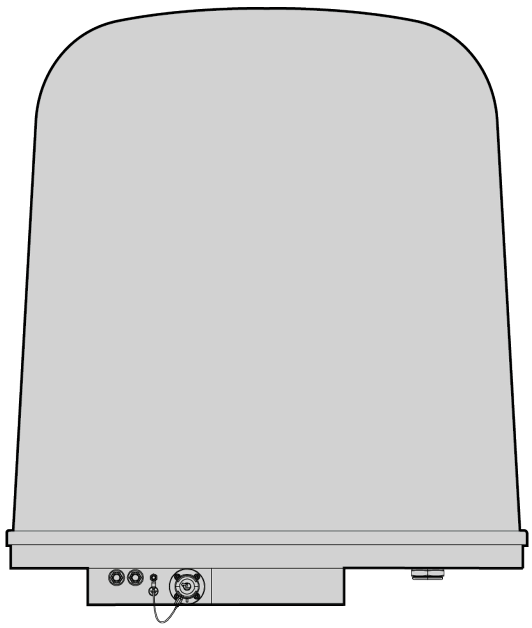
IRIS

Operator Manual



185.927.020 / Version B2

robin radar systems

RRS INTERNAL

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Warning Statements Regarding FCC rules

NOTICE

The 8900 MHz IRIS sensor does not comply to FCC rules. This warning only applies to IRIS sensor 9250 MHz with **FCC ID: 2A5YR-IRISA2F9250** and IRIS sensor 9650 MHz with **FCC ID: 2A5YR-IRISA2F9650**.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation. Changes or modifications not expressly approved by Robin Radar Systems B.V., could void the user's authority to operate the equipment. Any digital equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications.

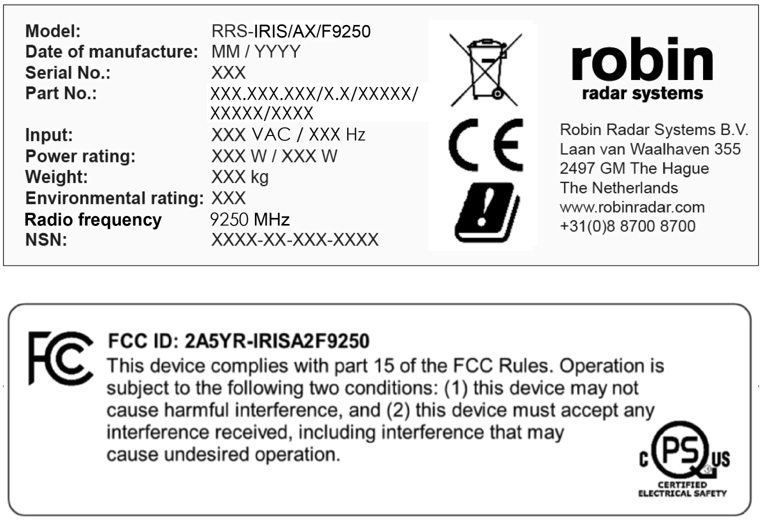


Figure 1: Type plate example

Contents

1. Safety Instructions

NOTICE

It is your own responsibility to read and comprehend the full document and other applicable documentation prior to using the radar system, and to follow all safety instructions. Please contact Robin for assistance or clarification in the event that the text of this document is not completely understood or comprehended. Robin does not accept any responsibility or liability for your misunderstanding of the information in this document. To the best of Robin's knowledge, the content of this document is complete, however, Robin does not guarantee the completeness of the content of this document.

Save these instructions for future reference.

Safety Symbols

⚠WARNING

Indicates a hazardous situation that can result in death or serious injury, if not avoided. May also result in property damage.

⚠CAUTION

Indicates a hazardous situation that can result in minor or moderate injury, if not avoided. May also result in property damage.

NOTICE

States company policy directly or indirectly related to safety of personnel or protection of property or information that is especially significant in understanding the product.

⚠WARNING

1. **Electrical Safety**
   a. **The radar system requires the mains supply to be externally fused using a 16 A fuse.** Failure to do so may result in the risk of electric shock, fire, or serious injury.
   b. **The mains voltage of the power source must correspond with the specifications of the rating plate of the processing station.** Unauthorized voltage can cause damage to the radar system.
   c. **Do not hot plug the radar cable. Always disconnect from mains power source when connecting or disconnecting the radar cable. In case the processing station includes a breakout box: Turn <OFF> the main switch/button first.** Arc flash and shock hazard.
   d. **The sensor is disconnected from the mains by unplugging the power connector from the processing station. Ensure both are easily accessible after installation.** Failure to do so may result in the risk of electric shock, fire, or serious injury.

2. **Work Area Safety**
    a. **Never expose yourself to transmitting energy within the hazard zone while the radar is active. The advised safety distance is 0.91 m (3 ft)**.
    b. **The radar system must be installed in a restricted-access location that is not accessible to unauthorized individuals, including ordinary persons or children.**
    c. **Install lightning protection!** Lightning protection is not provided with the system and protecting the radar system against lightning is the full responsibility of the user. Robin is not liable for any damage caused by lightning. Risk of electric shock, fire or serious injury.
3. **Service**
    a. **Do not open the radar, or any part of the processing station or the breakout box.** Risk of electric shock, fire or serious injury. All service must be made by a Robin Radar qualified service agent. Removing the radome or servicing any part of the radar system will void the warranty.

⚠ CAUTION

1. **Lifting and Hoisting**
    a. **Avoid touching the radome and only lift the radar at the bottom edge of the radome**. The radome is easily damaged.
    b. **Never touch the de-humidifier at the bottom side of the radar.** The membrane of the de-humidifier is easily damaged.
    c. **A minimum of two people are required to lift the radar.**
    d. **A minimum of two people are required to lift the Mobile Processing Station.**
2. **Commissioning**
    a. **Unauthorised frequency.** The transmit frequency of the radar requires an operating licence of the governing body of the country/state where the radar is to be used.
    b. **Protect the radar against severe hail storms.** Hail stones can damage the radome.
    c. **Protect the breakout box and/or processing station against heat. E.g., against continuous intense sunlight.** Ensure that the ambient temperature is kept between the temperature range stated below and corresponding to the selected processing station option:
        1. Mobile Processing Station: 0°C – 50°C (32°F – 122°F) at < 95% RH, non-condensing.
        2. Server Processing Station: 10°C – 35°C (50°F – 95°F) at 35% – 65 % RH , non-condensing

3. Rugged Processing Station: -25°C – 50°C (-13°F – 122°F) at < 95% RH.

d. **Do not top load radar. The upper side of the sensor must never be obstructed or covered (including decorative stickers) nor should vertical load be applied.** Failure to follow this instruction can cause damage to the radar system.

e. **Beware of bending cables when temperatures are below -10°C (14°F) or above 70°C (158 °F).** Failure to follow this instruction can cause damage to cables.

f. **Do not bend cables beyond the minimum bend radius.** Failure to follow this instruction can generate interference or cause damage to cables.

3. **Maintenance**

a. **Disconnect from mains power source prior to maintenance.** Failure to follow this instruction may result in death or serious injury.

b. **Use covers to seal and protect connectors from harsh environments when disconnected.** Connectors are easily damaged. Moist and debris can hamper accurate operation.

c. **Maintenance must be made by a Robin Radar qualified service agent whenever the radar, breakout box and/or processing station need to be opened.** Failure to follow this instruction will void the warranty.

d. **Inspect cables and connectors following any cable manipulation, movement, or reinstallation. Check for breakage of parts and any other conditions that may affect radar operation. If damaged, repair before use.**

e. For optimal performance, ensure the radome is clean before each operation. Dust, dirt, debris, grime, stickers and glue will reflect RF signal and negatively impact the performance of the radar. However, the radome should only be cleaned when necessary:

1. Avoid touching the radome surface unnecessarily to maintain the finish. The appearance of a matt finish (F9) radome is easily compromised.
2. Do not use abrasive materials or excessive force during cleaning. The finish is easily damaged.

NOTICE

1. **Transport**
   Bear in mind that the radar is delicate, electronic equipment, and thus has to be treated carefully. Robin Radar Systems is not responsible for consequential damage to the equipment if these instructions are not followed.
   a. **Disconnect all electronic connections prior to transport and use covers to protect connectors.**
   b. **All equipment is packed in the original packing material (or equivalent) prior to transport/shipping of goods.**
   c. **All goods shall be shipped in an upright position, no more than 2 crates in height. No other crates/boxes/materials shall be shipped on top of the goods.**
   d. **Check the contents of the crate/box against the packing list located inside and/or outside the crate/box. If there are any items missing, immediately inform the responsible Site Supervisor and/or Robin Radar Systems.**
   e. **All goods shall be securely braced during shipment.**
2. **Storage**
   a. **Disconnect all electronic connections prior to storage and use covers to protect connectors.** Connectors are easily damaged.
   b. **Store the radar system in a secure area within a temperature range of -46°C – 65°C (-50.8°F – 149°F) and a relative humidity of < 95% at 40°C (104°F)**. Condensation under fluctuating storage temperatures may cause damage to the radar system.
   c. **Avoid the risk of damaging the radar system by weather, dust, dirt, debris and grime.**

1.1. Radiation Safety

Radiation safety involves minimizing exposure to harmful radiation to protect health. IRIS is considered a low-level radiation source, and maintaining a one-meter distance is generally sufficient for work area safety. The safe distance calculations in the section below are based on ICNIRP guidelines.

The IRIS Radar System features two 12 Watt antennas installed on each opposite side. As the radar rotates and transmits only while in motion, the average radiation is significantly lower. With the radar spending only 3.33% of its time on a target, the average radiation power is reduced to 0.4 Watt. As a result, the safe distance is 0.91 meter (3 feet).

Elevation Effect

Elevating the radar results in a shorter vertical safe distance, allowing for installation on various objects while maintaining a safe distance below the radar as shown in Figure 2: Horizontal & vertical safe distance on page 11.

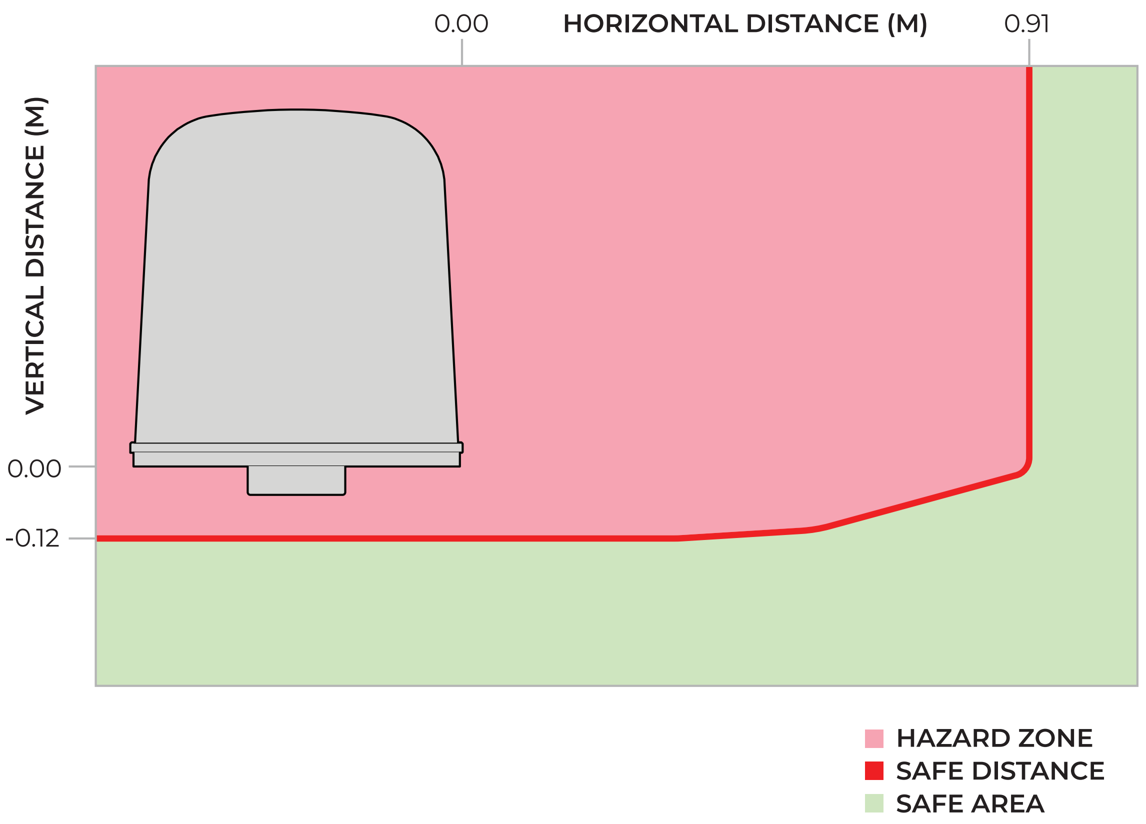


Figure 2: Horizontal & vertical safe distance

2. Intended Use

The IRIS Drone Detection Radar is a system specifically designed to track and monitor small drones (UAS – Unmanned Aerial Systems). Its intended uses are primarily for security and safety in various environments. The key applications involve protecting critical infrastructure, monitoring airspace and supporting anti-drone systems.

3. Introduction

The IRIS Operator Manual provides practical guidance and best practices for the safe and efficient operation of the IRIS Radar System. While it explains how to install the sensor effectively, it does not include detailed procedures for installing processing stations or the software tools required for operation.

Installation guidelines for processing stations, which may vary based on hardware configurations, are provided in a separate installation manual. Similarly, instructions for setting up and using the necessary software are found in specific software manuals. This document focuses on operational insights, safety protocols, and tips to optimize radar usage.

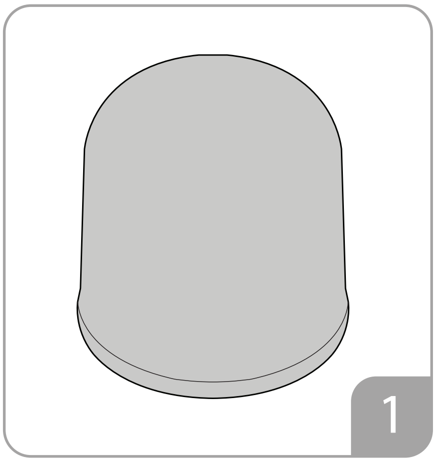
Related Information

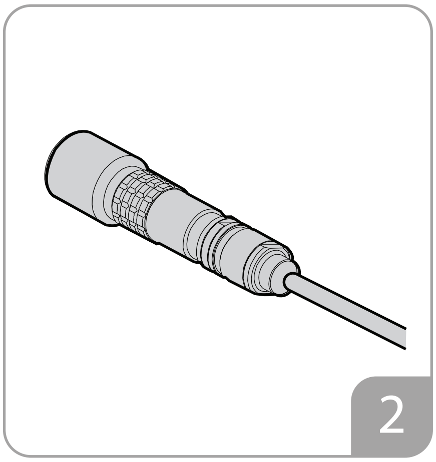
Reference Documents on page 55

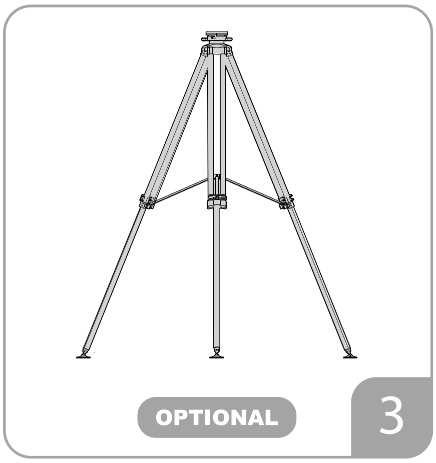
4. About IRIS

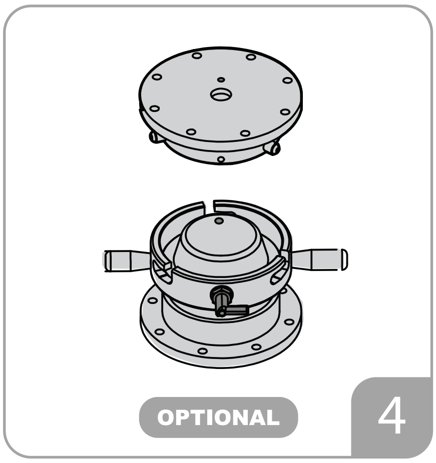
IRIS is an accurate and versatile 3D C-UAS radar that offers best-in-class detection, classification and the earliest warning possible. It's mission-proven with military vehicles, law enforcement and critical VIP protection. With 360-degree azimuth coverage and a large elevation coverage of 60 degrees, IRIS provides accurate data and time to react. MIL-STD Certified, it’s lightweight at 29 kg, low-power (SWaP), capable of on-the-move (OTM), and built to deploy and integrate seamlessly into a system of sensors.

5. Component Identification



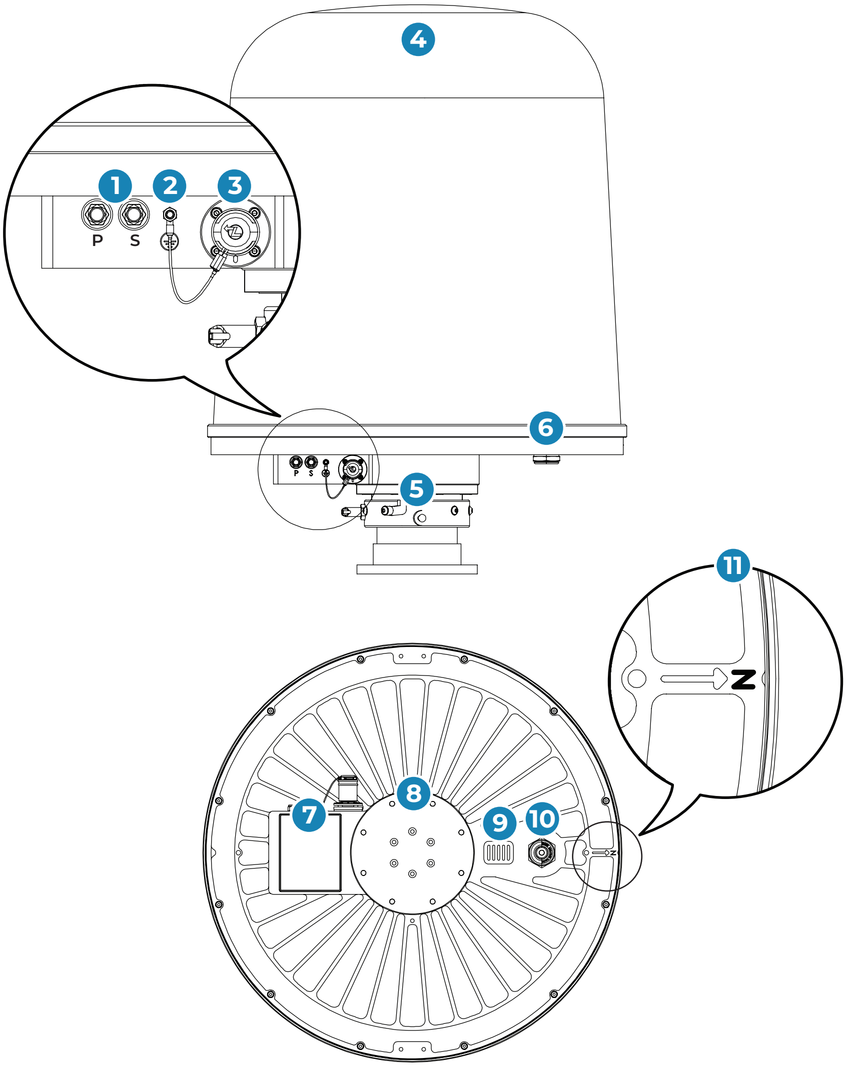






Item	Description
1	Sensor
2	Radar cable
3	Tripod (optional add on)
4	Quick mount (optional add on)

5.1. Sensor



Item	Description
1	OTM GNSS antenna connections (not used)
2	Grounding terminal[1]
3	Power/data connector
4	Radome
5	Quick mount
6	Breather valve (side view)
7	Type plate
8	Mounting flange
9	Dehumidifier
10	Breather valve (bottom view)

[1] The grounding terminal also holds the dust cap with a metal retainer chord.

Item	Description
11	Alignment arrow

5.2. Radar Cable

⚠ CAUTION **Do not bend the radar cable beyond the 92 mm (3.62 in) minimum bend radius.** Failure to follow this instruction can generate interference or cause damage to the radar cable.

The radar cable, shielded for optimal performance, supports data and power and connects the radar to the breakout box. The connector is equipped with a Push-Pull self latching mechanism with alignment dot to ensure secure connectivity. The radar cable is available in different lengths up to 50 m (164 ft). The standard length is 10 m (33 ft).

5.3. Quick Mount

The quick mount is a fastening system with bayonet used to rapidly mount the sensor and minimize installation time. The quick mount is secured to the mounting flange with eight M8*20 mm countersunk Torx and a tightening torque of 9.9 Nm. The counter flange can be secured to a variety of objects.

Alignment Lock

The quick mount is equipped with a locking lever to ensure proper alignment in the desired direction.

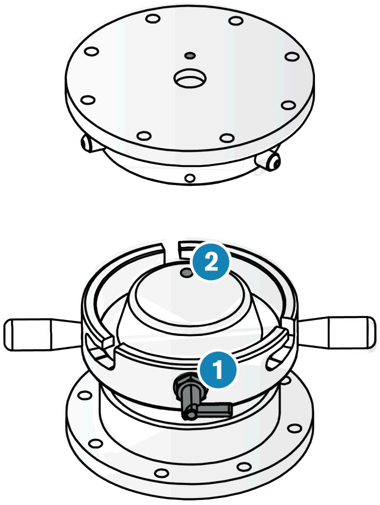


Figure 3: The quick mount with locking lever [1] and alignment pin [2].

5.4. Tripod

The sensor can be installed on a heavy duty tripod with individually adjustable legs that allow installation over uneven terrain. The load capacity is 40 kg (88 lb) and the maximum height is

240 cm (95 in). The robust design ensures high stability and the use of high-quality materials makes this tripod very durable and low maintenance. The tripod is fitted with a quick mount and a bubble level which can be used to level the radar on the horizontal and vertical plane. The standard tripod feet have anchor holes which provide optimized stability and support on snow, sand, or soft earth. A set of three stainless steel spikes is included when needed. The sensor with tripod is able to withstand wind speeds up , regardless of the installation height. Three weight plates are included when ballast needs to be added to each individual leg in case of high winds. Add 20 kg (44 lb) of ballast to each weight plate to account for wind speeds up to 32 m/s (72 mph).

6. Software

While this manual primarily focuses on hardware, it's important to note that the software included may require periodic updates. Updates ensure optimal performance, security, and compatibility with the latest features. Users are encouraged to regularly check for new releases and update their software to match the applicable documentation.

7. Set Up

7.1. Temperature Requirements

Ensure that the operating temperature is between -46°C – 50°C (-50.8°F – 122°F), with a relative humidity of < 95% at 40°C (104°F).

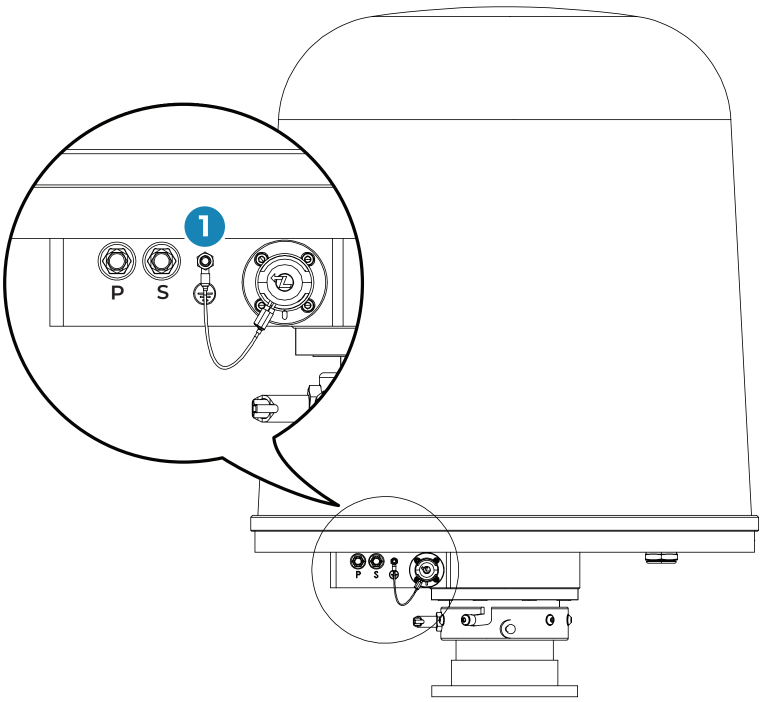
7.2. Power Requirements

The mains voltage of the power source must correspond with the specifications of the rating plate of the processing station and radar. Unauthorized voltage can cause damage to the radar system.

7.3. Electrical Grounding Requirements

⚠WARNING	**Ground the radar system!** Grounding the radar system is the full responsibility of the user. Risk of electric shock, fire or serious injury.

The radar operates on 48 VDC and establishes grounding through the radar cable. It is advised to connect an additional grounding cable to the grounding terminal of the bottom flange of the radar [1]. Note that the grounding terminal also holds the dust cap with a metal retainer chord. Do not remove the dust cap with retainer chord from the terminal. Place the lug of the grounding cable directly on the grounding terminal and on top of the retainer.



7.3.1. Lightning Protection

⚠WARNING

Install lightning protection! Lightning protection is not provided with the system and protecting the radar system against lightning is the full responsibility of the user. Robin is not liable for any damage caused by lightning. Risk of electric shock, fire or serious injury.

7.4. Space & Airflow Requirements

⚠ CAUTION

1. Ensure that the connector on the bottom of the radar remains accessible for maintenance.
2. The radome, breather valve and the dehumidifier should not be obstructed or covered.

7.5. Setting up the Radar

7.5.1. Mounting Flange

⚠ CAUTION	Ensure that the surface is capable of supporting the combined weight of the radar and, if necessary, the tripod along with its ballast. This includes accounting for all dynamic forces, such as wind or forces encountered while in motion (if mounted on a vehicle), that could impact the weight distribution.

The radar is equipped with a bottom mounting flange for secure placement onto various objects. For optimal performance, ensure the radar is mounted level. The provided mounting surface/flange must be level within 0.5° in static deployments. Secure the radar with eight M8 bolts with a tightening torque of 14 Nm. We recommend to use a anti-seize grease (for example Copaslip) to extend the life of the bolts and threads. The quick mount may be provided to rapidly mount the sensor and minimize installation time.

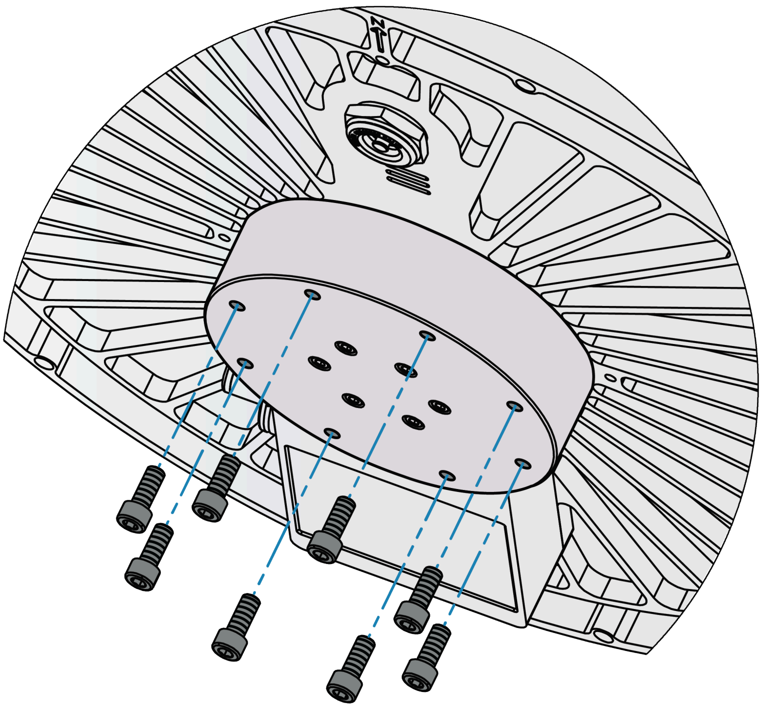


Figure 4: View of the mounting flange on bottom side of the radar.

The IRIS Interface Drawing [185.980.002] includes detailed mounting requirements.

7.5.2. Alignment Arrow

To help align the radar with true north or the direction of travel, the bottom flange has an engraved arrow with an indentation on the side of the radome bottom. The alignment arrow can be particular useful when there is no internet access and maps cannot be downloaded.

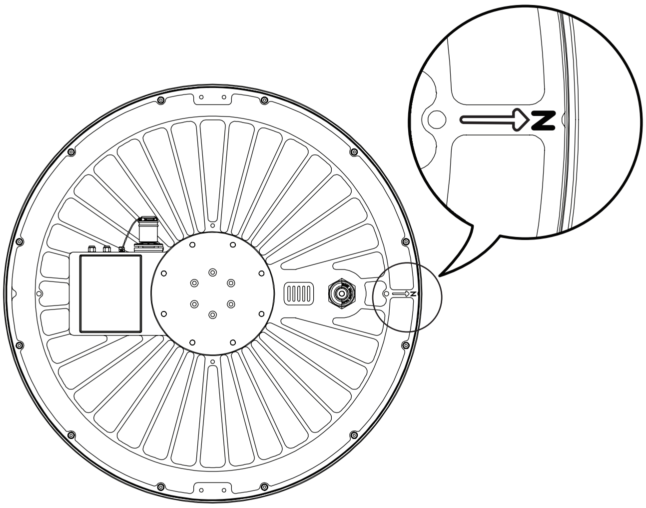


Figure 5: The alignment arrow is located on the bottom of the radome.

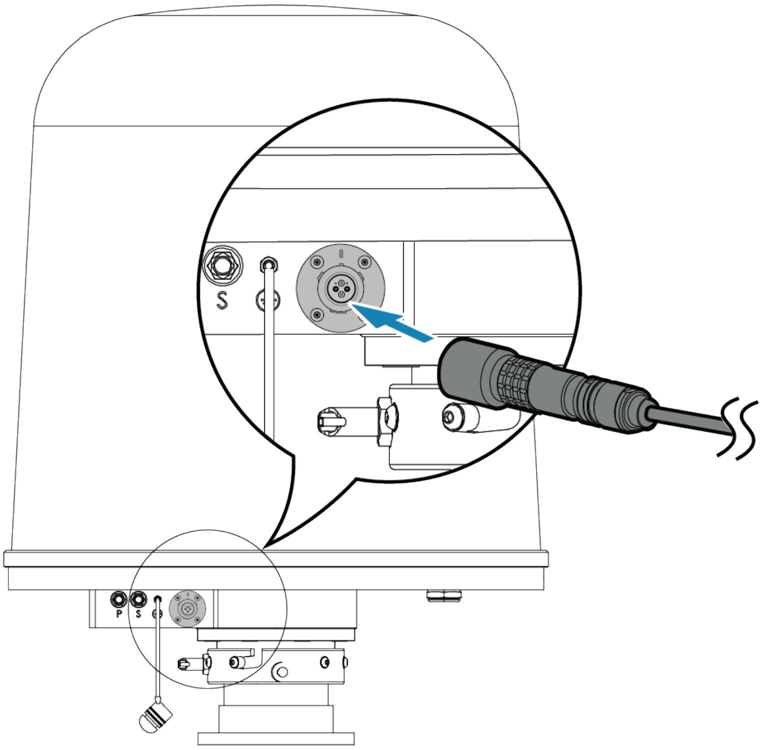
7.6. Connecting the Radar Cable

⚠WARNING **Do not hot plug the radar cable. Always disconnect from mains power source when connecting or disconnecting the radar cable. In case the processing station includes a breakout box: Turn <OFF> the main switch/button first.** Arc flash and shock hazard.

STEPS

1. **Inspect cables and connectors following any cable manipulation, movement, or reinstallation. Check for breakage of parts and any other conditions that may affect radar operation. If damaged, repair before use.**
2. **Use covers to seal and protect connectors from harsh environments when disconnected.** Connectors can easily be damaged. Moist and debris can hamper accurate operation. Remove covers prior to connecting the cable.

   The covers from the cable connector and radar connector can be put together to prevent debris in the covers during operation.
3. Layout the radar cable between the radar and the processing station. **Do not bend cables beyond the minimum bend radius.** Failure to follow this instruction can generate interference or cause damage to cables.
4. It is recommended to secure cables every 100 cm (40 in) with cable ties or cable mounts with a minimum width of 0.5 cm (2 in.) to avoid tripping hazard.
5. Locate the power/data connector on the bottom side of the radome. Note the red alignment dots on both connectors.
6. Align and insert the connector and push until click. Ensure that the radar cable is fully inserted and locked inside the socket.
7. To disconnect the cable, use thumb and index finger to push the flange of the connector on the chassis and pull out the cable.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8. Operation

NOTICE

1. Operational applications may require periodic updates. Updates ensure optimal performance, security, and compatibility with the latest features. Users are encouraged to regularly check for new releases and update their software to match the applicable documentation.
2. Please refer to the IRIS Reference Documents [185.927.024]. In this document you will find a list of reference documents regarding operational applications for the IRIS Radar System.

The sensor operates without physical controls and is primarily managed through a software application. This software provides a comprehensive interface for real-time operation, monitoring, and adjustments, allowing users to access and control all features remotely. While a connected processing station can also interact with the sensor, its manual control capabilities are limited to basic functions, such as powering the sensor on or off.

9. Radar Performance

Radar, short for "Radio Detection and Ranging," is a technology built on the use of electromagnetic waves to detect and locate objects within its operational range. By transmitting radio waves and analyzing the reflected signals from targets, the radar system can measure the distance, speed, and direction of objects and entities. Combining range information with the azimuth angle allows for precise target location determination. Additionally, the radar system calculates the Radar Cross Section (RCS) of the target by analyzing the strength of the reflected signal. This analysis allows for the classification of the target.

Radar performance refers to the effectiveness and capabilities of a radar system in detecting, tracking, and identifying targets. The performance of a radar system is a balance determined by several key factors:

1. Radar coverage area: The spatial region that a radar system can effectively monitor and surveil. This area is determined by the radar's scanning capabilities, beam width, and maximum range. A larger coverage area enhances the radar's situational awareness and threat detection capabilities.
2. Range: The maximum distance at which a radar can detect a target. Longer range capabilities allow for early detection of potential threats.
3. Sensitivity: Radar sensitivity refers to its ability to detect weak signals. Higher sensitivity allows the radar to detect smaller or more distant targets.
4. Resolution: The ability to distinguish two or more closely spaced targets as separate entities. Higher resolution enables better target detection and tracking.
5. Accuracy: The degree of correctness in measuring a target's position, speed, and other attributes. High accuracy is crucial for precise targeting and tracking.
6. Doppler capability: Radar with Doppler capability can detect the relative motion between the radar and the target. This information helps determine the target's velocity and direction.
7. Signal processing: Advanced signal processing techniques help enhance radar performance by reducing noise, clutter, and interference, improving target detection and tracking.
8. Radar cross-section (RCS) of targets: RCS refers to how detectable an object is by radar. Lower RCS values mean targets are less visible to radar, making them harder to detect.
9. Environmental conditions: Weather conditions can impact radar performance. For instance, rain, fog, or snow can attenuate radar signals, reducing its effective range.

9.1. Optimal Setup Environments

Achieving optimal radar performance requires a thorough evaluation of environmental, operational, and technical factors, which are covered in detail later in the next chapters. Before deploying the sensor, review the key considerations outlined below to ensure a successful operation.

Terrain and Line of Sight

- **Ensure an unobstructed view.** Radars operate on the principle of line-of-sight propagation, requiring a clear path between the sensor and the target. Preferably select locations free from obstructions like buildings, hills, or dense vegetation.
- **Try multiple locations.** Since radar performance can vary significantly due to local terrain, enabling multiple installation options is recommended. Even small positional adjustments can improve performance.
- **Optimize placement.** Install the radar as low as possible while maintaining line of sight to minimize ground clutter. Higher placements improve line of sight but increase clutter, requiring a balance based on the target area.
- **Define the area of interest.** Focus on the most critical regions for detection, as optimizing for specific directions may affect performance in others.

Environmental Conditions

- **Consider weather impact.** Radars can be affected by rain, snow, or extreme temperatures. Solar loading, especially in sunny locations, can cause overheating. Rain, light or heavy cause a certain amount of clutter. Consider seasonal and local weather variations when using the radar.
- **Asses dynamic environments.** Dense or hilly environments may significantly reduce detection range compared to open, flat terrains.

Clutter and Interference

- **Minimize Clutter.** Select a location with minimal clutter sources, such as buildings, parked vehicles, or highways, to reduce false alarms and improve target detection.
- **Avoid interference.** Position the radar away from electromagnetic sources like power lines, high-power transmitters, and industrial equipment that could cause interference.

Legal and Security Requirements

- **Regulatory compliance.** Obtain necessary permits and adhere to frequency band and height regulations for radar operation.
- **Secure equipment** Protect the radar from theft, vandalism, or unauthorized access with suitable security measures.

Optimization and Testing

- **Perform initial tests.** Run the radar for at least one hour at a new location to gather baseline data before fine-tuning software configurations.

1. If accurate and detailed terrain elevation data is available (e.g. elevation data per square meter), you can ask Robin to calculate a line of sight diagram for one or more installation locations. This diagram provides an indication for areas that are obstructed for a given flight level.
2. If it is not feasible to achieve the required coverage with a single sensor, consider multiple radars. The software will automatically merge the data from the two sensors. Consult Robin or your distributor for more information.

9.2. Targets

Targets refer to objects or entities that reflect radar signals back to the radar system. When a radar system transmits radio waves, these waves encounter various objects in their path. Targets, such as aircraft (including UAVs), vehicles, or birds, reflect or scatter a portion of the radar energy back towards the radar antenna, where it is received.
The radar system processes the received signals and analyzes the echoes to identify and track these objects as 'targets'. Initially, raw detections, or 'plots', are generated from the received signals which represent the presence of objects within the radar's coverage area. These plots are then further analyzed to determine target characteristics, such as size, shape, and material composition, which influence their radar cross-section (RCS). Ultimately, the radar system continuously tracks the detected targets, providing valuable information about their movements and behavior.

Target Detection

The initial step in the radar process is target detection. This involves determining whether a target is present by detecting the return of radar signals reflected from objects in the environment. The primary goal of detection is to recognize the existence of any reflecting target, regardless of its size, shape, or composition. This step focuses on identifying the presence of potential objects without delving into detailed information about their characteristics.

A key aspect of target detection is distinguishing targets from static background signals. The radar system determines the background by constantly analyzing the environment. Static background signals are typically reflections from stationary objects such as buildings, trees, or the ground. By identifying these static signals, the radar can better detect dynamic targets, which are usually moving objects. However, it is important to note that not all targets are dynamic; stationary targets like hovering drones can also be detected.

Target Tracking

When four consecutive plots from the same object are correlated and analyzed, they form a track. Tracks provide a more coherent representation of the motion and behavior of detected objects compared to individual plots. It starts unclassified and is classified based on the overall track properties from the 5th plot. [note outbound/inbound delta].

Target Classification

Following detection and tracking, classification takes place after five consecutive plots. Once the presence of targets is confirmed through detection and tracking, the next step is to categorize and classify these detected objects into specific groups based on their unique characteristics. Classification involves analyzing additional features of the radar returns to differentiate between different types of objects. This process provides more detailed information beyond mere detection, such as determining whether the detected object is a drone, a bird, or another specific category. To assign a classification, the track runs through the IRIS Classification Decision Tree on page 39. The decision variables are Micro Doppler, RCS, Altitude, Velocity. Classification keeps updating with the track being held against the classification tree constantly.

Target Characteristics

The effectiveness of target detection and classification is linked to a range of distinctive characteristics. These attributes include not only the physical dimensions and composition of the target but also a variety of other defining factors. The table below describes a variety of target characteristics and their influence on the process of detection and classification.

Drone Characteristics	Effect on RCS
Type	Multirotors or multicopters, fixed wings and various types of UAVs typically have different Radar Cross Sections (RCS) due to their distinct shapes, sizes, and construction. The rotating blades of a multirotor differ from a fixed wing with their exposed surfaces like wings and fuselage.
Size	The RCS quantifies the amount of radar energy that is scattered back towards the radar system when the object is illuminated by radar waves. Generally, larger drones tend to have a larger RCS. This is because a larger surface area allows for more radar energy to be reflected back to the radar system, making the drone more detectable. Smaller drones typically have a smaller RCS. The smaller the drone, the less surface area is available for scattering radar energy, resulting in a weaker radar return.
Composition	Material used in drones can impact its detectability by radar. For instance, metallic and carbon surfaces tend to reflect radar signals more effectively, while non-metallic materials like plastic or wood may scatter or absorb radar energy, potentially influencing the radar's ability to detect and characterize the object accurately.

Drone Characteristics	Effect on RCS
Shape	Objects that are flat reflect the signal better than objects with a rounded shape. Note that a flat surface only reflects well if it is oriented perpendicular to the radar. On the contrary, if the surface is at an angle, it becomes almost invisible ("stealth principle").
Aspect Angle	The aspect angle is the angle at which a drone is observed by the radar system in relation to the radar's line of sight. The radar return from a drone can vary based on the aspect angle. A drone can be seen from the front, side, behind or anywhere in between. Furthermore there is the azimuth and elevation angle providing a complete description of a drone's orientation in space. The concept of aspect angle is a bit more nuanced when applied to a drone since drones don't have a distinct "front" or "side" in the same way that traditional vehicles or birds do. The elevation angle of the drone plays a significant role. If the drone flies in the same direction as the wind, it is in a more horizontal position than when it flies in the opposite direction of the wind, which influences the aspect angle and RCS that is seen by the radar. A fast drone is also tilted further. Note that this only applies to multirotor drones as fixed wings do not share these flight characteristics.
Speed	The radar system needs some independent measurements before it can classify an object as drone. If the drone flies fast, it can be closer before it is classified as drone.
Distance to the radar	Reflected signal levels from an object decrease rapidly with the distance to the radar. The detected radar signals are corrected for range to give a range independent RCS. When the received signal falls below the detection level, that target is no longer seen. For targets with a small RCS this will happen at shorter distance. Targets with a large RCS may be detected on a longer distance.

9.3. Challenges and Disruptions

Various obstacles and disturbances can affect the performance and effectiveness of the radar system. These challenges arise from a combination of factors and environmental conditions, impacting the radar's ability to accurately detect and track targets. Common radar challenges and disruptions include:

1. Clutter: Unwanted echoes from surrounding objects, terrain, or atmospheric (weather) effects that can obscure or mask real targets.

2. Signal Attenuation: Loss of radar signal strength as it travels through the atmosphere, rain, dust or snow, reducing detection range and accuracy.
3. Multipath: Interference caused by radar signals taking multiple paths while traveling to and from the target, resulting in ghost or false echoes.
4. False Alarms: Erroneous radar detections that result in the identification of non-existent targets, leading to unnecessary alarms and increased workload for operators.
5. Jamming and Interference: Deliberate or unintentional transmission of signals to disrupt radar operation or overload the receiver.

Operators need to be proactive and responsive in managing challenges and disruptions, utilizing their understanding of radar principles and system behavior to ensure accurate and reliable radar operations.

9.3.1. Clutter

Clutter refers to unwanted or undesirable signals that are received by a radar system but do not originate from actual targets of interest. These signals can arise from various sources and can interfere with the radar's ability to detect and track real targets accurately. Radar clutter can significantly affect the radar's performance and reliability, making it essential to minimize its impact.

The radar operates according to the concept of line-of-sight, meaning it cannot see through objects. Instead, it can only detect objects directly within its line of vision. All objects within the range of the radar reflect and absorb RF signal in different quantities. All objects of interest are called targets. All other objects are called clutter.
The most common sources of radar clutter are listed in the section below.

Ground Clutter

Radar signals can reflect off the ground, buildings, mountains, and other terrain features, creating false echoes that can be mistaken for real targets. Ground clutter raises the local noise level, making it harder to detect weak reflections from actual targets.

1. **Ground**: The ground reflects a part of the signal. Ground clutter (reflections) disturbs all objects stationary and moving.
2. **Vegetation**, especially in windy conditions, introduces dynamic elements to ground clutter, complicating target detection. Trees and hedges can obstruct or partially reflect radar signals, leading to scattered radar signals and adding to the clutter. The irregular structure of vegetation can cause radar signals to be absorbed or blocked, resulting in reduced radar returns or "shadows" behind these obstacles. Additionally, the motion of tree branches or leaves can create moving radar returns, which can be mistaken for actual targets. Detecting objects behind dense vegetation is challenging for radar systems
3. **Dikes & Embankments**: Both being very similar and can cause radar clutter in certain situations. The interaction between radar signals and dikes & embankments can vary depending on several factors, including the materials and shapes of the structures

and the angle of incidence of the radar beam. Dikes & embankments are generally sloped which causes the radar signal to be reflected upward instead of directly back into the receiver of the radar. The effect of radar beams reflecting back to the receiver is something to be avoided when possible.

4. **Rock Formations & Natural Elevations**: Hills, slopes, valleys, and depressions interact with radar signals similarly to dikes and embankments. These features scatter radar signals, which can obscure real targets.
5. **Buildings & Man-Made Structures**: Reflections from buildings, roads, bridges, and other structures can cause unwanted echoes. Buildings, especially those with large, smooth surfaces like windows or corrugated metal sheets used on roofs, are notorious for causing significant radar clutter due to strong reflections.

Sea Clutter

In maritime environments, radar signals can reflect off waves and the surface of large bodies of water, generating clutter that can obscure real targets like drones or birds. The mirror-like effect of flat water surfaces complicates altitude measurements, while waves can disturb the detection of low-flying targets.

Weather Clutter

Various weather phenomena can scatter radar signals, causing unwanted reflections that may appear as clutter.

1. **Rain**: Rain causes signal clutter. Even in light rain, the radar signal can experience disruptions, making it challenging to detect targets effectively. Rain has a scattering effect and can significantly enhance the multipath effect, leading to further signal complexities and signal attenuation. The heavier the rain, the more it affects the radar's performance and reliability.
2. **Snow**: The physical properties of snowflakes make them less effective at reflecting radar signals back to the radar antenna as they scatter in multiple directions rather than reflecting directly back to the radar receiver. While snow still causes signal attenuation and distortions, especially during heavy snowfall or when snow is wet, its effects on radar signals are generally less severe compared to heavy rainstorms.
3. **Hail**: Hailstones are irregularly shaped ice balls that can be denser and more compact than snowflakes. When radar signals encounter hailstones, they can cause strong reflections directly back to the radar receiver. The larger size and irregular shape of hailstones enhance their ability to reflect radar signals effectively, leading to stronger radar echoes and more significant disruptions compared to snow. In severe hailstorms, the strong radar reflections from hail can overpower the radar system, making it challenging to detect other targets accurately and potentially causing clutter and false alarms. Overall, hail has a more disruptive effect on radar signals than snow due to its larger size, irregular shape, and higher density, resulting in more intense radar reflections.
4. **Fog**: Condensed water droplets that are airborne, also reflects radar signals. However, compared to rain, the impact is relatively smaller as the effect worsens with larger droplets.

5. **Sand or Dust**: Sandstorms can produce significant clutter in radar systems, The airborne sand particles can scatter and reflect radar signals, creating unwanted echoes that can obscure or interfere with the detection of other objects, including actual targets of interest. Sandstorms are notorious for causing disruptions to radar operations in desert regions.

Radio Frequency Interference (RFI)
External sources of electromagnetic radiation, such as electronic devices or other radars operating on the same frequency, can interfere with radar signals. This interference, often referred to as Electro-Magnetic Interference (EMI), contributes to clutter, making it harder to detect and distinguish desired signals from unwanted noise. Modern regulatory standards aim to minimize interference issues by ensuring proper device design and operation.

9.3.2. Reducing Clutter

Mitigating or reducing clutter is a critical aspect of radar signal processing to improve target detection accuracy and enhance overall radar performance. However, it's essential to understand that complete elimination of clutter is often challenging, especially in certain environments with high clutter density or complex scenarios. Operators must strike a balance between clutter reduction and maintaining sensitivity to detect weak or distant targets. This can be done by creating blanking sectors, clutter fences or by relocating the radar system. The radar system reduces the impact of clutter through signal processing techniques, adaptive algorithms, and advanced filtering methods to improve radar performance.

Signal processing
The reflected signal is received and filtered for static objects (e.g. terrain, vegetation, buildings etc.), then it is filtered for locally moving objects called variant filtering (e.g. leaves on a tree, etc) and then filtered for rain- and sea-clutter. A threshold is determined based on the type of clutter to strike a balance between detecting the maximum number of desired targets while minimizing false detections. In heavy clutter areas the detection threshold is increased which generally leads to a loss of detection of smaller targets.

Blanking Sectors
By configuring the radar system or creating a blanking sector, the operator can avoid transmitting signals in certain directions where clutter is likely to occur (e.g., directly from buildings or raised areas of ground), though radar signals can still be received in these sectors. Creating a blanking sector can be particularly useful when dealing with multipath effects. Additionally, blanking sectors can be created to prevent interference with other radar systems or equipment that are transmitting on the same radio frequency

Clutter Fences
A clutter fence is a physical barrier or structure strategically placed around the radar installation to minimize the effects of clutter from unwanted signals. A clutter fence acts as a shield to reduce the interference caused by reflections from nearby objects, terrain, or environmental conditions. Clutter fences are typically constructed using materials that are

reflective to radar signals. The fence's design may include elements like metal plates, mesh, or other materials specifically chosen to attenuate clutter reflections or to send the reflections upwards rather than back into the radar. Terrain masking is another way of creating a clutter fence which involves using the natural landscape to block certain radar signals. For instance, a hill or ridge can obstruct radar echoes originating from the other side, reducing unwanted reflections from that direction. It's important to note that while clutter fences can be effective in reducing certain types of clutter, they may not completely eliminate clutter in all scenarios.

Relocating the Radar

Relocating a radar system to a different location can be an effective strategy to reduce clutter in some cases. The impact of clutter on radar performance is often influenced by the radar's surroundings, such as terrain, buildings, or other objects that can reflect or scatter radar signals. By moving the radar to a more suitable location with less complex terrain and fewer obstacles, operators can potentially minimize clutter and improve radar performance. Here are some considerations when relocating a radar to reduce clutter:

1. Line of Sight: The radar's line of sight refers to the direct path between the radar antenna and the target or the surrounding environment. By relocating the radar to an area with a clear line of sight to the desired targets and less clutter-producing objects, clutter effects can be reduced.
2. Elevation: Changing the radar's elevation can influence clutter reflections. Adjusting the radar's elevation may help mitigate clutter from certain sources, such as ground clutter or reflections from nearby structures.
3. Distance from Clutter Sources: Increasing the distance between the radar and clutter-producing objects, such as buildings or mountains, can help reduce the strength of clutter echoes.

It's essential to conduct thorough site surveys, simulations, and analysis to assess the potential benefits of relocating the radar in clutter reduction. Moreover, combining radar relocation with other clutter mitigation techniques, such the use of clutter fences, can lead to more effective clutter management and improve the radar's ability to detect and track real targets accurately.

9.3.3. Signal Attenuation

Signal attenuation refers to the loss of signal strength as it propagates through various media, such as the atmosphere, rain, snow, or other objects. It is a natural phenomenon that occurs due to the scattering, absorption, and reflection of the radar signal along its path. Several factors contribute to radar signal attenuation:

1. Atmospheric Attenuation: The Earth's atmosphere can absorb and scatter radar signals as they travel through it. The degree of attenuation depends on the radar frequency and atmospheric conditions, such as humidity and precipitation.
2. Rain and Precipitation: Raindrops, snowflakes, and other forms of precipitation can absorb and scatter radar signals, reducing their intensity and range. Even light rain or precipitation can lead to signal attenuation.

3. Terrain and Obstacles: Radar signals can also be attenuated by physical objects, such as mountains, buildings, trees, and vegetation. These objects can block or reflect radar signals, causing signal loss.
4. Free Space Path Loss: As the radar signal propagates in free space (vacuum), it naturally experiences signal attenuation due to the inverse-square law. The signal power decreases with the square of the distance from the transmitter. The reflected signal follows the same principles, which means it also undergoes attenuation as it travels back to the radar.
5. Multipath Propagation: In multipath propagation, radar signals encounter multiple paths while traveling to the target and back. When the reflected signals arrive at the radar antenna with different phases, they can interfere and cause signal cancellation or attenuation.
6. Radio Frequency Interference (RFI): External electromagnetic radiation, such as from other radar systems or electronic devices, can interfere with the radar signal and lead to signal overload.
7. Frequency Dependence: Radar signal attenuation can vary with frequency. Higher frequency signals generally experience more significant attenuation in certain environments, while lower frequency signals can penetrate obstacles better but may suffer from increased atmospheric attenuation.
8. Absorption by Objects: Some objects may absorb radar signals more effectively than others, leading to specific signal attenuation characteristics for different materials.

9.3.4. Multipath

Multipath refers to the phenomenon where radar signals encounter multiple paths before reaching the receiver. This occurs when radar waves reflect off objects in the environment such as buildings, terrain features or water. Instead of a direct path from the radar transmitter to the target and back to the receiver, the signals take alternative paths, resulting in multiple signal arrivals at the receiver.
Multipath propagation can introduce several challenges in radar systems such as ghost targets or signal fading.

Ghost Targets
When radar signals reflect off one or more objects, the receiver may receive additional echoes that appear as ghost targets. These ghost targets can confuse the radar system, leading to incorrect range, velocity, or position measurements. To mitigate the effects of ghost targets, a blanking sector can be created. Also consider relocating the radar.

Height Fluctuations
The constructive and destructive interference between the direct and reflected waves can cause height fluctuations also known as signal fading. This fading can result in fluctuations in the received signal strength, leading to errors in radar measurements. These errors occur when the signal from the target [C] is received in the lower and upper beam [D, E], while the

indirect path is only received in the lower beam [E], resulting in combined height calculation discrepancies.

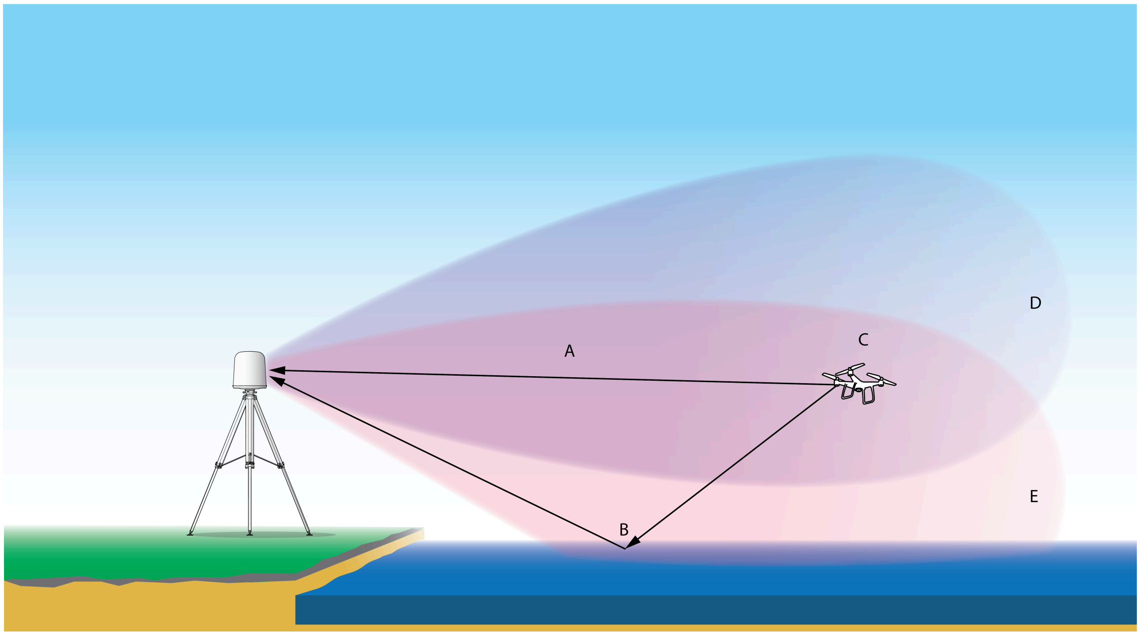

Figure 7: A longer indirect path reflecting off water (or any other large reflecting surface) creates calculation errors .

Mitigating signal fading can be achieved through relocating the radar in such a way that natural terrain features block the view of the reflecting surface. This is known as terrain masking. By lowering the height or moving the radar further away from water bodies, natural obstructions like trees or raised areas of ground can be used to the user's advantage.

The key is to prevent strong reflections from these objects bouncing back to the radar and causing saturation or excessive phase noise. The objects and terrain features available must have the ability to absorb or scatter the radar signal in a different direction. Examples of suitable blockers are trees, hedges or rock formations that both absorb the signal and scatter it omni directionally. Dikes or embankments are also suitable and although they are large reflectors, they scatter the signal upward into the sky because of their backward slope. In contrast, buildings, cars, or solid walls are examples of poor blockers that have a negative impact on the signal, as their vertical surfaces will reflect large amounts of energy back to the radar.

Overall, addressing radar multipath is crucial to ensure accurate and reliable radar measurements, especially in complex environments where reflections and obstructions are prevalent.

9.3.5. False Alarms

False alarms occur when a radar system mistakenly detects or classifies a non-existent target or interprets noise, clutter, or interference as a real object. False alarms are a significant concern in radar systems, as they can lead to unnecessary actions, wasted resources, and decreased confidence in the radar's reliability. Reducing false alarms is crucial for ensuring radar effectiveness and avoiding unnecessary responses.

Target occlusion

Target occlusion can happen when a target's signature is obscured or masked by another object as it crosses its path. In this scenario, the object (clutter or other obstruction) can temporarily block or interfere with the radar signals from the target, leading to a momentary loss or degradation of the target's radar signature. This occlusion effect can pose challenges in accurately tracking and identifying the target during certain positions or movements in relation to other objects in the environment.

Target mimicking

When target occlusion occurs another phenomena often occurs where clutter takes on the characteristics or signature of a target. This is also know as "stolen tracks". In this scenario, the clutter or unwanted echoes from the environment can resemble the radar signature of an actual target, making it challenging for the radar system to differentiate between the two. As a result, the radar may incorrectly identify the clutter as a target, leading to misclassification.

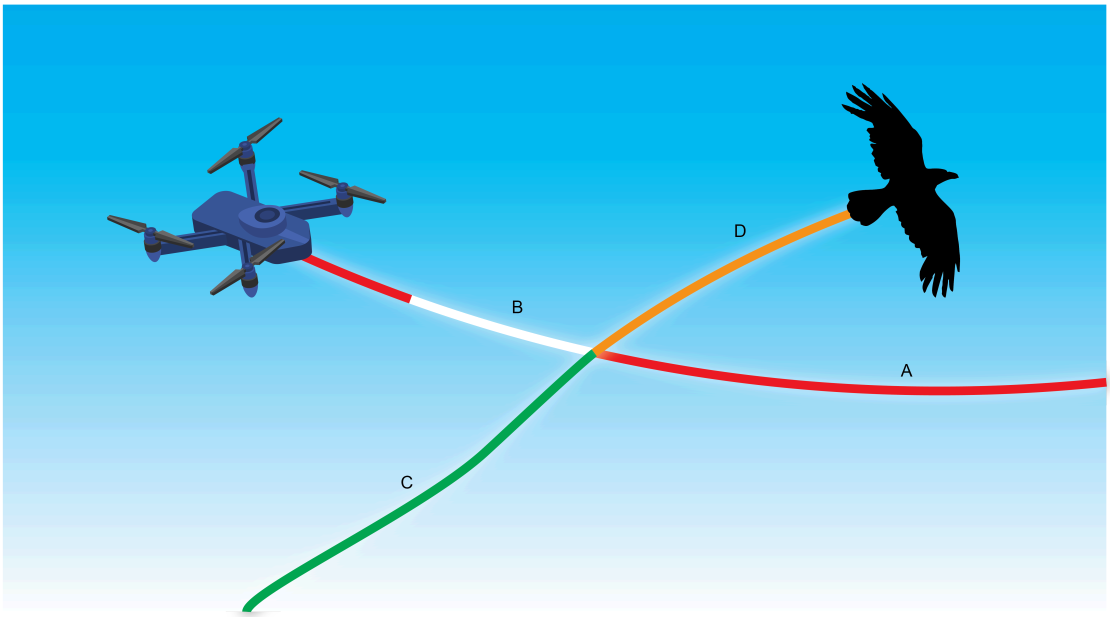

Figure 8: Target occlusion and mimicking during crossing.

Item	Description
A	Drone track
B	Temporarily loss of target
C	Bird track
D	Target mimicking occurred at crossing and the bird track changes into a suspected drone track

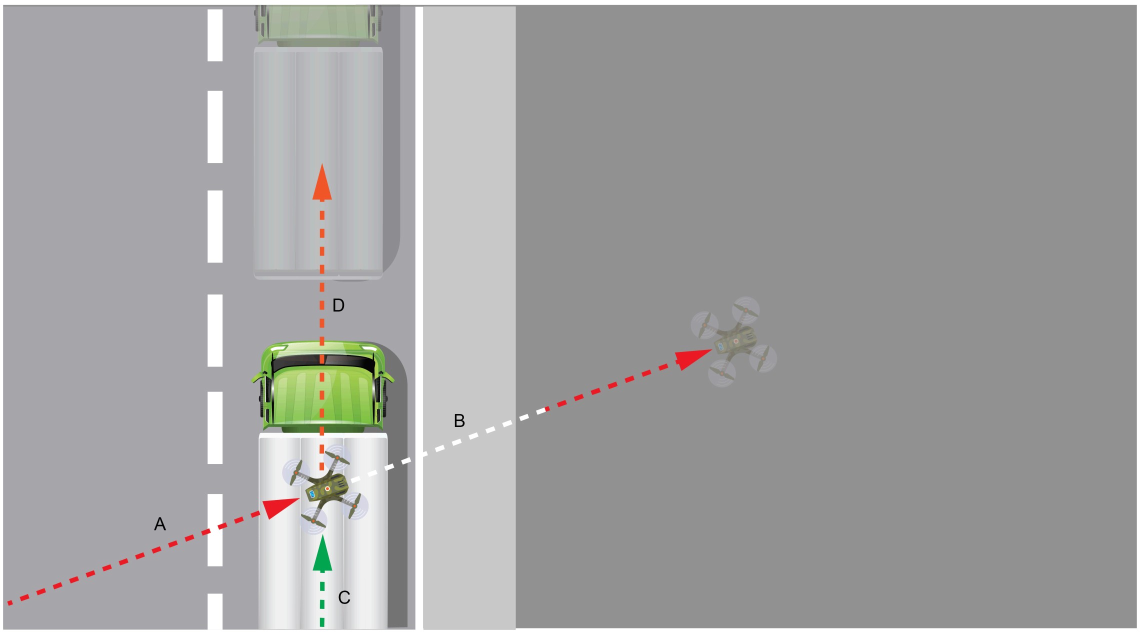

Figure 9: Target occlusion and mimicking during crossing can also happen with vehicles or other objects.

Item	Description
A	Drone track
B	Temporarily loss of target
C	Vehicle track
D	Target mimicking occurred at crossing and the vehicle track changes into a suspected drone track. Note that this phenomena can happen with all kinds of objects such as farming machines, air-conditioning systems or motor cycles.

9.4. Ground Level

One aspect of the deployment process involves establishing the position of the radar. The radar position includes the longitude, latitude and altitude of the radar, and the ground level. The longitude, latitude and altitude of the radar is measured by the on-board GPS sensor, and can be fine-tuned or set manually by the user if necessary, along with the ground level. The ground level is very important for target classification and therefore influences false positives or false alarm rates.

Determine where drones are expected to fly when setting the ground level in hilly terrain, slopes or mountains. Drones will not be classified correctly when they fly under the set ground level.

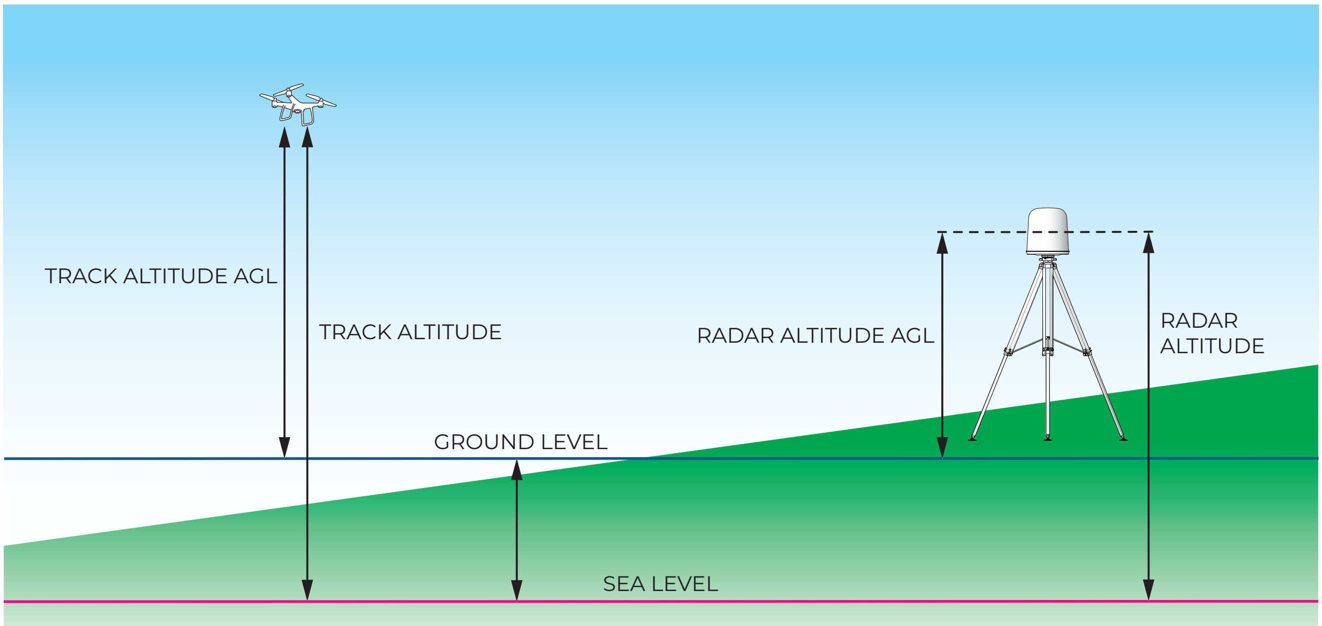

Figure 10: Referencing the radar position and targets

9.5. IRIS Classification Decision Tree

For drone classification the IRIS Classification Decision Tree is used to determine if a track can be classified as a DRONE. All of the below mentioned decisions in the IRIS Decision Tree can be adjusted in the IRIS Configuration file. Adjusting settings can improve the radar performance. If the radar is not working as expected, follow all steps of the decision tree yourself and evaluate at each step whether the settings made are having the desired effect.

See appendix for a larger image of the IRIS Classification Decision Tree.

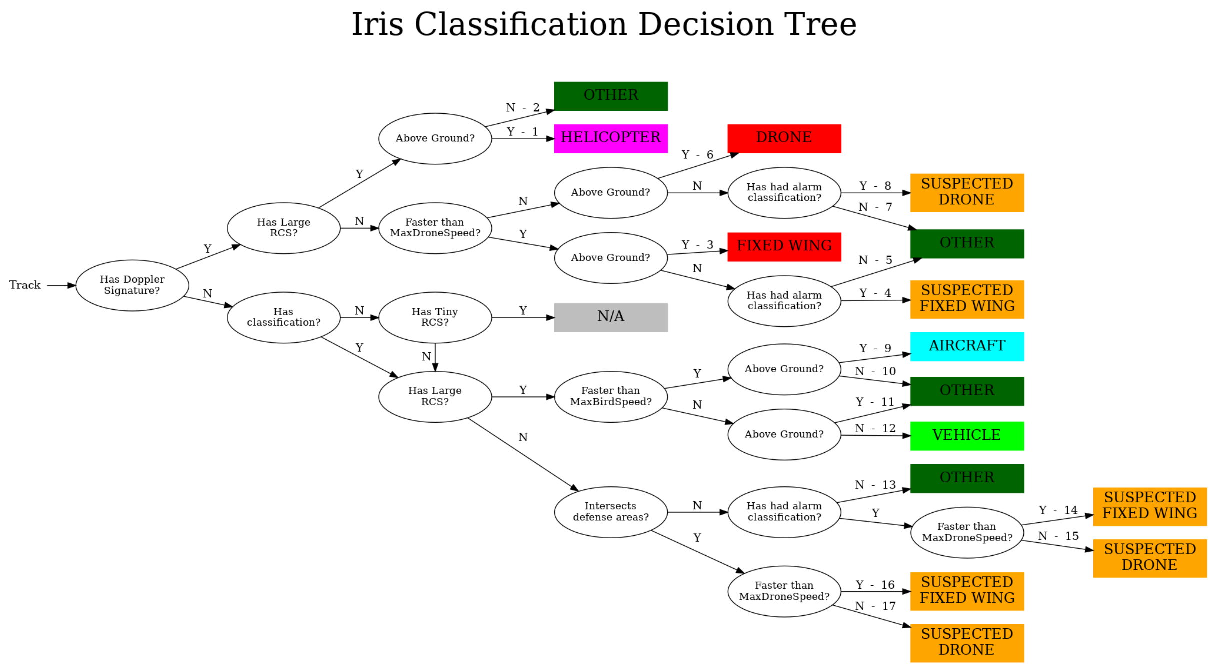

Figure 11: IRIS Classification Decision Tree

In the IRIS Classification Decision Tree the following decisions must be made, when a track is detected:

- **Has Doppler Signature?** The decision is made based on both DNN_DRONE_COUNT and DNN_DRONE_PERCENTAGE settings (DNN count-based classification) or PROBABILITY_BASED_DRONE_SIGNATURE (DNN probability-based classification). The count is based on the set classification window and the percentage is for the number of plots that is set in MAX_COUNT_FRACTION (configurable, default = 120). That is the maximum number of plots to evaluate when calculating DNN_DRONE_PERCENTAGE. The question is answered: how many plots are wide and does the track look like a drone?
- **Has Large RCS?** The decision is based on three consecutive plots where RCS is larger than MIN_LARGE_TARGET_TRACK_RCS. The value is in dBm^2. If this value is less than the set value (default = 5.0), the track might be classified as a DRONE. If this value is set too high, all objects with Doppler signature are identified as a DRONE, for example helicopters. If only small drones are expected in the area, the value can be set to a lower value.
- **Has classification?** A track has a classification field. If a track is already classified, the field is filled, if not, the field is empty. The decision tree checks if the classification field is filled. If not, the RCS of the full track is checked to start the classification.
- **Has tiny RCS?** This check is to determine whether a track is worth classifying. Tracks with a very small RCS (default < -30 dBm^2) are usually harmless; think large insects. The decision is based on the history of the entire track where RCS is larger than MIN_TRACK_MEDIAN_RCS. The value is in dBm^2. If this value is less than the set value (default = -30), the initial classification is postponed until the track has an RCS large enough for classification. If this value is larger than the set value, the track is classified according to the next step in the decision tree ("Has large RCS?").

- **Above ground?** The decision is based on three consecutive plots above ground level with a margin. The ground level refers to the altitude above sea level (WGS-84 Ellipsoid) of the lowest point within the radar coverage area, and is defined based on a horizontal plain. When this level is set too high, most drones will fly below the radar. If the level is set too low, also vehicles on the road will be identified as drones/helicopters. The ground level can be set in the Radar Control Panel in the Drone Viewer software. When set the configuration file will be updated automatically. The value can also be changed manually in the IRIS Configuration file. An absolute value (track altitude relative to ellipsoid) is set in XML and a relative value (track above ground level relative to ground level) in the Drone Viewer software. See Ground Level on page 38 for further explanation.
- **Faster than MaxBirdSpeed/MaxDroneSpeed?** This decision is based on three consecutive plots having a speed higher than the set max bird/drone speed (BIRD_MAX_SPEED or DRONE_MAX_SPEED). The maximum drone speed can be set in the IRIS Configuration file. The maximum bird speed is a hard coded value, which is set to 130 km/h. With this value most of the birds around are covered and the limit ensures that airplanes and such can be properly classified.
- **Intersects defense area?** In the Drone Viewer software (alarm) areas can be defined (see 500.927.001 Drone Viewer User Manual). One of them is the Defense Area.

  Small moving targets without Doppler signature that will approach this area within 60 seconds (extrapolated in time by the PREDICTION_WINDOW - configurable in the IRIS Configuration file) are classified as SUSPECTED FIXED WING or SUSPECTED DRONE without being classified as a FIXED WING/DRONE first. However, the track must contain at least 10 seconds of data (CALCULATION_WINDOW - configurable in the IRIS Configuration file) to do this prediction and the track must be above ground level.

  Once the Defense area is defined, the PREDICTION_WINDOW, CALCULATION_WINDOW and MAX_DEVIATION can be defined in the IRIS Configuration file. The default prediction window is ‘60’ seconds. The default calculation window is ‘10’ seconds. Making this windows smaller can result in more suspected drones and fixed wings.

  The default MAX_DEVIATION is '0.5'. The MAX_DEVIATION determines how straight tracks must be to be classified as SUSPECTED. As an example, if MAX_DEVIATION is set to '0' then only perfectly straight tracks will be SUSPECTED. The higher the deviation, the more alarms may occur.

  Change these settings until the number of false alarms is acceptable.

The other (alarm) areas that are described in the 500.927.001 Drone Viewer User Manual can also be used to influence the number of false positives. They just do not directly affect the classification tree, because most areas already act on the plot extraction phase.

- **Has had an alarm classification?** This check is done to ensure that once a track has an alarm, that it always keeps that alarm state. So, a DRONE can be classified as a SUSPECTED_XXX later, but can never be classified as a DRONE -> OTHER later.

To adjust the settings, find the configuration class CLASSIFICATION in the IRIS Configuration file:

```
IRISRADAR
{
    …
    CLASSIFICATION
    {
        …
        SMALL_TARGET_ALTITUDE_MARGIN 5
        LARGE_TARGET_ALTITUDE_MARGIN 50
        MAX_COUNT_FRACTION 120
        MIN_LARGE_TARGET_TRACK_RCS 5
        MIN_TRACK_MEDIAN_RCS -30
        DRONE_MAX_SPEED 30.0
        DNN_DRONE_COUNT 2
        DNN_CLASSIFICATION_WINDOW 10
        DNN_DRONE_PERCENTAGE 20
        PREDICTION_WINDOW 60
        CALCULATION_WINDOW 10
        MAX_DEVIATION 0.5
        PROBABILITY_BASED_DRONE_SIGNATURE
        {
            ENABLED TRUE
            CLASSIFICATION_WINDOW 6.5
            MIN_COUNT 3
            THRESHOLD 0.6
            LONG_RANGE_RANGE 10000
            LONG_RANGE_THRESHOLD 0.6
        }
        …
        ; When count-based DNN classification enabled,
          DNN_DRONE_COUNT,DNN_CLASSIFICATION_WINDOW and DNN_DRONE_PERCENTAGE
          is used (deprecated)
        ; When probability-based DNN classification enabled,
          PROBABILITY_BASED_DRONE_SIGNATURE is used (default)
    }
    …
}
```

10. Maintenance & Service Instructions

Please refer to the IRIS Service Manual [185.970.002] / [185.970.001] for in-depth information regarding servicing.

10.1. General Safety

The maintenance of the radar is the responsibility of both the supplier as well as the end-user. Frequently check the radar system to maintain optimal detection performance and detect errors as soon as possible.

All maintenance and repair work in which that the radar system to be opened must only be carried out by an authorised service agent.

The supplier will check and maintain the radar system in accordance with the service contract.

10.2. Periodic Checks

- During operation, check the network (security) connections and reception of radar data in the IRIS Radar software application.
- For optimal performance, ensure the radome is clean before each operation. Follow cleaning instructions.
- Inspect cables and connectors following any cable manipulation, movement, or reinstallation.
- During operation, monitor for any mechanical noise coming from the radar. If anything appears abnormal or unusual, please contact Robin for further assistance.

10.3. Cleaning the Radome

⚠ CAUTION

1. Avoid touching the radome surface unnecessarily to maintain the finish. The appearance of a matt finish (F9) radome is easily compromised.
2. Only clean when necessary.
3. Do not use abrasive materials or excessive force during cleaning. The finish is easily damaged.

Materials Needed

- Soft lint-free non-woven cloth
- Soft washing brush
- Mild, non-abrasive cleaner or isopropyl alcohol. **Avoid using harsh chemicals or abrasive cleaners, as they may damage the finish.**

- Distilled warm water. The maximum allowed temperature is 50°C / 122°F.

STEPS

1. Only clean the radome when necessary to avoid unnecessary contact and identify specific areas requiring cleaning, such as stains, fingerprints, or smudges.
2. Ensure the radar is powered off before cleaning. RF radiation hazard.
3. Gently remove loose dust or debris from the radome using a soft washing brush.
4. Mix a mild, non-abrasive cleaner with distilled water as per the cleaner's instructions. Isopropyl alcohol may be used undiluted.
5. Dampen the microfiber cloth with the prepared cleaning solution.
6. Wipe the radome surface using gentle, circular motions. Focus on stained or soiled areas without applying excessive pressure.
7. Dry and dab the radome immediately with a dry section of the cloth to prevent water spots. Avoid excessive force and allow for further air drying.

Safely Removing Bugs with a Damp Cloth

1. Drape a damp lint-free non-woven cloth over the radome where bugs are stuck. Let it sit for about 15 minutes. This softens the bug residue, making it easier to wipe off without scratching the radome's surface.
2. Wipe or brush off gently. Focus on stained or soiled areas without applying excessive pressure.
3. Dry and dab the radome immediately with a dry cloth to prevent water spots. Avoid excessive force and allow for further air drying.

10.4. De-icing

De-icing the surface of the radar is the process of removing ice and preventing ice buildup for a certain period to maintain optimal detection performance. When the ambient temperature is 0°C (32°F) or lower, a deposit or coating of ice may form on the surface of the radar. Icing hampers the function of the radar, affecting its efficiency and performance.

⚠ CAUTION

1. Prioritize safety by wearing appropriate protective gear, including gloves and goggles.
2. **Do not de-ice the radar mechanically!** Use **only a soft washing brush** to gently remove loose snow or ice deposits. The radome damages easily.
3. After de-icing, ensure to dry the surface with a soft cloth to prevent reformation of ice.

De-icing Fluids

Spraying Glycol based de-icing fluids may be used as a method for de-icing.

Warm Water

If ice has accumulated on the surface of the radar, rinsing the sensor with warm water is a method for de-icing. The maximum allowed temperature is 50°C (122°F). Always exercise caution when using water for de-icing, especially in very cold conditions, to avoid creating hazardous conditions due to re-freezing.

Hot Air

Hot air may also be used as a method for de-icing. A heater may be used or a hot air blower, making sure not to overheat one spot. The maximum allowed temperature is 50°C (122°F).

11. Technical Data

11.1. IRIS A2 Specifications

Table 1: Rated Data

Rated Data	
Voltage Rating	48 VDC
Power Rating [nominal / maximum]	200 W / 336 W
Technology	FMCW
Frequency Band	X-band
Frequency	8900 MHz, 9250 MHz or 9650 MHz
Tuning Range 8900 MHz	8775 – 9100 MHz (except: 8850 MHz[2])
Tuning Range 9250 MHz	8975 – 9300 MHz (except: 9058 MHz[2])
Tuning Range 9650 MHz	9500 – 9800 MHz (except 9600 MHz[2])
Power Output	2 x 12 W
Revolutions Per Minute	30 rpm
Update Rate	1s
Instrumented Range	5 km (3.1 mi) or 12 km (7.5 mi) with Long Range Mode[3]
Azimuth Coverage	360°
Elevation Coverage	60° (-10° offset angle)
ERP / EIRP	62 dBm, 32 dBW / 64 dBm, 34 dBW
Radiation Safe Distance (10 W/m^2 Point)	0.91 m (3 ft)

Table 2: Environmental Conditions

Environmental Conditions	
Environmental Rating	IP66/Type 4
Operating Temperature	-46°C – 50°C (-50.8°F – 122°F), STANAG 4370: Cat. C2 (cold), Cat. A1 (hot dry)
Operating Relative Humidity	< 95% at 40°C (104°F)

[2] The design of the signal generator prevents it from operating at this frequency. The IRIS RADAR GUI (IRIS FW 5.1 and processing station SW 24.01) will issue a warning if the chosen sweep parameters (center and bandwidth) cover this frequency.

[3] Certain published performance metrics do not apply when operating in Long Range Mode.

Environmental Conditions	
Storage Temperature	-46°C – 65°C (-50.8°F – 149°F)
Storage Relative Humidity	< 95% at 40°C (104°F)
Operating Height (AMSL)	< 2000 m (<6560 ft)
Operating Wind Speed	≤ 47 m/s (105 mph)
Operating Wind Speed for Tripod	≤ 20 m/s (45 mph)
Idle Wind Speed	≤ 47 m/s (105 mph)
Idle Wind Speed for Tripod	≤ 20 m/s (45 mph)
Vibration Severity	STANAG 4370: Method 401

Table 3: Mechanical Data

Mechanical Data	
Upmast Dimensions	550 dia*630 mm (21.7 dia*24.8 in)
Upmast Weight (Excluding Foot / Pedestal)	29 kg (64 lb)
Radome Material	Quartz
Sensor Colour	‣ RAL 9016, Traffic White ‣ RAL 1039, Sand Beige ‣ RAL 1039-F9, Sand Beige ‣ RAL 6031-F9, Bronze Green ‣ BTF, Brun Terre de France

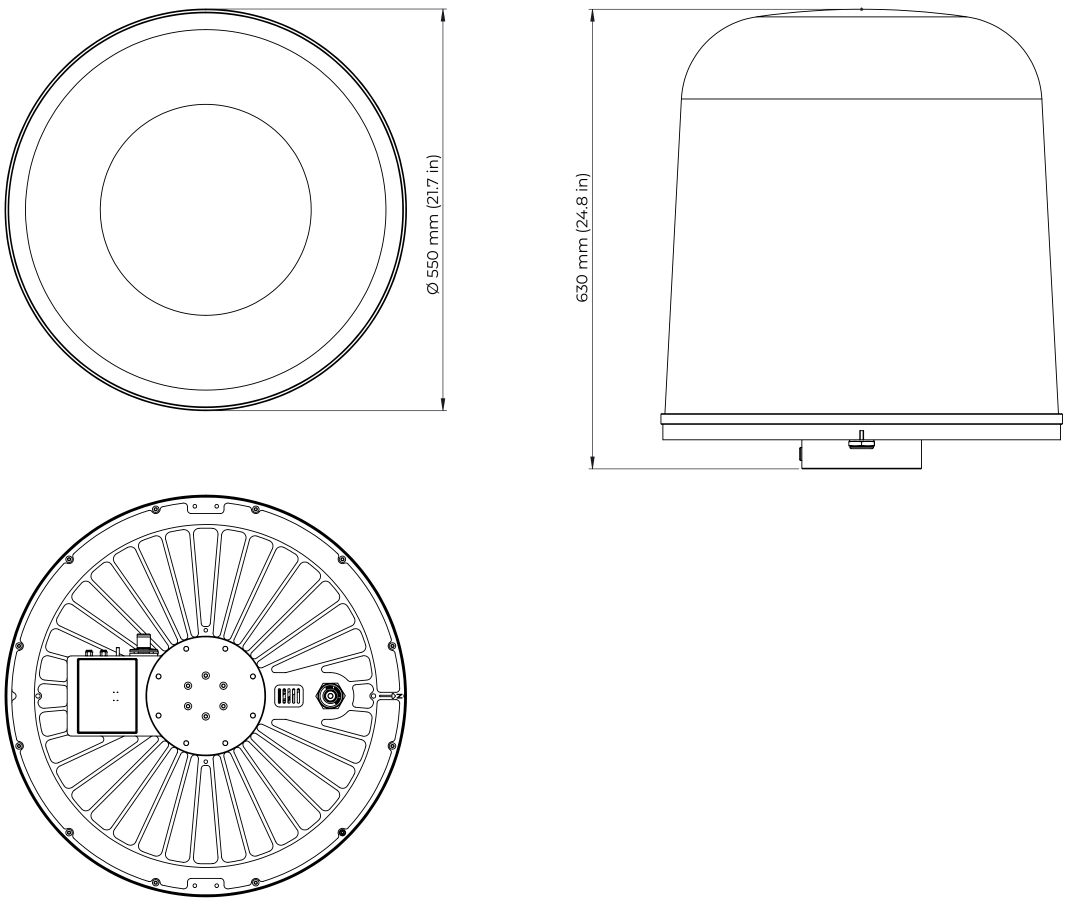

Figure 12: Upmast dimensions

Table 4: System Performance

System Performance	
Angular Resolution	8900 MHz = 7.5° 9250 MHz = 6.9° 9650 MHz = 6.0°
Angular Accuracy	8900 MHz = 0.75° 9250 MHz = 0.69° 9650 MHz = 0.6°
Range Resolution	7.2 m (23.6 ft)
Long Range Resolution	17.2 m (56.69 ft)
Range Accuracy	0.6 m (2 ft)
Long Range Accuracy	1.44 m (4.72 ft)
Elevation Resolution	20°
Elevation Accuracy	1°[4]
Maximum Doppler Velocity	8900 MHz = 33.68 m/s (75.34 mph) 9250 MHz = 32.41 m/s (72.50 mph) 9650 MHz = 31.07 m/s (69.50 mph)
Resolution	8900 MHz = 1.26 m/s (2.82 mph) 9250 MHz = 1.22 m/s (2.73 mph) 9650 MHz = 1.16 m/s (2.59 mph)
Accuracy	8900 MHz = 0.104 m/s (0.23 mph) 9250 MHz = 0.102 m/s (0.22 mph) 9650 MHz = 0.104 m/s (0.23 mph)

Table 5: Radar Cable: Mechanical Data

Radar Cable: Mechanical Data	
Product Name	IRIS Radar Cable A2
Number of Cables Sensor to Processing Station	1

[4] Between the centre of the lowest beam and the centre of the highest beam (resp. -5° and +45° by default).

Radar Cable: Mechanical Data	
Material (Sheathing)	LSZH
Cable Length	‣ 5 m (16.4 ft) ‣ 10 m (33 ft) ‣ 15 m (49.21 ft) ‣ 25 m (82.02 ft) ‣ 30 m (98.43 ft) ‣ 50 m (164 ft)
Minimum Bend Radius	92 mm (3.62 in)

Table 6: Hardware Compatibility

Hardware Compatibility	
Mechanical Interface	Flange mounting: can be mounted on any structure (e.g., pole, mast) with compatible flange. More info: IRIS A2 Interface Drawing [185.980.002].
External Connections	‣ Radar power/data connector ‣ Two SMA connectors (OTM) ‣ Earthing point
Processing Station Options	‣ IRIS MPS A2 ‣ IRIS RPS A2 ‣ IRIS SPS A2 ‣ IRIS IPS A2
Add Ons	‣ Quick mount with alignment lock ‣ Tripod
Multi-radar	Connect up to four sensors simultaneously

Table 7: Software Overview

Software Overview	
Operating System	LTS Ubuntu

Software Overview	
Software Tools	IRIS Radar GUI Drone Viewer IRIS Installation Wizard Db Analyses
API	XML interface ASTERIX interface (CAT034, CAT048) SAPIENT V2 Compliant interface Cursor-on-Target (CoT)

Table 8: Certification

Certification	
Sensor	CE marked MIL-STD-810 compliant (includes OTM) STANAG 4370 compliant: AECTP 300 (Climatic), AECTP 400 (Mechanical), AECTP 500 (EMC & Electrical) FCC, part 15 compliant (9250 and 9650 MHz only) Certified by QPS to applicable UL/CSA standard (9250 and 9650 MHz only)

Table 9: Transport Case

Transport Case	
Suprobox	Dimensions: 1070*820*720 mm (42.1*32.3*28.3 in), weight: 39 kg (86 lb)
Suprobox Crate	Dimensions: 1335*1000*900 mm (52.56*39.37*35.43 in)

12. Troubleshooting IRIS Radar

Issue: Radar Not Operational / Dropped or Missing Packets / Low Throughput

Description: These issues often occur due to disconnected or poorly connected fiber optic connections, as well as environmental factors like debris and moisture.

Root Cause: Issues with fiber optic connections (fiber10GB, fiber1GB) affecting data transmission.

Solution:

- Open terminal and check 'ifconfig' to verify status and IP addresses of 'fiber10GB' and 'fiber1GB'.

```
fiber10GB: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 9700
        inet 192.168.129.1  netmask 255.255.255.0  broadcast 192.168.129.255
        ether f8:f2:1e:a9:87:cd  txqueuelen 1000  (Ethernet)
        RX packets 50760137  bytes 491104741244 (491.1 GB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 142  bytes 19335 (19.3 KB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0
        device memory 0x96200000-96280000

fiber1GB: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        inet 192.168.128.1  netmask 255.255.255.0  broadcast 192.168.128.255
        RX packets 50805  bytes 6134371 (6.1 MB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 55241  bytes 4256287 (4.2 MB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0
        device memory 0x96280000-96300000
```

- Ensure 'fiber10GB' and 'fiber1GB' are running; If not, do not start the radar and contact Service & Support!
- Check IRIS Radar GUI for error statuses related to the motor and radar. If both issue an error, the 1GB fiber is disconnected/broken. Please contact Service & Support.
- Go to **Settings> Radar Control** - tab **General** and verify 'RX Link Budget 10GB'; it should be green, between 20%-80%. The aimed value is 50%, but any value within this range is acceptable for proper 10GB fiber connection.

Radar SFP Status

Temperature 10Gbit:	44.7031
RX Link Budget 10Gbit:	65.7%
Temperature 1Gbit:	36.957
RX Link Budget 1Gbit:	105.0%

- Contact Service & Support if issues persist or 'RX Link Budget 10GB' is (red) outside optimal range.

13. Recycling & Disposal

NOTICE

1. This product complies with European Directive 2012/19/EU on Waste Electrical and Electronic Equipment (WEEE), as implemented in The Netherlands under ID number WEEENL0839 and registered with Stichting OPEN (Registration No. RL00038478).
   When disposing of this product:
   a. It is prohibited to transfer the product, whether operational or at the end of its life, to any foreign person or entity.
   b. The product must not be discarded as household waste. Instead, it should be recycled or disposed of in accordance with local regulations.

   For proper disposal and recycling options, please consult your local waste management authority
2. This product is subject to recycling regulations in France (Triman logo). This product must be sorted. Please follow local sorting and recycling instructions in accordance with the applicable regulations.

FR
Cet appareil et ses accessoires se recyclent
À DÉPOSER EN MAGASIN
OU
À DÉPOSER EN DÉCHÈTERIE
Points de collecte sur www.quefairedemesdechets.fr

14. Appendix

14.1. Abbreviations

Abbreviation	Description
ADS-B	Automatic Dependent Surveillance-Broadcast
AGL	Altitude Ground Level
dBi	Decibel relative to isotropic antenna
dBm	Decibel relative to one milliwatt
EIRP/ERP	Equivalent (Isotropic) Radiated Power
FMCW	Frequency Modulated Continuous Wave
GUI	Graphical User Interface
GPS	Global Positioning System
IPS	Integrator Processing Station
KVM	Keyboard Video Mouse
LAN	Local Area Network
MPS	Mobile Processing Station
MRU	Motion Reference Unit
Nm	Newton Meter
OTM	On the Move
RPS	Rugged Processing Station
SPS	Server Processing Station
WGS-84	World Geodetic System 1984

14.2. Reference Documents

Ensuring the safe, efficient, and effective use of the radar system relies heavily on the availability of clear and accessible documentation. In response to the modularity of our product offerings, we adopt a modular documentation approach where various deliverables complement and support the effective use of the radar system. Rather than consolidating all the necessary information into one extensive manual, this approach ensures that the information provided to users is both specific and relevant, reducing the complexity typically associated with large manuals and allowing for more efficient updates when changes are needed.

A separate document titled 'IRIS Reference Documents [185.927.024]' outlines the specific documentation required for the radar system. Please note that these document references focus solely on our proprietary systems and do not include information or references for third-party supplier devices.

This content is subject to changes.

If you have any questions about this document, please contact Robin Radar by sending a message to info@robinradar.com.
www.robinradar.com