YOUR MISSION, OUR TARGET

SURVEILLANCE MOVEMENT RADAR

TECHNICAL SPECIFICATION

X-BAND SURVEILLANCE MOVEMENT RADAR

200W DUAL SOLID-STATE TRANSCEIVER, INDOOR VERSION

IN ACCORDANCE WITH ICAO 9476-AN/927 STANDARD

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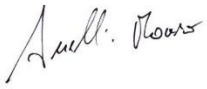
Quality Assurance Control	Mauro Anelli		01/07/2024

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GENERAL INDEX

FIGURE INDEX

TABLE INDEX

1. INTRODUCTION

1.1 SCOPE

To the best of ICS Technologies' knowledge, the information and illustrations in this document are correct, however ICS Technologies reserves the right to amend any detail within, during the lifecycle of the product. In the event of this document being up-issued, the latest issue of the document will take precedence.

1.2 PREAMBLE

The family of radar **SMR**, solid-state radar series, exploits the ICS TECHNOLOGIES twenty years' of experience in the provision and installation of radars solutions for Coastal Surveillance and airport applications, in accordance with the latest international technical handouts.

SMR solid-state radar series is a next generation of surface movement radars designed to secure safe transportation of passengers and cargo from the time the aircraft has landed until it is safely parked and ready to unload.

The outstanding capabilities of the SMR ensures reliable detection of very small targets and produce an overall clear, high-resolution radar awareness of the coverage area, day and night and in all weather conditions.

This document (ID_ST_SMR) describes the *ICS technologies SRL* 200W dual down-mast radar system, specifically designed to meet EUROCAE ED-116, EUROCONTROL, and WMO standards.

1.3 GENERAL DESCRIPTION

SMR is an advanced Surface Movement Radar (SMR) system designed to ensure uninterrupted airport operations, particularly in scenarios where even minimal disruptions to control systems are unacceptable.

To meet these high demands, **SMR** offers full redundancy of its critical components, ensuring the radar sensor remains operational even during preventive or corrective maintenance activities.

The system features a highly efficient 21-foot antenna that delivers exceptional angular resolution and a continuous refresh of the surrounding radar image, providing reliable and detailed situational awareness.

In its indoor configuration, **SMR** is equipped with two solid-state transceivers that operate in Hot/Stby mode and enable software-defined frequency tuning across the entire band (9.3 ÷ 9.5GHz), effectively mitigating interference and ensuring seamless operation.

Each transceiver may include as option a knowledge-based embedded tracker that automatically adjusts the number of scans required to initiate a track. This adjustment is based on the local clutter density and how effectively a series of consecutive plots define a potential target trajectory, optimizing tracking performance in real time.

The output data from the transceivers complies with EUROCONTROL standards, ensuring seamless integration into airport control systems for enhanced operational efficiency and reliability.

1.4 TECHNICAL PECULIARITIES

The experience gained over the years has allowed ICS Technologies to design a completely innovative radar characterized by numerous technical peculiarities that make it unique on the market and providing tangible advantages to the customers.

These peculiarities are focused on simplifying the installation phase, a significant improvement in system performance, reduced maintenance routine.

1.4.1 PLUG & PLAY CONCEPT

The **SMR** radar series is designed according to the concept of “Plug&Play” of ICS Technologies which provides extreme simplicity in the installation of the system thus allowing to save time on site.

Any radar sub assembly is provided with external MIL-STD connectors together with a cable kit pre-assembled and tested at factory.

No more wiring activities to be carried out on-site, no possibility of errors or necessity of special tools. With **SMR** the installation becomes simple, time saving and convenient.

Figure 1 - External radar sockets

1.4.2 REDUCED MAINTENANCE ROUTINE

The **SMR** radar series is designed with the focus to provide a cutting-edge solution characterized by a reduced maintenance routine:

- The motor-reducer assembly is installed inside the turning unit, thus not exposed to atmospheric agents;
- antenna rotation by geared motor or direct motor, without the use of transmission belts that requires periodic maintenance or tensioning or replacement;
- an innovative direct hollow shaft encoder thus without the loss of accuracy caused by mechanical chain or belt between encoder and shaft;
- an integrated hose device for a smooth purge and refilling of the oil inside the motor-reducer assembly;
- an oil level sensor which provides a warning in case the oil level, in the antenna gear box, is below the recommended level. Warning available over the Built-in Test Equipment and the SNMP digital interface

1.5 EXPORT CONTROL REGIMES – DUAL USE REGULATION

The equipment under the scope of this document is subject to Authorization process according to Regulation (EU) No. 1232/11 of the European Parliament of 16 November 2011 amending Council Regulation (EC) No. 428/2009 setting up a Community regime for the control of exports, transfer, brokering and transit of dual-use items.

2. LIST OF ACRONYMS

ACP	*Azimuth Change Pulses*
ARP	*Azimuth Reset Pulse*
BITE	*Built-In Test Equipment*
BW	*Band Width*
IF	*Intermediate Frequency*
LRU	*Line Replaceable Unit*
MDR	*Minimum Detection Range*
MTBF	*Mean Time Between Failures*
PW	*Pulse Width*
RF	*Radio Frequency*
SNMP	*Simple Network Management Protocol*
STC	*Sensitivity Time Control*
SUT	*System Under Test*
VSWR	*Voltage Standing Wave Ratio*

Table 1 - Acronym's list

3. SYSTEM CONFIGURATION

3.1 STANDARD CONFIGURATION AND OPTIONS

The **SMR** radar consists of a down-mast configuration with two 200W solid-state transceivers housed inside an indoor cabinet. The two transceivers are linked through an RF switch, enabling remote selection of the transceiver to connect to the antenna and operate seamlessly.

A flexible, low-loss RF waveguide path connects the radar antenna to the RF switch, channelling the RF energy necessary for radar transmission and reception. To optimize system performance and prevent moisture formation inside the waveguide, an active pressurizer is employed to introduce warm air into the waveguide.

SMR is designed to meet latest EUROCAE ED-116, EUROCONTROL, and WMO standards, and it is composed by:

- Turning unit XTUN-AS/T1
- Antenna unit XAAC-2111/C
- Two by single indoor transceiver XSST-2000/EI with embedded tracker
- 2 way RF switch

Standard supply

Antenna supply unit	AMC0060800
Man aloft switch	AMC0002500
Plug&Play cable kit selected	- 5 meters - 10 meters - 20 meters - 30 meters - 40 meters - 50 meters
Waveguide kit selected *(including PBR connectors and installation ancillaries)*	- 5 meters - 10 meters - 20 meters - 30 meters - 40 meters - 50 meters
Active dehydrator for elliptical waveguide	KIT0003900
User and Installation manual	ID_UI_SMR

Table 2 – Standard supply

Advanced techniques	
Sector blanking	●
Power sector mode	●
Time and Frequency diversity	●
Doppler processing	○
Extended working temperature *(Outdoor equipment)*	
Standard temperature range → -25°C ÷ +55°C	●
De-icer kit for Extended temperature range → -50°C ÷ +55°C	○
Built-in Test Equipment	
Full capability (*including RF receiving and transmitting chains status*)	●
Oil level warning	●
Motor temperature sensor	○
Encoder pulses	
16.384 pulses per revolution	●
Encoder redundancy	
Dual head encoder	○
External interfaces	
Control, monitoring and video through Ethernet 1000BaseT	●
SNMP v2c digital interface	●
Multimode fiber optic link, instead of Ethernet	○
Processing and tracking	
Embedded extractor-tracker module	○

● Standard feature ○ Optional feature

Table 3 – Standard and Optional features

4. ARCHITECTURE

4.1 CONFIGURATION

The SMR radar configuration consists of the following units, represented in “Figure 2:

- Down-mast radar, which includes:
  - Turning Unit with Plug&Play socket panel
  - 21ft antenna unit, circular polarization
- Two by 200W dual X-Band transceiver with embedded tracker module
- 2 way RF switch
- Antenna supply unit
- Man aloft switch
- Active dehydrator (*Optional*)
- Layer 2 managed switch (*Optional*)

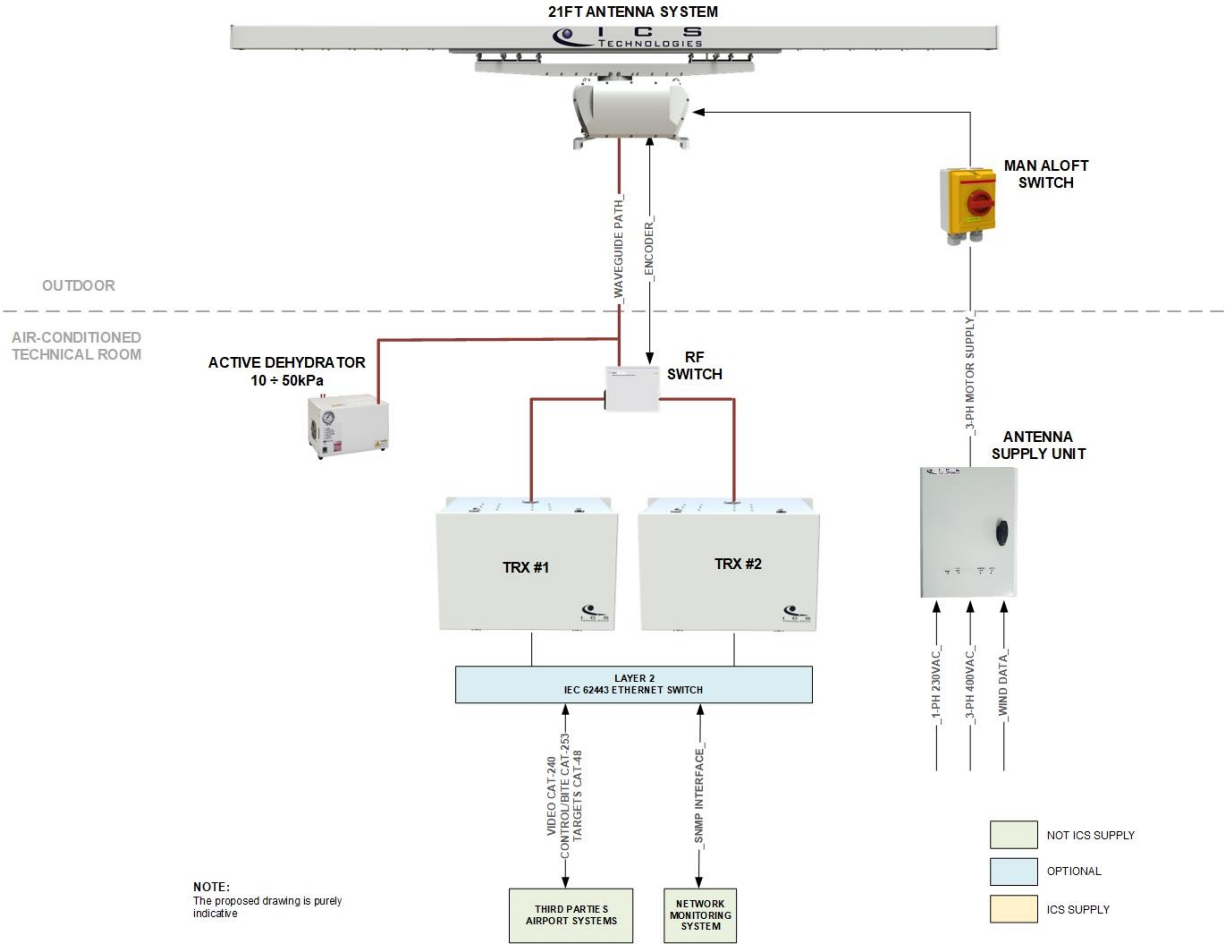


Figure 2 - Configuration layout

4.2 ANTENNA UNIT XAAC-2111/C

The proposed radar solution is characterized by a 21ft fan-beam antenna circularly polarized.

The dimensions and weight that characterize the proposed antenna are shown below:

WIDTH	DEPTH	HEIGHT	WEIGHT
6810 mm	303 mm	110 mm	60 kg

Table 4 – Antenna dimensions and weight

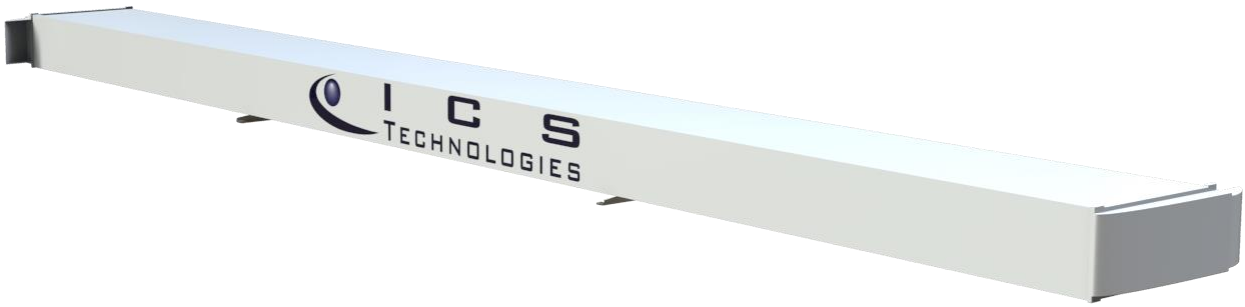


Figure 3 – Mechanical outline, 21ft antenna

4.2.1 ANTENNAs PARAMETERs

GENERAL PARAMETERS	Antenna type	Slotted waveguide array
	Operating frequency	From 9300 to 9500 MHz
	RF power handling (peak)	≤50kW
	VSWR	Better than 1.2:1
SPECIFIC PARAMETERS 21FT ANTENNA UNIT XAAC-2111/C	Polarization	Circular
	Vertical beam shape	Fan beam
	Gain	≥ 33.5 dBi
	Beam width (at-3dB) • Horizontal • Vertical	 <0.34° <25°
	Sidelobe level	< -27dB

Table 5 – Antenna Unit Technical data

4.3 TURNING UNIT XTUN-AS/T1

TURNING UNIT XTUN-AS/T1	Turning unit weight	≅ 300 kg
	Operating frequency	From 9250 to 9550 MHz
	RF-LOSS	<0.5dB
	Motor type	3kW, 3-phase
	Motor mains	3 x 400 Vac
	Gearbox lubrification	Oil
	Nominal Rotation rate	The turning unit is capable of rotating the 21ft antenna at 6 RPM ≤ Speed ≤ 60 RPM
	Azimuth encoder	16.384 pulses dual head encoder
	Azimuth accuracy	≤0.1° with active encoder correction via calibration map
	Encoder type	Direct drive, hollow shaft
	Safety interlocks	Turning gear is fitted with a suitable locking mechanism to prevent the antenna from moving during maintenance.
	Oil level warning	Provides a warning in case the oil level, in the antenna gear box, is below the recommended level. Warning available over the Built-in Test Equipment and the SNMP digital interface
	Motor temperature sensor (*Optional*)	Provides a warning in case the motor temperature reaches 120 degrees Celsius. Warning available over the Built-in Test Equipment and the SNMP digital interface

Table 6 – Turning Unit Technical data

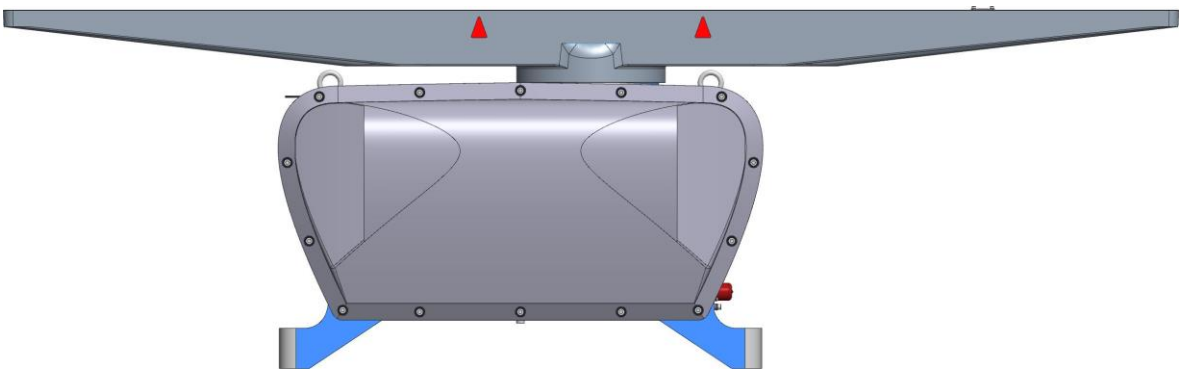


Figure 4 – Turning Unit Mechanical outline

4.4 RADAR TRANSCEIVER

4.4.1 ARCHITECTURE

The following figure shows the architecture of the radar transceiver in single (green part) or dual configuration (green + yellow part).

From the system control center is possible remotely to continuously exchange data with the radar transceiver, to verify the performance data of the system, and monitoring the status of any LRU (built-in test feature).

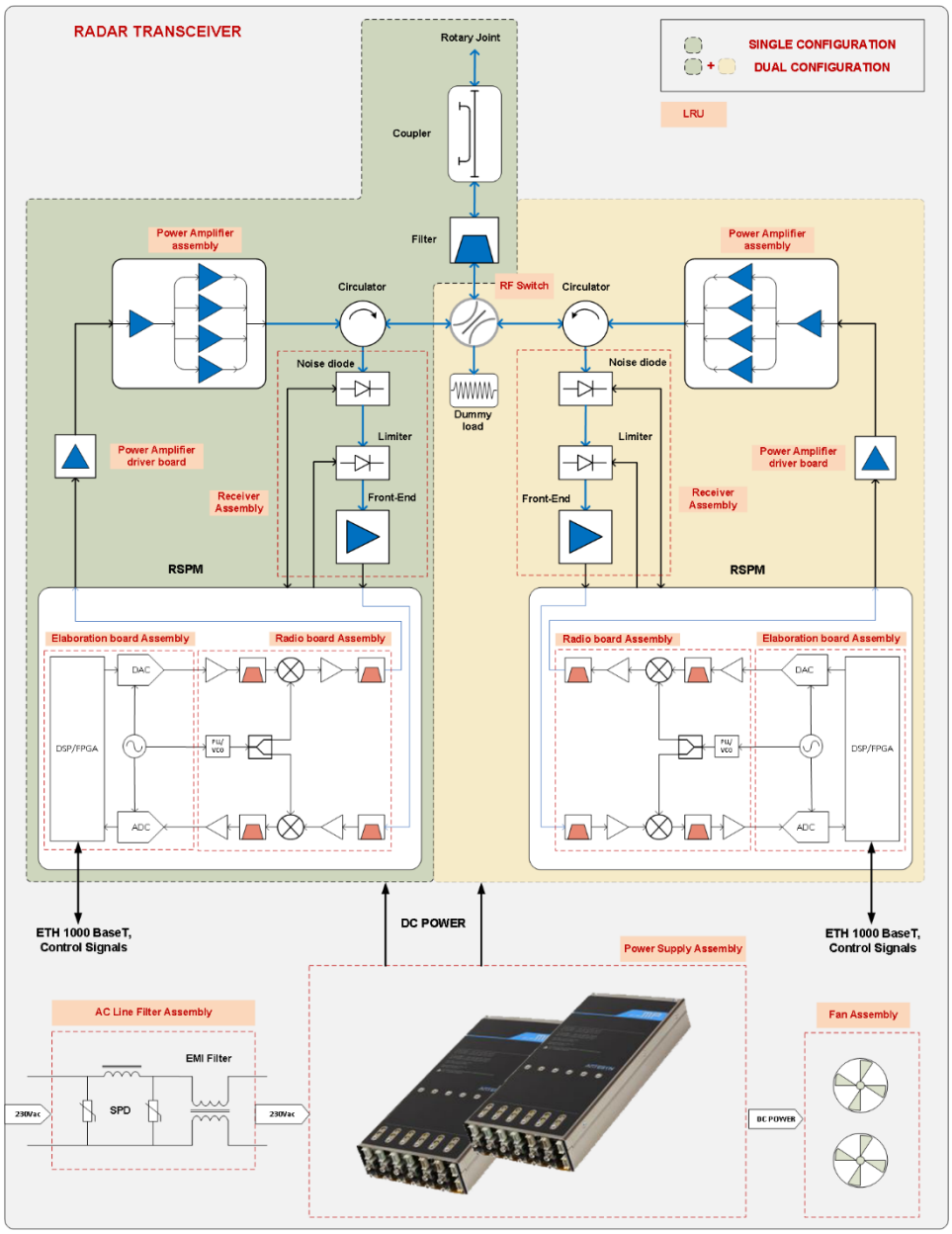


Figure 5 –Transceiver Architecture

4.4.2 Transmitter parameters

Radar transmitter characteristics are summarised in the following table:

CHARACTERISTICS	VALUE	COMMENT
Operating Frequency	9.3 ÷ 9.5 GHz	X-Band
Number of Frequency Channels	Up to 16	Up to 4 frequencies simultaneously
Transmission technique	Frequency and Time diversity	*Optional*
Modulation type	FM - up to 30MHz	
SSPA RF peak	200 Watts	53 dBm
Power Amplifier	GaN	
Pulse width (PW)	40 ns ÷ 100 µs	
PRF	≤ 8 kHz	
Duty Ratio	Up to 20%	*According to the MODE of OPERATION set*
Stagger	Up to 15%	
Pulse Compression Ratio	> 500:1	Note that Export Licence (Dual use) is required for systems with Pulse Compression ratio greater than 150:1
Waveform Transmission	LFM / NLFM	

Table 7 - Transmitter characteristics

4.4.3 Receiver parameters

Radar receiver characteristics are summarised in the following table:

CHARACTERISTICS	VALUE	COMMENT
A/D conversion	A/D 16bit clock 400MHz	
Dynamic Range	≥140dB *(According to the MODE of OPERATION set)*	Including STC limiter & Pulse compression gain
Minimum Discernible Signal (MDS)	Down to -130dBm	Equivalent after pulse compression
Noise Figure - Low Noise Front End	≤ 2.5dB	

Table 8 - Receiver characteristics

4.4.4 Transceiver parameters

Radar transceiver characteristics are summarised in the following table:

CHARACTERISTICS	VALUE	COMMENT
Radar type	Coherent, pulse compression	
Doppler processing	Proprietary algorithm	Doppler processing enables best target separation taking into consideration additional info from doppler processing.
Minimum Range	≤ 30 metres	
Range Cell Size	1 m, 2m, 4m, programmable	Subject to Export Licence (Dual use) constraints. Export licence is required if pulse compression is used to generate a range cell size of <30m.
Modes of operation	Up to 16	Selectable and configurable. A mode of operation is a pre-configured radar setting specifically determined in order to enhance radar detection under specific condition (i.e. heavy rain, fast moving targets, …). SMR radar family allows to use up to 16 different modes of operation. The selection of the running mode of operation may be manual or automatic and is in charge of the control console.
Instrumented Ranges	Up to 10.000 m	Limited to 10000m according to ICAO ED-116.
Time or Range Sidelobes	< -60dB	
Target Separation (range)	10m (1m cell)	
Warm Up time	On detection of a master display, the unit will “wake up” and be ready for transmission within 45 seconds.	Thanks to solid-state nature of the unit, no warmup time is required.
Sector transmission	16 simultaneous blanking sectors • Sector bearing: 0-359° • Sector width: 10°-350° • Resolution: 1°	Transmission over pre-defined arcs can be inhibited to avoid transmission over bridges, buildings other structures or inland.
Power sector mode	Definition of up to 16 individual sectors, where the transmitted power can be adjusted	Each sector may be given individual power attenuation up to 16dB
Built-in Test Equipment	Automatic monitoring and reporting of system sub-assemblies’ integrity	• System Status • Antenna speed • SSPA Over temperature Alarm • Encoder Status (ACP, ARP) • Power supply status • Communication status • Safety Switch status

		• RF switch status, Etc • Continuous monitoring of Power output • VSWR & receiver sensitivity for timely indication of system degradation, if any
Transceiver control	Ethernet	1000BaseT
SNMP (Simple Network Management Protocol)	Diagnostic monitoring and control of the radar sensor via SNMP protocol	v2c
Wind data interface	Wind data input interface (intensity and direction) used for smart management of the antenna supply unit	RS485 digital interface NMEA 0183 (MWV sentence)

Table 9 - Transceiver characteristics

4.5 EMBEDDED EXTRACTOR-TRACKER

The embedded Extractor-Tracker interprets radar observations to identify real targets from clutter, and to output target positions, speed and heading, together with size and confidence data.

The system applies filters and pre-processing techniques before extracting plots (individual detections which meet size and radar return strength criteria).

Plot data is used to automatically initiate tracks where a sequence of plots following a predictable path are detected, and tracks are maintained by associating plots with existing tracks, with filtering applied to smooth out any jitter arising from the plot extraction process.

Moreover, the extractor-tracker module incorporates a machine learning module for advanced target classification and identification. This module leverages deep learning algorithms to analyse radar signatures and discerning the various types of target, i.e. aircraft, vehicles or other objects, within the specified coverage area.

4.5.1 FILTERING TECHNIQUES

- **Land Mask**:
  - World vector shoreline land masking using built-in database of world shoreline data (static or moving platforms supported).
  - User defined polygon sets defined in world x,y coordinates and is automatically converted into polar space.

- **Video Filtering:**
  - Gain control
  - Adaptive FTC (Fast Time Constant)
  - STC (Sensitivity Time Control)
  - Scan Integration

- **CFAR Processing**:
  - Fully configurable Adaptive Thresholding using moving-window averaging techniques.

- **Clutter Mapping:**
  - A Clutter Map is built up by long-term averaging of radar returns for fixed radar installations
  - The Clutter Map can be proportionally subtracted from incoming video to attenuate or remove permanent echoes

- **Area Dependent Processing:**
  - Tracker parameters can be assigned different values in different areas, to accommodate installation specific tracking issues
  - Polygon set is defined in world x,y coordinates and is automatically converted into polar space.

- **Plot Extraction:**
  - Configurable plot geometry (min/max range and azimuth)
  - Configurable plot intensity threshold

- **Automatic Track Initiation (ATI):**
  - Non-ATI areas can be defined by a static mask. Complex polygons defined in x,y coordinates. Can be any shape or size.
  - Independent areas can be configured for radar processing, track initiation and tracking.
  - Optional automatic suppression of plots over land areas using world vector shoreline database (supplied as standard).

- **Tracking:**
  - Alpha-Beta motion filter, with manoeuvre detection
  - Fully configurable filter settings to set allowable speeds and accelerations
  - Multi-hypothesis tracking for resilience in cluttered environments
  - Model Based Tracking for site specific or application specific requirements (such as small target detection or setting up high detectability zones)
  - Video Based Tracking for extended tracking of existing targets at the extreme ranges of radar coverage

- **Doppler Processing (Optional):**

ICS radar uses a proprietary algorithm to perform Doppler processing of the received radar signal. it enables best target separation taking into consideration additional info from Doppler stream.

4.5.2 BANDWIDTHS

In output from the radar, video Data Messages are binary encoded in conformity of the standard “EUROCONTROL Specification for Surveillance Data Exchange – ASTERIX Category

Video Data Messages are binary encoded messages in conformity of the standard “EUROCONTROL Specification for Surveillance Data Exchange – ASTERIX Category 240: Radar Video Transmission Edition 1.3”, that is built on standard sized UDP/IP packets, avoiding the use of Ethernet jumbo frames. Video output is characterized by 8 bits logarithmic.

The following output video streams, based on customer selection, can be selected with corresponding bandwidths:

TYPE OF VIDEO		CORRESPONDING BANDWIDTH
Targets	-	≈1Mbit/s
Unprocessed video	Uncompressed video	≈160Mbit/s
	ZLIB compressed video	≈120Mbit/s
	ZLIB compressed video (decimated)	≈10Mbit/s
	ZLIB compressed video	≈1Mbit/s

Table 10 – Video stream and bandwidth

4.5.3 SERVER CONTROLS AND INTERFACE

Although the Extractor-Tracker has a Graphical User Interface (GUI) to support configuration and maintenance, it is normal operated as a black-box server which receives radar video, processes the data and outputs a combination of either video or tracks onto a network. The GUI is available to display activity and report status and messages.

Raw video, processed video, plots and tracks can be displayed in the main PPI area. The view in this area can be adjusted with the PPI View controls (left, right, up, down, zoom in and zoom out).

A recording facility allows short recordings to be made for off-line diagnostic purposes.

The Process Configuration boxes allow different processing stages to be enabled and configured. Not all options may be available, depending on licensing options and radar input restrictions.

The Network Distribution may be enabled and configured.

The Cursor position shows the range, azimuth and x,y position of the pointer relative to the radar position. An azimuth of 0 represents North and positive values increase clockwise.

4.5.4 TARGET TRACKING

Tracking is performed using Alpha-Beta techniques which allows to achieve stable vectors. The configurable filter is based on a dynamic mathematical model describing the target movements. This model is used to predict the vehicles' behaviour between measurements. Each time a plot is assigned to the target, a position measurement is derived, and this measurement is used to correct the state of the dynamic model. Manoeuvres are detected to allow resetting of the Alpha-Beta filter parameters.

PARAMETER	VALUE	COMMENT
Maximum number of targets	> 1000	
Track Initiation	Max initiation speed 500 m/s	
Raw video accuracy	≤7.5m (at 95% confidence level)	Point source
Reported target position accuracy	≤7.5m (at 95% confidence level)	
Target speeds	Programmable minimum and maximum target speed for initiation in the range 0 to 1000 m/s	
	Programmable minimum and maximum target speed for tracking in the range 0 to 500 m/s	
Tracking Performance	Target range = 7NM, Speed = 10 Knts Measured Position Errors: σrange = 5m, σazimuth = 0.07 Deg σxy = 12.5m Measured Course Error: σcourse = 0.2 Deg Measured Speed Error: σspeed = 0.05 Knts	Performance figures are typical but depend on exact characteristics of target. Target assumed to be moving in straight line and estimates above obtained after 3 minutes observation. Quoted values of σ are standard deviations of errors.
	Target range = 7NM, Speed = 100 Knts Measured Position Errors: σrange = 30m, σazimuth = 0.13 Deg σxy = 30m Measured Course Error: σcourse = 0.3 Deg Measured Speed Error: σspeed = 0.1 Knts	
	Target range = 20NM, Speed = 20 Knts Measured Position Errors: σrange = 5m, σazimuth = 0.06 Deg σxy = 43m	

	Measured Course Error: σcourse = 0.2 Deg Measured Speed Error: σspeed = 0.2 Knts	
Track swap	Automatic (extended) coasting of tracks during crossing manoeuvres to minimize track swap.	
False Tracks	False track rate can be adjusted using ATI integration time to balance false track rate against integration time. Dynamic Thresholding and clutter processing to reduce effects of clutter on false track creation.	

Table 11 - Target tracking

4.6 BUILT-IN TEST FEATURE DESCRIPTION

The Built-in test feature (BITE) thus allows operators and system engineers to continuously monitor, on-site or remotely, the system performance and to identify easily and accurately, in case of failure, the part or assembly in failure to be replaced.

The following table describes all the parameters that the radar system is automatically able to monitor and report in real time to system operators:

NOTICE	"***RF receiving chain***" and "***RF transmitting chain***" real time diagnostics requires transceiver to be equipped with the "FULL BITE" option.

QUERY	BITE INDICATION	BIT MEANING (0=Normal 1=Triggered)
RTX_CBIT	INHIBIT	This bit is set to 1 when the RTX inhibits the RF transmission. RF transmission is inhibited for 2 main causes: a) The Safety Switch is open The RF waveguide switch isn't in the correct position
	-	Spare. Always set to 0
	COMMUNICATION	This bit is set to 1 when there is a lack of communication between the transceiver and the software application.
	DAC	This bit is set to 1 when there is an error within the Digital Analog converter chain. The fault indication is irrelevant if shown during Mode of transmission's change and persists for less than 3 seconds.
	POWER SUPPLY	This bit is set to 1 when the transceiver doesn't receive the correct voltage or current from the power supply.
	ANTENNA SPEED	This bit is set to 1 when the antenna rotation per minute diverge from the set speed more than +/- 2 RPM
	TX BITE	This bit is set to 1 when the transceiver sense that the output transmission power is out of tolerance.
	RX BITE	This bit is set to 1 when the transceiver sense that received power is out of tolerance.
	ENC2 HL	This bit is set to 1 when the transceiver sense that Heading Line signal from secondary channel of the encoder is not present.
	ENC2 ACP	This bit is set to 1 when the transceiver sense that Azimuth Clock Pulse signal from secondary channel of the encoder is not present.
	ENC1 HL	This bit is set to 1 when the transceiver sense that Heading Line signal from primary channel of the encoder is not present.

	ENC1 ACP	This bit is set to 1 when the transceiver sense that Azimuth Clock Pulse signal from primary channel of the encoder is not present.
	TEMPERATURE	This bit is set to 1 when the temperature of one of the electronic boards is out of higher tolerance
	CPUs (Integrity)	This bit is set to 1 when there is a lack of communication between electronic boards.
	RF SWITCH	This bit is set to 1 when the RF switch is not working.
	SAFETY	This bit is set to 1 when the Safety Switch is open.
LRU_STATUS	lru_status,lru_0_report	ElaborationA PCB fault
	lru_status,lru_1_report	ElaborationB PCB fault
	lru_status,lru_2_report	Controller PCB fault.
	lru_status,lru_3_report	Spare. Always set to 0
	lru_status,lru_4_report	This bit is set to 1 when the Digital Analog Converter primary channel is not working. The fault indication is irrelevant if shown during Mode of transmission's change and persists for less than 3 seconds.
	lru_status,lru_5_report	This bit is set to 1 when the Digital Analog Converter secondary channel is not working. The fault indication is irrelevant if shown during Mode of transmission's change and persists for less than 3 seconds.
	lru_status,lru_6_report	This bit is set to 1 when transceivers sense a lack of SATA connections
	lru_status,lru_7_report	This bit is set to 1 when the Elaboration PCB primary channel is not working. The fault indication is irrelevant if persists for less than 3 seconds.
	lru_status,lru_8_report	This bit is set to 1 when the Elaboration PCB secondary channel is not working. The fault indication is irrelevant if persists for less than 3 seconds.
	lru_status,lru_9_report	This bit is set to 1 when the system has not elements to calculate the correct squint correction. The fault indication is irrelevant if persists for less than 10 seconds during antenna rotation speed change, transmission mode change or STBY-TX transition
	n.a.	Spare. Always set to 0
SSPA_1 OVERTEMP	sspa_1 overtemperature	This bit is set to 1 when the temperature of Solid State Power Amplifier (SSPA) is too high. Two SSPAs are usual in transceiver redundant configuration.
SSPA_2 OVERTEMP	sspa_2 overtemperature	
SSPA_1 PRESENCE	sspa_1 presence	This bit is set to 1 when the presence of the Solid State Power Amplifier (SSPA) is not sensed by the transceiver. Two SSPAs are usual in transceiver redundant configuration.
SSPA_2 PRESENCE	sspa_2 presence	

OIL LEVEL WARNING	Oil_warning	This bit is set to 1 when transceivers sense the oil level, in the antenna gear box, is below the recommended level
MOTOR TEMPERATURE WARNING	Motor_Temperature_warning	This bit is set to 1 when transceivers sense the motor temperature over the 120 degrees Celsius
VSWR	vswr	Normal for numerical value < 2

Table 12 - Built-in test (BITE) description

4.7 SYSTEM POWER SUPPLY

The SMR radar systems requires two main power supplies:

- 230Vac 1-phase, at 50 or 60Hz.
- 400Vac 3-phase, at 50 or 60Hz.

The overall maximum electrical absorption is 4.5kW.

Average power consumption, with low wind-load, is 1000W.

4.8 MAN ALOFT SWITCH

The man aloft switch is designed to be installed such that it is still viewable for the person who is carrying out maintenance tasks.

When set to the ‘OFF’ position the transceiver/gearbox is isolated from all AC power thus stopping the antenna rotation and transmission.

The man aloft switch allows, once set to ‘OFF’ position, to insert a safety padlock that doesn’t allow anyone else, with the exception of the maintenance engineer, to reposition the status to ‘ON’, thus exposing the operators to a dangerous situation.

4.9 SAFETY INTERLOCKS

In addition to the man aloft switch, the turning unit is equipped with an appropriate locking mechanism to securely immobilize the antenna during maintenance activities, enhancing the safety of personnel performing the service.

5. EXTERNAL INTERFACES

5.1 RADAR VIDEO

Video Data Messages are binary encoded messages in conformity of the standard “EUROCONTROL Specification for Surveillance Data Exchange – ASTERIX Category 240: Radar Video Transmission Edition 1.3”, that is built on standard sized UDP/IP packets, avoiding the use of Ethernet jumbo frames. Video output is characterized by 8 bits logarithmic.

5.2 RADAR CONTROL & STATUS PROTOCOL

Control Data Messages are binary encoded messages in conformity of the standard “EUROCONTROL Specification for Surveillance Data Exchange – ASTERIX Category 253: Remote Monitoring & Control Edition 11”, that is built on standard sized UDP/IP packets.

5.3 RADAR TRACKED TARGETS (*OPTIONAL*)

Ethernet 1000BaseT, UDP/IP Protocol

- ASTERIX
  - CAT-048 or
  - CAT-010 or
  - CAT-062 (*Option*)

5.4 SNMP INTERFACE

v2c SNMP (Simple Network Management Protocol) digital interface both as control and monitoring of radar performance.

5.5 WIND DATA

Ethernet 1000BaseT, UDP/IP interface

- NMEA 0183 (MWV sentence)

6. GENERAL DESIGN & CONSTRUCTION

Designed and constructed to ICS TECHNOLOGIES standards of practice.

The radar's parts have been suitably designed to be durable against typical environmental conditions of out-door coastal installation, without displaying detectable damage for corrosion of their metallic part, material and components.

6.1 QUALITY CONTROL AND QUALITY ASSURANCE

ICS Technologies SRL is an ISO9001 and ISO14001 certified company.

Figure 6 - ISO certifications

6.2 SAFETY

Designed and constructed to ICS TECHNOLOGIES own standards of practice. Refer to installation and maintenance manual before proceeding to installation or maintenance operations.

A Man aloft safety switch is provided for inhibits rotation of turning unit. In this event, transceiver automatically stops transmission. In any case, before proceeding to any installation or maintenance procedure, the operator must refer to installation and maintenance manual provided with the system.

6.3 CE MARKING

System is provided with CE certification.

The system is compliant with R&TTE Directive and the equipment meet the following essential requirements:

- Radio Equipment Directive 2014/53/EU
- Machinery Directive MD 2006/42/EC
- ROHS 2011/65/EU

6.4 MAINTENANCE

System is designed for high availability (99.99%) with reduced preventive maintenance routines and replaceable items are arranged in sub-assemblies (LRU) with ease of access for maintenance purposes or substitution. Mean Time To Repair (MTTR) is reduced to minimum through the embedded Built-in self-test that provides clear identification for fault-finding.

Mean Time To Repair (MTTR) is of 1 hour for all the LRUs of the radar system.

AVAILABILITY AND MTBF

Level	DESCRIPTION	Q.ty	MTBF (hours)	MTTR (minutes)	AVAILABILITY (%)
1	**SMR** (3)	**1**	**32136**	**240**	**99,994%**
1.1	**Radar Antenna System**	**1**	107063	**120**	**99,998%**
1.1.1	Gear motor assembly (1)	1	150000	30	
1.1.2	Encoder (1)	1	3328800	30	
1.1.3	Rotary joint (1)	1	430000	60	
1.1.4	WG Assembly (2)	1	21000000	30	
1.2	**200W Redundant Transceiver (1)**	1	56994	60	**>99,99%**
1.2.1	Single Transceiver (1)	2	38055	60	
1.2.2	Waveguide switch assembly (1)	1	36654155	60	
1.3	**Antenna Supply Unit XASU-2133/EI (1)**	**1**	**250000**	**30**	**>99,99%**
1.4	**Safety Switch XSSW-1000 (1)**	**1**	**4320000**	**30**	**>99,99%**

Table 13 - Availability and MTBF

NOTE:

(1) according to the rules and criteria of the MIL-HDBK-217/F Standard

(2) empirical evaluation, based on the past history of the component.

(3) 25 °C Ambient temperature and 230 V mains supply assumed

(4) MTBCF or mean time between critical failures it is when the failure prevents the primary operation of system

(5) MTTR or Mean Time To Repair is the amount of time necessary for de-installing the already existing Item and re-installing a new one.

In this regard, the proposed configuration is arranged with the transceivers located within a cabinet and LRUs are accessible by opening the front panel. Any replaceable item is easily identifiable through its label (ID, Part Number and Serial Number) and removable by disconnecting connectors and removing the screws.

From the moment of supply, the systems are guaranteed for at least 15 years of obsolescence.

Almost all the LRUs that make up the radars are designed internally and consequently obsolescence is studied and manage to give the end customer a solution of continuity.

Also, for the few COTS components we still guarantee the 3F standard (Form, Fit and Function).

7. ENVIRONMENT

Transportation and storage environment requirements

Temperature	Indoor equipment → +65°C ÷ -40°C Outdoor equipment → +65°C ÷ -65°C	IEC 68-2-l, Test Ad IEC 945 IEC 68-2-2 Bd.IEC 945

Table 14 – Transportation and storage environment requirements

Operational environment requirements

Temperature	Indoor equipment → +55°C ÷ -15°C Outdoor equipment → +55°C ÷ -25°C	IEC 68-2-l, Test Ad IEC 945 IEC 68-2-2 Bd.IEC 945
Humidity	Indoor equipment → RH 10% ÷ 80% Outdoor equipment → Up to 100% non-condensing	EUROCAE ED-116, January 2004
IP protection class	Outdoor equipment → IP66	IEC-60529
Vibration	All frequencies between: • 2Hz ÷ 13.2Hz ± 1.0mm • 13.2Hz ÷ 100Hz at 7m/s2, • 2h at each resonance otherwise 30Hz in all three axes	IEC-60945 (ed.4, 2002-8) IEC-60068-2-6
EMC immunity	EMC Immunity	89/336/EEC
EMC emission	EMC Emission	
EMF	EMF Human exposure	EN-62311:2008
Radar emission	Radiated and Conducted Emission	EN55022
	Current Harmonics, Emission	EN61000-3-2
	Voltage Fluctuations, Emission	EN61000-3-3
Acoustic noise	55dB (A) / 70dB (A) Reference level 1 pW	DS/ISO 3743 or 3746 IEC 945
Hail	Up to a diameter of 12mm at 17m/s	EUROCAE ED-116, January 2004
Rainfall	Up to 16mm/hr	EUROCAE ED-116, January 2004

Table 15 – Operational environment requirements

7.1 WIND CONDITIONS

Wind requirements

Operational wind	The radar antenna is designed and tested to operate in horizontal relative wind conditions up to 80 kts (41m/s) NOTE 1
Survival wind	The radar antenna is designed and tested to survive, in not-operative condition, in relative linear wind conditions up to 136 kts (70m/s) @0RPM NOTE 1

Table 16 – Wind requirements

NOTE 1 wind means a horizontal wind flow without significant turbulences, please see paragraph 9.2.

7.2 ICE ACCRETION

Outdoor equipment is designed to withstand an ice accretion rate of 6.4mm/h with a total loading of 24 kg/m2 and remain operational and safe.

7.3 PAINT FINISH

The antenna system is finished in Signal White (RAL 9003).

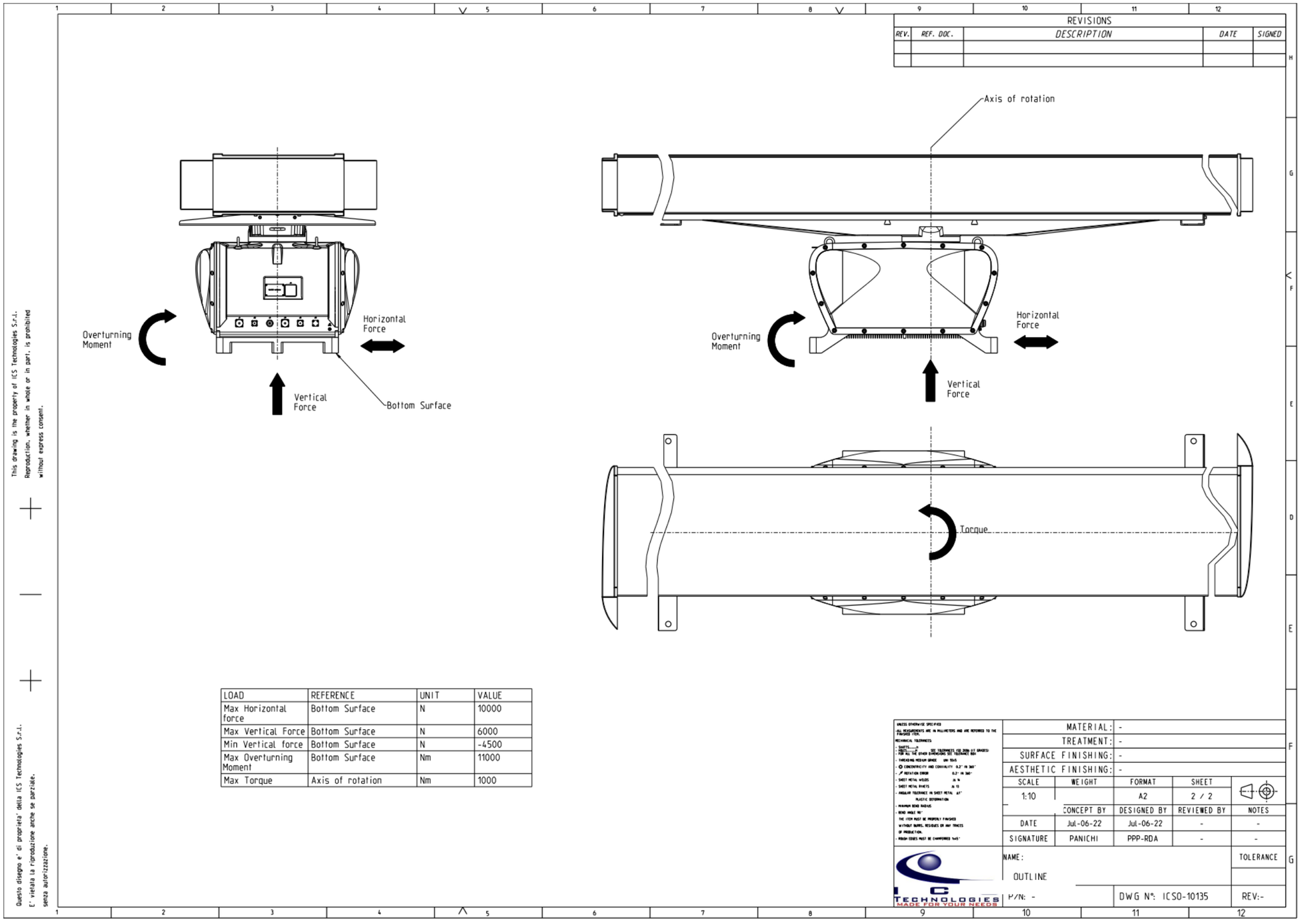
Outdoor equipment is power coating painted. Painting is performed according to ICS Technologies specification that establish metal pre-treatment, use of primer and a specific grade of a top-coat.

Painting is guaranteed for 15 years from exfoliation and layer corrosion due to atmospheric environment.

8. DIMENSIONS AND WEIGHTS

RADAR MODEL	RADAR ASSEMBLY	WIDTH	DEPTH	HEIGHT	WEIGHT
SMR		6810 mm	750 mm	915 mm	≅360 kg
		712 mm	501 mm	550 mm	30 kg
		712 mm	501 mm	550 mm	30 kg

Table 17 - Dimensions and weights



LOAD	REFERENCE	UNIT	VALUE
Max Horizontal force	Bottom Surface	N	10000
Max Vertical Force	Bottom Surface	N	6000
Min Vertical force	Bottom Surface	N	-4500
Max Overturning Moment	Bottom Surface	Nm	11000
Max Torque	Axis of rotation	Nm	1000

Figure 7 – Turning unit and antenna – Moment of forces

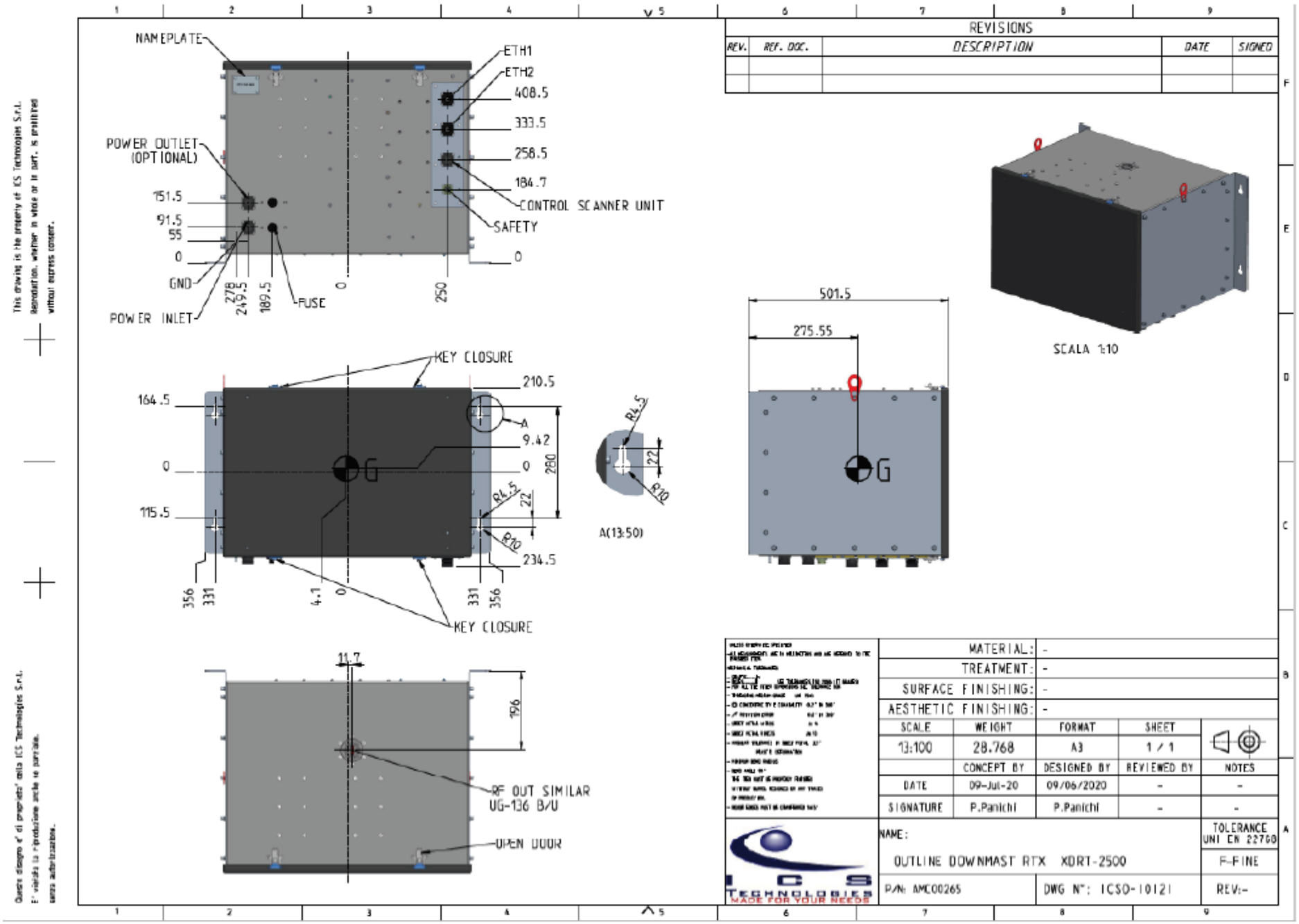


Figure 8 –Transceiver - Dimensional layout

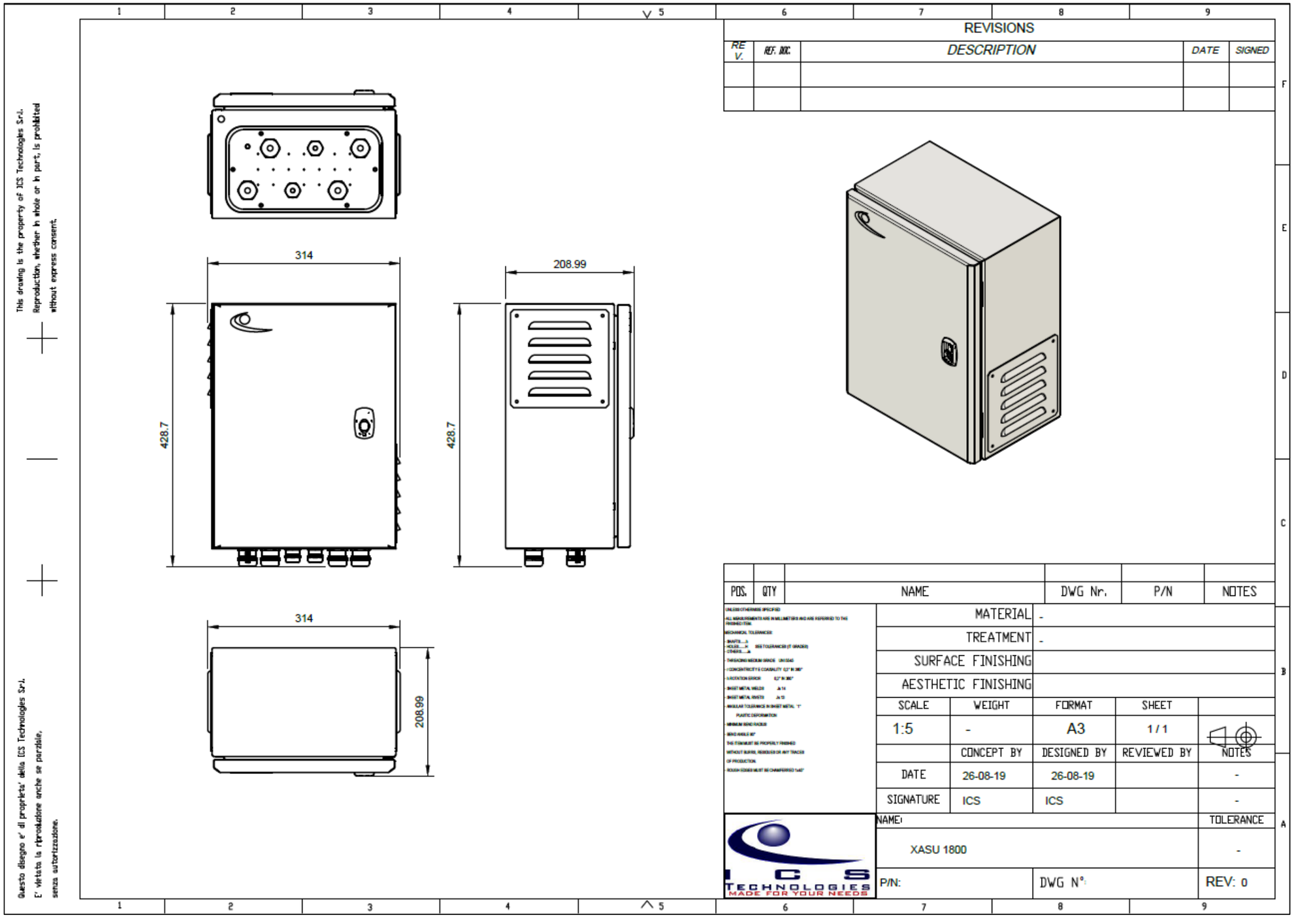


Figure 9 – Antenna Supply Unit - Dimensional layout

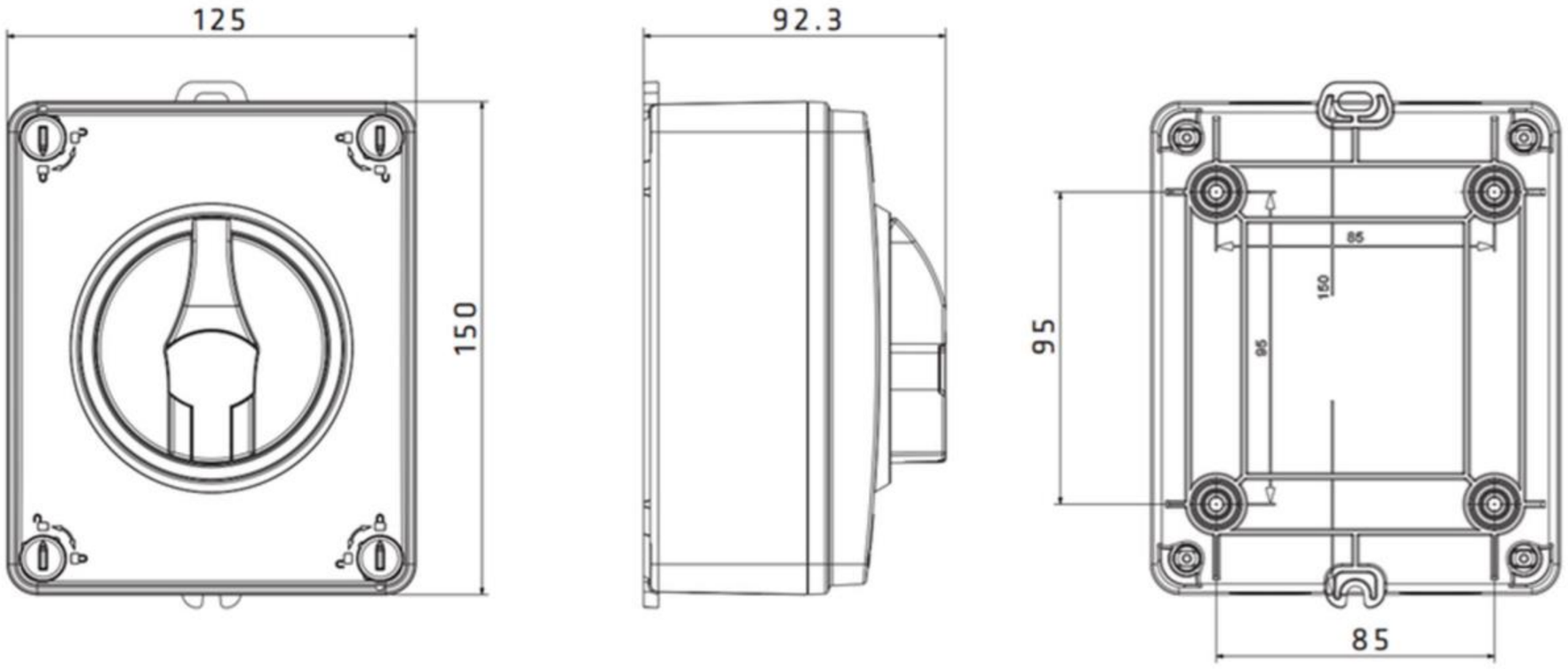


Figure 10 - Safety switch - Dimensional layout

9. INSTALLATION SITE ARRANGEMENTS

Essential things to take into account during the preparation of radar site are:

- Proper dimensioning of mast/tower (lightning protection and stiffness)
- Proper dimensioning of platform clearances for accessing the radar

9.1 LIGHTNING PROTECTION

The IEC 62305 series of standards are reference regulation design, giving the user a tool kit of rules and options to provide lightning protection for a structure. The standards cover structure protection and equipment protection, with regard to the effects of direct and indirect lightning discharge. Lightning is a natural phenomenon where, for the purpose of analysis and design, a statistical approach is taken. No lightning protection system is 100% effective. A system designed in compliance with the standard does not guarantee immunity from damage. Lightning protection is an issue of statistical probabilities and risk management.

A system designed in compliance with the standard IEC 62305 should statistically reduce the risk to below a pre-determined threshold.

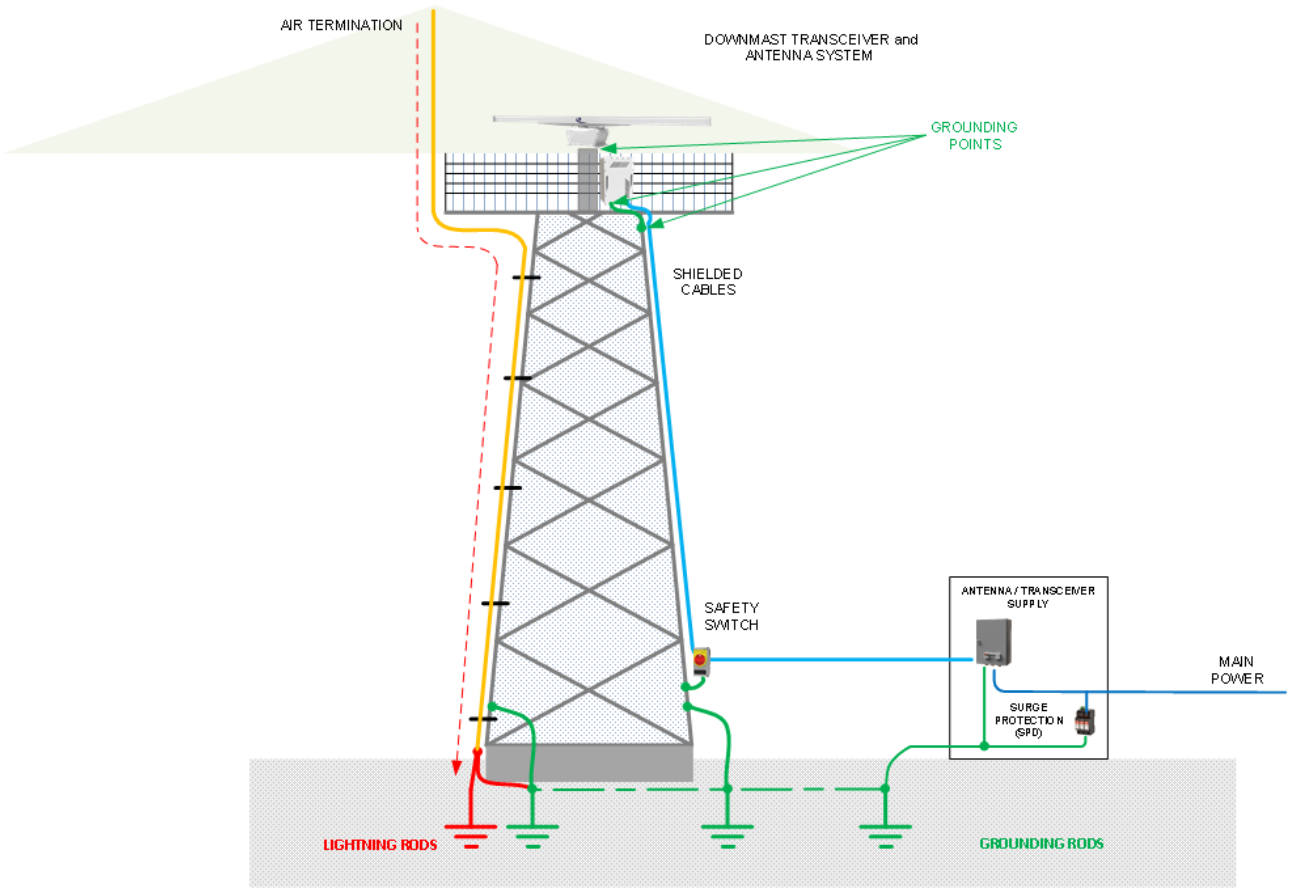


Figure 11 - Example of lightning rod for up mast configuration

9.2 CONSIDERATIONS ABOUT TOP BUILDING'S AND BOXED TOWERS INSTALLATION

WARNING:	The installation on the top of building is a critical issue introducing serious safety risks, and should be always avoided whenever possible. Any liability or responsibility for the result of improper of unsafe installation is disclaimed.

According to IALA Guideline No. 1111 Ed.1:

Par. 1.4.3.2 - Wind Considerations

"Rotating antennas are sensitive to excessive turbulence. Therefore, the positioning of an antenna in relation to the type of tower can be critical. For example, open lattice towers cause less turbulence around an antenna than closed towers. Note that, in general, antenna specifications only provide maximum wind limits in the horizontal plane"

Par. 1.4.3.2 - The Venturi Effect

If wind passes upwardly on a slope or around a building as illustrated by figure 3 and figure 4, it generates a Venturi effect and causes a strong increase in the wind velocity at a given height above the surface. The height can be determined by local measurement, but may vary with wind speed and direction. It is not recommended to install, for instance, radar antennas directly in the Venturi.

The installation of radar scanner units in areas with strong winds or on the top of a building as well, is a critical issue due to the wind load. Wind pattern around tall buildings or tall solid structures may generate contrary and sometimes risky safety problem at an unimaginative level. This problem was observed and is in existence for nearly 2 to 3 centuries around the globe. This became the reason for the initial investigations using wind tunnel. The increase in wind pressure in high-rise buildings or closed towers it is proved. Due to changes in climatic conditions, phenomena such as hurricanes, typhoons, and storms often occur, which lead to a significant increase in wind pressure, a change in the magnitude of instantaneous extreme impact.

WARNING:	As general rule, radar scanner unit should be never installed on closed towers or top building's edges. Wind loads Operational and Survival data given with the antenna specifications are only valid for a horizontal wind flow.

In fact, front wind hitting a building face will break-up creating a lamination effect of the wind flows with sensitive vertical wind magnitude increase, venturi effect with low pressure areas and turbulences in general, as shown in figures.

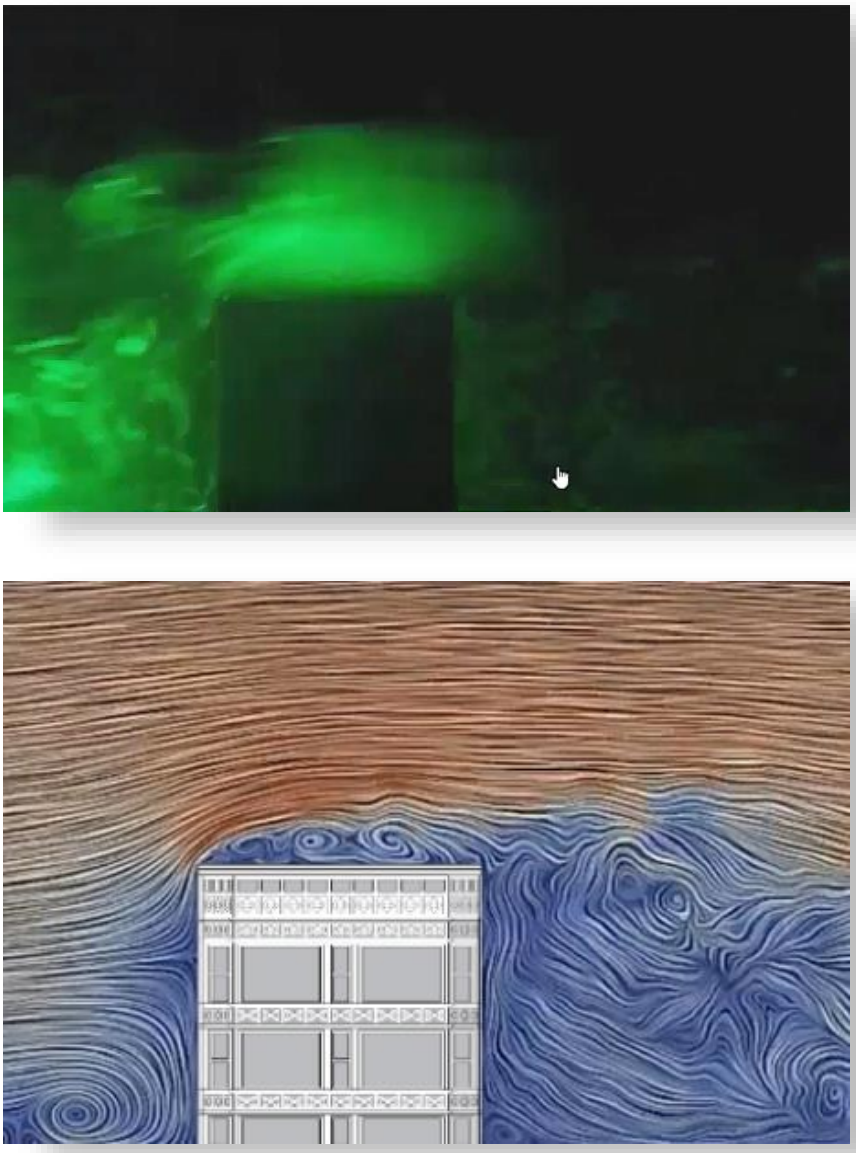


Figure 12 Wind Effects on Buildings

In details:

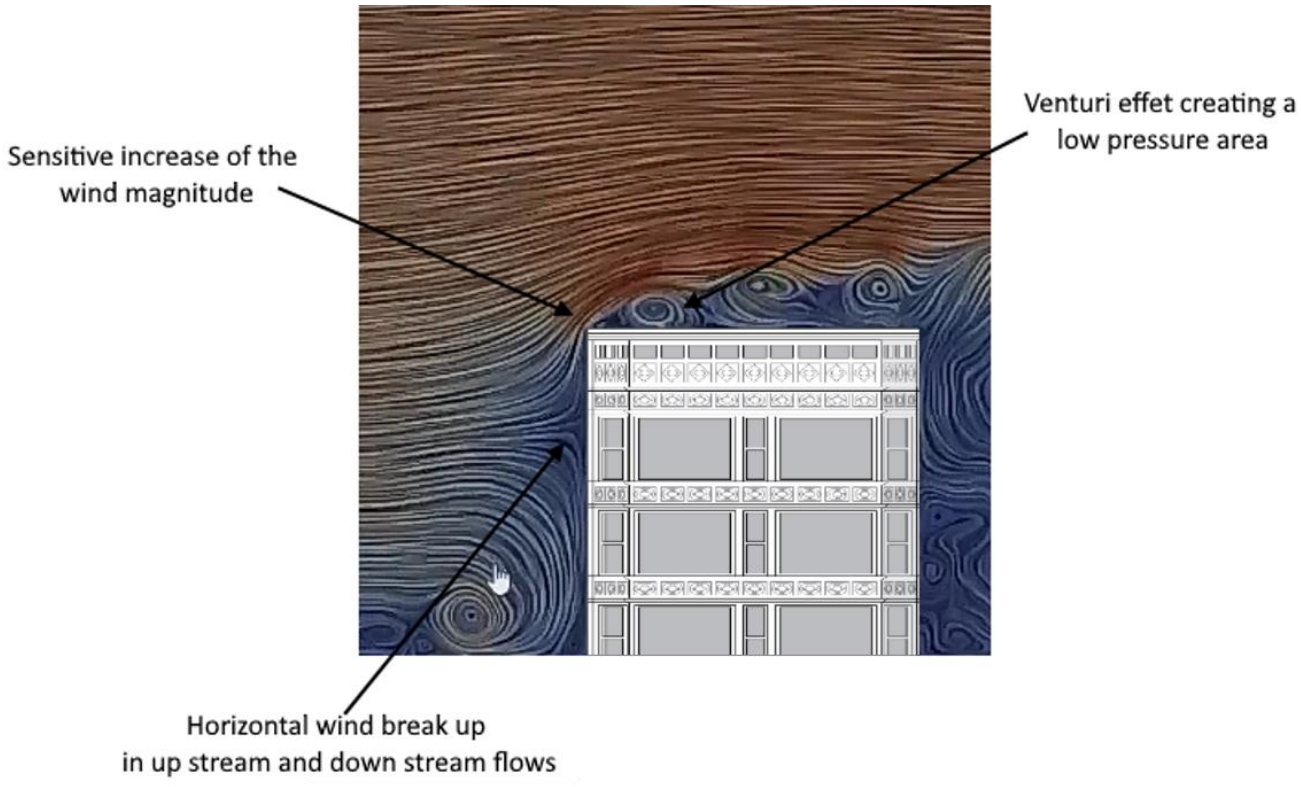


Figure 13 Wind Effects on Buildings Details

WARNING:	The increase of the vertical up stream wind magnitude, magnified by the venturi effect, will result in a combination of unexpected forces on the rotation unit. Consequently, a radar scanner unit installed on closed towers or top building's edges may be subject to instantaneous extreme impact with serious risk of structural failure.

If installation on closed towers or on the top of the building cannot be avoided, choose an alternative installation position, away from edges and installing the scanner unit on an appropriate open-frame pedestal, where turbulences and wind magnitude increase are mitigated.

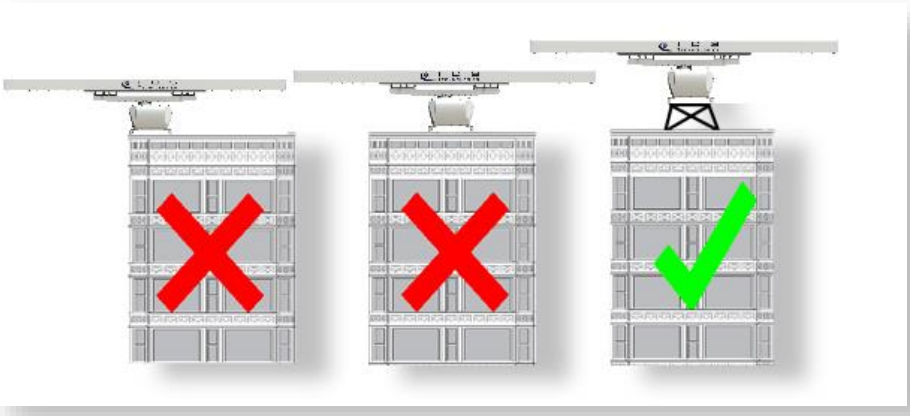


Figure 14 Roof Top Installation

Keep always a safe distance of at least 2 meters from the building's hedge

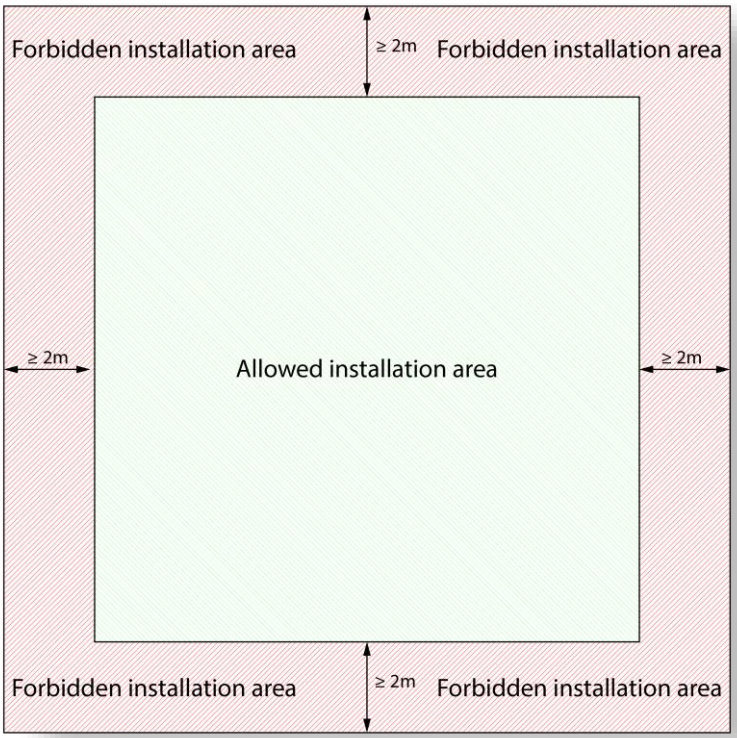


Figure 15 Roof Top Allowed Installation Area

9.3 RADAR HORIZON SCOUT

The fixing of the radar system must be carried out to allow easy access to the unit, assuring the easiest management of the maintenance operations. The free scout of the radar horizon is affected by scanner unit's mechanical installation; assure to leave at least 30° free sight form radar antenna to any possible obstacle on the mast platform (fence, antenna dishes, metallic poles, etc.).

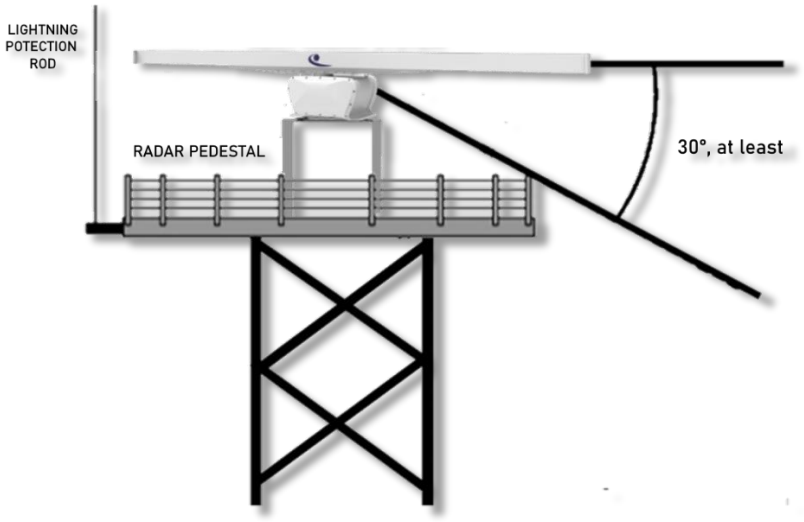


Figure 16 - Radar Horizon Considerations

9.4 RADAR TOWER STIFFNESS

Moreover, the radar supporting structure requirements should be derived by the desired radar performance. The typical radar parameters to be taken into consideration concern the torsional stiffness, and necessary for the correct sectioning of the tower, are listed below:

PARAMETER	VALUE
Main drag harmonic frequency due to rotation	60 rpm, corresponding to pulse frequency of 2Hz (two force peaks for each rotation).
Maximum admissible basement torsion respect to ground, under maximum torque	≤0.05°

Table 18 - Tower stiffness requirement