e.g. tower transmitter) and provides a second mechanism to tilt the antenna for maintenance issues.
3	Line Protection	The line protection box includes all necessary components for overvoltage protection of antenna control lines and RF-Signal.
4	RF-Splitter	The RF-Splitter filters and distributes the RF-Signal to all installed DF-Channels for further signal processing. Maximum 24 DF-Channels can be connected. As an option, the RF Splitter can be extended with a second LNA (Low Noise Amplifier) in order to provide the redundancy and consequently increase the reliability of the system. Additionally the RF-Splitter can be equipped with a maintenance test function for controlling the function of LNAs. The options can be combined: Option 1: Without redundancy and without test function Option 2: With redundancy and without test function Option 3: Without redundancy and with test function Option 4: With redundancy and with test function The option 4 provides the most reliability and is strongly recommended to use.

System Components		
Nr.	**Component**	**Description**
5	DF-Channel	The DF-Channel is the responsible unit for signal processing and the bearing computing. It includes a receiver, which have a RF-Signal as an input, and the DF-Processing components which provide the bearing data via RS232 protocol as an output. Depending on customer requirements, the DF Channel can operate in ATC frequency band or marine band or both.
6	DF-Control System	The DF-Control System (MOXA Nport Device) represents a data concentrator. This unit collects all the serial data from all DF-Channels connected and transmits it to all connected remote stations via LAN.
7	Antenna Control	The Antenna Control unit generates north, east, south and west signals for each antenna dipole to provide the Doppler modulation.
8	Antenna Model	The Antenna Model allows the testing of the bearing accuracy of the system without the antenna. Using the additional RF-Generator, the bearing angles of 0°, 90°, 180° and 270° can be adjusted and tested. (If the antenna model is used, the RF-Splitter has to be ordered with a test function)
9	RF-Generator	As an option RHOTHETA offers a RF signal generator in order provide test signals. The RF-Generator can be connected to all test inputs of the system and can be used to assess all necessary parameters such as sensitivity, test of squelch level or frequency deviation test of the system.
10	UPS	Optionally the uninterrupted power supply (UPS) can be installed in the cabinet. UPS provides at least 30 minutes of system operation without AC power supply. UPS can also be equipped with a network card module to provide the status control of UPS and supply system via LAN.
11	DC Power Supply	DC Power Supply unit provides +15 V, -15 V and +5 V supply voltage for RF-Splitter and DF-Channels.
12	Audio Module	The Audio Module is an optional unit used for transmitting audio signals from DF-Channels over LAN. The Audio Module includes 4 audio in-streamers in a 1U 19'' rack, so that 4 DF-Channels can be connected to it. It is necessary to purchase additional audio modules to cover more than 4 DF-Channels.

System Components		
Nr.	**Component**	**Description**
13	Network Switch (Cabinet)	The position 13 on a block diagram is the Network Switch, which is installed in the cabinet as a standard unit. It combines all systems which have an LAN connection and represents the network endpoint of the cabinet.
14	Network Switch (Tower / Engineering Room)	The position 14 on a block diagram is the network switch, which is installed in a tower or in the engineering room. This switch is an optional unit unless the redundancy of the data connection between the cabinet and engineering room is required. In this case, the switch should be ordered by RHOTHETA due to the special configuration which provides the redundancy of data ports.
15	Data Transfer via Ethernet Lines	This option provides the transfer of DF data via Ethernet lines. Additionally, the second port of both switches (13 and 14) can be configured to allow the connection of the second Ethernet line in order to provide redundancy.
16	Data Transfer via Fibre Optic Lines	This option provides the transfer of DF data via fibre optic lines. In order to use this option the appropriate switch should be equipped with an optical interface to allow the connection of fibre optic lines. Additionally, the second port of both switches (13 and 14) can be configured and equipped with the optical interface to allow the connection of the second fibre optic line in order to provide redundancy.
17	Data Transfer via Telephone Lines	This option provides the transfer of DF data via standard telephone cables. In order to use this option, modems are necessary. One data transfer line A includes modem A1 inside the cabinet and modem A2 which is installed in the engineering room or tower. Additionally, the second line B with modems B1 and B2 can be configured in order to provide redundancy. In this case modems and both switches (13 and 14) have to be purchased.
18	Industrial PC (Cabinet)	In order to control and monitor the DF system, the industrial PC can be installed inside the cabinet as an option.
19	HMI “DF-Commander” (Cabinet)	HMI – Human Machine Interface “DF-Commander” for the installation on the industrial PC (18) inside the cabinet. The “DF-Commander” should have a channel monitoring option in order to provide the technical setup, control and monitoring of the system.

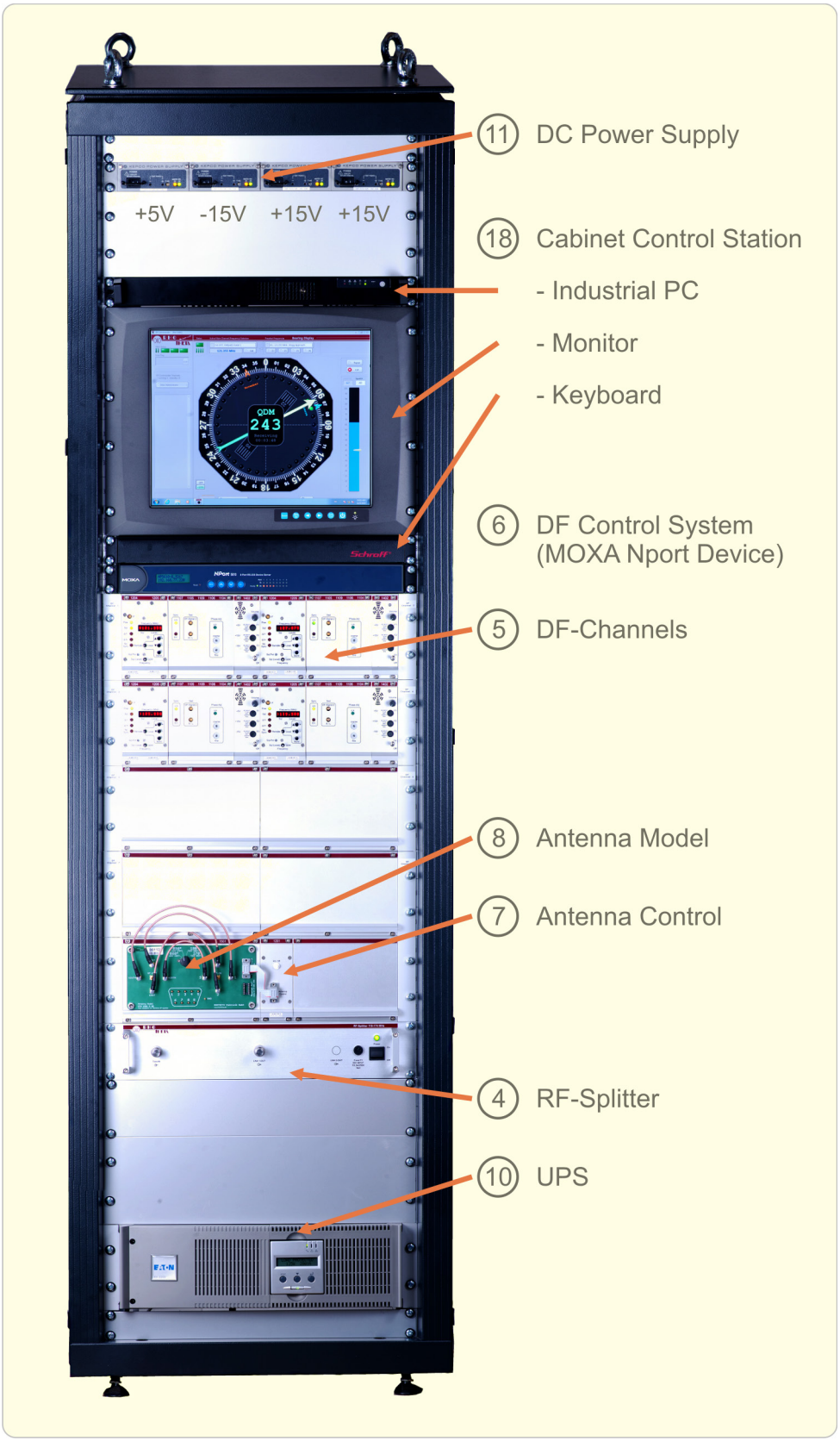
System Components		
Nr.	**Component**	**Description**
20	PC (Engineering Room)	This PC is intended to be installed in the engineering room for the technical monitoring and remote control of the DF system.
21	HMI “DF-Commander” (Engineering Room)	HMI – Human Machine Interface “DF-Commander” for the installation on the PC (20) in the engineering room. The “DF-Commander” should have a channel monitoring option in order to provide the technical setup and control of the system.
22	Audio Ex-Streamer	Every controller remote stations or technical monitoring stations can optionally be equipped with the Audio Ex-Streamer devices. The Audio Ex-Streamer units provide the audio output interface, which can be connected to an audio amplifier or be integrated in the customer defined audio system.
23	PC (Tower)	This PC represents the controller remote station and is intended to be installed in the tower in order to provide the DF information to the ATC or VTS controller.
24	HMI “DF-Commander” (Tower)	HMI – Human Machine Interface “DF-Commander” for the installation on the PC (23) in a tower. The “DF-Commander” should be configured according to the ATC or VTS controller requirements.
-	AIS Suppression (Low pass)	Suppression of AIS signals with a low pass filter, which is installed in a shelter (cabinet) between the shelter RF-Input and the RF Splitter (s. Pos. 4). AIS suppression is recommended to be used if the distance between AIS transmitter with an EIRP of 10W and the Direction Finder is less than 200m. Provide the suppression of signals on 161.975 MHz and 162.025 MHz and limits the marine band to 157.425 MHz (Attenuation 0.8 dB)

System Components		
Nr.	**Component**	**Description**
-	AIS Suppression (Notch)	Suppression of AIS signals with a notch filter, which is installed in a shelter (cabinet) between the shelter RF-Input and the RF Splitter (s. Pos. 4). AIS suppression is recommended to be used if the distance between AIS transmitter with an EIRP of 10W and the Direction Finder is less than 200m. Provide the suppression of signals from 161,965 MHz to 162,035 MHz with more than 20 dB Pass frequencies in the range from DC to 157,500 MHz and 166,600 MHz to 470,000 MHz with an attenuation of smaller than 0,75 dB 157,500 MHz to 161,600 MHz and 162,500 MHz to 166,600 MHz with an attenuation of smaller than 3,5 dB
-	Mast flange	Flange used for the installation of the antenna on a shelter
25	Obstacle Light	Optional safety accessory for the RT-1000 antenna mast. There exist two orderable variations: Single Obstacle Light and Double Obstacle Light.
26	PTT Module	Optional module used for the transmission of the ground transmitter suppression signal via LAN.

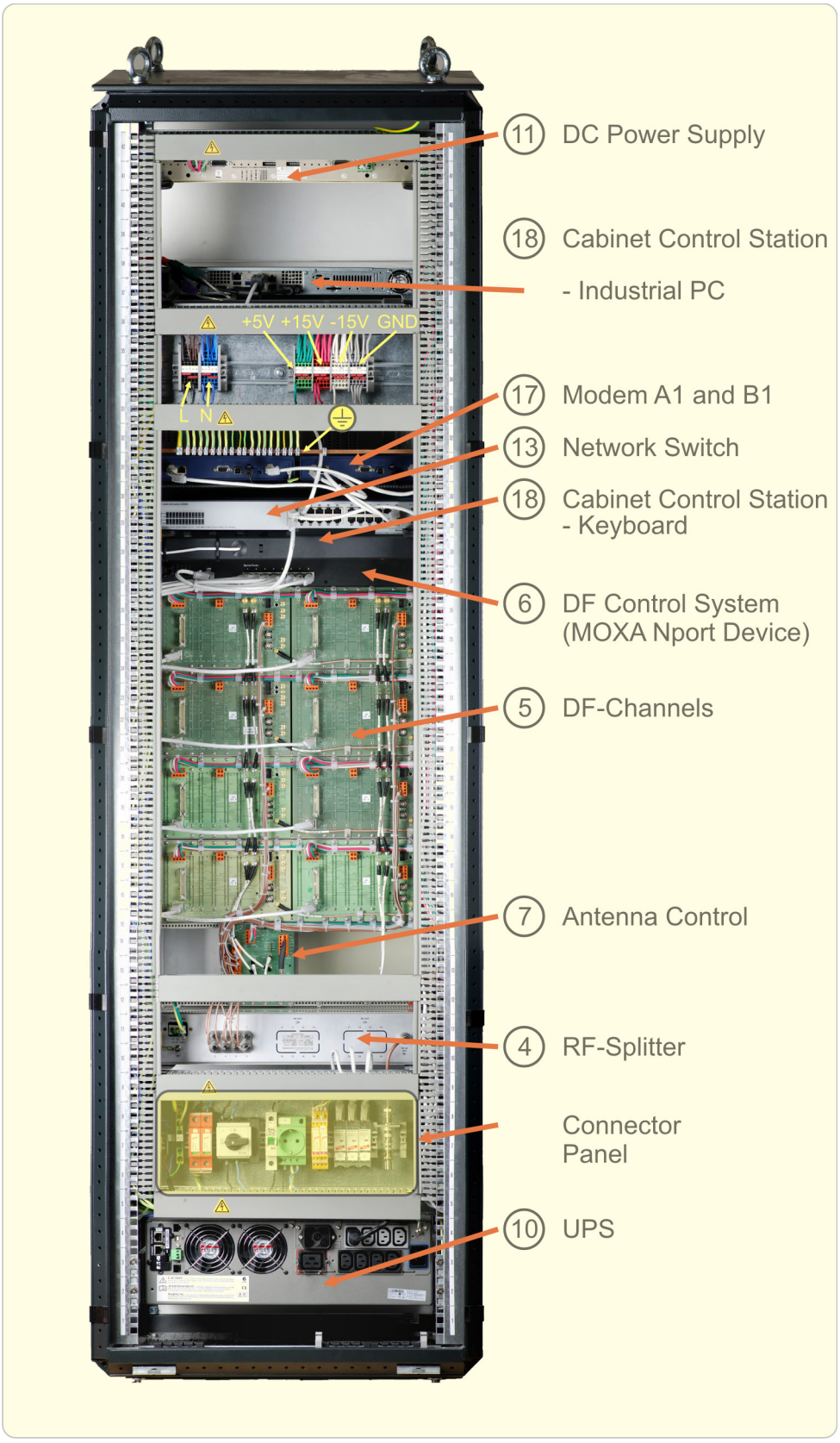
Note:
All system components delivered by RHOTHETA are tested by RHOTHETA. Their interoperability within the Air Traffic Control environment is confirmed by means of EC Declarations of Suitability for Use for each single system component.
All other components, e.g. supplied by the operator, have to be tested for compatibility by the operator in the course of a Site Acceptance Test (SAT). In this case, the operator has to provide an EC declaration of suitability for Use or an EC declaration of verification of systems, respectively.

4 System Configuration

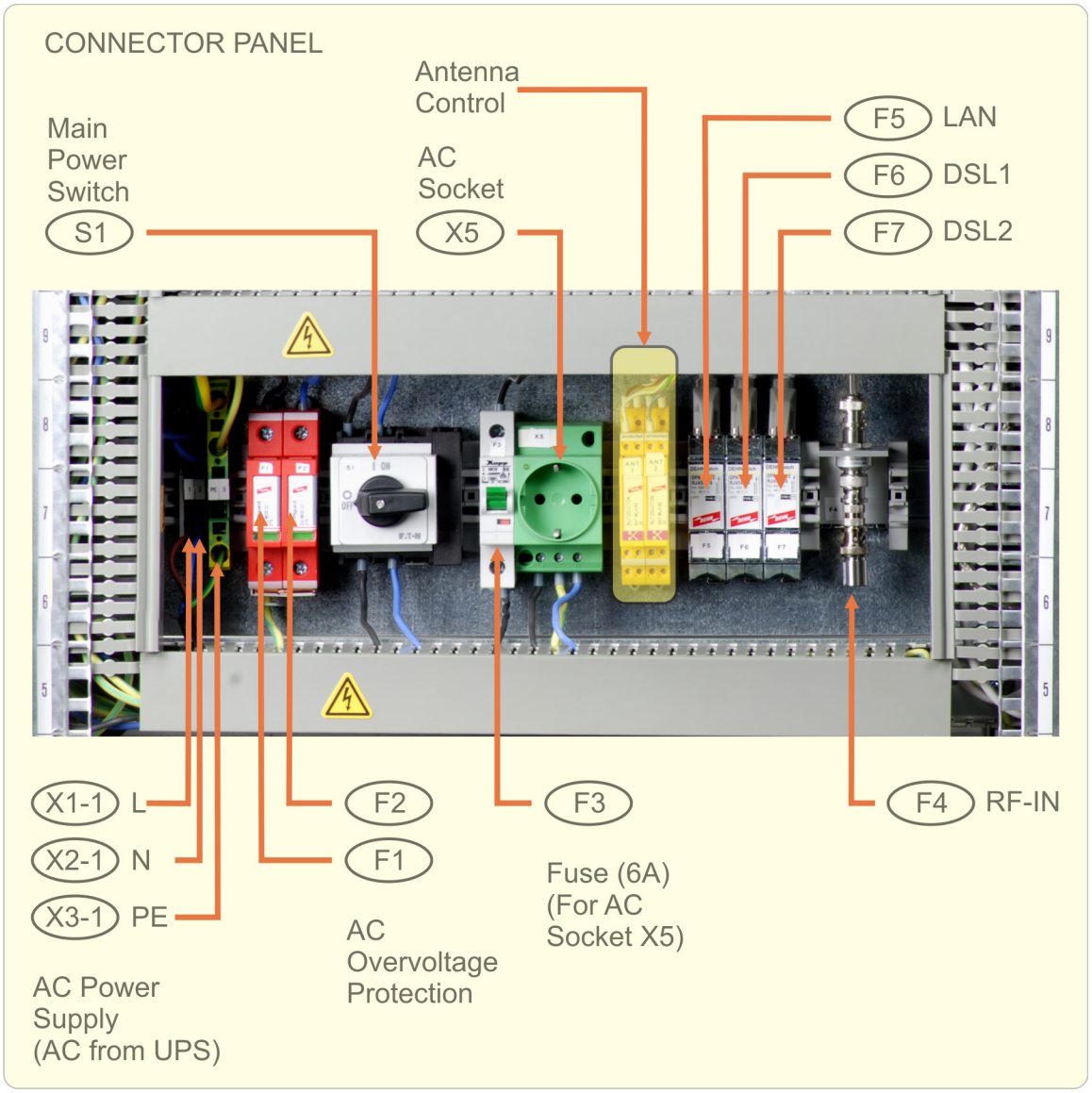
4.1 Front View

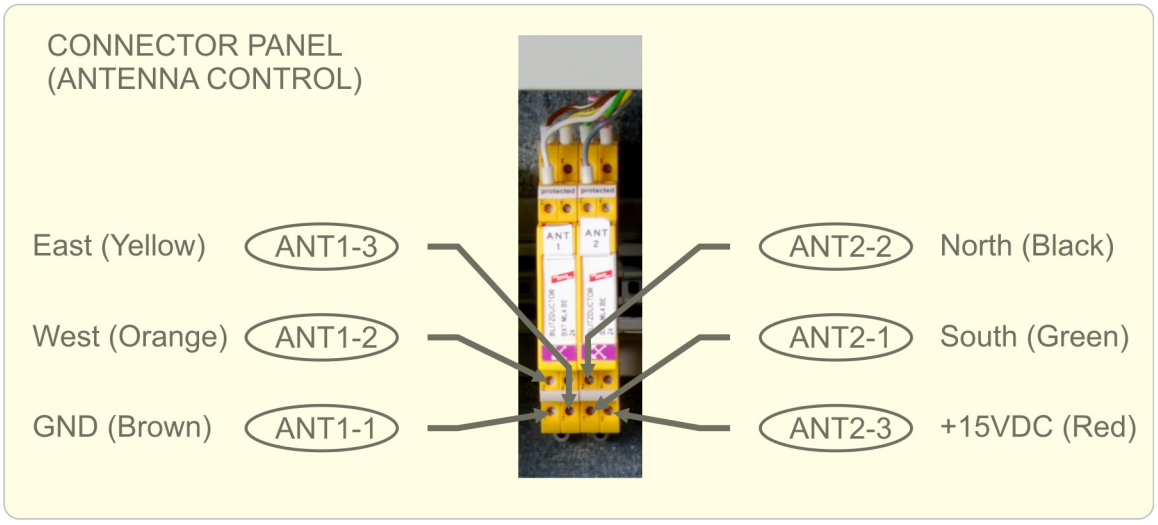


4.2 Rear View


+5V +15V -15V GND
L N
11 DC Power Supply
18 Cabinet Control Station
- Industrial PC
17 Modem A1 and B1
13 Network Switch
18 Cabinet Control Station
- Keyboard
6 DF Control System
(MOXA Nport Device)
5 DF-Channels
7 Antenna Control
4 RF-Splitter
Connector
Panel
10 UPS

4.3 Connector Panel





5 Operation

5.1 Switching ON and OFF

Please control whether the following components are switched off, before connecting the AC Power:

- Main power switch (S1)
- DC Power Supply (+5 V, -15 V, +15 V, +15 V)
- RF-Splitter
- All DF-Channels

After the system is connected to power and connected according to block diagram, switch ON the components in the following order:

- UPS (if this option is available)
- Main power switch (S1)
- DC Power Supply from left to right (+5 V, -15 V, +15 V, +15 V)
- RF-Splitter
- All DF-Channels
- IPC

If it is necessary to switch OFF the system, so please switch off the components in the following order:

- Shut down the IPC
- Switch off all DF Channels
- Switch off the RF Splitter
- Switch off the DC Power supply from right to left (+15 V, +15 V, -15 V, +5 V)
- Switch off the main switch (S1)
- UPS (if this option is available)

5.2 System configuration

1. Please configure the DF-Control System (MOXA Nport Device) according to the manual “DF Control System”.

2. Please configure the switches and modems according to manual “Network Interface”.

3. Please configure the Audio Module (if this option is ordered) according to the Audio Module manual.

4. Please configure the DF-Channel and DF-Commander according to the manual “DF-Commander”.

6 Technical Characteristics

6.1 Basic System Characteristics

System Characteristics		
Parameter	**Condition**	**Data**
DF Method	-	Doppler (3 kHz rotation frequency)
Bearing sensitivity	118,000 – 136,975 MHz, *±2°bearing fluctuation*	≤ 5 µV/m [4] (≤ 2,5 µV/m typ.)
	156,000 – 174,000 MHz, [6] *±2° bearing fluctuation*	≤ 5 µV/m (≤ 2,5 µV/m typ.)
Bearing accuracy	118,000 – 136,975 MHz [8]	2° RMS 1° RMS (Opt.) [7]
	156,000 – 174,000 MHz [8][6]	2° RMS 1° RMS (Opt.) [7]
Response time [1]	*With sufficient signal strength*	≤ 260 ms [4] (< 200 ms typ.)
Minimal signal duration [2]	-	400 ms
Internal system resolution	-	0,5°
Frequency range [3]	*Air band VHF* *Marine band VHF*	118,000 – 136,975 MHz 156,000 – 174,000 MHz [6]
Channel Spacing	*Air band VHF:* *Marine band VHF:*	25 kHz / 8,33 kHz (Option) 25 kHz
Bearable modulation types	-	A3E, F3E, A3X (ELT-modulation)
Number of DF Channels	-	max. 24
Polarization	-	vertical
Polarization Error	*With field vector rotation up to 45°*	±1° [4]
Cone of Silence	*Bearing Fluctuation ±5°*	≤ 45° [4]
MTBF [5]	*Complete System*	48.500 h (4 channels basic system) 35.000 h (8 channels basic system)[9]
Service Life		15 years

1) *Time required to determine and to put out a bearing value at the bearing channel interface. The remaining time between this value and 500 ms is the maximum permissible processing time of the network and bearing indicator output.*
2) *Minimum required signal duration to determine a bearing value*
3) *Frequency range depend on the software configuration (Unlock Options)*
4) *Requirement as per NfL II 43/03 [1-1]: 500 ms. The remaining time between the specified value and those 500 ms is the maximum permissible processing time of the network and bearing indicator output.*
5) *Refer to document 12-9-1-0015-3-2-61 MTBF Estimation*
6) *This frequency range is only valid without using the AIS Suppression*
7) *Option with improved Bearing Accuracy 1° RMS*
8) *Measured in undisturbed wave field, with not modulated signal, with sufficient signal strength*
9) *Basic system includes DF Core System (DF Channel, Antenna, Antenna Control, RF Splitter), DF Control System (Nport device, Switch), Power Supply. For other combinations, refer to document 12-9-1-0015-3-2-61 MTBF Estimation*

6.2 Receiver Characteristics

Receiver Properties			
Parameter	**Condition**	**Limit**	**Typical**
Sensitivity			
Sensitivity AM	118,000 – 174,000 MHz, m = 30%, f_{mod} = 1 kHz, 12 dB SINAD [1)]	-101 dBm	-110 dBm
Sensitivity FM	118,000 – 174,000 MHz, Δf = 3 kHz, f_{mod} = 1 kHz, 20 dB SINAD [2)3)]	-107 dBm	-115 dBm
Large Signal Immunity			
Intermodulation IMD3 (3rd Order)	118,000 – 174,000 MHz [1)]	≥ 70 dB	73 dB
Blocking dynamic	118,000 – 174,000 MHz [1)]	≥ 80 dB	95 dB
Cross modulation	118,000 – 136,975 MHz [1)]	≥ 80 dB	-
Selectivity			
Adjacent channel rejection	AM, 25 kHz [1)]	≥ 60 dB	65 dB
	AM, 8,33 kHz [1)]	≥ 60 dB	65 dB
Spurious response rejection [4)]	118,000 – 174,000 MHz [1)]	≥ 70 dB	80 dB
Image Rejection	118,000 – 174,000 MHz [1)]	≥ 70 dB	100 dB
AF Signal Quality			
Total harmonic distortion THD	AM (m=30%, f_{mod} = 1 kHz) [1)]	≤ 5 %	-
	AM (m=90%, f_{mod} = 1 kHz) [1)]	≤ 10 %	-
	FM [3)]	≤ 5 %	-
Signal to noise ratio S/N	AM [1)2)]	≥ 40 dB	60 dB
	FM [3)]	≥ 40 dB	-
Dynamic			
Dynamic Range AM	[1)]	≥ 100 dB	-

1) *Measured according to ETSI EN 300 676 [1-7]*
2) *Measured with ITU O.41 filter*
3) *Measured according to 12-9-0-2-8-1-1 Messprozeduren.doc [Rev 1.01]*
4) Except *1st image frequency*

6.3 Antenna Characteristics

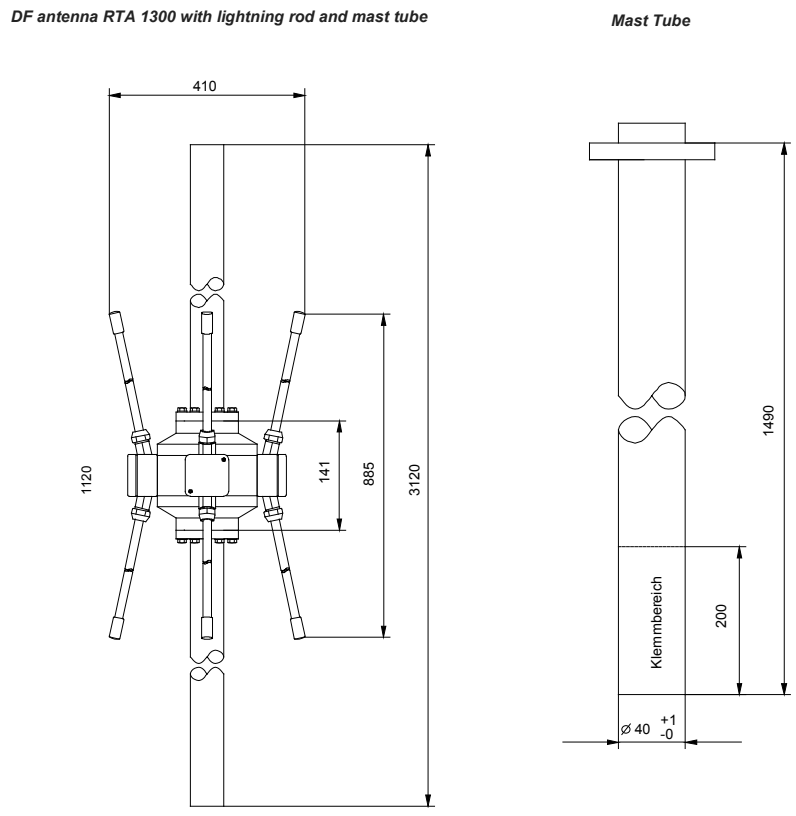
6.3.1 Electrical Characteristics

Antenna		
Parameter	**Condition**	**Data**
Antenna type	-	Compact Antenna
Number of radiators	-	4 Dipole Antennas
Antenna connectors[1)]	-	*6 Flat Connectors 2,8x0,8 mm*
	-	*BNC Connector*
Antenna Gain	118,000 – 136,975 MHz	≥ -6 dBi
	156,000 – 174,000 MHz	≥ -11 dBi
Coin of silence	± 5° bearing fluctuation	≤ 45°

1) *Connection of the RT-1000 antenna with special RT-1000 antenna cable*

6.3.2 Antenna Mechanical Characteristics

Antenna RTA 1300.A with Antenna Mast RTA 1306.A



Mechanical Characteristics			
Subsystem	**Width**	**Height**	**Weight**
RT-1000 Antenna RTA 1300.A	400 mm	3120 mm	10,2 kg

6.3.3 Antenna Environmental Conditions

Environmental Conditions		
Parameter	**Condition**	**Data**
Wind load	*With constant wind speed of 150 km/h* *With constant wind speed of 180 km/h*	135 N 195 N
Maximum wind speed	-	≤ 240 km/h
Operating temperature range	-	-40°C…+80°C
Storage temperature range	-	-40°C…+80°C

6.4 Cabinet Characteristics

Environmental Conditions		
Parameter	**Condition**	**Data**
AC Power Supply	*Without UPS* *With UPS*	115V … 230V (± 15 %) 230V (± 15 %)
AC Power Consumption	4 Channels 8 Channels 12 Channels 16 Channels 24 Channels	≤ 400 W ≤ 450 W ≤ 500 W ≤ 550 W ≤ 600 W
Dimensions	Height (incl. foot and eyelet) Width Depth	210 cm 60 cm 60 cm
Weight	2 m cabinet with 3 to 8 DF Channels	≤ 250 kg
Operating temperature range	-	+5°C…+40°C
Storage temperature range	-	+5°C…+40°C

7 Legal Information

7.1 Legal Limitations of Use within the EU

Due to its conformance to “Directive 2014/53/EU on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC”, declared in the EU declaration of conformity, the equipment may be used within the European Union without limitations regarding the use of frequencies in those countries.
National limitations or requirements for special operational permissions might exist for the use within Vessel Traffic System or Air Traffic Control applications.

7.2 EU Declaration of Conformity

Hereby, RHOTHETA Elektronik GmbH declares that the product RT-1000 Multichannel is in compliance with the essential requirements to be put on the market, and with other relevant provisions:

- Directive 2014/53/EU on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC
- Directive 2014/30/EU relating to electromagnetic compatibility
- Directive 2014/35/EU relating to electrical equipment designed for use within certain voltage limits
- Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment

A copy of the EU declaration of conformity is available at http://www.rhotheta.com/

7.3 Approval / Authorization of the Direction Finder RT-1000 Multichannel as a System in Air Traffic Management

After successful installation of all components and north alignment of the direction finder antenna as described in the manual sub-part “Recommendation of Antenna Installation”, the system is ready for operation. But before bearings may be transmitted to an aircraft, approval from the appropriate authority must be obtained. This approval is regulated differently in every country.

NOTE
Authorization or approval of the device itself and as a system within the air traffic management is regulated differently in every state.

NOTE
Explanations refer to the state of rules in 2017. They are subject to change or alteration.

7.3.1 Approval in the Federal Republic of Germany / EU

The approval of the system RT-1000 Multichannel Core System is carried out in Germany according to the FSMusterzulV (air traffic control systems and equipment Pattern Approval Regulation).

NOTE
This Regulation determines the requirements for type certification of equipment for air traffic control and lays down the procedure of the type certificate. In addition, it regulates the labeling and inspection of systems and equipment.

The German “Bundesaufsichtsamt für Flugsicherung“ (BAF) (= Federal Supervisory Authority for Air Navigation) performs as national regulatory authority for type certification according to “FSMusterzulV”.

The “Bundesaufsichtsamt für Flugsicherung” issues the type approval of an air-traffic control facility or equipment if the requirements as defined in §4 FSMusterzulV are fulfilled.

The approval number is labelled on the RT-1000 Multichannel.

Approval label:
The components of the direction finder RT 1000 Multichannel Core System are provided with labels which contain the approval number of the “Bundesaufsichtsamt für Flugsicherung”. These signs must not be removed nor covered.

They are attached to the following points in the system:

Bearing Channel:	backside of the rack
Antenna Control Unit:	backside of the rack
RF Splitter:	backside of the housing
Antenna Unit:	on the antenna housing next to the dipole housing of North dipole

7.3.2 EC Declaration of Suitability for Use

All system components delivered by RHOTHETA are tested by RHOTHETA. Their interoperability within the Air Traffic Control environment is confirmed by means of EC Declarations of Suitability for Use for each single system component.
All other components, e.g. supplied by the operator, have to be tested for compatibility by the operator in the course of a Site Acceptance Test (SAT). In this case, the operator has to provide an EC Declaration of Suitability for Use for those components.

In the European Union, the RT-1000 Multichannel may be provided as a system for air traffic management at the service only if it has been successfully tested for compliance with the essential requirements and relevant implementing rules for interoperability.
For this purpose, the air traffic control organizations will perform an EC-verification of the system according to the interoperability regulation (EC) No. 552/2004 and the relevant implementing rules for interoperability. The authority will confirm this in an EC declaration of verification of systems.

The EC Declaration of Verification of Systems must be handed over to the national supervisory authority.

NOTE
National supervisory authority for Germany is the “Bundesaufsichtsamt für Flugsicherung” (BAF).

8 Notes