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Analysis of An MSSR Target Loss Caused By A Tripped Antenna-Motor Rcbo And An Open-Door Sensor Fault During A Lightning-Accompanied Storm

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Abstract

The Monopulse Secondary Surveillance Radar (MSSR) enables Air Traffic Controllers (ATC) to monitor aircraft position, altitude, and identity through transponder interrogation. At a branch of Indonesia's air navigation service provider, aircraft targets disappeared from an ELDIS MSSR display during heavy rain accompanied by lightning, together with an input alarm on the ATC System's System Management Console (SMC). This article analyzes the cause and handling of the disturbance using a descriptive case study comprising field observation, inspection of Local Control and Monitoring System (LCMS) parameters, and root-cause tracing along the radar's electrical path and sensors. The target loss was attributed to a tripped Residual Current Circuit Breaker with Overcurrent Protection (RCBO) that interrupted the antenna-motor power supply, together with a bad-contact open-door sensor in the antenna shelter; lightning involvement is inferred from timing and was not verified by measurement. Cleaning the sensor and shelter, switching the RCBO back on, and restarting the radar per the service provider's Director's Decree No. KP 35 of 2019 restored stable target display. This single case suggests the importance of adequate lightning protection and grounding in radar installations and of CNS technicians' readiness for systematic electrical troubleshooting to maintain aviation surveillance reliability.

Keywords: MSSR radar, lightning strike, lightning protection, open door sensor, aviation surveillance reliability

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Introduction

Air transportation plays a vital role for Indonesia as an archipelagic nation, so flight safety and orderliness depend heavily on the readiness of the air

navigation facilities managed by Indonesia's air navigation service provider. One of the primary surveillance facilities used by Air Traffic Controllers (ATC) to monitor aircraft movement is the Monopulse Secondary Surveillance Radar (MSSR), a secondary radar that works by interrogating an aircraft's transponder to obtain accurate position, altitude, and identity data, in contrast to a primary radar, which only detects the reflected signal from an aircraft's body (Orlando, 1989; Strohmeier et al., 2014).

MSSR radar antennas are generally mounted on an open tower structure at an elevated location to achieve optimal detection range, a condition that in turn makes the radar installation vulnerable to direct and indirect lightning strikes (Rakov & Uman, 2003). Lightning can damage antenna structures and, through induced surge currents, the control and sensor circuits connected to them when protection is inadequate (International Electrotechnical Commission [IEC], 2010; Gomes & Diego, 2011). Beyond antenna-structure protection, the reliability of the grounding system within an electrical installation is also a determining factor in the effectiveness of channeling lightning surge current to earth, thereby minimizing the risk of damage to electronic equipment and control sensors (Sarker et al., 2025).

At the Radar Equipment Engineering Unit of a branch of the service provider, an ELDIS-brand MSSR radar system is used to support air traffic services within the airport's airspace. However, under extreme weather conditions of heavy rain accompanied by lightning, the MSSR radar once experienced a disturbance in which aircraft targets disappeared from the Radar Monitoring Module (RMM) monitoring display, together with an input alarm appearing on the ATC System's System Management Console (SMC), requiring systematic root-cause tracing to ascertain the cause and the appropriate handling steps.

A disturbance event caused by extreme weather of this kind underscores the importance of CNS technicians' understanding of the electrical architecture and protection systems within a radar installation, given that mishandling or a lack of awareness of standard procedures is one of the human-error factors that can slow the restoration of aviation navigation services (Reason, 1990; Olaganathan, 2024). This technical competence is also shaped through technicians' direct involvement in handling problems in the field, which has been shown to contribute to the work readiness of aviation vocational technicians (Lubis, 2021; Darni et al., 2025).

Rather than claiming novelty beyond a single case, the contribution of this article is a documented troubleshooting sequence that other CNS units can reuse. This article aims to (1) analyze the cause of the aircraft-target loss on the ELDIS MSSR radar following a lightning-strike event, (2) document the handling steps taken until the radar returned to normal operation, and (3) review the principles

of lightning protection and grounding in a radar installation as a technical reference for other CNS and Radar Equipment units facing similar cases.

Research Method

This study uses a descriptive qualitative method with a case study approach, as put forward by Baxter and Jack (2008), which is suitable for systematically describing the process of identifying and analyzing a technical problem in a single unit of study based on field data and technical standard documents, without aiming for statistical generalization.

Data were collected directly at the work site, at the Radar Equipment Engineering Unit of the service provider's branch, during the period of 4 April 2022-31 August 2022. The object of this study is the ELDIS-brand MSSR radar system, based on a disturbance event on 10 May 2022 at 20:53 local time, namely the appearance of a radar input alarm on the ATC System's SMC coinciding with heavy rain accompanied by lightning.

The tools and references used in the analysis process included: the SMC ATC System and radar RMM monitoring screens to monitor aircraft-target status; the Local Control and Monitoring System (LCMS) to check radar-equipment parameters and alarm status; the distribution power panel and Multiple Circuit Breaker (MCB) to check the power-supply path; and the service provider's Director's Decree No. KP 35 of 2019 as the reference for the radar system's standard operating procedure (SOP). The listed instruments did not include dedicated electrical measuring devices (for example, an insulation tester or clamp meter), so the diagnosis rests on monitoring displays, alarm status, and visual and physical inspection.

The analysis stages carried out were as follows: (1) checking the SMC ATC System display and the radar RMM monitor to confirm the alarm status and aircraft-target display; (2) checking parameters on the LCMS in the radar building to identify the active alarm type; (3) checking the distribution power panel to trace the interrupted power-supply path; (4) waiting for safe weather conditions before accessing the antenna shelter directly; (5) checking the physical condition of the open-door sensor on the antenna shelter to identify damage caused by the lightning strike; and (6) carrying out handling in the form of cleaning the affected components and restarting the radar system per the SOP, followed by verifying the aircraft-target display on the RMM and ATC System.

Results and Discussion

Object Profile and Scope of the Study

The object of this study is the ELDIS-brand Monopulse Secondary Surveillance Radar (MSSR) system at the Radar Equipment Engineering Unit of a branch of the service provider, which functions to support air traffic services within the airport's airspace. As a surveillance facility whose antenna is mounted on an open tower structure to achieve optimal detection range, the MSSR radar has a high degree of vulnerability to extreme-weather disturbances, including direct and indirect lightning strikes that can affect the electrical components and control sensors in the antenna shelter.

MSSR Radar Working Principle and Vulnerability to Lightning Strikes

The MSSR radar works by transmitting an interrogation signal toward an aircraft's transponder, which then replies with a signal containing altitude and identity data, allowing the target position to be determined more accurately than a primary radar, which relies solely on reflected signals (Orlando, 1989). Because a radar antenna is generally mounted at a high, open location, the radar installation is vulnerable to becoming a lightning-strike point, whether through a direct hit on the antenna structure or through surge current induced via the power-cable and sensor-cable paths leading to the equipment inside the shelter (Gomes & Diego, 2011; Liang et al., 2013). Protection against these effects is addressed in the IEC 62305 series (IEC, 2010).

Problem Identification

On 10 May 2022 at 20:53 local time, during a routine equipment check per KP.35, the SMC ATC System display showed a radar input alarm, coinciding with heavy rain accompanied by lightning that had occurred beforehand. The involvement of lightning is inferred from the temporal coincidence with the storm; no lightning-counter or weather-station record is documented in the data analysed here. Further checking on the RMM monitor showed that the aircraft target did not appear at all on the monitoring display, with the potential to disrupt Air Traffic Controllers' ability to monitor aircraft movement within the airport's airspace.

Analysis Stages and Findings

The analysis was carried out in stages to trace the root cause of the radar disturbance, starting from checking the monitoring display through to physical inspection of components in the field. Table 1 presents a summary of the analysis stages together with the findings at each stage.

Table 1 Analysis Stages and Findings in Handling the MSSR Radar Open-Door Alarm

No.	Analysis Stage	Finding / Action
1	Checking the SMC ATC System display	radar input alarm appeared, coinciding with heavy rain accompanied by lightning
2	Checking the radar RMM monitor	Aircraft target not displayed on the monitoring screen
3	Checking parameters on the LCMS	Active open-door sensor alarm found
4	Checking the distribution power panel	RCBO found in tripped/down position, interrupting the antenna motor power supply
5	Checking the MCB panel	Normal condition
6	Physical inspection of the open-door sensor on the antenna shelter	Bad contact condition found; lightning involvement suspected but not verified
7	Cleaning the sensor and shelter, switching the RCBO back on, and restarting the radar system per SOP KP 35/2019	Radar target restored and displayed normally and stably on the RMM and ATC System

Table 1 shows that two conditions were found: a tripped RCBO that interrupted the antenna motor power supply, and an open-door sensor in the antenna shelter with a bad-contact condition. The loss of the aircraft target is attributed mainly to the tripped RCBO, since the antenna could no longer rotate and transmit target data normally, whereas the open-door sensor is associated with the alarm shown on the LCMS and SMC; this study did not establish whether the open-door alarm itself affects radar operation, nor why the RCBO tripped. Because the sensor had to be cleaned of dirt and residual moisture, contamination cannot be excluded as a contributing cause of the bad contact, in addition to or instead of lightning. The tripped-RCBO condition is consistent with studies showing that nuisance tripping of residual current circuit breakers is widely reported due to transient disturbances on electronic loads and certain environmental conditions (Roldán-Porta et al., 2014), while the bad-contact condition at the open-door sensor is consistent with findings that outdoor electrical connectors are prone to degradation in current-carrying performance due to vibration and environmental exposure (Zhang et al., 2025), making periodic health monitoring of connectors an important part of preventive maintenance for radar electronic equipment (Song et al., 2024).

Figure 1 presents a flowchart of the handling process carried out, starting from checking the SMC and RMM displays, checking the LCMS parameters and the distribution power panel, the decision to wait for safe weather conditions before accessing the antenna shelter, through to checking the open-door sensor and the final handling in the form of component cleaning and a radar-system restart per SOP KP 35/2019.

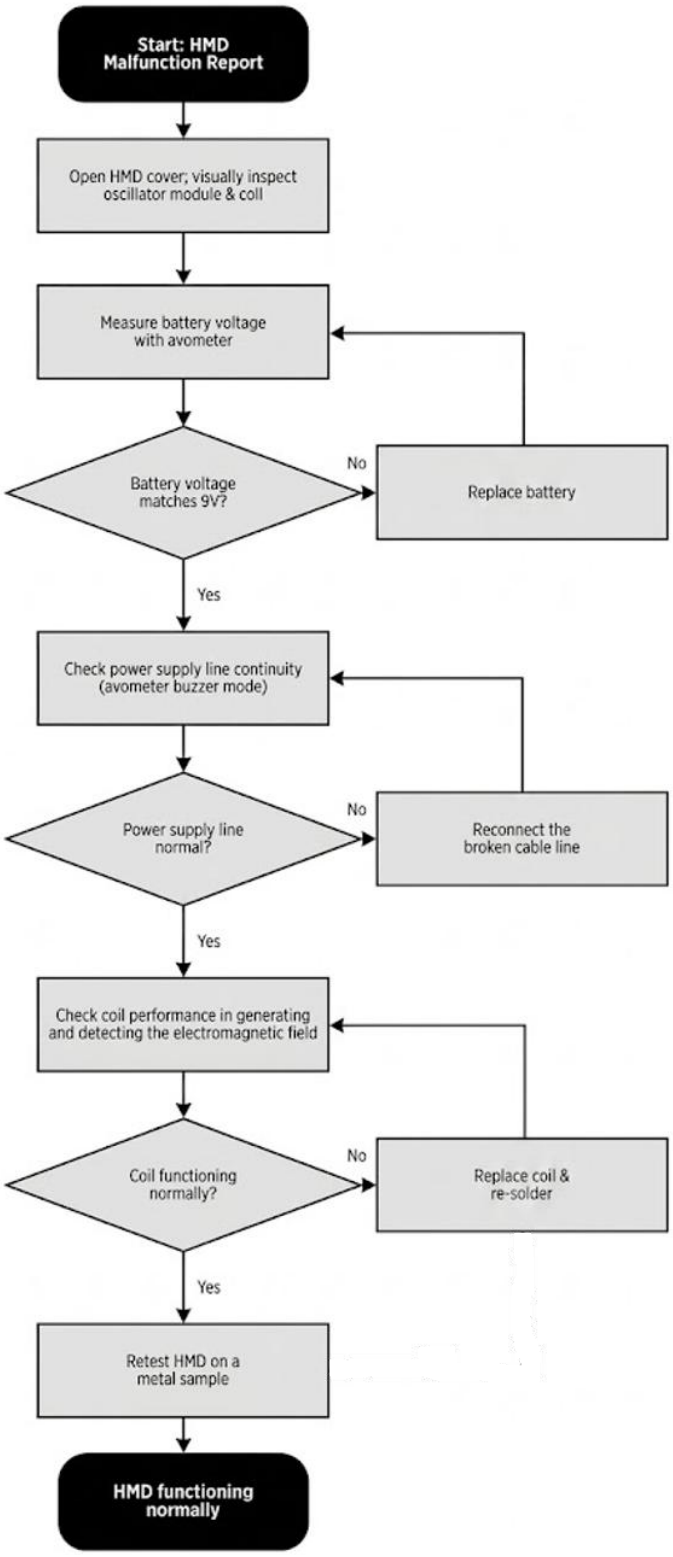


Figure 1 Flowchart of the MSSR Radar Open-Door Alarm Handling Process Due to a Lightning Strike at the service provider's branch (Source: Authors' analysis of the 2022 case records)

Lightning Protection and Grounding Systems in the Radar Installation

The bad-contact condition found at the open-door sensor, possibly related to the lightning-accompanied storm, points to the importance of an adequate

lightning protection and grounding system in a radar installation. Conceptually, a radar installation can be divided into several Lightning Protection Zones (LPZ), as presented in Table 2, a conceptual classification following the zoning concept of IEC 62305-1 (IEC, 2010) that illustrates the degree of exposure to lightning strikes and electromagnetic fields at each part of the installation.

Table 2 Classification of Lightning Protection Zones (LPZ) in the Radar Installation

Protection Zone	Description	Example in the Radar Installation
LPZ 0A	Area at risk of direct lightning strikes and full electromagnetic field exposure	Radar antenna and open tower structure
LPZ 0B	Area protected from direct strikes but still exposed to the full electromagnetic field	Area around the lightning-protection air terminal/finial
LPZ 1	Area within a protected structure; surge current has been reduced through the grounding and bonding system	Distribution power panel and control sensors in the antenna shelter
LPZ 2	Further-protected area with additional electromagnetic field reduction	Radar electronic equipment room (signal processing, receiver/transmitter)

Table 2 places the open-door sensor and the distribution power panel in LPZ 1, an area that should already be protected through grounding and bonding; this placement is a conceptual assumption, since no site survey is reported. The bad-contact condition found here may indicate that surge-current channeling along the grounding path needs evaluation, but this cannot be concluded without measurements, because grounding performance depends on soil resistivity, electrode condition, and configuration (Sarker et al., 2025; Malanda et al., 2018; Institute of Electrical and Electronics Engineers [IEEE], 2015), and staged surge protective devices (SPDs) along the power path limit transient overvoltage before it reaches sensitive equipment (Ahmad et al., 2018; Yang et al., 2026). Grounding resistance, SPD condition, and air-terminal condition were not recorded in this case, so periodic inspection of these elements as part of preventive maintenance (Al-Duais et al., 2022) is offered as a suggestion rather than a finding.

Handling and Verification

Handling was carried out by cleaning the open-door sensor and the antenna shelter area of dirt and residual moisture that could trigger bad contact, switching the RCBO back on at the distribution power panel, and restarting the radar system according to the stages in SOP KP 35 of 2019, comprising checking the MCB sequence, standby mode, LCMS login, activating MSSR-1, setting the antenna rotation to 10 rpm, checking the RF Switch channel, activating Power TX, through to verifying the SSR auto-backup function. Verification was carried out by observing the RMM and SMC ATC System displays, which showed that the aircraft target was again detected normally and the LCMS status had returned to an alarm-free condition.

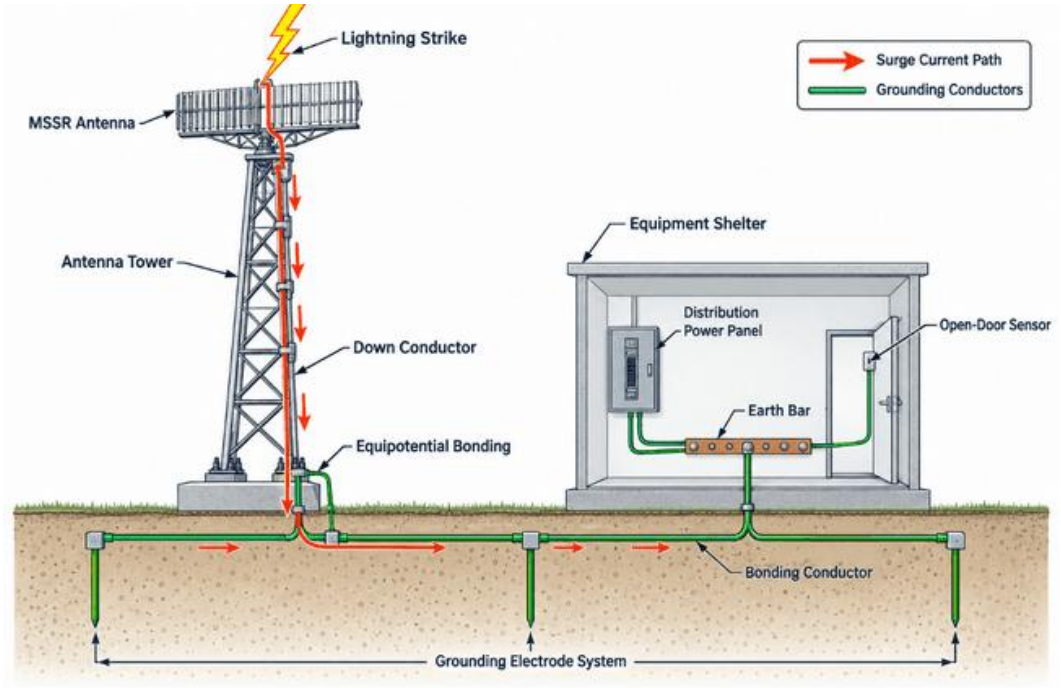


Figure 2 Conceptual Illustration of a Lightning Strike on the MSSR Radar Antenna Shelter and the Open-Door Sensor Protection Path (Source: Authors' conceptual illustration)

Figure 2 presents a conceptual illustration of the lightning-strike path toward the radar antenna structure through to causing a disturbance at the open-door sensor and the distribution power panel inside the shelter, as a visual complement to the explanation of the radar installation's vulnerability to lightning strikes described in the previous section.

Importance of Technician Competence and Compliance with Standard Procedures

This case study confirms that handling a radar disturbance caused by extreme weather requires strict compliance with standard operating procedures, including the occupational-safety aspect of waiting for safe weather conditions before accessing an antenna shelter located in an open area at high risk of subsequent lightning strikes. Unawareness of or negligence toward standard procedures is one of the human-error factors that can slow the restoration of aviation navigation services or endanger technician safety (Reason, 1990; Olaganathan, 2024). Technicians' competence in performing electrical troubleshooting and handling the radar protection system is also shaped through direct involvement in handling problems in the field, which has been shown to contribute to the work readiness of aviation vocational technicians (Lubis, 2021) and to the alignment of technical understanding with industry work systems (Darni et al., 2025). Beyond technicians' readiness in reactive disturbance handling, the application of scheduled preventive and corrective maintenance strategies also plays an important role in maintaining the reliability of complex equipment under conditions of imperfect inspection, as reviewed in a historical

study of preventive and corrective maintenance models in aerospace systems (Ulansky & Raza, 2024).

Discussion

This case suggests that an MSSR radar disturbance that coincides with a lightning-accompanied storm is not necessarily due to direct damage to the radar's main electronic components, but can originate from relatively simple yet critical points, such as the open-door sensor and the circuit breaker (RCBO) on the antenna motor's power supply path. The systematic approach -- from checking the monitoring display, tracing the electrical path, through to physically inspecting the sensor -- was effective in isolating the two fault points in this case. Given that radar installations are generally located in open areas prone to lightning strikes (Rakov & Uman, 2003; Gomes & Diego, 2011), periodic evaluation of the lightning protection and grounding system, accompanied by strengthening technicians' competence in electrical troubleshooting procedures, is a suggested step to sustainably maintain the reliability of aviation surveillance services.

Limitations. This is a single case, so the findings cannot be generalized. The data date from 2022 (4 April–31 August 2022), so the account relies on records of a past event. Lightning involvement is inferred from timing, and no lightning-counter, weather, or physical-trace record is documented. The cause of the RCBO trip was not investigated (for example, load current, motor insulation resistance, and cable condition were not recorded), and the risk of repeated tripping was not assessed. The duration of the radar outage and the contingency actions taken by air traffic control are not documented. Grounding resistance, SPD condition, and air-terminal condition were not measured, so the protection-related statements are suggestions for further evaluation.

Conclusion

The loss of the aircraft target on the MSSR radar was attributed to a tripped RCBO on the distribution power panel that interrupted the antenna motor's power supply, and a bad-contact open-door sensor was found in the antenna shelter and associated with the input alarm. Both occurred during heavy rain accompanied by lightning, but the involvement of lightning is inferred from timing and was not verified by measurement or lightning records. The staged analysis, from the SMC and RMM displays through the LCMS parameters to physical inspection, isolated both points. Cleaning the sensor and shelter, switching the RCBO back on, and restarting the radar per SOP KP 35 of 2019 restored normal, stable target detection on the ATC System. This single case suggests that radar reliability under extreme weather depends on lightning protection and grounding and on technicians' compliance with safety and troubleshooting procedures; periodic evaluation of the protection system and strengthening of technician competence are suggested, to be supported by measurement data in future work.

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AI Declaration

The author acknowledges the use of artificial intelligence (AI) tools in supporting the preparation of this manuscript. The author remains fully responsible for the accuracy, originality, and integrity of the research and its findings.

Disclosure statement

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