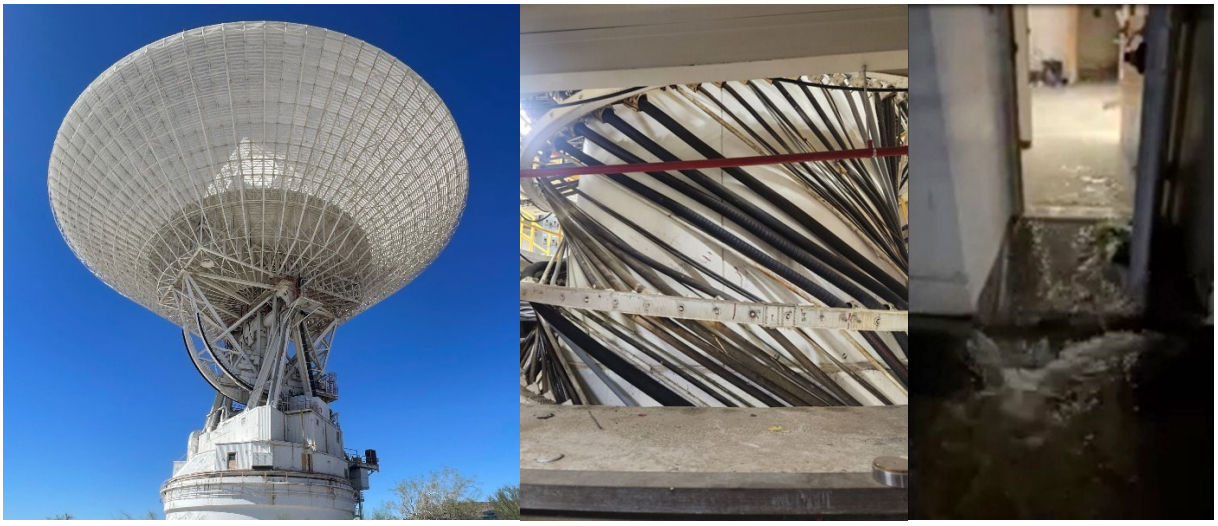
National Aeronautics and Space Administration

Deep Space Station 14 (DSS-14)
Azimuth Over-Rotation Mishap

Mishap Classification: Mishap Type A

NMIS Case Number: 25-103154



Date of Mishap: September 16, 2025
Date of Report: March 30, 2026

CONTENTS

FIGURES

TABLES

Acknowledgements

The Deep Space Station 14, or DSS-14, Over-rotation Mishap Investigation Board would like to acknowledge the support received throughout the investigation from NASA's SCaN (Space Communications and Navigation) Program, the NASA Engineering and Safety Center (NESC), NASA's Jet Propulsion Laboratory Deep Space Network project, and site staff at the Goldstone, Madrid, and Canberra Deep Space Communication Complexes (GDSCC/MDSCC/CDSCC). Without their expert contributions, candor, and mission focus, this investigation would not have been possible.

1. Approval and Summary

1.1 Signature Pages

1.1.1 Investigating Authority Signatures

To the best of my knowledge the report contents are accurate and complete, and I concur with the documented findings and recommendations.

Voting Members

Andrew Maynard Digitally signed by Andrew Maynard Date: 2026.04.01 08:04:06 -04'00'

Andrew Maynard
Chair
Assistant Deputy Associate Administrator for Programs, Science Mission Directorate

Jonathon King Digitally signed by Jonathon King Date: 2026.03.31 07:35:30 -05'00'

Jonathon King
Deputy Chair/Technical SME
Moon-to-Mars Program

James Bush Digitally signed by James Bush Date: 2026.03.31 09:07:28 -04'00'

Aaron Bush
Safety Officer
Office of Safety and Mission Assurance

Ian Maddox Digitally signed by Ian Maddox Date: 2026.04.02 16:17:44 -04'00'

Ian Maddox
Human Factors/Technical SME
Office of the Chief Engineer

Joseph Obrien Digitally signed by Joseph Obrien Date: 2026.03.31 16:24:58 -04'00'

Joseph O'Brien
Technical SME
Near Space Network

Non-Voting Members

Charu Esper
Executive Secretary
Chief of Staff, SCaN

TED SOBCHAK Digitally signed by TED SOBCHAK Date: 2026.03.31 08:53:39 -04'00'

Ted Sobchak
Technical SME
SCaN Program

Ex Officio

I assure the following:

1. The investigation was conducted in conformance with NASA policy and NASA Procedural Requirements (NPR) 8621.1D.
2. The investigation process was impartial, independent, and non-punitive.
3. The mishap investigation report contains all the required elements.
4. The mishap investigation report accurately identifies proximate causes, root causes, and contributing factors. The process was followed, and causes were identified and labeled correctly.
5. Adequate facts have been gathered and analyzed to substantiate the findings.
6. Recommendations reasonably address the causes and findings.
7. Each recommendation is associated with or traceable to at least one significant finding.

Lester Jean Digitally signed by Lester Jean Date: 2026.03.31 08:17:50 -04'00'

Lester Jean, CSP
Ex Officio
NSC Mishap Investigation Specialist
Kennedy Space Center, NASA

1.1.2 Advisors' Signatures

I sign this report indicating that the report sufficiently meets the legal requirements for NPR 8621.1D.

DANIEL THOMAS Digitally signed by DANIEL THOMAS Date: 2026.04.02 12:09:34 -04'00'

Dan Thomas
Legal Advisor
Office of General Counsel

I sign this report indicating that it is consistent with the policies and procedures in my functional area.

James Russell Digitally signed by James Russell Date: 2026.03.31 09:13:55 -04'00'

James J. Russell
Public Affairs Advisor
Office of Communications

1.1.3 Consultants

Name	Organization	Function/Subject Matter Expertise (SME)
Mark Balzer	NASA/NESC	JPL Principal Mechatronics Engineer
Justin Huebner	NASA/SCaN	Network Integrity and Cybersecurity
Isabel Hernandez	NASA/OSMA	Human Factors Expert

Table 1: MIB Consultants

1.2 Executive Summary

NASA's large 70-meter radio frequency antenna (Deep Space Station 14, or DSS-14) at the Goldstone Deep Space Communications Complex (GDSCC) near Barstow, California, over-rotated, causing stress on the cabling and supports in the center of the structure. Water lines from the antenna's fire-suppression system were also damaged, resulting in flooding in the facility. No injuries were reported, and the antenna is offline.

As this report will detail, following the troubleshooting of an issue with the antenna's emergency stops (E-stops), the technical team at GDSCC overrode and bypassed multiple safeguards that would normally have prevented over-rotation. The team eventually considered the safeguards themselves to be at fault rather than realizing the antenna was at risk of over-rotation, leading to an inadvertent bypass of these important mechanisms.

The Mishap Investigation Board (MIB) investigated the mishap and identified root causes associated both with the design of the system and with the management and operations of the system. The investigation revealed inadequate training, insufficient written procedures, a reliance on undocumented behaviors and tacit knowledge, and deficiencies in the antenna's control logic.

In addition to the root causes listed above, the hydraulic limit system — the final failsafe against over-rotation — was discovered to have been severely damaged to the point of inoperability in an unknown and undocumented prior incident. The MIB also was unable to find evidence that the performance of the hydraulic limit system at DSS-14 had been operationally tested in more than twenty years.

A rigorous Human Factors Analysis and Classification System (HFACS) assessment was performed, revealing some cultural and behavioral challenges. Antenna operators failed to sufficiently plan off-nominal activities while troubleshooting and operating outside their training and qualifications. Personnel directing and executing tasks did not sufficiently consider the potential consequences of the actions being taken, exacerbating the damage to the antenna in the process. These actions took place in an environment that prioritized a rapid return to operations over the health of assets or personnel.

The MIB has provided a number of specific findings, observations, and recommendations based on the investigation. Findings are derived from analytical evidence and represent conclusions reached through the investigative process. Recommendations have been written to address each finding and some of the observations, focusing primarily on seven critical areas: training, technical rigor, vigilance, design remediation, procedure remediation, roles and responsibility reform, and safety

and mission assurance. It is the MIB's position that implementation of the recommendations presented will prevent future recurrence of this kind of mishap and will ultimately lead to a more robust Deep Space Network (DSN) for NASA and its partners.

2. Narrative and Facts

2.1 Mishap Context

The mishap occurred at DSS-14, a critical 70-meter antenna used for communicating with deep space missions, located at the GDSCC. The GDSCC complex is one of three complexes that make up NASA's DSN, along with sites in Madrid, Spain (MDSCC) and Canberra, Australia (CDSCC). The network is supported by the Deep Space Operations Center (DSOC) at NASA's Jet Propulsion Laboratory (JPL) in Pasadena, California, which serves as the central hub for DSN communications. The DSN project is managed under NASA's SCaN (Space Communications and Navigation) Program, which is part of the Space Operations Mission Directorate (SOMD) at NASA Headquarters in Washington.

The DSN project is administered under contract with JPL. Operations at GDSCC are conducted through a subcontract between JPL and a company named Peraton, which is responsible for the operations and maintenance of GDSCC facilities. Peraton also manages operations at the DSOC, coordinating between the network and the missions that utilize it.

Prior to 2017, each complex was responsible for the 24/7 operation of the assets located at its respective site. In 2017, the DSN adopted an operational concept known as "Follow the Sun." Under this model, operational control of all antennas across all three sites is managed by the complex currently in daylight. In this approach, link control operators (LCO) staff a centralized control room to oversee primarily automated processes, with control transferring between sites at the start and end of each shift. A Technical Site Monitor (TSM) remains at each site overnight, after network control has shifted to retain a "boots-on-the-ground" presence for any anomalies that cannot be handled remotely. Additional detail on the "Follow the Sun" model is provided in DSN document 842-328-B, located in the data archive associated with this report. The TSM's responsibilities, as defined in DSN project documentation, generally include managing on-site emergencies and equipment failures. However, during the mishap investigation, TSM duties were observed to vary significantly by location and operator.

During any shift, the LCOs and the TSMs at each site are under the authority of the supervisor on duty (SOD), who is responsible for the overall network management during that shift. In general, SODs are experienced personnel drawn from the pool of LCOs. Antenna operations are largely automated and pre-scheduled, requiring little manual engagement on the part of LCOs, who primarily serve to monitor those automated processes. Maintenance tasks are generally performed during day shift with maintenance teams composed of one or more engineers (e.g., a Servo Systems Engineer (SSE)) and technicians.

In addition to personnel directly supporting antenna operations, there are other elements that enable the DSN to function smoothly. Peraton contractor staff at the DSOC coordinate with missions utilizing DSN, acting as the primary customer interface. Security officers at each site are responsible

for the physical security and for managing physical access control. There also is a cadre of engineers known as Operations Engineers (OEs) contracted under Peraton at a facility in Monrovia, California, near Pasadena.

In DSN operations, multiple mechanisms are used to identify and escalate issues and anomalies across the three complexes. Voice loops between the control centers allow communication between the SOD and TSMs at other sites. Discrepancy Reports (DRs) are handled in a JPL-managed data system called the DR Management System (DRMS), which tracks any deviation from nominal operations resulting in a service loss. Flash reports are used by the DSN to rapidly escalate significant problems recorded in DRMS to project and program management within both the DSN and SCaN.

Goldstone Geographical Context

Goldstone is a geographically dispersed site, covering many square miles of the Fort Irwin installation in Southern California's Mojave Desert. The key site elements are shown in Figure 1, below, including an access-control gate to the south and a complex containing management offices and a cafeteria known as "Echo" near the center of the facility. The "Mars" site contains both the GDSCC control room (known as SPC-10), the DSS-14 antenna, and other outbuildings.

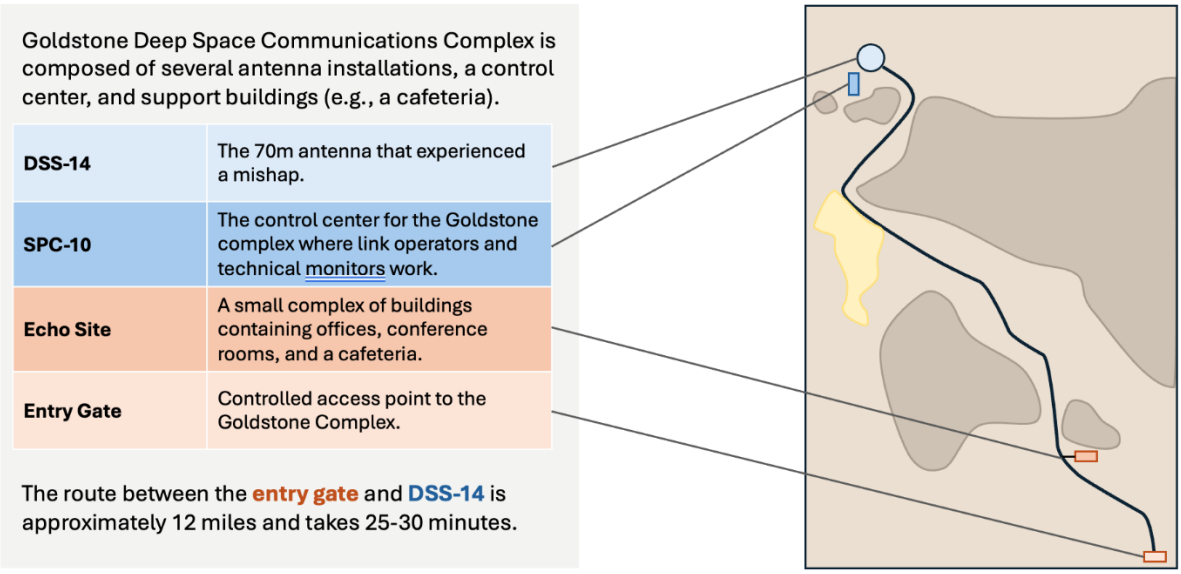


Figure 1: GDSCC Geographical Context

Antenna Orientation

The DSS-14 antenna was originally built as a 64-meter antenna and began operations in 1966 after three years of construction. In 1988, it was upgraded to its current 70-meter configuration to add additional capability and modernize internal electronics. As shown in Figure 2, it consists of a stationary cylindrical base approximately 10 meters tall and 30 meters in diameter, topped with a large rotating structure. The top structure provides both azimuth and elevation rotation and houses control systems and antenna hardware.

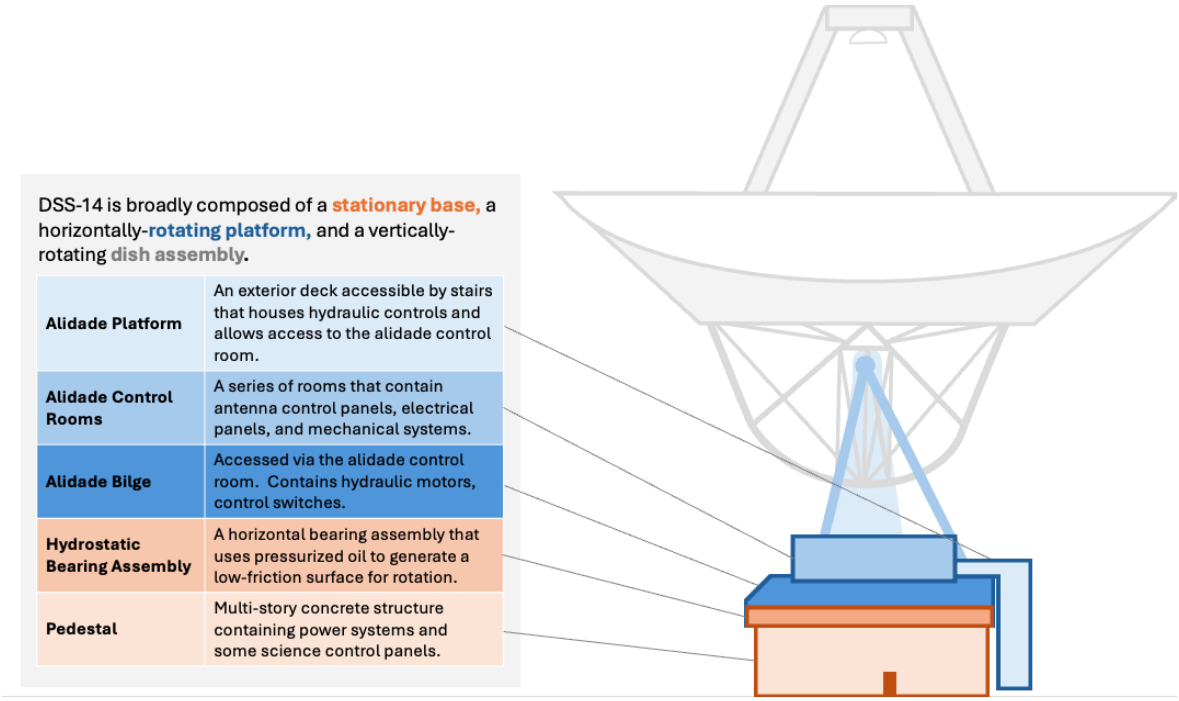


Figure 2: DSS-14 Physical Context

A collection of flexible hoses and cables runs between the static and rotating structures, carrying power, data, and working fluids (e.g., fire-suppression water and coolant). This set of hoses and cables, along with supporting structural elements, comprises the "cable wrap." The slack in these hoses and cables allows azimuth rotation in either the clockwise (CW) or counterclockwise (CCW) direction, measured from a "neutral" point where the hoses and cables hang vertically (see Figure 3). The slack length constrains how far the antenna can rotate CW and CCW from neutral in the azimuth direction without damaging the hoses and cables. When not in use, DSS-14 is moved to a stow position of 180 degrees in the CW wrap.

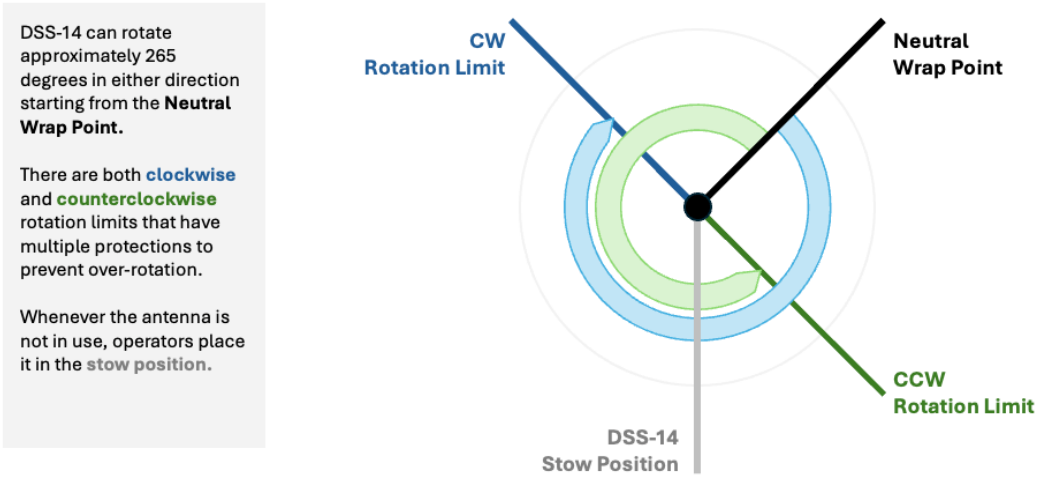


Figure 3: DSS-14 Rotation Diagram

The images in Figure 4 show the wrap as “neutral” at the clockwise rotation design limit, and in the over-wrap state observed in the mishap.

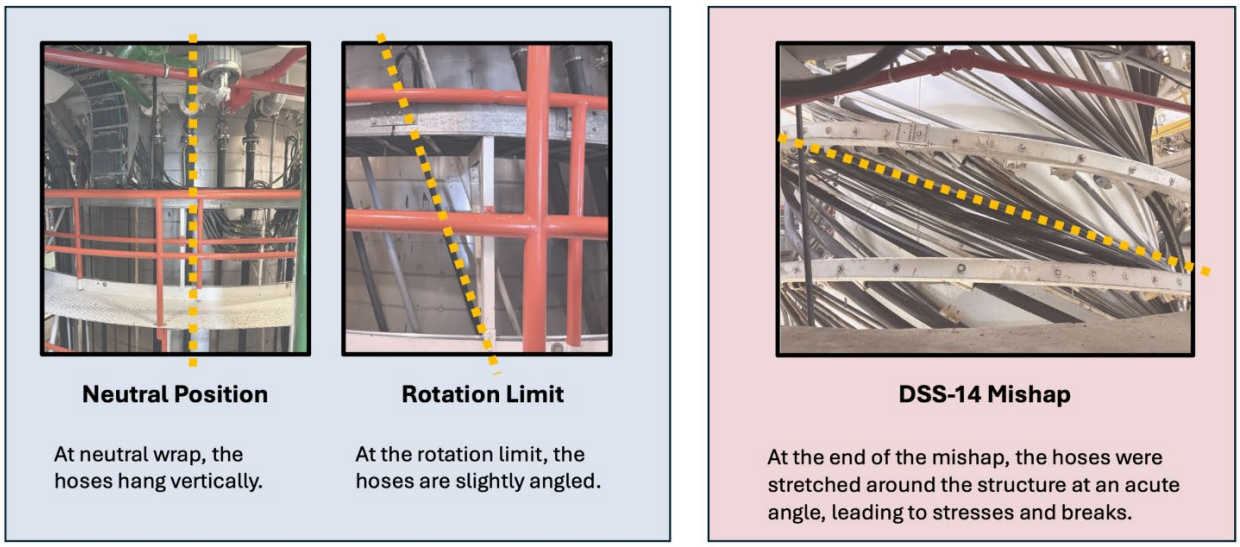


Figure 4: DSS-14 Rotation Limit Photographs

Antenna rotation is managed by the Antenna Pointing Controller Assembly (APCA). The APCA receives telemetry from antenna sensors and routes this data to operator consoles. The APCA also routes commands received from the consoles back to the antenna systems through the lower-level Antenna Logic Controller (ALC). For simplicity, this report refers to these two components, along with the sensors and end effectors on the antenna, as the “antenna control system.” However, the MIB acknowledges that many other antenna functions are managed through different mechanisms.

Antenna Azimuth Rotation Limits

There are four key system elements that inhibit rotation of the antenna past its design limits:

- A **software pre-limit** in the APCA issues caution messages to operator consoles indicating the antenna is approaching rotation limits. When this limit is triggered, the APCA software sends a “STOP ANTENNA” command, ceasing rotation. This command can be overridden by LCOs or TSMs from the control center.
- A **hardware pre-limit** in the APCA uses input from mechanical switches mounted on the rotating antenna, which trip at rotation angles slightly beyond the software pre-limits. When these switches trigger correctly, a warning is sent to LCO’s indicating the pre-limit has been violated. The antenna software then stops motion and cannot be remotely overridden. Personnel must enter the antenna at the alidade position and manually move it away from the pre-limit angle.
- A **hardware final-limit** in the APCA uses an additional set of limit switches mounted on the rotating antenna, which trip at rotation angles slightly beyond the hardware pre-limits. If both the hardware pre-limit and final-limit switches are triggered, a warning is sent to LCOs indicating the limit has been violated. The antenna then stops and cannot be moved remotely. Personnel must enter the antenna and perform actions in two locations to manually move it away from the final-limit angle.

- The **hydraulic limit system**, consisting of mechanisms and hydraulic elements, serves as a final failsafe beyond the hardware final-limit. It operates independently of both software and electrical power systems. When correctly armed and activated, it releases hydraulic system pressure and stops all antenna motion. Personnel must enter the antenna and perform functions in three locations to manually move the antenna away from the limit angle.

2.2 Mishap Description

For the purposes of this investigation, the MIB considers the mishap to span the period between 2025-09-16T10:01Z and 2025-09-16T11:54Z, when the undesired outcome (damage to the facility) and the proximate causes of the mishap are believed to have occurred.

At 10:01Z, facility logs for the Cooling Water Pump 4 (CWP-4) pressure show a hose carrying fire-suppression water from the DSS-14 antenna's stationary base to the rotating structure was sufficiently damaged to cause uncontrolled flooding into the antenna's base. This damage occurred while the antenna was actively tracking the Juno spacecraft, rotating CW in azimuth while significantly beyond CW rotation design limits.

At 10:30Z, an OE, on a break from supporting a test at an adjacent antenna, noticed water rushing out of the DSS-14 antenna structure. Shortly afterward, based on witness accounts, four on-site employees (two TSMs, an OE, and a security officer) began investigating the source of the flooding. They walked through the flooded area of the facility to identify the water source prior to the arrival of a facilities team and opened doors to redirect water away from critical hardware.

At 10:55Z, a DSN flash report indicated the DSS-14 Transmitter Heat Exchanger was inoperable, potentially suggesting coolant hoses also had ruptured. Transcripts of voice logs between GDSCC and MDSCC personnel indicate the water leak was communicated by a GDSCC TSM to the MDSCC SOD at 11:44Z, along with intentions to bring the antenna to the stow position.

At 11:47Z, a TSM stationed in the GDSCC control center commanded the antenna to the stow position, the typical orientation of the antenna when not tracking a spacecraft. However, due to the configuration at the time, this command caused the antenna to rotate further into the over-wrap condition, likely resulting in additional damage to the facility. At 11:54Z, the antenna reached the stow position, set the brakes, and halted all motion.

2.3 Events Prior to the Mishap

At an unknown time and date that likely significantly predates the mishap, the DSS-14 antenna's CW hydraulic limit was rendered inoperable due to damage, wear, and misalignment (see Appendix H) and was not repaired. The MIB was unable to locate any documentation confirming that this system had been tested, and it is believed that the damage went unnoticed by site personnel. A 2004 test plan is the most recent artifact found that clearly addressed an intent to test the DSS-14 CW hydraulic limit, but the DSN was unable to supply corresponding test reports.

At 2025-09-15T14:45Z, the day preceding the mishap, GDSCC maintenance personnel were called to the DSS-14 antenna to troubleshoot an anomaly associated with the antenna's E-stop system. The

E-stop system at DSS-14 consists of several red buttons distributed at various points around the antenna, providing workers with means to halt the antenna's motion in an emergency. Several additional related failures were identified and addressed by maintenance staff over the same troubleshooting period, including issues with the lubrication pumps associated with both azimuth and elevation servo systems. The MIB did not attempt to investigate the root cause of the initial issue that prompted the maintenance team to be called to the antenna.

During troubleshooting, multiple component resets and reboots were performed. [redacted]

At 2025-10-16T01:07Z, command logs indicate antenna control was returned to operations and maintenance personnel departed for the day. At 02:59Z, the DR related to the troubleshooting effort was closed, briefly describing a repair to a lubrication pump. Once control was returned, GDSCC TSMs began positioning the antenna for the next scheduled operation.

At 01:31Z, the antenna rotated into the CW hardware pre-limit. At 02:22Z, the maintenance personnel were recalled to recover the antenna from a stop triggered by the CW hardware pre-limit. They moved the antenna CCW out of the pre-limit, returned the antenna to service, and again departed for the day.

Between 07:08Z to 07:25Z, the antenna encountered CW hardware pre-limit stops multiple times. In each case, a TSM entered the antenna to recover it from the stop and return it to operations, as detailed in Section 3.6.3.

[redacted]

[redacted]

At 09:46Z, the GDSCC TSM commanded the antenna to track for an upcoming communication pass. The antenna rotated in the CW direction, unknowingly past all limits and into the over-wrap condition, at which point the mishap occurred.

2.4 Events Following the Mishap

Between 2025-09-16T12:15Z and 12:30Z, a GDSCC facilities team arrived at DSS-14 and received instructions from the facilities manager to shut off domestic water and fire water and close a Post Indicator Valve (PIV). As a result, water ceased flowing. After an additional 30-45 minutes, the water had been largely contained.

Around 13:00Z, the facilities manager arrived and performed an electrical safety check to confirm the water did not carry a dangerous current.

At 14:50Z, logs indicate that onsite personnel switched the antenna into a lockout mode, preventing remote commanding. The electrical safety check was repeated at 16:00Z, concluding the immediate emergency response to the mishap.

At 2025-09-17T00:58Z, the SCaN DSN program executive was notified of the mishap. A series of program-level notifications and discussions took place over the next several hours. At the conclusion of these discussions, the SCaN program manager, the SCaN deputy program manager for Operations, and the SCaN program executive for the DSN decided to visit the mishap site. The SCaN DSN program executive remained at GDSCC for several days, conducting interviews and assessing the scope of the damage before traveling to MDSCC and CDSCC to collect witness accounts from the rest of the team at those sites.

On or about 2025-09-20, the SCaN Program began convening an investigation authority initially expected to be a Failure Review Board (FRB) in alignment with JPL processes. After further consultation, the SCaN Program recommended NASA's SOMD establish an MIB. The MIB was chartered on 2025-09-24, and an FRB composed primarily of JPL personnel was chartered shortly thereafter. The FRB performed an independent investigation and is preparing an independent mishap report.

2.5 Extent of Injuries

No personnel sustained injuries in the period preceding, during, or after the mishap.

2.6 Extent of Damage

At the time of this report, the damage assessment is limited to visual inspection of antenna systems and to identifying remediation costs associated with returning the antenna to a safe position for troubleshooting and repair. Repair costs are estimated by the DSN but have not been independently validated by the MIB.

At the end of the mishap, log files showed multiple cautions and warnings indicating high temperatures of antenna components; however, testing of those systems cannot be performed until the antenna damage is largely repaired.

2.6.1 Damage to the Cable Wrap

For this investigation, the cable wrap is composed of fluid hoses, power and data cables, and other structural elements. These structural elements include large steel rings connected by steel support rods and wire cables acting as tension members. Each ring carries fairleads that support and guide the hoses and cables. Figure 5 shows hoses, cables, and structural elements — including steel rings, support rods, and several fairleads — in various states of damage.

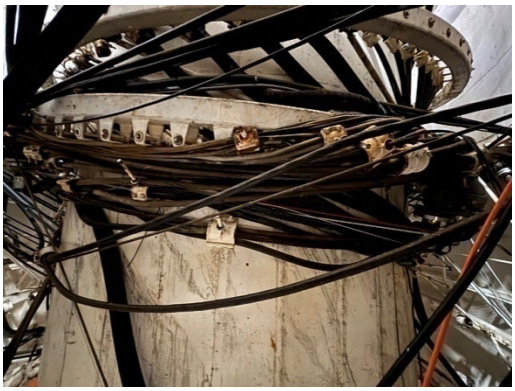


Figure 5: Cable Wrap Damage

Eleven hoses were present in the wrap at the time of the mishap, and all 11 will require replacement. One hundred twenty-five cables were present in the wrap at the time of the mishap. Of these, 11 are obsolete and do not need to be replaced. Of the remaining 114, the damage assessment indicated at least 85 were clearly broken; any cables not clearly broken will require inspection and recertification prior to reuse.

There are seven rings — two outer rings at the top of the rotating structure and five inner rings that are suspended down into the stationary antenna base — requiring 56 connecting rods, all rods will require replacement. The rings themselves do not need to be replaced.

Wire cables maintain tension between the inner and outer rings, and these wire cables will also require replacement. At least 30 of the 2,688 fairleads used to guide cables and hoses along the rings will require replacement, while the remaining fairleads will require inspection and recertification. Each ring has a set of casters and brackets that guide the ring as it rotates, and all seven sets of casters and brackets will require replacement.

2.6.2 Damage to Other Antenna Components

Structural and mechanical systems outside of the cable wrap also were damaged. Walls surrounding the cable wrap were damaged by the wrap's structural components, while other walls were damaged by flooding. Drywall affected by the damage and flooding tested positive for asbestos, requiring abatement. The fall protection systems used to ensure worker safety when operating on the cable wrap from the alidade were damaged and require replacement and requalification. Several hooks, cable grips, and trays used to support cables and hoses either before or after they enter the wrap were damaged and require replacement. Fire protection systems also will require inspection and repair.

Figure 6: Structure Damage

2.6.3 Remediation and Response

When elements of the cable wrap ruptured, water from the hoses drained a significant amount — estimated at 200,000 gallons — into the antenna's base. The rupture of cooling water hoses containing glycol resulted in the water being classified as an environmental hazard. Water trucks were deployed over multiple days to pump the contaminated water out of the antenna and transport it to a safe disposal site. The cost of this service was included in the mishap remediation expenses.

Several tests were performed to assess the functionality of antenna systems and establish a plan for recovering the antenna from the over-wrap state. On 2025-10-15, the MIB approved a test to assess the functionality of the Hydrostatic Bearing Assembly (HBA) and determine whether it could operate without active thermal control. The test was successful, allowing recovery personnel to develop a plan for antenna recovery without bringing temporary cooling equipment on site. Other tests are understood to have occurred without MIB concurrence, including tests of the E-stop system. The labor and materials costs associated with these tests were included in the mishap remediation expenses.

On 2025-10-27, the MIB approved a procedure to recover the antenna from the over-wrap condition and return it to a neutral wrap state, with all cables and hoses oriented vertically. The unwrap procedure was carried out over 10 workdays (12 calendar days) from 2025-10-29T17:22Z to approximately 2025-11-13T01:00Z. The labor and materials costs associated with this procedure were included in the mishap remediation expenses.

2.6.4 Damage and Remediation Cost

Damage estimates were provided by the DSN project and were not independently validated by the MIB. The MIB notes that the estimates were based on low-fidelity analysis and included several assumptions that could either increase or decrease the actual repair cost. The MIB considers it highly unlikely that the cost will decrease below the Type A threshold of $2 million.

Damage and Recovery Costs for DSS-14 Mishap	
Labor and Material – Initial	$ 580,000
Labor – Planned	$ 700,000
Material – Planned (Min/Max)	$ 2.82M / $3.32M
TOTAL	**$ 4.1M / $4.6M** (Min/Max)

Table 2: Damage and Remediation Cost Estimates

2.6.5 Other Potential Damage Sources

The antenna cannot be powered up and tested until the existing damage has been remediated. The MIB notes the following systems were identified in cautions and warnings at the conclusion of the mishap:

- Servo Hydraulics (Oil Reservoir Temperature)
- Hydrostatic Bearing Assembly (Oil Temperature)
- Hydrostatic Bearing Precharge Pumps (Failed)
- Azimuth Drive Point 4 Pressure Transducer (Calibration Fault)
- Main Equatorial Torquer Power Supply Fuse (Failed)

The MIB also notes that APCA logs provided may not capture cautions, warnings, or other damage indicators from systems not directly involved with antenna positioning.

3. Investigation

3.1 Approach and Objectives

The primary MIB objective was to enhance operational safety by determining the root cause of the mishap, identifying contributing factors, and recommending corrective actions to prevent recurrence. In addition to providing recommendations specific to the 70-meter antenna at GDSCC, the MIB also evaluated and proposed corrective measures applicable across all three DSN sites.

The DSS-14 MIB was chartered on 2025-09-25, and a kickoff meeting was held virtually via Microsoft Teams on 2025-09-29. This kickoff included the entire MIB team (voting, non-voting, and advisory members), the chair of NASA JPL's DSS-14 FRB, the SCaN deputy program manager for Operations, the DSN program executive, and the Antenna Front End, Facilities, and Infrastructure office manager. The meeting introduced all participants and formed the foundation of the collaborative working relationship amongst primary parties moving forward.

On 2025-10-03, the DSN program executive provided a mishap overview from their perspective, summarizing the interviews conducted and presenting site photographs. To support the investigation, a centralized data repository was established to ensure all MIB information requests were systematically documented and captured.

The investigation was conducted in compliance with NPR 8621.1D, NASA Procedural Requirements for Mishap and Close Call Reporting, Investigating, and Recordkeeping, and all MIB members completed the required training.

Throughout the investigation, the MIB maintained daily contact and used multiple tools to facilitate communication, coordination, documentation, and analysis. The MIB conducted site visits to all three Deep Space Communication Complexes. Further discussion on the investigation process and tools is detailed in the body of this report.

3.2 Investigation Chronology

The MIB met both virtually and in person from 2025-09-29 until completion of the investigation and this report. Several site visits were conducted to support the investigation. A GDSCC site visit took place from 2025-10-07 to 2025-10-08 and included a briefing from the JPL/Peraton team on the information known at that time, followed by an extensive tour of the damaged antenna complex. The tour focused on relevant hardware, such as limit switches, sector switches, etc., and included interviews with site personnel.

The MIB reconvened for an in person working session from 2025-10-20 to 2025-10-21 at NASA Headquarters in Washington. During this session, the team focused on identifying and mapping the key events that contributed to the incident, creating a clear timeline of actions and decisions leading up to the occurrence. The team also worked to define and catalog unresolved questions requiring further clarification to support a comprehensive understanding of the situation. A significant focus was placed on planning and initiating a structured root cause analysis to uncover underlying factors and systemic issues that may have contributed to the mishap. This approach established a

foundation for accurate reporting, informed corrective actions, and the prevention of similar occurrences in the future.

An MDSCC site visit occurred from 2025-11-04 to 2025-11-06 to conduct informal interviews with controllers and engineers and to tour the undamaged 70-meter antenna, which is nearly identical to the damaged DSS-14 antenna. Discussions focused on the role of various operations and maintenance team members, documentation practices, and functional testing of the hardware and hydraulic limits.

The MIB produced its 30-day status report on 2025-11-12, as required by NPR 8621.1D. The MIB convened for another in person working session on 2025-11-20 at NASA Headquarters to begin work on the root cause analysis. A subset of the MIB again visited GDSCC from 2025-12-02 to 2025-12-03 for follow-on discussions with the JPL and Peraton teams and to participate in the antenna control hardware/software testing performed to inform theories related to the mishap. Interviews and tours clarified roles within operations and maintenance teams, highlighted documentation gaps, and documented functional testing practices for hardware and hydraulic limits.

The MIB chair provided an interim briefing to senior NASA leadership on 2025-12-04, summarizing investigation status and information learned to date. The briefing outlined preliminary findings, key lines of inquiry, and any immediate safety considerations identified by the board. Leadership acknowledged the update and concurred with the board's planned investigative path, while emphasizing the importance of continued data collection and cross-center coordination. No formal conclusions or corrective actions were issued at this stage, as the investigation remained ongoing.

A subset of the MIB conducted a CDSCC site visit from 2025-12-16 to 2026-12-17 to perform additional interviews and investigate differences in antenna operations and best practices that may have helped prevent the mishap. These discussions contributed to observations and informed the MIB's recommendations.

The MIB produced a 60-Day status report on 2025-12-19, as required by NPR 8621.1D.

INVESTIGATION TIMELINE

Methodology

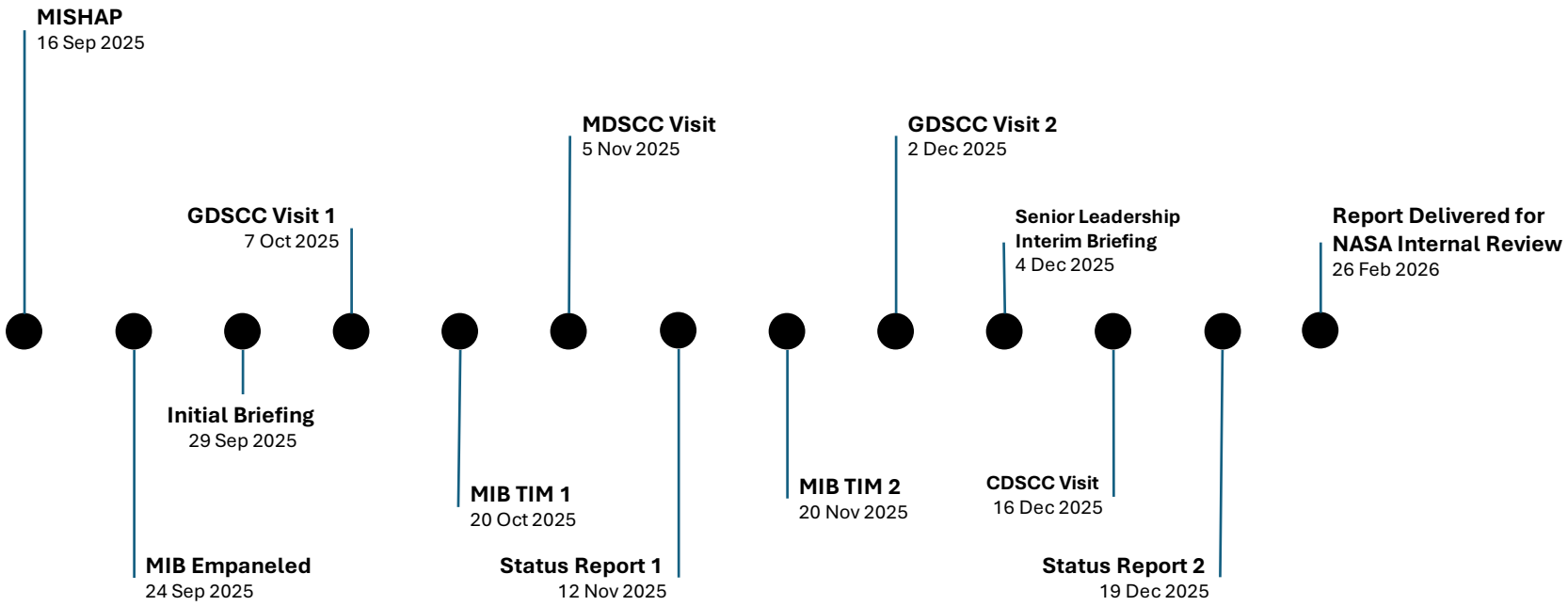


Figure 7: Investigation Timeline

3.3 Data Collection

More than 50GB of digital data files, logs, procedures, photos, and video were collected over the course of the investigation and archived in NASA's SCaNVAS system and the DSS-14 MIB Microsoft Teams site. Although not a comprehensive list of every file in the archive, Appendix D: File List provides a list of key evidence gathered and reviewed as part of the MIB's investigation.

3.4 Site Inspections

Over the course of the investigation, the MIB conducted several site inspections. Below is a table detailing each visit, complete with its respective date and description.

Site Name	Inspection Date	Inspection Description
Goldstone Deep Space Communications Complex	2025-10-07 to 2025-10-08 & 2025-12-02 to 2025-12-03	Initial site visit to receive an in-brief from JPL Deep Space Network and Goldstone site team, view the site operations control room, inspect the damaged DSS-14 antenna, and conduct witness interviews. Return visit to closely inspect the hydraulic limits and stops and remove hydraulic stop hardware for independent detailed mechanical inspection by the NASA Engineering & Safety Center (NESC).
Madrid Deep Space Communication Complex	2025-11-04 to 2025-11-05	MIB inspection of the operations control room, a tour of DSS-63, and discussions with technical experts from the operations and maintenance teams.
Canberra Deep Space Communications Complex	2025-12-16 to 2025-12-17	MIB inspection of the operations control room, a tour of DSS-43, and discussions with technical experts from the operations and maintenance teams.

3.5 Challenges Encountered

The investigation and recovery efforts faced multiple challenges that affected the timeline, resource allocation, and overall efficiency of the mishap response. These challenges are categorized as follows:

- **Lack of IRT/Execution of MPCP:** The MIB did not find evidence of the implementation of a formal Interim Response Team (IRT) or a proper execution of a Mishap Preparedness and Contingency Plan (MPCP). Several key steps were not taken to impound data logs and evidence. NPR 8621.1D directs an IRT to perform several critical activities that were missed (or performed without the rigor required):

    - Preserve potential evidence, document the scene, and obtain witness statements immediately following the mishap.
    - With cognizant Safety Office, supervisors, and OPS support, collect and formally impound appropriate data, records, equipment, witness statements, and facilities that may be involved in the mishap.
    - At the earliest opportunity, notify the contracting officer or contracting officer's representative if drug testing for contract personnel is to be implemented according to the contract or applicable agreements.

    Once notified of the mishap, the SCaN Deep Space Network (DSN) program executive (PE) immediately traveled to the site, arriving one day later. While on site, the PE conducted nonprivileged interviews with GDSCC staff to understand what had happened and perform an initial assessment of the scope of the damage. They collected photographs and data as possible and prepared a presentation briefing on 2025-10-03. While the PE's effort was instrumental in securing critical information, it was insufficient to meet the requirements of an IRT per NPR 8621.1D. It should be noted that the PE was not given the responsibility nor authority to act as a one-person IRT. Their efforts to preserve information and secure data are sincerely appreciated by the MIB.

- **Management of other agency priority work:** The DSN and activities at GDSCC operate in a 24/7 environment, necessitating constant ongoing work by personnel that were pivotal to the mishap investigation. GDSCC and the DSN project could not be paused to allow personnel uninterrupted time to locate, generate, and deliver critical artifacts and evidence to the MIB. This caused delays in the MIB scheduling interviews and receiving responses to questions and data requests. It should be noted that the MIB understands the workload constraints that DSN and GDSCC team were operating under and the MIB appreciates the significant extra effort that personnel worked to respond to the many requests for information.

    Additionally, the MIB itself was composed of several subject matter experts who had key roles in ongoing high priority NASA missions and efforts. While their expertise was critical to this investigation, there were times when other priority agency work (Artemis II campaign, SMD/SOMD, and SCaN Program critical needs) had to take precedence. The MIB Chair balanced these competing priorities and released team members to perform time-sensitive

agency work as appropriate; however, this resulted in schedule delays in conducting the investigation and producing this report. Longer investigation timelines can delay the dissemination of important lessons learned to the broader workforce and postpone the identification and mitigation of existing hazards, increasing the risk of recurrence before corrective actions are implemented. To mitigate this issue in the future, special consideration should be given — when appointing employees to a MIB — to selecting members whose existing responsibilities are unlikely to conflict with the investigation's priority. Early coordination with program and mission leadership should occur prior to board activation to secure resource commitments and minimize conflicts with ongoing high-priority agency work.

- **Lack of readily available S&MA documentation:** The MIB encountered challenges due to the lack of readily available Safety and Mission Assurance (S&MA) products. For example, a fault tree or Failure Mode, Effects, and Criticality Analysis (FMECA) for DSS-14 was not available for review. The MIB spent a great deal of time with GDSCC personnel and multiple site visits over several months to gain an understanding of the details and nuances of the antenna control system and fault and protection logic.

- **Government shutdown:** From 2025-10-01 to 2025-11-12 the U.S. government experienced a partial government shutdown due to a lapse in appropriations. This occurred in the early stages of the mishap investigation and resulted in delays as exigencies were processed for the investigation and support team, travel approvals were processed to visit the mishap site, and access to some potential subject matter experts was limited or postponed.

3.6 Mishap Timeline

Over the course of the investigation, the MIB identified six critical events leading up to and including the mishap itself.

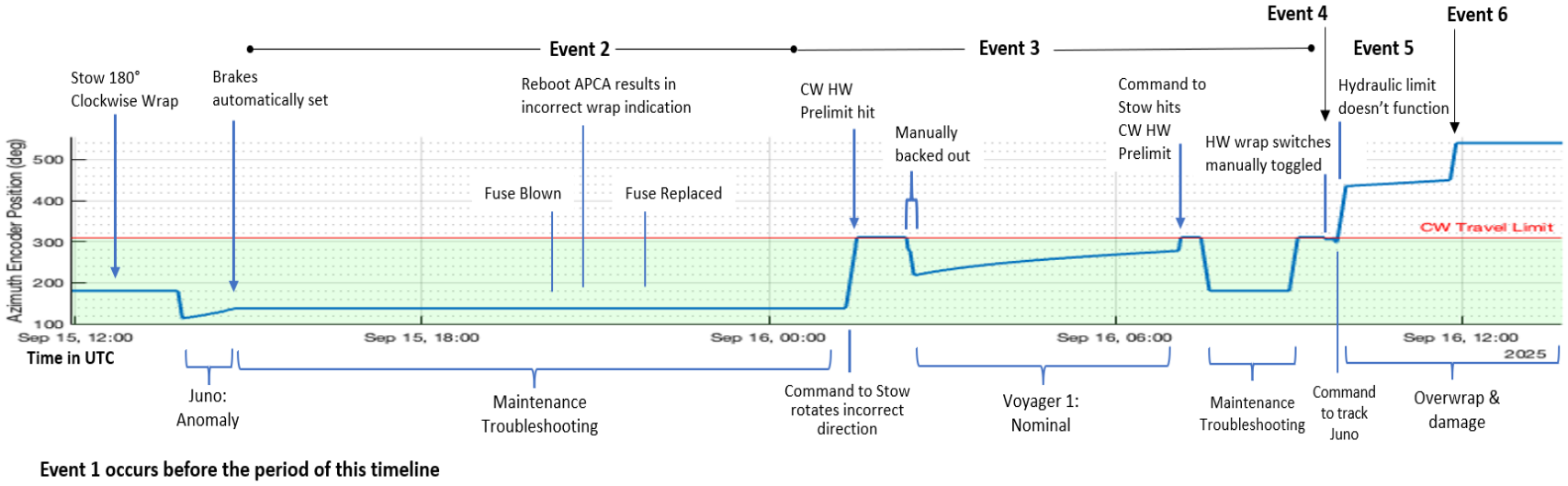


Figure 8: Mishap Timeline

Event 1 [redacted]

Event 2 [redacted]

Event 3 [redacted]

Event 4 [redacted]

Event 5 [redacted]

Event 6 [redacted]

3.6.1 Event 1: *Hydraulic Limit System Rendered Inoperable*

[redacted]

[redacted]

3.6.2 Event 2: *APCA Reboot while FD-1 Fuse Blown During Trouble-Shooting*

[redacted]

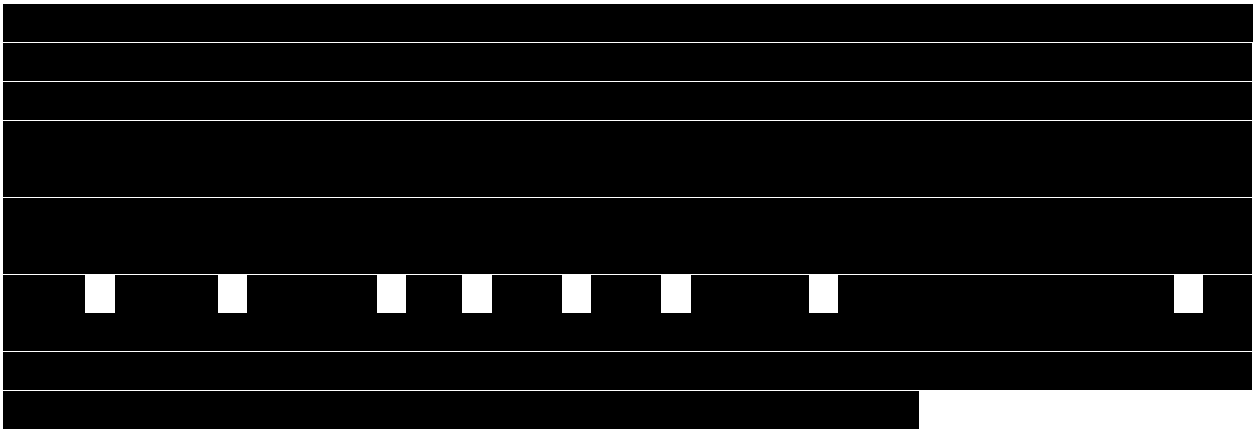
[redacted]

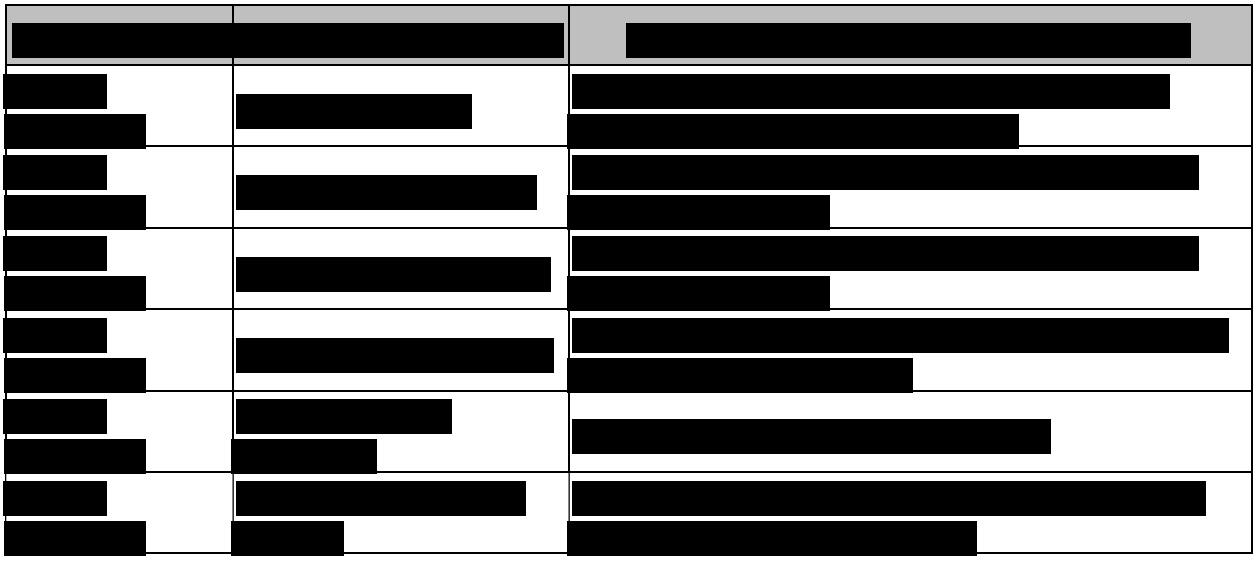
[redacted]	[redacted]	[redacted]
[redacted]		[redacted]
[redacted]		[redacted]

[redacted]

[redacted]	[redacted]	[redacted]
[redacted]		[redacted]
[redacted]		[redacted]

[redacted]





[redacted]

[redacted]

[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

3.6.3 Event 3: *Antenna Repeatedly Driven Into Limits During Operations*

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

[redacted]

[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

3.6.4 Event 4: *Sector Switches Manually Exercised*

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]	[redacted]	[redacted]

[redacted]

3.6.5 Event 5: *Antenna Returned to Track*

[redacted]

[redacted]

3.6.6 Event 6: *Antenna Sent to Stow*

[redacted]

3.7 Data Analysis

The MIB employed a structured, systematic analysis approach consistent with NASA Procedural Requirements (NPR) 8621.1D for mishap investigations to ensure thoroughness, objectivity, and compliance with agency standards. The investigative methodology integrated multiple analytical tools and processes to identify causal contributing factors, organizational influences, and additional observations. The investigation produced the following key products:

- **Human Factors Assessment Report** – Summarizes findings from NASAHFACS analysis (see Section 3.7.1 for summary and Appendix G for complete report).
- **Safety Assessment** – Details various safety and risk-related documents and material reviewed as a part of this MIB investigation.
- **Events and Causal Factor Tree (E&CFT)** – through the process of Root Cause Analysis (see Section 3.7.3), a detailed graphical representation of event sequences and causal relationships was generated (see Section 3.7.4).

3.7.1 Human Factors Assessment

Recognizing the critical role of human performance in aerospace operations, the MIB conducted a Human Factors Assessment using the NASA Human Factors Analysis and Classification System (NASA HFACS) tool and taxonomy. The analysis focused on the human actions associated with the

six critical events described in Section 3.6 and identified the human factors that contributed to those actions. A detailed analysis is provided in Appendix G, which also includes observations and findings specific to the human factors assessment.

The HFACS assessment generally corroborated findings presented in the main body of the report but utilizes a structured taxonomy to precisely characterize the factors observed and to generate specific findings and observations. Common human factors identified in the HFACS included:

- Personnel exceeding their roles and performing tasks for which they had neither training nor proficiency
- Consistent lack of risk analysis and real-time assessment when taking actions
- Cautions, warnings, and system automation providing misleading or insufficient information to operators
- Lack of oversight over critical decisions made in maintenance and operations, with the DSN project exercising little management over discrepancy closure

Some highly significant findings and recommendations from the human factors analysis are covered in Sections 4 and 6 of this report. Findings and recommendations stemming from human factors analysis are identified in those sections and reference the relevant sections of the assessment in Appendix G.

3.7.2 Safety Assessment

The MIB conducted a safety assessment by reviewing requirements and standards, risks, and lessons learned. The assessment identified expired and/or unenforced NASA, JPL, and Occupational Safety and Health Administration (OSHA) requirements and standards (see Obs 1, Obs 6). While full adherence may not have entirely prevented the mishap, following these requirements and incorporating lessons learned into plans and procedures could have mitigated key risk factors and potentially reduced incident severity.

- **Safety Requirements, Standards, and Guidance**
  The MIB conducted a formal assessment of applicable safety requirements, standards, and guidance from NASA, JPL, and OSHA; however, contractor-specific requirements were not reviewed (See Appendix C for a complete list of safety documents reviewed). The assessment was performed to identify any missing requirements or gaps in compliance with common practices that may have contributed to the mishap.

- **Known Open Risks**
  Additionally, the MIB identified 10 open DSN risks, some of which have been open for more than 12 years. Three risks are specific to DSS-14, and seven apply to the DSN as a whole. For the three DSS-14-specific risks (opened between 2014 and 2023), JPL notes that obsolescence in software, hardware, and the electrical distribution system can lead to failures that render the antenna unavailable.

  For the remaining seven open risks across the DSN program (opened between 2021 and 2022), JPL identifies workforce attrition, unfunded required maintenance, unfunded facilities staffing,

unfunded succession planning, potential knowledge gaps, and building and fire suppression system obsolescence (See Appendix E for a complete list of open DSS-14/ DSN specific risks).

- **Applicable Lessons Learned**
  The MIB also reviewed the NASA Lessons Learned Information System (LLIS) and identified three lessons learned that were applicable to this mishap (see Appendix C for a detailed list of LLIS entries). These lessons are associated with:
  - **Job Hazard Analysis (JHA)** – "*Before work is to be performed on critical ground support equipment, DSN requires that a contractor conduct a JHA (Job Hazard Analysis) and implement the specified controls before work proceeds.*"
    - A proper JHA was not performed before four employees entered the flooded antenna structure during the mishap. Had one been conducted, employees would know not to enter the structure until facilities had shut off the water and electricity to the building and issued the "all clear."
  - **Emergency Response and Communication –** *"Effective communications with employees is very important."* It is recommended that employees, *"improve field response performance and safety,"* including, *"provision of safety officer position,"* and emphasize, *"empowering the staff who must be present during emergencies."*
    - Through the MIB's investigation, it became apparent that individual roles, responsibilities, and communication pathways are somewhat nebulous. Had they been more defined and effective, it is possible that, at a minimum, mishap damage could have been reduced.
  - **Safety Hazard Assessments –** *"Failure to thoroughly assess the hazards of a job/task prior to performing the task may lead to safety incidents."* It is recommended, *"when it appears that tasks cannot be performed in a safe de-energized state, the task should be presented in an open forum with management and knowledgeable personnel for further assessment".*
    - Hazards were not thoroughly assessed, which could not have happened, *"in a safe de-energized state."* Had such an assessment been attempted, employees would have known not to enter the structure until facilities had shut off the water and electricity to the building and issued the "all clear," or if the task had been, *"presented in an open forum with management and knowledgeable personnel for further assessment."*

3.7.3 Root Cause Analysis

The Root Cause Analysis (RCA) process was documented through an Events and Causal Factor Tree (E&CFT), which visually represents the chronological sequence of events and their causal linkages. This comprehensive E&CFT provides traceability from the initiating event to the root causes and is included in its entirety in Appendix G.

A formal independent Fault Tree Analysis (FTA) was not conducted for this investigation. However, the RCA was cross-checked against the "Big Sheet" (the NASA Root Cause Analysis Tool located at https://secureworkgroups-grc.nasa.gov/mi) to identify any possible additional or undiscovered elements, thereby effectively addressing the intent of an FTA.

3.7.4 Events and Causal Factor Tree

Beginning with the Undesired Outcome (UO) of the mishap — identified by the MIB as "the DSS-14 70-m antenna sustained approximately $4.6 million in damages and amelioration"— an E&CFT was developed as part of the RCA to trace the UO, causal events, conditions, and contributing factors.

The "Five Whys" methodology was used to dig deep into why the events occurred on that day. This process concluded when sufficient data was no longer available, when the answer to the why question reached outside of NASA and NASA support contractors, when a cause was not an anomaly, or when a root cause was reached.

Using the NASA RCA process, the Board identified the following, and mapped them to the E&CFT:

- **Proximate Causes** – Immediate events or conditions that directly led to the mishap (the two events that immediately branch from the UO)
- **Intermediate Causes** – Events or conditions that existed before the proximate causes, directly resulted in their occurrence, and that, if eliminated or modified, would have prevented them (all events that occur immediately before the root causes, as well as any additional events requiring special attention)
- **Root Causes** – Fundamental systemic issues that, if eliminated or modified, would have prevented the intermediate cause from occurring, and the UO (the purple boxes at the bottom of each leg of the tree)
- **Contributing Factor** - An event or condition that may have contributed to the UO but that, if eliminated or modified, would not on its own have prevented the occurrence (the Board identified a single contributing factor—ECFT-31 on Leg B, "Hydraulic Limit," of the E&CFT)

In the sections below, the proximate causes, intermediate causes, contributing factors, and root causes from the E&CFT are presented. Additionally, other key findings and observations are detailed with supporting context and rationale. Each root cause and key finding will be linked explicitly to a recommendation in the following section.

3.7.5 Root Causes

Root Cause is an event or condition, primarily associated with organizational factors, that existed before the intermediate cause and directly resulted in its occurrence (indirectly caused or contributed to the proximate cause and subsequent UO). If eliminated or modified, the roots cause would have prevented the intermediate cause from occurring and the UO. Typically, multiple causes contribute to a UO. In the absence of a prevalent organizational factor, the root cause may be identified as undetermined. Based on this definition, the MIB identified four root causes that resulted in the UO:

ECFT #	Root Cause Summary
RC-1	GDSCC personnel were not properly trained
RC-2	GDSCC procedures are inadequate
RC-3	Control logic has inadequate state definition
RC-4	GDSCC is overly reliant on undocumented behaviors and institutional knowledge

Table 6: Root Cause Listing

3.7.6 Proximate Causes

Proximate Cause is an event that occurred, including any conditions existing immediately before the UO, directly resulted in its occurrence, and if eliminated or modified, would have prevented it (also, known as direct cause). Based on this definition, the MIB identified two proximate causes that resulted in the UO:

ECFT #	Proximate Cause Summary
ECFT-1	Antenna rotated into Clockwise (CW) over-wrap while tracking Juno mission
ECFT-2	Antenna rotated to stow, exacerbating CW over-wrap condition

Table 7: Proximate Cause Listing

3.7.7 Intermediate Causes

An Intermediate Cause is an event or condition that existed before the proximate cause, directly resulted in its occurrence, and that, if eliminated or modified, would have prevented the proximate cause from occurring. Based on this definition, the MIB identified eight intermediate causes that resulted in the UO. Parenthetical notation in the summary indicates which Root Cause is linked to the noted Intermediate Cause, if any.

ECFT #	Intermediate Cause Summary
ECFT-13	GDSCC TSMs disregarded recent prior antenna fault indicators (RC-1)
[redacted]	[redacted]
ECFT-24	No standard procedure for APCA reboot (RC-2)
[redacted]	[redacted]
ECFT-29	GDSCC personnel failed to follow hardware pre-limit recovery procedure steps (RC-1)
ECFT-30	TSM operated outside of proficiency, qualification, scope (RC-4)
ECFT-34	No functional state indicator exists
ECFT-36	Breech arm and stepped pin significantly damaged and/or misaligned prior to mishap
ECFT-37	GDSCC maintenance procedures do not require limit testing (RC-2)
ECFT-43	GDSCC staff failed to perform an adequate real-time assessment (RC-1)

Table 8: Intermediate Cause Listing

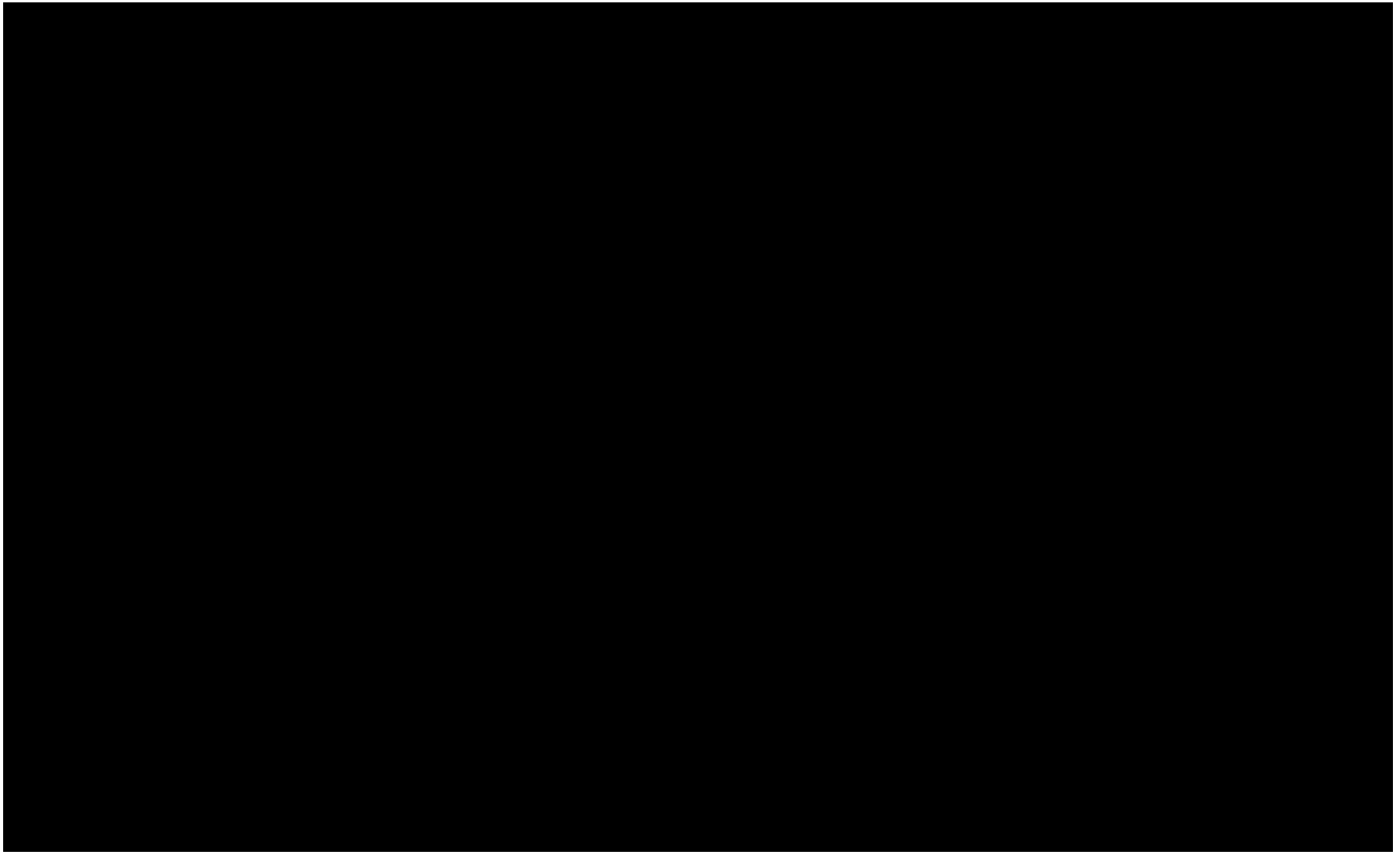
3.7.8 Contributing Factor

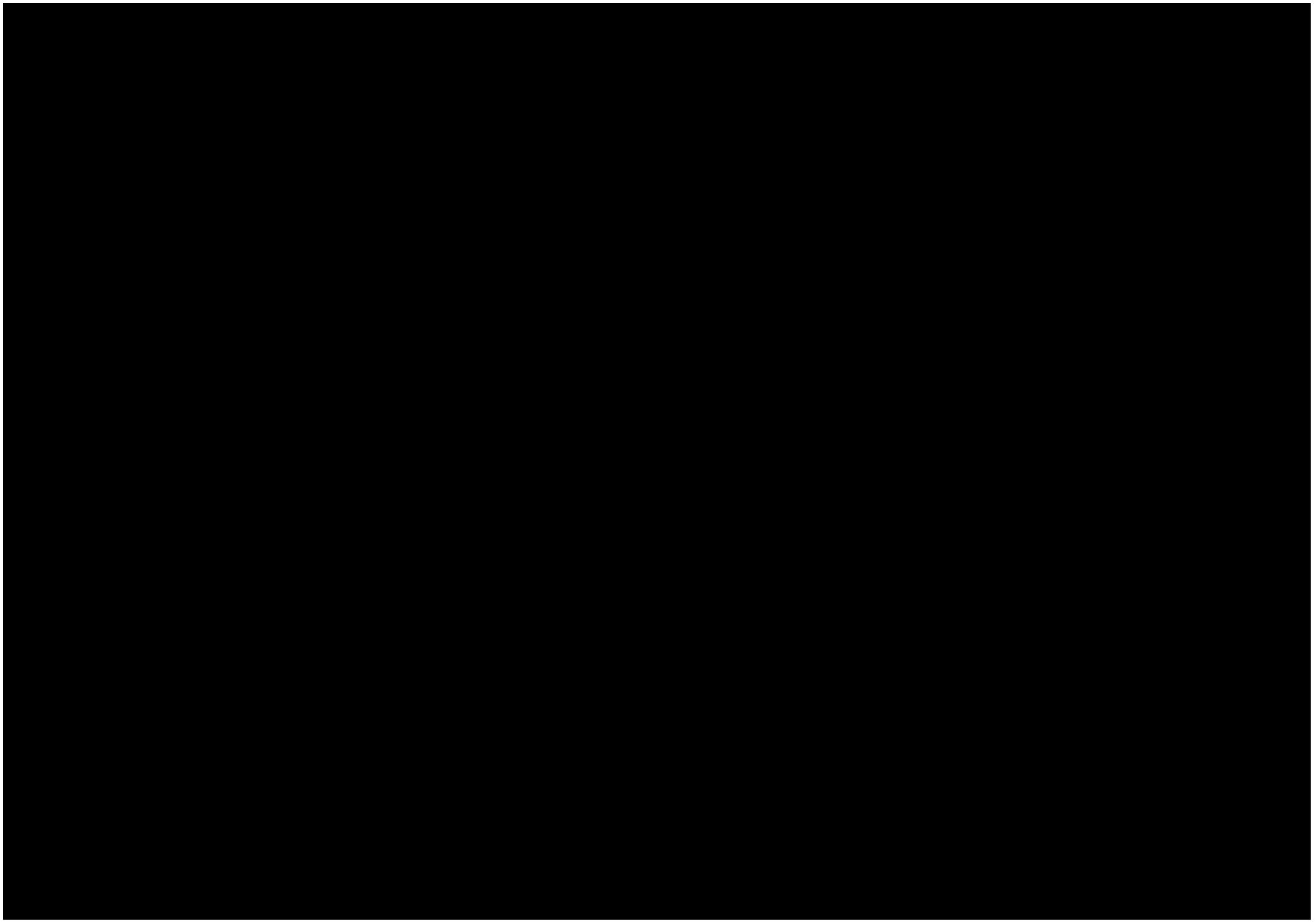
A Contributing Factor is an event or condition that may have contributed to the occurrence of an UO but that, if eliminated or modified, would not on its own have prevented the occurrence. Based on this definition, the MIB identified one contributing factor that resulted in the UO:

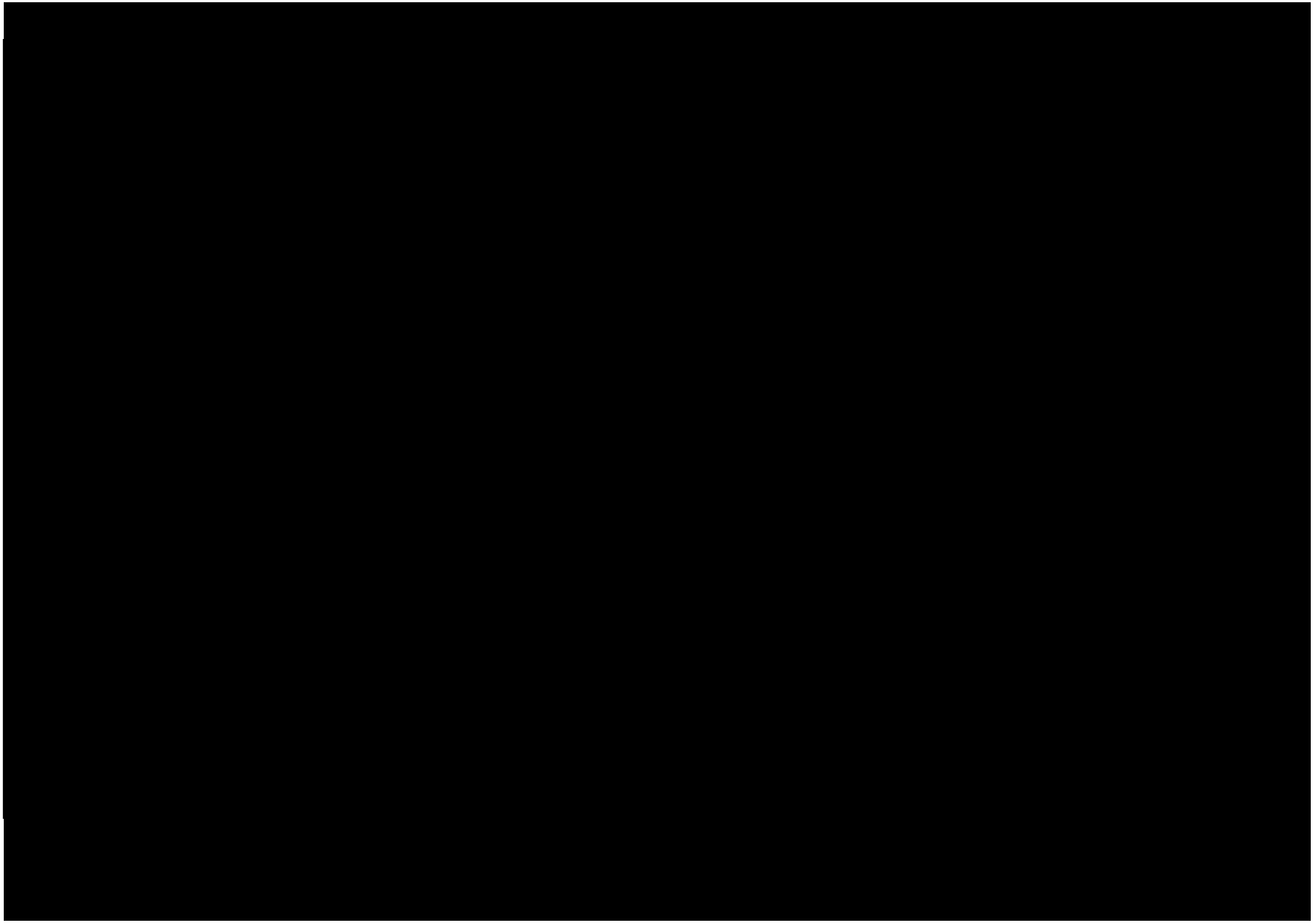
ECFT #	Contributing Factor Summary
ECFT-31	Functional state of hydraulic limit was unknown

Table 9: Contributing Factor Listing

The E&CFT is shown below. For visibility, it has been broken into the following diagrams: Figure 14: ECFT (Top Level), Figure 15: ECFT (Leg A, CCW Wrap Status), Figure 16: ECFT (Leg B, CW Hydraulic Limit), and Figure 17: ECFT (Leg C, Rotation to Stow).







4. Findings

A finding is a conclusion, positive or negative, based on facts established by the MIB during the investigation and may identify causes, contributing factors, and observations related to the mishap or close call. Each finding represents an evidence-based conclusion that documents the conditions, events, or circumstances that led to or influenced the mishap. Recommendations to address the MIB's findings are included in Table 10 to prevent recurrence and improve mission assurance. The final column lists the links to the related ECFT cause or HFAC finding associated with each finding. During the investigation, the MIB found 14 findings, as shown below.

Finding #	Finding Summary	Recommendation #	Links
F1	Goldstone personnel were not adequately trained for observed duties and actions taken	R2, R3, R4, R6	RC-1, H2.7.10
F2	Goldstone personnel did not adhere to standard operating procedures	R1, R2, R7	ECFT-29, H2.7.6
F3	Deep Space Network and Goldstone personnel operated DSS-14 with an inoperable hydraulic limit system	R12, R18	ECFT-36
F4	Goldstone teams provide Insufficient documentation to support maintenance activities	R1, R2, R10	H2.7.1
F5	Goldstone personnel and management promote personal heroics	R1, R10, R20	H2.7.4
F6	Goldstone personnel did not plan before executing actions	R1, R20	H2.7.7
F7	Deep Space Network and Goldstone procedures are inadequate for operations	R11, R16	RC-2
F8	Antenna control system provides inadequate state knowledge	R8, R9	RC-3, H2.7.3
F9	Goldstone is overly reliant on undocumented behaviors and institutional knowledge	R13	RC-4
F10	MPCP practices were not followed at multiple levels	R5	N/A
F11	The Supervisor on Duty (SOD) has an unclear role and insufficient authority over TSM decision-making at remote sites	R14	N/A
F12	Deep Space Network project has failed to ensure sufficient consistency in operations, best practices, and procedures across all three complexes	R4	N/A
F13	Goldstone personnel did not adequately assess the real-time situation	R20	H2.7.2, H2.7.9
F14	Goldstone personnel consistently show reduced vigilance	R9	H2.7.5

Table 10: Finding Summary

F1: Goldstone personnel were not adequately trained for observed duties and actions taken
Multiple key findings from this investigation share a common through-line; each of these events included actions or errors that could have been prevented through an effective training regimen. From interviews and site visits with personnel at all three DSN sites, the MIB has learned that training programs are site-specific and vary significantly in completeness. The SCaN Program and the DSN have not provided the capability to simulate off-nominal conditions and do not appear to perform simulations of off-nominal scenarios. There was no indication that the GDSCC TSMs received the cross-training necessary to execute complex maintenance troubleshooting or that they were expected to maintain proficiency over time.

At multiple points during the mishap, the MIB identified actions taken by GDSCC TSMs for which they were not adequately trained. This finding is most evident in Event 3, where TSMs backed the antenna out of pre-limits even though SOPs and instructions in caution and warning messages indicated the need for qualified maintenance staff. It is also evident in Event 4, where TSMs entered the antenna bilge to inspect a switch despite not being trained or qualified to judge proper operation. Across multiple events, the MIB determined that TSMs were not trained in risk assessment or in developing troubleshooting plans and approaches.

The MIB considers many of the HFACS findings, several of the mishap's root causes, and most of the key actions taken by personnel to have been exacerbated by insufficient training on off-nominal scenarios such as those encountered during this mishap.

F2: Goldstone personnel did not adhere to standard operating procedures
The MIB identified a single SOP relevant to operations rather than maintenance — a procedure for recovering an antenna from hardware limits. The SOP specifies a team of qualified personnel, one of whom is responsible for physically observing the cable wrap and ensuring the limit-recovery operation is conducted safely. The procedure was volunteered to the MIB by personnel at both MDSCC and CDSCC and identified as the top-level guidance applicable to Event 3. Both sites described site-specific modifications to that guidance since it was last revised in 2014.

A DSN-authored procedure from 2014 provided a degree of instruction on how to recover from hardware pre-limits. The MIB notes that the procedure is out-of-date and focuses primarily on 34-meter DSN antennas, which have substantially different hardware designs but does contain references to performing the same task for the 70-meter design. This procedure cannot be fully executed without multiple personnel and must be performed by qualified maintenance personnel; accordingly, GDSCC personnel following this procedure would not have attempted to recover the antenna from hardware pre-limits during Event 3.

F3: Deep Space Network and Goldstone personnel operated DSS-14 with an inoperable

[redacted]

F4: Goldstone teams provide insufficient documentation to support maintenance activities
In multiple areas and across several events, the MIB found documentation was insufficient to effectively execute maintenance on the antenna or to reconstruct the circumstances surrounding the mishap. This issue is most apparent during the unclear period when the hydraulic limit is believed to have become inoperable, but documentation is unavailable to pinpoint when the damage occurred, identify potential failure modes, or determine the circumstances under which a physical test of the hydraulic limits would have been necessary.

It also is evident during the troubleshooting effort, where DSN project personnel described the information needed to accurately identify the blown fuse as "hidden in the code." The MIB was also unable to determine from work documentation when the fuse was blown, when it was replaced, or who performed the replacement.

F5: Goldstone personnel and management promote personal heroics
Across the entirety of the mishap timeline, the MIB found consistent evidence that cultural factors at GDSCC had an adverse effect on the behaviors and decisions of on-site personnel. Personnel described themselves (and were described by personnel at other sites) as "willing to do whatever it takes to keep the antenna running." This attitude was positively reinforced by GDSCC management, DSN management, and SCaN Program management. This attitude directly contributed to team members' willingness to work extended hours (increasing fatigue), troubleshoot during off-shifts, perform tasks outside their job descriptions and qualifications, operate outside standard operating procedures, and skip tests or analyses that would have delayed the antenna's return to active operations.

Personnel interviewed by the MIB gave the impression that some elements at the DSN project or at GDSCC appeared to be focused primarily on "getting the antenna back up as quickly as possible." Both DSN project and GDSCC personnel took actions to test antenna systems that altered the antenna's configuration during the active investigation in an effort to accelerate recovery and recommissioning activities. This cultural push to rush to action and return the asset to service directly conflicted with the appropriate approach of thoughtful, safe, and risk-informed decision-making. Had GDSCC personnel acted with greater deliberation or shown more willingness to leave the antenna in a failed state at any point during the mishap, the undesired outcome likely would not have occurred.

F6: Goldstone personnel did not plan before executing actions
During both Events 3 and 4, the TSMs undertook novel and unorthodox actions in an attempt to recover the antenna and return it to operations, including hardware functionality tests and efforts to recover antenna limits while the antenna was in an ambiguous state. There is no indication the TSMs

or the on-call SSE developed any degree of work plan to cover the activity to identify likely hazards, required tools, test criterion, or key steps, like recording the initial position of sector switches before making changes. The MIB found no evidence that planning documentation was required and believes such requirements do not exist because it was never anticipated that TSMs would attempt operations posing a high degree of system risk or lacking an established process. The TSMs interviewed at both MDSCC and CDSCC indicated that performing tasks outside of existing protocol would have been considered unacceptable by site management. The extraordinary degree of site-specific autonomy granted to GDSCC TSMs was not accompanied by site-specific expectations to perform the planning necessary to safely develop or execute complex and novel procedures.

F7: Deep Space Network and Goldstone procedures are inadequate for operations

Across multiple roles and during multiple events, GDSCC personnel operated without SOPs or guidance that was up-to-date and relevant to the activities performed. In many cases, the MIB identified that no SOP or job plan existed. In other cases, the MIB determined that the plans or procedures provided to the sites by the DSN project were substantially out-of-date and did not provide useful information for the activities undertaken. Notably, most procedures reviewed by the MIB had not been updated to address changes from the "Follow the Sun" operational model. In addition, the recently updated "70M, 34M BWG, and HEF Antenna Subsystem Operations Manual (for V7)" still displays “[TBD]” in the critical alarm explanation section for most alarms, warnings, and cautions associated with this mishap.

F8: Antenna control system provides inadequate state knowledge

[redacted]

F9: Goldstone is overly reliant on undocumented behaviors and institutional knowledge

As described in RC-2, the procedures for operations at GDSCC are insufficient. They have largely been replaced by a institutional knowledge base and a set of undocumented behaviors and understandings about antenna systems and operations. In interviews with GDSCC personnel, antennas were described as "having personalities" that needed to be learned over time. Although leadership and high-criticality positions at GDSCC were almost entirely held by personnel with exceptionally long times in grade (in excess of 20-30 years), there was no evidence of a robust lessons-learned or knowledge-management function. At other control centers, the institutional knowledge and undocumented behaviors differed significantly, but there was no consistent attempt to share information or identify best practices.

This is evident in Event 1, where GDSCC institutional knowledge did not include awareness of common hydraulic-limit failure modes, even though lessons learned at other sites included this information. It also is evident in Event 3, where the set of acceptable behaviors included repeatedly driving the antenna into limits without attempting to troubleshoot or resolve the limit exceedances. This is further evident in Event 6, where personnel returned the antenna to stow as the default response when a simple stop would have prevented additional damage.

F10: MPCP practices were not followed at multiple levels

NPR 8621.1 is levied on all NASA programs and projects and describes agency expectations for preparing for and responding to mishaps such as the one investigated by this board. It sets requirements intended to ensure that programs and projects can respond confidently and effectively in the event of a mishap and that personnel involved in a mishap investigation understand their roles and responsibilities.

Neither the DSN project nor GDSCC implemented their mishap plans. Personnel from SCaN, DSN, and GDSCC did not secure the site for an investigation, performed multiple tasks inside the antenna after the asset was impounded by the MIB, and generally failed to carry out the duties described in Section 2.2 of the NPR. As a result, evidence required for the investigation was frequently delayed, and some required elements (e.g., alcohol and drug testing) were never collected.

Personnel associated with the mishap were not given an opportunity to provide privileged testimony. Interviews with the MIB occurred only after the involved personnel had participated in efforts to prepare an official explanation for the mishap and had been exposed to gossip and misinformation about the MIB's role. Consequently, testimony from personnel involved in the event was considered to be of limited value to the investigation. It should be noted that adherence to an MPCP cannot reduce the likelihood or impact of a mishap; therefore, this observation is not considered a formal finding. However, the MIB considers the lack of effective mishap response to be sufficiently concerning to treat this observation as equivalent to a formal finding. This state of affairs cannot be allowed to continue.

F11: The Supervisor on Duty (SOD) has an unclear role and insufficient authority over TSM decision-making at remote sites

Prior to the implementation of the Follow the Sun operations model, the SOD at a given site had clear authority to probe, review, and approve maintenance tasks performed on the antennas under their control. In reviews of voice loops and logs, the MIB determined that the SOD in control during Events 4, 5, and 6 did not question the plans or approaches of the remote TSM, even though they expressed surprise at the intent to return the antenna to service. Based on interviews and discussions with SODs at all three sites, it appears to the MIB that SODs do not consider themselves to be an approval authority over TSM actions, even though they held that authority under the previous operational model. This lack of clarity has resulted in TSMs actions having no clear peer-review, oversight, or approval mechanisms and places an inappropriate burden on TSMs to ensure that their actions are well-reasoned, technically sound, and appropriate — even in the absence of qualified and trained support.

F12: Deep Space Network project has failed to ensure sufficient consistency in operations, best practices, and procedures across all three complexes

The MIB conducted investigations and fact-finding efforts at both the MDSCC and CDSCC sites to develop additional context on DSN operations and the specific circumstances surrounding this mishap. At the other sites, the MIB identified operations, best practices, cultural expectations, and site-specific protocols that would likely have prevented this mishap had the issue occurred elsewhere. At MDSCC, cultural expectations focused on ensuring that the correct personnel were performing a given task and that maintenance personnel were performing maintenance activities. At CDSCC, best practices were in place to ensure that personnel did not act outside their proficiency.

At both sites, site-specific protocols called for the regular testing of the hydraulic limit system in response to observed system behavior. The MIB was unable to identify a compelling explanation as to why these best practices were not elevated to the project level and levied on all sites. The MIB considers the skills, qualifications, experience, and capability of the MDSCC and CDSCC personnel to be extraordinarily high and found many of the practices and recommendations provided to the board to be worthy of consideration at the project and program level.

F13: Goldstone personnel did not adequately assess the real-time situation
In multiple places and events, the MIB found GDSCC personnel demonstrated poor risk assessment and response. The decision not to physically test the antenna rotation limits is the most direct evidence of this finding — this decision effectively accepted the risk that the hydraulic limit would not be operable when needed, and it was never reconsidered or reviewed. During the events immediately surrounding the mishap, the risks of toggling the sector switches do not appear to have been considered at all. Following the mishap, personnel entered the antenna and walked through standing water without considering electrical or fall hazards. While this lack of risk assessment can be partly attributed to the fatigued mental state of the on-call personnel, the risks associated with making decisions while fatigued were also not considered. At no point does it appear that GDSCC personnel sufficiently considered what could go wrong as a result of their actions.

Given the apparent degree of autonomy granted to GDSCC TSMs, it is incumbent on those personnel to perform real-time risk assessments and exercise good judgement on determining whether to return the antenna to active operations. It is evident from subsequent events that this judgement was incorrect. This is particularly evident in cases where TSM personnel were in close physical proximity to the cable wrap, investigating issues with wrap status, and failed to physically observe the wrap direction to confirm it. It is the understanding of the MIB that this task can be a challenge for even seasoned technicians.

This is evident in the decision to discount prior fault indicators during Event 4 when assessing the overall state of the system. To a lesser extent, this finding also may apply to the decision to return the antenna to the stow position rather than simply stopping motion — and to the observers' decisions not to activate an emergency stop at the first sign of flooding.

F14: Goldstone personnel consistently show reduced vigilance
Throughout the mishap timeline, personnel involved with critical events demonstrated complacency -- a false sense of security that they understood the antenna's state, were sufficiently qualified to perform operations, and that the hazards associated with their actions were inconsequential or would not materialize. This factor also manifested in consistent decision-making bias towards believing information suggesting the antenna was nominal and disbelieving information that indicated the antenna was off-nominal. The MIB did not find evidence of reduced vigilance at MDSCC and CDSCC. Both sites demonstrated a healthy skepticism and attention to detail that would have led personnel to critically evaluate potentially hazardous actions like those seen in Events 2-4. This lack of vigilance at GDSCC, combined with the "hero mode" culture, created ideal conditions for poor decision-making during this mishap.

5. Observations

An observation is a factor, event, or circumstance identified during the investigation that did not contribute to the mishap or close call but, if left uncorrected, has the potential to cause a mishap or increase the severity of a mishap. Recommendations to address the MIB's observations are included to ensure all are resolved. During the investigation, the MIB made nine observations, as shown below.

Observation #	Observation Summary	Recommendation #
Obs1	At least four employees walked through flooded antenna structure to locate the source of the flooding before electrical power was shut off, creating risk of electric shock, falls, and contaminant exposure.	R15
Obs2	On-site staff at GDSCC, actively performing the hardware limit backout process, did not follow JPL Document 843-401_C *"Recovering Antennas from Hardware Limits Procedure."*	R14
Obs3	Preventive maintenance of limit systems lacking detail	R18
Obs4	Approach to DRs lacking appropriate level of rigor in some instances	R19
Obs5	DSN has not updated the JPL document *Mishap Reporting, Investigating, and Recordkeeping–DSN Standard Operating Procedure (Inter-Facility Control Document 842-20-337, Rev. A)* for more than 14 years past its expiration date, leaving personnel without current guidance aligned with DSN roles and processes.	R15
Obs6	DSN has not updated JPL Document *"Recovering Antennas from Hardware Limits Procedure (843-401_C)"* since September 24, 2014	R15
Obs7	DSN did not implement their Mishap Reporting, Investigating, and Recordkeeping-DSN Standard Operating Procedure (MRIR SOP), contingency planning, or Mishap Preparedness and Contingency Plan (MPCP) elements required by NPR 8621.1 during, or after the mishap	R15
Obs8	Available JPL and DSS-14 lessons learned not practiced, nor implemented into procedures.	R13
Obs9	[redacted]	R19
Obs10	The GDSCC antenna maintenance strategy is unclear, given current staffing levels and behaviors	R4

Table 11: Observation Summary

Obs1: At least four employees walked through flooded antenna structure to locate the source of the flooding before electrical power was shut off, creating risk of electric shock, falls, and contaminant exposure.

Based on witness accounts, once the flooding was discovered, at least four employees—two TSMs, an OE, and a security officer—walked through the flooded area before facility personnel arrived to locate the source of the flooding, film the conditions (Ref.: Video "DSS14 Flooding.3gp" in data archive), and assess the situation. However, by entering the flooded structure before electrical power was shut off, the employees were at risk of electric shock, falling down the stairs to the level below due to moving water, and possible exposure to contaminants. Despite **Obs5**, the MRIR SOP states, "The DSN O&M Contractor shall adhere to Occupational Safety & Health Administration (OSHA) and Cal-OSHA rules and regulations." Several OSHA rules and regulations were not followed, including 29 CFR 1910.331 and 29 CFR 1910.332 (training and scope for employees exposed to electrical hazards) and 29 CFR 1910.147 (Hazardous Energy and Lockout/Tagout). Someone could have been seriously injured as a result of these actions, but fortunately, there were no injuries sustained during this mishap. For a list of NASA and OSHA safety requirements, rules, and regulations related to this observation, see Appendix C.

For relevant evidence gathered, see Section 3.3.1. For supporting safety requirements, standards, and guidance, see Appendix C. For the MIB's recommended mitigations, refer to R3 in Table 12: Recommendations Listing.

Obs2: On-site staff at GDSCC, actively performing the hardware limit backout process, did not follow JPL Document 843-401_C "Recovering Antennas from Hardware Limits Procedure".

This DSN SOP contains a detailed approach to safely recover the 34-meter and 70-meter antenna systems from being driven into hardware limits. The procedure applies to both azimuth and elevation axis hardware limits and is intended to be followed any time an antenna is driven into the hardware limits. It also requires documentation of each instance the procedure is run in one of the appendices.

The procedure clearly states that an extraction team must be assembled and defines the training requirements for its members (Section 2.2). A few highlights of the training include a site-specific training document, identification of normal wrap and limit switch operation, using the checklist in Appendix C of the SOP for the extraction and documentation of the extraction, and validation of proper antenna motion direction. It is not clear that these procedures were well understood by the extraction team, which consisted of only the on-site crew member.

The extraction team should include qualified maintenance staff as outlined in Section 2.1.1, which identifies the personnel who should be considered for the extraction team. A separate extraction team was not assembled, and none of the procedures were documented. Section 2.1.2 outlines the duties of the operations team when hardware limits are encountered, which primarily involve supporting the extraction team. Two items of particular interest in this section include debriefing the extraction team to understand how the antenna reached the hardware limits and printing applicable logs with time tags for investigative review.

During the DSS-14 mishap, this procedure was never used, and the required steps were not followed to determine why the antenna was hitting the hardware limits. It also should be noted that the procedure is more focused on the 34-meter Beam Waveguide (BWG) systems, likely due to a previous 34-meter BWG cable wrap issue. Much of the technical procedure seems sound, but the lack of compliance with the SOP is concerning and likely contributed to the mishap. (Ref.: ***R4*** in Table 12: Recommendations Listing*)*.

Obs3: Preventive maintenance of limit systems lacking detail

Upon initial inspection of the hydraulic limit assemblies, visible damage was noted, as described in section 3.6.1. The MIB reviewed the initial maintenance documentation and found that the only job plan referencing the hydraulic limits was Job Plan 1065 (provided in the DSS14JobPlans.pdf consolidated package). This job plan lacked detail on how to inspect the hydraulic limit assemblies, and only required the technician to physically exercise the hydraulic limit plunger by hand to ensure it functioned.

The MIB was later made aware of maintenance document: 866-0001352 *Visual Inspection of the Servo Hydraulic Assembly (SHA)*. This document includes more detail than the initial job plans that were reviewed and does require a visual inspection of each of the major hydraulic limit components in the azimuth and elevation axes. However, when the Maximo logs were provided to the MIB, there was no detail included that would have captured pictures of the assemblies or even verbal descriptions of what was seen. The table below contains an excerpt from the Maximo logs showing Preventative Maintenance (PM) 10117 for the SHA visual inspection.

PMNUM	WONUM	DESCRIPTION	REPORTDAT	ACTFINIS	FREQUENC	STATU	PERSONGROU	ANTENN
10117	1824491	SHA Visual Inspection	05/01/2025	06/03/2025	2.00 WEEKS	CANPRI	HYDRO	14
10117	1833079	SHA Visual Inspection	07/01/2025	07/31/2025	2.00 WEEKS	CLOSE	HYDRO	14
10117	1828504	SHA Visual Inspection	06/01/2025	06/05/2025	2.00 WEEKS	CLOSE	HYDRO	14
10117	1833068	SHA Visual Inspection	07/01/2025	07/10/2025	2.00 WEEKS	CLOSE	HYDRO	14
10117	1824502	SHA Visual Inspection	05/01/2025	06/03/2025	2.00 WEEKS	CANPRI	HYDRO	14
10117	1828526	SHA Visual Inspection	06/01/2025	07/02/2025	2.00 WEEKS	CANPRI	HYDRO	14
10117	1841392	SHA Visual Inspection	09/01/2025	10/02/2025	2.00 WEEKS	CANPRI	HYDRO	14
10117	1837480	SHA Visual Inspection	08/01/2025	08/28/2025	2.00 WEEKS	CLOSE	HYDRO	14
10117	1837491	SHA Visual Inspection	08/01/2025	09/03/2025	2.00 WEEKS	CANPRI	HYDRO	14
10117	1841381	SHA Visual Inspection	09/01/2025	10/02/2025	2.00 WEEKS	CANPRI	HYDRO	14
10117	1849848	SHA Visual Inspection	11/01/2025		2.00 WEEKS	CAN	HYDRO	14
10117	1849837	SHA Visual Inspection	11/01/2025		2.00 WEEKS	CAN	HYDRO	14
10117	1845409	SHA Visual Inspection	10/01/2025		2.00 WEEKS	CAN	HYDRO	14
10117	1845398	SHA Visual Inspection	10/01/2025		2.00 WEEKS	CAN	HYDRO	14
10117	1703161	SHA Visual Inspection 2 WEEKS	12/01/2022	02/06/2023	2.00 WEEKS	CANPRI	HYDRO	14

Figure 18: Maximo Log Excerpt

The MIB observed that the PM is performed most of the time, but there is no supporting information provided. If there was damage, it is unclear where those details would be documented within the log. The MIB was unable to find any DRs or other documentation of the damage that occurred, or anything noting the hydraulic limit assemblies were in acceptable shape.

[redacted]

[redacted]

One additional note: the MIB learned through this process that the hydraulic limits are more complex and sensitive in terms of how the various components interface based on the NESC design assessment and the final post-incident condition of the limits. This design information is not documented at any of the sites and may represent technical detail that has been lost over time (Ref.: ***R11*** in Table 12: Recommendations Listing*)*.

Obs4: Approach to Discrepancy Resolution lacking appropriate level of rigor in some instances

The MIB reviewed all discrepancy reports associated with this mishap. Overall, the reports consistently lacked the level of detail necessary for a reviewer to understand and respond to current status or proposed plans. In no instance did the MIB find evidence of a critical review by peers or any authority nor did the MIB find evidence of any concurrence or approval of the closure of a report. The MIB also found no evidence that discrepancy reports are captured and incorporated into the project as lessons learned. The value of a discrepancy reporting system lies in its ability to communicate effectively about ongoing issues and to support the review of past discrepancies when considering design and operational changes; however, it is not clear if DSN is using the DRMS for either purpose.

Obs5: DSN has not updated the JPL document Mishap Reporting, Investigating, and Recordkeeping–DSN Standard Operating Procedure (Inter-Facility Control Document 842-20-337, Rev. A) for more than 14 years past its expiration date, leaving personnel without current guidance aligned with DSN roles and processes.

Per NPR 8621.1, "Center Directors (CDs) and Program/Project Managers shall address the following elements in their Mishap Preparedness and Contingency Plans (MPCPs)···An expiration date not to exceed five years from the effective date."

At the time of the DSS-14 mishap, the DSN equivalent of an MPCP was more 14 years past its expiration date and was written prior to the adoption of "Follow the Sun" operations. It is imperative that important plans, such as the MPCP, are kept current with DSN roles and processes so personnel

are aware of and understand how to use the most up-to-date version of the plan in the event of a mishap.

For relevant evidence gathered, see Section 3.3.1. For supporting Safety Requirements, Standards, and Guidance, refer to Appendix C. For the MIB's recommended mitigations, reference R8 in Table 12: Recommendations Listing.

Obs6: DSN has not updated JPL Document 843-401_C "Recovering Antennas from Hardware Limits Procedure" since September 24, 2014

In addition to Observation 2, which noted that this procedure was not followed while the antenna was being backed out of hardware limits, the procedure itself has not been updated since September 24, 2014. This represents a considerable period of time to not review and update a procedure, especially since the DSN shifted to the "Follow the Sun" operations during this timeframe. This impacts some of the leadership roles called out in the procedure (Ref.: ***R9*** in Table 12: Recommendations Listing*)*.

Obs7: DSN did not implement their *Mishap Reporting, Investigating, and Recordkeeping-DSN Standard Operating Procedure (MRIR SOP)*, contingency planning, or Mishap Preparedness and Contingency Plan (MPCP) elements required by NPR 8621.1 during, or after the mishap.

Regardless of Observation 5, the DSN did not implement its MRIR SOP, contingency planning, or the MPCP elements required by NPR 8621.1 during or after the DSS-14 mishap response. Examples of failures to provide required SOPs are enumerated in the HFACS in Appendix G.

For relevant evidence gathered, please see Section 3.3.1. For supporting relevant Safety Requirements, Standards, and Guidance, see Appendix C. For the MIB's recommended mitigations, please reference R13 in Table 12: Recommendations Listing.

Obs8: JPL and DSS-14 lessons learned not practiced, nor implemented into procedures

Available lessons learned from NASA's LLIS pertaining to JPL and DSS-14 Job Hazard Analyses (JHA), understanding roles and responsibilities during an emergency, and hazard assessments were not practiced and not incorporated into procedures. For the MIB's recommended mitigations, reference R7 in Table 12: Recommendations Listing.

Obs9: [redacted]

[redacted]

[redacted]

[redacted]

Obs10: The GDSCC antenna maintenance strategy is unclear, given current staffing levels and behaviors

The MIB observed varying strategies for executing antenna maintenance across the complexes, differing primarily in expectations for off-hours support. In general, MDSCC and CDSCC have embraced the "Follow the Sun" model and limit maintenance operations during off-hours, fully recognizing this approach increases antenna downtime. In contrast, GDSCC appears to minimize the impact of the "Follow the Sun" operational model by providing as much maintenance-equivalent support as possible for as much of the day as possible. However, the MIB observed that GDSCC does not have a sufficient number of system experts to support this approach. The MIB also noted that expert staff at GDSCC could be scheduled for a full shift, asked to remain on overtime to continue troubleshooting an issue, and then still be expected to be on-call after returning home. This scenario — observed in Events 2 and 3 — violates NASA standards for maximum consecutive hours worked and, in the case of this mishap, contributed to the accidental over-wrap of DSS-14 as described in the HFACS in Appendix G.

6. Recommendations

The MIB makes the following recommendations based on the root, proximate, and contributing causes, key findings, and observations which led to the mishap and resultant undesired outcome.

Recommendation #	Recommendation Summary	Associated Finding	Link
R1	The SCaN Program, DSN project, and GDSCC should incentivize technical rigor over personal heroics	F2, F4, F5, F6	H3.1.1
R2	The SCaN Program, DSN project, and GDSCC personnel should assess risk prior to acting	F1, F5, F6, F13	H3.1.4
R3	The DSN project should reform the TSM Role to match expected training and proficiency	F1, F2, F4	RC-1, H3.1.2
R4	The SCaN Program and DSN project should implement consistent roles with effective training for personnel at all levels	F1, F12	RC-1, Obs10
R5	The SCaN Program and DSN project should develop safety and mission assurance products at all levels	F10	RC-1, RC-2
R6	The SCaN Program and DSN project should implement integrated training simulations for off-Nominal scenarios	F1	RC-1, ECFT-31, ECFT-34
R7	The DSN project should ensure that all operations and maintenance personnel are trained and incentivized to decline requests for operating outside of the boundaries for their role	F2	RC-1, ECFT-29
R8	The DSN project should remediate the design of the hydraulic limit system	F8	RC-3, ECFT-31, ECFT-34
R9	Antenna control software should accurately inform human operators	F8, F14	RC-3, ECFT-26, H3.1.6
R10	GDSCC personnel should be vigilant and skeptical	F13	H3.1.5

Recommendation #	Recommendation Summary	Associated Finding	Link
R11	The DSN project should ensure that all key procedures and products are updated on a five-year cycle	F7	RC-2
R12	The DSN project and Control Complexes should rigorously track inspection and test outcomes	F3	RC-1, RC-2, ECFT-36
R13	The SCAN Program and DSN project should increase reliance on Control Complex expertise	F9	RC-4
R14	The SCaN Program and DSN project should reassert SOD authority over TSM operations	F11	RC-4
R15	The DSN project should update expired MPCP products and add additional information necessary to comply with NASA standards for mishap response	N/A	Obs5, Obs6, Obs7
R16	The DSN project should track site-specific procedure development and utilization	F7	RC-2
R17	The DSN project should establish a Discrepancy Reporting process to include steps for a peer review and approval of the closure actions performed for high priority or critical discrepancies	N/A	Obs4
R18	The DSN project should establish a clear, comprehensive procedure for testing the hydraulic limits	F3	RC-1, RC-2, ECFT-36
R19	[redacted]	N/A	Obs9
R20	GDSCC supervisors should implement a mandatory annual training module on electrical hazards, to include flood conditions, and document completion aligned with current	F13	Obs1

Recommendation #	Recommendation Summary	Associated Finding	Link
	OSHA guidance (See Appendix C) in the appropriate Learning Management System (LMS)		

Table 12: Recommendations Listing

Supporting evidence, background, and/or clarifications of the recommendations follows:

R1: The SCaN Program, DSN project, and GDSCC should incentivize technical rigor over personal heroics

While availability of DSN assets for scheduled data collection is undoubtably important to the agency and humanity at large, the focus must be consistent, reliable operations over the long term – not the next minute of uptime. A degree of technical rigor is critical to consistent and reliable operations, yet it was not evident in the events surrounding the mishap or its aftermath. The MIB identified evidence of this cultural factor at multiple levels: within the SCaN Program, the DSN project, and the GDSCC subcontract. It is therefore likely that the ultimate solution will require a culture change at the program level, in which the program intentionally and consistently focuses on the technical management of network operations. To respond to this recommendation, the SCaN program manager should partner with the Office of the Chief Engineer (OCE) to establish the types of technical changes at the project level that result in program-level oversight and approval, and then issue directives as needed to ensure such topics are elevated to the program for review. The program may also use SCaN-internal and agency awards programs to recognize high-quality work on technical efforts. The program may consider establishing and regularly reviewing performance metrics intended to incentivize technical excellence. The MIB recommends that SCaN and the DSN request support from NASA's OCE on other mechanisms for culture change. The desired outcome of this objective is a program, project, and complex that experience fewer serious mishaps.

R2: The SCaN Program, DSN project, and GDSCC personnel should assess risk prior to acting

Actions described in this report and enumerated in the HFACS appendix are linked by a consistent lack of risk assessment. The TSMs and the SSE were given multiple opportunities to stop, consider the implications of an action, and identify a way to proceed that limited or mitigated the risk to either the asset or personnel. In none of these cases did the MIB find evidence that personnel took those opportunities. Personnel should be trained on risk assessment and should explicitly develop plans to perform tasks that incur a risk to either the asset or personnel. The MIB acknowledges that this recommendation could be taken to an unhealthy extreme that impedes operations and, therefore, encourages the program and the project to find a reasonable balance between operational tempo and the health of both systems and personnel. The MIB also observes that the plans generated by the DSN and GDSCC during the unwrap procedure clearly showed that both groups are proficient in the type of risk assessment and consideration this recommendation proposes. The desired outcome of this recommendation is a cadre of thoughtful, rigorous personnel who consistently act in their own best interests and in the best interests of the network.

R3: The DSN project should reform the TSM role to match expected training and proficiency

The DSN control centers demonstrate markedly different implementations of the TSM role. At MDSCC, the position holds precisely to the responsibilities defined in DSN-level documentation. At CDSCC, TSMs are permitted to operate outside the define role based on personal confidence and experience, but under a clear management expectation that they may always say no to tasks outside their comfort or training, supported by a reasonably rigorous site-specific training plan. At GDSCC, the TSMs appear to be encouraged to act outside their enumerated roles and, as evidenced during this mishap, outside their experience, training, and proficiency. Both a MDSCC-equivalent model (no deviation from defined roles) and a CDSCC-equivalent model (minor deviations with strong management support to decline) are feasible, as are other approaches. The DSN must establish the role clearly and consistently across sites, train the personnel on the information they need to execute it, and provide incentives for TSMs to stop before they exceed that training and proficiency. The desired outcome of this recommendation is a network-wide cadre of TSMs who are fully trained, highly proficient, and have the skills necessary to respond appropriately to any anomaly they're intended to address.

R4: The SCaN Program and DSN project should implement consistent roles with effective training for personnel at all levels

In conversations and interviews with personnel at all three sites, the MIB noted significant differences in roles and responsibilities, a lack of coordinated training for personnel fulfilling those roles, and wide variation in expected behaviors for operating the network. These inconsistencies contributed to undesirable outcomes with respect to TSM accountability. The SCaN Program and the DSN should establish clear roles and responsibilities for all maintenance and operations roles and establish a training and certification plan that ensures personnel across the DSN have a uniform understanding of their role in the network.

Given SCaN's intent to explore an omnibus support contract that spans both DSN and NSN operations, their participation is necessary to ensure training and staffing e xpectations a re appropriately reflected and funded in future contracts. The MIB strongly recommends that SCaN and the DSN collaborate with both NASA OCE, with CSIRO (Commonwealth Scientific and Industrial Research Organisation) personnel supporting CDSCC, and with the joint forum recommended in R13 to develop a training plan that can be implemented across all sites with minimal tailoring. This training and certification plan should be reviewed by existing operations organizations within NASA (e.g., Flight Operations Directorate, Exploration Ground Systems, etc.) as well as peer organizations in partner governments. The desired outcome of this recommendation is a workforce that understands and is incentivized to operate consistently and effectively with personnel across the entire project.

R5: The SCaN Program and DSN project should develop safety and mission assurance products at all levels

It is ultimately the responsibility of the SCaN Program to ensure that its own baseline, as well as the baseline for each of its projects, is relevant and provides accurate guidance on its technical and programmatic state. The MIB identified that the SCaN Program does not have an MPCP or a similar product that would guide program-level involvement in a mishap. Neither the DSN project nor SCaN

Program have the safety and mission assurance products necessary to develop a complete understanding of failure modes and effects or hazards. The MIB identified that the SCaN Program has not established or enforced configuration management expectations on the DSN, and the DSN project has not prioritized ensuring these products exist and are up to date. These gaps must be addressed. The MIB recommends that SCaN and the DSN work with the Office of Safety and Mission Assurance (OSMA) to establish a prioritized list of required products and a plan for their development. The desired outcome of this recommendation is a technical baseline that adequately incorporates the S&MA discipline and enables improved project understanding of the vulnerabilities of its systems and operations.

R6: The SCaN Program and DSN project should implement integrated training simulations for off-nominal scenarios

Events 3–6 of this mishap, as well as the initial mishap response (see OKF-1), indicate that the organizations responsible for responding to off-nominal scenarios — SCaN, the DSN project, and personnel at the three control centers — have not trained in how to respond. Roles and responsibilities were unclear, the correct actions were unknown, and incorrect actions were frequently taken. The MIB recommends two sets of integrated training activities be implemented as "paper simulations." The first series of simulations should focus on how personnel should respond to complex scenarios such as the circumstances of this mishap and should ensure that personnel understand when an antenna should be taken out of service versus continually troubleshot; these simulations should be primarily supported by control center and DSN personnel with SCaN oversight. The second series of simulations should focus on the execution of mishap procedures and should be supported by all relevant organizations. These simulations should occur regularly, not less than annually and should exercise the full escalation path for the scenario, including any call trees or communication requirements. The desired outcome of this recommendation is a workforce at the complex, project, and program levels that fully understands its roles and responsibilities for off-nominal scenarios and knows how to communicate and work with one another to fully resolve them.

R7: The DSN project should ensure that all operations and maintenance personnel are trained and incentivized to decline requests for operating outside of the boundaries for their role

The MIB observed clear cultural differences between the MDSCC and CDSCC control complexes and the behaviors exhibited at GDSCC during this mishap. In interviews and discussions with TSMs, operators, and supervisors at both international sites, it was clear that personnel felt comfortable refusing direction that fell outside their comfort level, qualifications, proficiency, or role. The MIB recommends that SCaN and the DSN ensure that this cultural factor is established at GDSCC through a combination of training and incentivization. Personnel should feel empowered and supported to decline tasks they are not qualified or prepared to perform and should not be rewarded for attempting tasks outside their role or proficiency. The desired outcome of this recommendation is to instill at GDSCC the critically important cultural factors the MIB identified at MDSCC and CDSCC.

R8: The DSN project should remediate the design of the hydraulic limit system

[redacted]

[redacted]

R9: Antenna control software should accurately inform human operators

The complexities of the antenna control system notwithstanding, it is clear that the DSS-14 antenna control software generated misleading and confusing data on the operational state of the antenna to LCOs and TSMs. The project should comprehensively review software logic as well as caution and warning strategies in the context of failure modes and effects analysis and incorporating peer reviews from other NASA organizations familiar with operations and ground systems used to support critical activities (e.g., Near Space Network, Flight Operations Directorate, NASA Kennedy Space Center Operations). The desired outcome of this recommendation is to ensure the antenna control system reliably supports human decision-making and minimizes misinformation. At a minimum, the specific items identified by the MIB should be addressed:

1. Inaccurate, Numerous Cautions and Warnings: [redacted]

2. Cautions and Warnings that are Over-Common: [redacted]

3. Cautions and Warnings that Immediately Resolve: [redacted]

4. Cautions that Should Be Warnings: [redacted]

5. Caution and Warning Instruction Updates: In its log review, the MIB found many cautions and warnings included brief instructions such as “notify maintenance” or “check with maintenance.” In cases where the DSN determines that the correct response is to stop the antenna or to safe the antenna, that instruction should be added to the message. Training should be updated to make clear that the instructions in a caution or warning are mandatory.

6. Add Data for Cross-Checks: [redacted]

R10: GDSCC personnel should be vigilant and skeptical

Beginning as early as 2025-09-15, logs show that the system began exhibiting issues with the cable wrap. Personnel reported noticing the antenna was in unusual places and was responding in unexpected ways. Cautions and warnings associated with wrap direction changes, limits, and wrap inconsistencies occurred consistently through the multiple events in the mishap. At several points, the wrap indication plots used by console operators were blank. In the MIB’s judgement, there was sufficient information by Events 4 and 5 to warrant skepticism of data on console and to prompt personnel to reconsider their assumptions about the nature of the failures. All personnel, but especially those in a decision-making role, should be trained on a healthy level of skepticism of console data. The MIB recommends that SCaN and the DSN request support from NASA’s Flight Operations Directorate on both console design and operator training with this factor in mind.

R11: The DSN project should ensure that all key procedures and products are updated on a five-year cycle

The technical baseline for the DSN project is significantly out of date. The MIB requests for current data products were met primarily by documents released prior to 2010, including some dating back to 1966. Documents with recent issue dates (2023–2024) focused primarily on antenna control system operations and contained numerous TBDs in areas directly relevant to this mishap. Some products were marked as released in the future (2027). The MIB recommends a comprehensive scrub of the DSN technical baseline to track and close TBDs associated with antenna operations and to review all products with issue dates earlier than 2020 to ensure no updates are necessary. In a separate recommendation (R13), the MIB requests that a working group composed of DSN site personnel establish a prioritized list of updates and new procedures needed; that prioritized list should also be addressed. This working group should also be utilized to review and concur on updates to key products. The desired outcome of this recommendation is a set of documentation that is consistently useful for project personnel, well-understood by the implementing complexes, incorporates site-specific lessons learned, and supports a technically rigorous project culture.

R12: The DSN project and Control Complexes should rigorously track inspection and test outcomes

The MIB was unable to determine, based on records provided by the DSN, when damage to the CW breech arm and stepped pin of the hydraulic limit system were damaged. Maintenance records that

should have shown when damage was noted and accepted were not available. Records of maintenance inspections of the hydraulic limit system merely stated "pass." At some point, inspections deviated from the requirements in DSN 867-00030-C — both in damage assessment and required remediation — and these deviations do not appear to have been recorded or approved. The DSN should address these shortcomings through both training on existing procedures and through increased expectations on inspection recordings; at a minimum, any deviations from nominal configuration should be noted. The MIB also recommends that inspection records be accompanied with photographic evidence. When troubleshooting or complex repair efforts are undertaken by maintenance staff, the MIB recommends they be treated similarly to operations discrepancies and reported to the project in a similar manner. This approach will increase the likelihood that similarities are noted across the antennas and remediated through design or operational changes. The desired outcome of this recommendation is an operations data set that can appropriately inform a rigorous review process, support future investigations, if necessary, and provide adequate understanding of antenna status for remote personnel (e.g., SODs).

R13: The SCAN Program and DSN project should increase reliance on Control Complex expertise

The SCaN Program and DSN project should formally leverage the technical expertise of all three DSN control complexes by establishing a DSN chief engineer–led working group responsible for shared lessons learned, coordinated procedure development, and joint review of discrepancies and maintenance issues, while actively incentivizing participation from MDSCC and CDSCC to strengthen network-wide operational rigor. The MIB conducted interviews and fact-finding visits to all three DSN control complexes. Both the MDSCC and CDSCC sites demonstrated valuable expertise, described useful lessons learned, and proposed valuable suggestions to improve network operations. The MIB was unable to find evidence that the DSN project regularly made use of those resources. The MIB recommends the formal chartering of a technical working group chaired by the DSN chief engineer with participation from the three DSN complexes and respective Oes, with the following responsibilities:

- Sharing of knowledge and lessons learned
- Review of site-specific procedures or common practices to assess technical value of network-wide implementation
- Review and concurrence on changes to job plans or procedures
- Review of significant discrepancies to establish lessons learned and determine appropriate design or operations responses.
- Review of significant maintenance troubleshooting issues to establish lessons learned and determine appropriate design or operations responses.

This working group also should be given responsibility for conducting an exhaustive review of the existing DSN operations and maintenance procedure baselines, identifying procedures that are out-of-date or irrelevant, identifying areas where a procedure should exist (e.g., APCA Reboot), and prioritizing the authoring or update of procedures.

The MIB strongly recommends that the DSN consider the personnel at MDSCC and CDSCC as an invaluable technical resource and seek opportunities to make use of their knowledge and expertise.

The MIB further recommends that SCaN and the DSN project explore ways to positively incentivize participation from international partners.

R14: The SCaN Program and DSN project should reassert SOD authority over TSM operations

The DSN project's documentation on roles and responsibilities (DSN 842-328-B) clearly indicates that the SOD, regardless of location, has overall accountability for DSCC operations, including the health of DSN assets at all sites. This documentation also outlines the roles of the TSM and indicates that tasks should be "coordinated" by the TSM. The MIB recommends revising the language in Section 2.2.6 of this document to clearly indicate that the SOD has oversight and approval authority for TSM actions while the network is under their command. Oversight and approval of TSM proposals to repeatedly back the antenna out of limits (Event 3) and inspect sector switches (Event 4) would likely have prevented either action. As described in the recommendations, TSMs also should be trained to reject directives that exceed their training, qualifications, or capabilities. The DSN project to establish a clear chain of command for delegated authority to on-site personnel to remove an antenna from service, given failure signatures. The MIB believes this chain of command may have been eroded over time as a result of the "Follow the Sun" ConOps. The desired outcome of this recommendation is improved oversight and approval for TSM activities.

R15: The DSN project should update expired MPCP products and add additional information necessary to comply with NASA standards for mishap response

The DSN should update the expired JPL Document 842-20-337, "Mishap Reporting, Investigating, and Recordkeeping: DSN Standard Operating Procedure (Inter-Facility Control Document)," and ensure that all applicable personnel are trained on it. The DSN should develop, approve, and implement a current revision of IFC 842-20-337, which is integrated with Center/Program MPCPs to fully comply with NPR 8621.1 requirements. The DSN has not updated the JPL document Mishap Reporting, Investigating, and Recordkeeping—DSN Standard Operating Procedure (Inter-Facility Control Document 842-20-337, Rev. A) for more than 14 years past its expiration date, leaving personnel without current guidance aligned with DSN roles and processes. The DSN should continually update the plan no later than every five years, as required by NPR 8621.1, and send the approved version to the OSMA Mishap Investigation Program Executive. The SCaN Program should additionally consider updates and modifications to program-level documentation that clearly articulates the degree of program involvement in high-visibility or significant mishaps. The intent of this recommendation is to remediate the lack of program-level planning for mishaps and ensure that personnel responding to a mishap have a clear understanding of roles and responsibilities.

R16: The DSN project should track site-specific procedure development and utilization

While the MIB recognizes the value of site-specific procedures and does not discourage their use where appropriate, the fact that two out of the three sites had site-specific practices specifically focused on limit testing and ensuring the operation of the hydraulic limit system cannot be ignored. At a minimum, the DSN should be aware of any site-specific protocols associated with site operations and should review those practices for consistency with project-level expectations, as well as for potential elevation to a project-wide procedure. In general, the MIB recommends that the use of site-specific processes be rare. The desired outcome of this recommendation is a well-understood

and minimal set of site-specific deviations, along with a consistent review process for capturing site-specific lessons learned.

R17: The DSN project should establish a Discrepancy Reporting process to include steps for a peer review and approval of the closure actions performed for high priority or critical discrepancies

Such a closure review should include personnel from the DSN Project. The SCaN Program should identify the escalation criteria that the DSN project should apply to high-visibility or high-impact discrepancies. The intent of this recommendation is to ensure that products from the DR process are useful to the larger project and the SCaN Program.

R18: The DSN project should establish a clear, comprehensive procedure for testing the hydraulic limits

[redacted]

R19: [redacted]

[redacted]

R20: GDSCC supervisors should implement a mandatory annual training module on electrical hazards, to include flood conditions, and document completion aligned with current OSHA guidance (See Appendix C) in the appropriate Learning Management System (LMS)

Additionally, GDSCC supervisors should update emergency response procedures to require area clearance and confirmation of power shutdown before personnel enter any flooded structure. Supervisors will verify compliance during drills and actual events. The intent of this recommendation is to remediate lapses in personal safety judgement identified in Event 6.

APPENDIX A: ACRONYMS

Acronym	Definition
ACA	Antenna Control Assembly
ALC	Antenna Logic Controller
AM	Actuating Mechanism
APCA	Antenna Pointing Controller Assembly
ASI	Antenna Servo Interface
BWG	Beam Waveguide
CCW	Counterclockwise
CDSCC	Canberra Deep Space Communications Complex
COR	Contracting Officer's Representative
CSP	Certified Safety Professional
CW	Clockwise
CWP	Cooling Water Pump
DLM	Depot-Level Maintenance
DR	Discrepancy Report
DRMS	Discrepancy Report Management System
DSCC	Deep Space Communications Complex
DSN	Deep Space Network
DSOC	Deep Space Operations Center
DSS-14	Deep Space Station 14
E&CFT	Events and Causal Factor Tree
E-Stop	Emergency Stop
FD-1	Fuse Designation 1
FOD	Flight Operations Directorate
FRB	Failure Review Board
GDSCC	Goldstone Deep Space Communications Complex
HBA	Hydrostatic Bearing Assembly
HFACS	Human Factors Analysis and Classification System
HLS	Hydraulic Limit System
ICD	Interface Control Document
IRT	Incident Response Team
JHA	Job Hazard Analysis
JPL	Jet Propulsion Laboratory

LCO	Link Control Operator
LLIS	Lessons Learned Information System
LMS	Learning Management System
M&O	Maintenance and Operations
MDSCC	Madrid Deep Space Communications Complex
MIB	Mishap Investigation Board
MPCP	Mishap Preparedness and Contingency Plan
NASA	National Aeronautics and Space Administration
NESC	NASA Engineering and Safety Center
NMIS	NASA Mishap Investigation System
NSC	NASA Safety Center
NSN	Near Space Network
OE	Operations Engineer
OSHA	Occupational Safety and Health Administration
OSMA	Office of Safety and Mission Assurance
PIV	Post Indicator Valve
PM	Preventive Maintenance
RC	Root Cause
RCA	Root Cause Analysis
SCaN	Space Communications and Navigation
SHA	Servo Hydraulic Assembly
SME	Subject Matter Expert
SOD	Supervisor on Duty
SOMD	Space Operations Mission Directorate
SSE	Servo Systems Engineer
STS	Status Display
TSM	Technical Systems Monitor
UO	Undesired Outcome

APPENDIX B: CHARTER

National Aeronautics and Space Administration

Mary W. Jackson NASA Headquarters
Washington, DC 20546-0001

September 26, 2025

Reply to Attn of: Space Operations Mission Directorate

TO: Distribution

FROM: Associate Administrator for the Space Operations Mission Directorate

SUBJECT: Amendment to DSS-14 Azimuth Over-Rotation Mishap Investigation Board Charter

The purpose of the amendment is to update the voting and advisor members sections of the Mishap Investigation Board Charter (see enclosure). The Technical SME, Narbeth Hartoonian has been removed and the Public Affairs Advisor, Caitlin O'Neill, will be replaced by James R. Russell. No other member names are changed but included below for completeness.

MIB members are relieved from collateral duties for the appointment period.

Members

The appointing official has sought and received OCE and OSMA concurrence on the MIB composition and roles.

Chair (Voting):

- Andrew Maynard – Assistant Deputy Associate Administrator for Programs, Science Mission Directorate

Voting Members:

- Safety Officer – James Aaron Bush – Office of Safety and Mission Assurance
- Human Factors / Technical SME – Ian Maddox – Office of the Chief Engineer
- Technical SME – Ted Sobchak – SCaN Program
- Technical SME – Joseph O'Brien – Near Space Network
- Technical SME – Jonathan King – Moon to Mars Program

Non-Voting Members:

- Ex Officio – Lester J. Jean – Office of Safety and Mission Assurance
- Executive Secretary – Charu Esper – Space Operations Mission Directorate

APPENDIX B: Charter (Continued)

Advisors (Required):

- Legal Advisor – Dan Thomas – Office of General Counsel
- Public Affairs Advisor – James R. Russell – Office of Communications
- NASA Safety Center (NSC) Mishap Support Specialist – Lester J. Jean – NSC

The investigation will require support from multiple organizations and should engage resources as necessary. Please cooperate fully with this investigation and provide any technical data, expertise, or other support to this investigation.

Matters relating to the appointment and investigation including administrative, logistical, and information technology support functions can be addressed to Rebecca Durden, SCaN Chief of Staff.

Kenneth Bowersox

Digitally signed by Kenneth Bowersox
Date: 2025.09.26 13:59:24 -04'00'

Kenneth D. Bowersox

Enclosure

Distribution:
SOMD DAA/J Montalbano
Office of Communications/W Boyington
Office of the Chief Engineer/J Pellicciotti
Office of Safety and Mission Assurance/R Deloach
NASA Mishap Manager/M Masters
DSS-14 Mishap Investigation Board Members/
Aaron Bush
Ted Sobchak
Joe Obrien
Ian Maddox
Charu Esper
Jonathan King
Lester Jean
Dan Thomas
Jimi Russell
Andrew Maynard
SCaN DAA/K Coggins
SCaN ADAA/P Baldwin
SCaN Chief of Staff/R Durden

APPENDIX B: Charter (Continued)

National Aeronautics and Space Administration

Mary W. Jackson NASA Headquarters
Washington, DC 20546-0001

September 24, 2025

Reply to Attn of: Space Operations Mission Directorate

TO: Distribution

FROM: Associate Administrator (AA) for the Space Operations Mission Directorate

SUBJECT: DSS-14 Azimuth Over-Rotation Mishap Investigation Board Charter

Background:

On Sept. 16, NASA's large 70-meter radio frequency antenna at its Goldstone Deep Space Communications Complex near Barstow, California (Deep Space Station 14, or DSS-14), over rotated, causing stress on the cabling and piping in the center of the structure. Hoses from the antenna's fire suppression system were also damaged, resulting in flooding that was quickly mitigated. No injuries have been reported. The antenna is offline while NASA investigates the cause, assesses the structure, and makes repairs. NASA's SCaN (Space Communications and Navigation) Program is working with the Jet Propulsion Laboratory (JPL) Deep Space Network team to assess and mitigate mission impacts.

The initial stabilization and evidence collection effort is nearing completion. Materials being collected include photographs, documentation, voice recordings, electronic logs, interviews and descriptions of the event. A timeline of the sequence of events leading up to the mishap is being developed.

This event is currently classified as a NASA Mishap Type B based on the estimated value of the property that was damaged, requiring a Mishap Investigation Board (MIB) with at least three voting members. As the Appointing Official (AO), consistent with NPR 8621.1D, I hereby appoint the DSS-14 MIB as the investigating authority (IA) and issue this charter.

Mishap Investigation Board and Objectives:

Damage to the GDSCC 70m antenna represents a significant event for the DSN. The antenna will be offline until the extent of the damage can be determined, and the root cause of the mishap can be determined and addressed. A multi-stakeholder Mishap Investigation Board (MIB) is hereby established, comprised of members from across NASA, a majority of whom are fully independent of the mishap.

The DSS-14 Azimuth Over-rotation Mishap Investigation Board will:

1. Complete evidence collection and timeline of events.

Enclosure

APPENDIX B: Charter (Continued)

2. Determine the root and contributing causes of the event.
3. Determine if the situation at DSS-14 is present on the other 70m antennas.
4. Identify and recommend any changes or actions required to ensure the future safety of personnel and equipment at the DSN.

Members

The AO has sought and received OCE and OSMA concurrence on the MIB composition and roles.

Chair (Voting):

- Andrew Maynard – Assistant Deputy Associate Administrator for Programs, Science Mission Directorate

Voting Members:

- Safety Officer – James Aaron Bush – Office of Safety and Mission Assurance
- Human Factors / Technical SME – Ian Maddox – Office of the Chief Engineer
- Technical SME – Ted Sobchak – SCaN Program
- Technical SME – Joseph O'Brien – Near Space Network
- Technical SME – Jonathan King – Moon to Mars Program
- Technical SME – Narbeh Hartoonion – NASA Office of Inspector General

Non-Voting Members:

- Ex Officio – Lester J. Jean – Office of Safety and Mission Assurance
- Executive Secretary – Charu Esper – Space Operations Mission Directorate

Advisors (Required):

- Legal Advisor – Dan Thomas – Office of General Counsel
- Public Affairs Advisor – Caitlin O'Neill – SCaN Mission and Stakeholder Engagement
- NASA Safety Center (NSC) Mishap Support Specialist – Lester J. Jean – NSC

Authority, Primacy, and Coordination

The MIB has primacy over collateral investigations, except OIG criminal investigations. The Chair will report only to the AO (or designee) during the investigation.

JPL is running a concurrent Failure Review Board (FRB). Any information sharing (i.e. information that will be contained within the mishap investigation report authorized for public release) must be consistent with NPR 8621.1D. Privileged testimony cannot be shared under any circumstances.

Period of Investigation

The MIB shall commence upon issuance of this appointment and is expected to conclude its investigation within 75 workdays of the mishap. If more time is needed, the Chair will submit a written extension request with rationale to the AO. The MIB will:

APPENDIX B: Charter (Continued)

- Provide a publicly releasable status report every 30 workdays from the date of appointment until the mishap investigation report (MIR) is signed.
- Complete and submit a signed MIR to the AO.
- Conduct an out-brief to the AO and endorsers as part of the MIR endorsement review. Stakeholder readouts beyond endorsers may be directed by the AO.

Conclusion

The Mishap Investigation Board will formally conclude its work when it has:

- Completed evidence collection and documented a verified timeline and factual sequence for this Type B mishap.
- Determined and documented proximate, root, and contributing causes.
- Developed recommendations that are clear, verifiable, achievable, measurable, and traceable to significant findings.
- Issued NASA Advisories if immediate action is warranted or NASA-wide implications exist; OSMA will distribute advisories Agency-wide.
- Finalized and delivered the MIR with required signatures; the AO verifies compliance and releases the IA from duty.

Post-investigation activities (e.g., Corrective Action Plan (CAP) development) are outside the MIB's scope. The AO will task and manage those actions after MIR endorsement.

Kenneth Bowersox

Digitally signed by Kenneth Bowersox
Date: 2025.09.24 19:10:55 -04'00'

Kenneth D. Bowersox

APPENDIX B: Charter (Continued)

National Aeronautics and Space Administration

Mary W. Jackson NASA Headquarters
Washington, DC 20546-0001

March 26, 2026

Reply to Attn of: Space Operations Mission Directorate

TO: Distribution

FROM: Acting Associate Administrator for the Space Operations Mission Directorate

SUBJECT: Second Amendment to the DSS-14 Azimuth Over-Rotation Mishap Investigation Board Charter

The purpose of this second amendment is twofold: (1) revised estimates of property damage have resulted in reclassification of the event from a NASA Mishap Type B to a Type A; and (2) in accordance with NPR 8621.1D, the composition of the board's voting membership is being adjusted to ensure an odd number. Ted Sobchak, previously a voting member, will remain on the board as a technical subject matter expert in a non-voting capacity. No other membership changes are being made; however, the full board composition is restated below for completeness. All members remain relieved of collateral duties for the duration of the appointment period.

Members

The appointing official has sought and received OCE and OSMA concurrence on the MIB composition and roles.

Chair (Voting):

- Andrew Maynard – Assistant Deputy Associate Administrator for Programs, Science Mission Directorate

Voting Members:

- Safety Officer – James Aaron Bush – Office of Safety and Mission Assurance
- Human Factors / Technical SME – Ian Maddox – Office of the Chief Engineer
- Technical SME – Joseph O'Brien – Near Space Network
- Technical SME – Jonathan King – Moon to Mars Program

Non-Voting Members:

- Ex Officio – Lester J. Jean – Office of Safety and Mission Assurance
- Executive Secretary – Charu Esper – SCaN Program
- Technical SME – Ted Sobchak – SCaN Program

APPENDIX B: Charter (Continued)

Advisors (Required):

- Legal Advisor – Dan Thomas – Office of General Counsel
- Public Affairs Advisor – James R. Russell – Office of Communications
- NASA Safety Center (NSC) Mishap Support Specialist – Lester J. Jean – NSC

Matters relating to the appointment and investigation including administrative, logistical, and information technology support functions can be addressed to Charu Esper, SCaN Chief of Staff.

JOEL MONTALBANO Digitally signed by JOEL MONTALBANO Date: 2026.03.26 15:01:20 -04'00'

Joel R. Montalbano

Enclosure

Distribution:
SOMD/A. Lowry
OCOMM/W. Boyington
OCE/J. Pellicciotti
OSMA/N. Vassberg
NASA Mishap Manager/M. Masters
DSS-14 Mishap Investigation Board Members/
Aaron Bush
Joe Obrien
Leigh Forbes
Charu Esper
Jonathan King
Lester Jean
Dan Thomas
Jimi Russell
Andrew Maynard
SCaN/K. Coggins
SCaN/P. Baldwin
SCaN/C. Esper

APPENDIX C: RELEVANT PROCEDURES, DOCUMENTS, AND RISKS

Safety Requirements, Standards, and Guidance		
Document #	**Document Title**	**Document Details**
NPR 8715.1B	NASA Occupational Safety & Health Programs	
NPR 8621.1	NASA Procedural Requirements for Mishap and Close Call Reporting, Investigating, and Recordkeeping	
NPR 8715.3	NASA General Safety Program Requirements	• Requesting Relief from Agency Mission Assurance Requirements
DocID 44598, Rev. 14	JPL Laboratory Mishap Preparedness and Contingency Plan (JPL MPCP)	• Released: 5/17/2021
842-20-337	JPL/DSN Mishap Reporting, Investigating, and Recordkeeping -- DSN Standard Operating Procedure for Inter-Facility Control	• Released: April 13, 2006
JPL Form 2885-G	JPL/Goldstone Deep Space Communications Complex (GDSCC) Subcontractor Environmental, Health and Safety Plan Requirements	• JPL/GDSCC Subcontractor Environmental, Health and Safety Requirements
29 CFR 1910.331 29 CFR 1910.332	Occupational Safety and Health Standards - Electrical	• Training (employees exposed to electrical hazards) • Scope for (employees exposed to electrical hazards)
OSHA 29 CFR 1910.333	Selection and Use of Work Practices	• Electrical
OSHA 29 CFR 1910.147	The Control of Hazardous Energy (Lockout/Tagout)	• Lockout/Tagout
OSHA 29 CFR 1910.335	Safeguards for Personnel Protection	• PPE (Eye/Face/Head Protection) • Insulating Equipment
N/A	OSHA Flood Preparedness & Response Guidance	• Worker Protection • PPE • Contaminated Water Hazards

Open DSN Risks					
DSN Risk ID	**DSN Risk Title**	**Date Opened**	**LxC**	**Risk Focus**	**Status**
DSN-166	GDSCC (DSS-14) 70m Transmitter Controller, O/S Obsolescence	5/13/2014	3x3	DSS-14	OPEN
DSN-171	GDSCC (DSS-14) 70m Transmitter Hardware Failure Causes Extended Outage	5/12/2014	3x3	DSS-14	OPEN
DSN-372	DSS-14 Antenna Electrical Failure	5/18/2023	3x3	DSS-14	OPEN
DSN-362	Reduced Workforce Leads to Critical Failures	5/13/2022	4x4	DSN	OPEN
DSN-334	DSN Failure Due to Long Term Maintenance/Deferment	1/8/2021	5x4	DSN	OPEN
DSN-359	Loss of Key Personnel	11/13/2021	3x5	DSN	OPEN
DSN-392	Insufficient Facilities Staff Causes Schedule Slips and Delays of Critical Tasks	4/4/2024	3x4	DSN	OPEN
DSN-322	Lack of Funding for Succession Planning	1/8/2021	4x3	DSN	OPEN
DSN-323	GDSCC Building Obsolescence	Unknown	Unknown	DSN	OPEN
DSN-313	DSCSS Fire Detection/Suppression Obsolescence	Unknown	Unknown	DSN	OPEN

Lessons Learned		
Lesson ID #	**Lesson Title**	**Applicable Lesson Learned**
14101	DSN Antenna Damaged by Dropped Handrail	*"Before work is to be performed on critical ground support equipment, DSN requires that a contractor conduct a JHA (Job Hazard Analysis) and implement the specified controls before work proceeds."*
5256	JPL Emergency Response: The Station Fire	*"Effective communications with employees is…very important." It is recommended that employees, "improve field response performance and safety," including, "provision of safety officer position," and emphasize, "empowering the staff who must be present during emergencies."*
2696	Substation Arc Flash Mishap	*"Failure to thoroughly assess the hazards of a job/task prior to performing the task may lead to safety incidents." It is recommended, "when it appears that tasks cannot be performed in a safe de-energized state, the task should be presented in an open forum with management and knowledgeable personnel for further assessment."*

APPENDIX D: FILE LIST

D.1 Drawing and Documents

Document Number	Document Title	Release Date
837-218	DSN Follow the Sun Operations Concept	2015-10-15
837-076-I	70M, 34M BWG, and HEF Antenna Subsystem Operations Manual (for V7)	2024-10-22
842-328-B	Responsibilities and Protocol for Real-Time Operations	2025-01-13
843-401-C	Recovering Antennas from Hardware Limits Procedure	2014-09-17
866-000020	70m Antenna Emergency Stop Switch	2010-01-04
867-000030-C	Servo Hydraulics Assembly (SHA) Operation and Maintenance Manual	2010-11-12
867-000036-D	0m Antenna Logic Controller (ALC) Operation and Maintenance Manual	2020-11-05
867-000059	Hydrostatic Bearing Hydraulics Assembly (HBA) Operation and Maintenance Manual	2004-05-04
9435708-E	Hyrdaulic Schematic Hydrostatic Bearing Assy	2001-09-21
9435749-A	Hydraulic Limit Switch Actuating Mechanism	Unknown (1968?)
9436345-1B	Cable Wrap-Up Assy Redesign Modification	1970-03-25
9436350-B	Cable Wrap-Up Ring Installation	1970-03-25
9436361-D	Link, Ring Support, Azimuth Cable Wrap Assembly, 70-Meter	1993-03-21
9437543-B	Cable Tray Installation, Circular	1971-03-10
9617510-A	Limit Switch Assembly, Azimuth and Elevation, 70M Antenna – DSS-14	DRAWING NOT DATED.
9617698-A	Hydraulic Limit Switch Valve Assembly	DRAWING HAS MULTIPLE DATES. 2001-09-21, 2018-01-12, 2025-01-09, 2001-12-18

9617701-F	Hydraulic Circuit Diagram, Servo Hydraulics Assembly, 70-meter	2003-10-15
9620870-J	Simplified Diagram, 70M Emergency Stop Loops	DRAWING HAS MULTIPLE DATES. 2025-05-09, 2025-05-13, 2003
GDSCC_WO_Details_PrintTRM-E-Stops	Work Order Details Report, WO 1833895	2025-07-09
866-000020	70m Antenna Emergency Stop Switch Performance Verification Procedure	2010-01-04
NO NUMBER ISSUED	“DSS-14 HBA Thermal Experiment”	2025-10-15
MANY (866-00***, others with 4-digit identifiers)	“DSS-14 Job Plans”	Dates vary from 2014 to 2024.
N/A	“Fire Height Trend”	NOT DATED, covers 2025-09-15, 2025-09-16.
No Number Issued	“DSN 70m Cable Unwrapping Procedure” in many versions	2025-11-03 (final)
893-000189	“DSS-14 Azimuth Cable Wrap Unwind Report”	2025-12-18
No Number Issued	Multiple Presentations on Unwrap from various GDSCC and DSN sources	2025-10-06
Many	Duplicate Drawings from Initial Delivery	
NO NUMBER	Statement from Charles Clark on Event 4	2025-09-16
Many (>25)	Duplicate References from Earlier Deliveries	
810-078-A2	DSN Incident Investigation and Failure Review Standard Practice	2015-01-15
NO NUMBER ISSUED	Written Responses to MIB Questions on hydraulic limit assembly operations	2025-11-21
868-000076-A	70M Antenna SHA and ALC Installation Procedure	2003-09-19
869-000078	ALC and SHA Acceptance Procedure	2002-11-15
869-000078-REPORT-061130-A	DSS-63 ALC, SHA, and HBA Acceptance Test Report	2006-12-13
869-000078-REPORT-070905	DSS-63 ALC, SHA, and HBA Acceptance Test Report	2007-09-11

869-000078-RESULTS-051027	70m ALC/SHA and HBA Assemblies – DSS-43 Hardware Acceptance Test Results	2006-03-21
869-000078-RESUTS-061130	DSS-63 Antenna Logic Controller (ALC), Servo Hydraulics Assembly (SHA), and Hydrostatic Bearing Assembly (HBA) Acceptance Test Results	2006-12-05
Many	Duplicate Job Plans from Earlier Deliveries	2025-12-09
No Number Issued	DRMS Records (XLS format)	2025-11-20
No Number Issued	Narrative on 70m HBA Epoxy Grouting History	2025-12-02
Many	Monthly Status Reporting from Peraton/GDSCC	2025-11-19
No Number Issued	70m Azimuth Hydraulic Limits Operation (PPT)	2025-11-09
No Number Issued	DSN Presentations on readiness for Follow the Sun	2017-06-21
839-0128-K	70M BWG HEF Antenna Controller Test Design and Procedures	2025-08-12
No Number Issued	Narrative and Analysis of Limit Exceedances on DSS-14	2025-12-22
813-112-D	DSN Testing Standards and Guidelines	2025-12-02

D.2 Graphics and Photographs

Document Number	Description	Date
N/A	“G82 Pumps – zoom”	2025-10-21
N/A	“G82 Pumps”	2025-10-21
N/A, Many	“CWP-3 Pressure”, etc.	2025-10-10
N/A, Many	“G-82 CWP-4”, etc.	2025-10-10
N/A, Many hundred	Videos and Photos of Damage	2025-10-10
N/A, Many	Photographs of Sector Switches	2025-10-07
N/A, Many	Photographs of Console Displays	2025-10-07
N/A, Many hundred	Photographs of MDSCC 70m antenna systems	2025-10-07
N/A	Screenshots of DRMS System	2025-11-20
N/A	“Limit Diagram, DSS-63”	2025-12-05

D.3 Emails and Other Correspondence

Subject	To	From	Date
RE: Simplified Explanation - DSS-14	Brooks, Andrew	Brod, Alex	2025-10-13

D.4 Data Logs

Log Source	Logged Duration	File Type	Date Delivered
ALB	2025-09-15, 2025-09-16	.GDSCC	2025-10-10
ALAN (Network Traffic)	2025-09-15	PDF	2025-10-10
ALC	2025-09-15, 2025-09-16	Screenshots of console (image files)	2025-10-10
APCA	2025-09-10 to 2025-09-17	Plaintext	2025-10-10
NRT	Unknown, not used	Plaintext	2025-10-10
DRMS (discrepancy logs)	2025-09-12 to 2025-09-19	Word Export	2025-10-10
NMC	2025-09-15, 2025-09-16	Plaintext	2025-10-10

D.5 Personnel Logs and Interviews

Description	Logged Duration	Date Delivered
Voice Loop Recordings	2025-09-15, 2025-09-16	2025-10-10
Ops Chief Written Logs	2025-09-14 to 2025-09-17	2025-10-10
GDSCC Entry and Exit Logs	2025-09-16	2025-10-10
Photographs of TSM Paper Logs	2025-09-15, 2025-09-16	2025-10-07
Ops Chief Interviews		2025-12-11
GDSCC Personnel Interviews (TSMs, SSEs, Others)		2025-10-07

D.6 Other Products

Product	Description
“DSS-14 K-Vac pumpout”	Manifests for water pumping (mishap remediation).

APPENDIX E: DETAILED SEQUENCE OF EVENTS

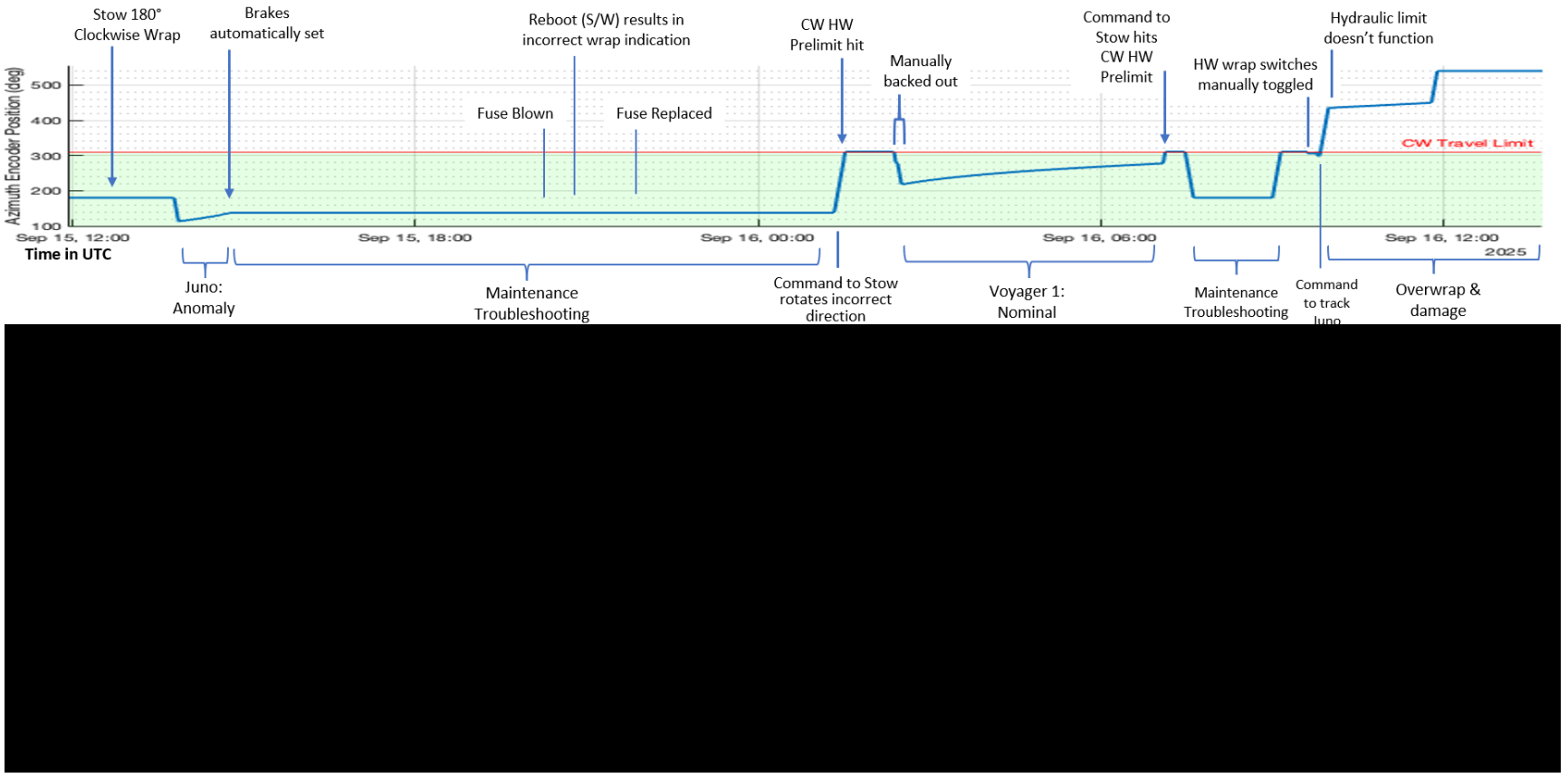


Figure 19: Sequence of Events

Sequence of Events

Nominal Passes (2025-09-14 & 2025-09-15)

The timeline begins on 2025-09-15 showing the antenna in the stow position being prepared for its next support. On 2025-09-14T20:56:11Z, the antenna supports Voyager 1 which successfully completes and is returned to the stow position in preparation for its next support. At 2025-09-15T05:07:13Z, DSS-14 begins a successful support of New Horizons. At the completion of this pass, the antenna is returned to the stow position in preparation for the next scheduled support.

Juno Pass (2025-09-15)

[redacted]

[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

[redacted]

[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

[redacted]

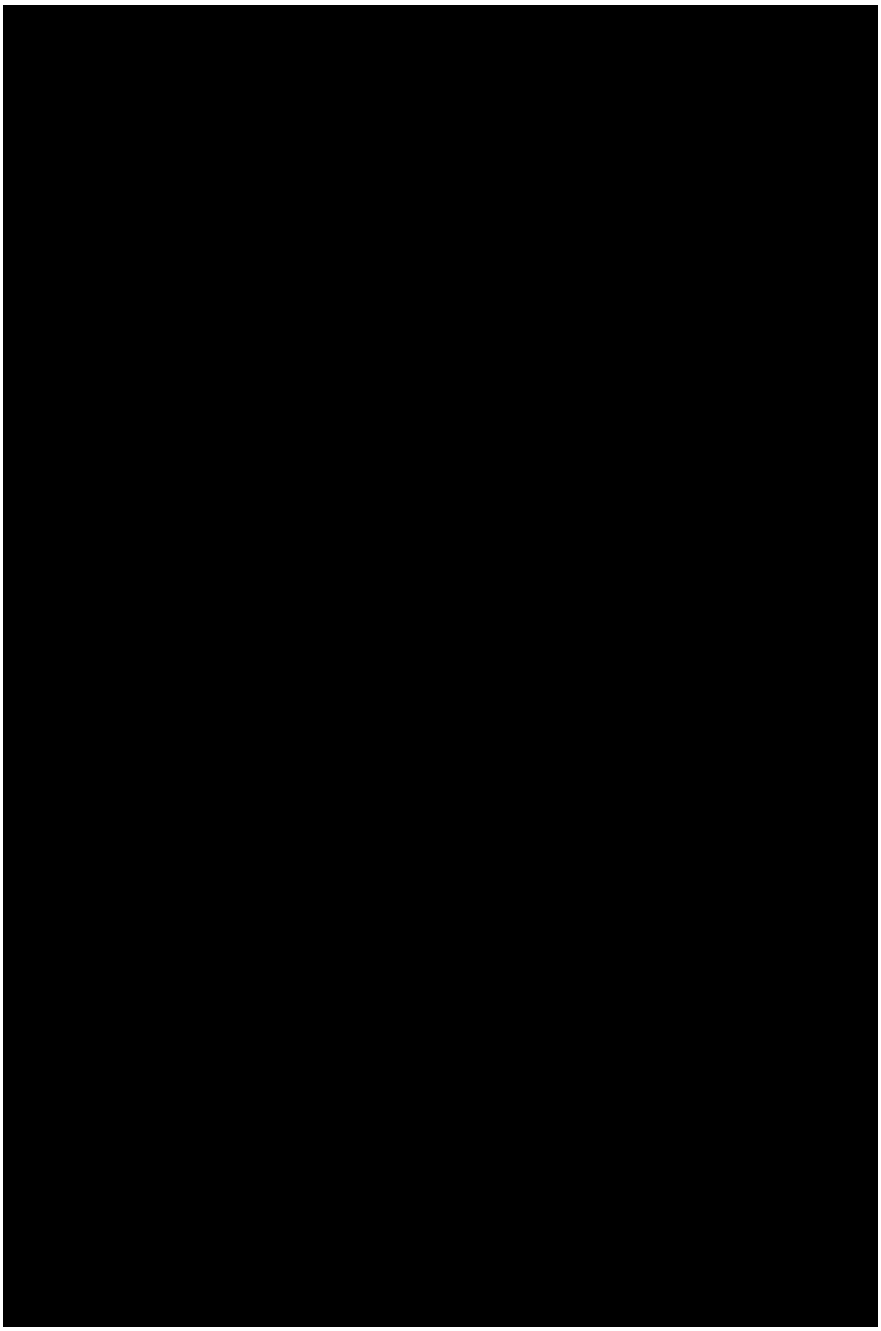
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

[redacted]

[redacted]

[redacted]



.

[redacted]

Resume Juno Track

[redacted]

[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

[redacted]

[redacted]	[redacted]	[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Maintenance Troubleshooting

[redacted]

[redacted]

[redacted]

[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

[redacted]

[redacted]

[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

[redacted]

[redacted]

[redacted]

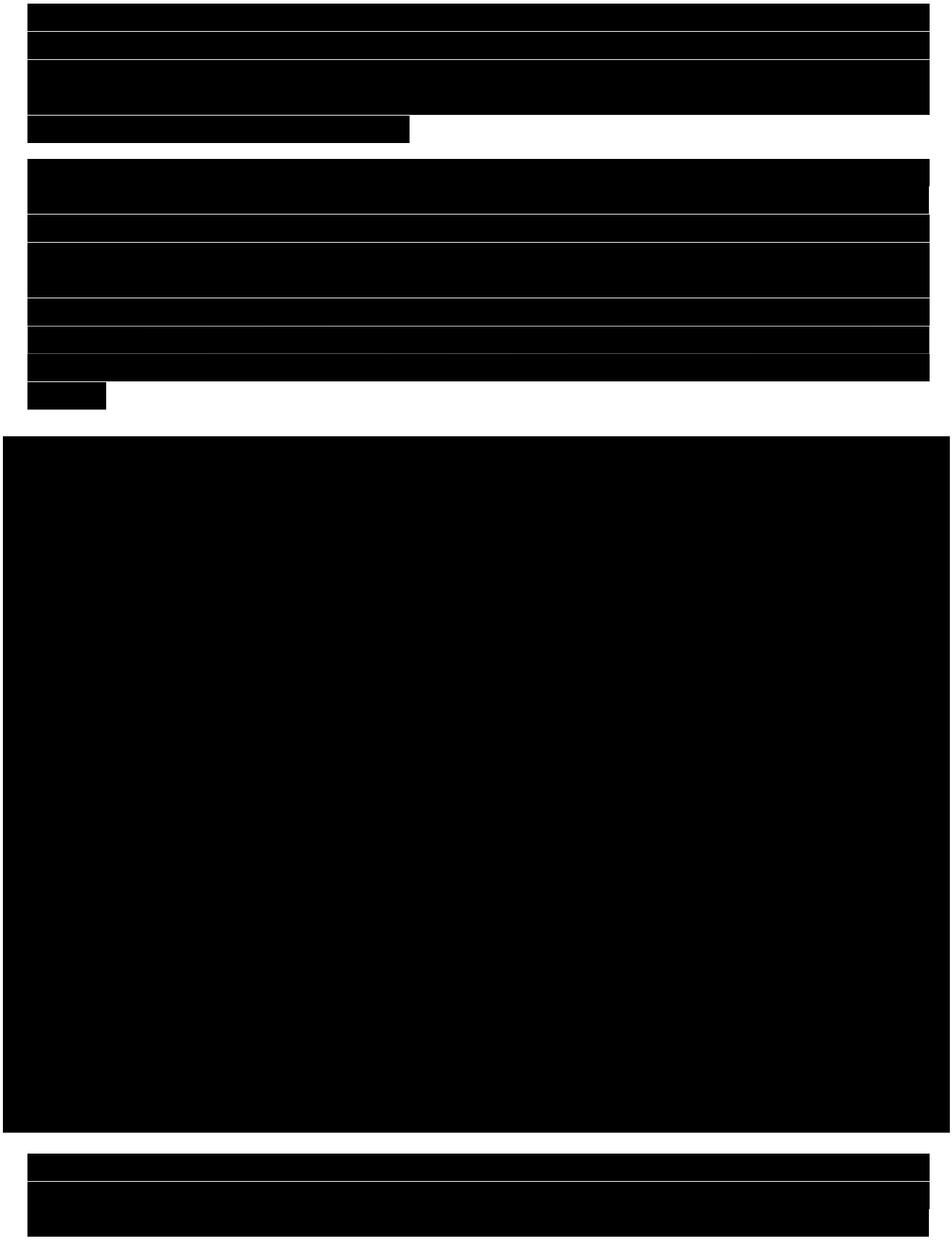
[redacted]

[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

[redacted]

[redacted]

[redacted]



[redacted]

[redacted]

Voyager 1 Support (2025-09-16T02:30:45)

[redacted]

Maintenance Troubleshooting

[redacted]

[redacted]

Juno Support (2025-09-16T09:00:33)

At this point, the antenna is setup to support the next Juno pass (SCN-61) and begins slewing to its starting position of 75 degrees CW at 2025-09-16T09:00:33Z.

[redacted]

[redacted]

[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

However, the antenna continued to drive through the CW hydraulic limit past the 45 degrees neutral position, where the sector switches change the wrap. This transition is observable in the data as the antenna continues to drive to the 75 degrees CW position commanded (actually 75 degrees CCW). This position is approximately 120 degrees past the CW wrap hydraulic limits. At this point, the antenna was significantly over-wrapped with no remaining limits to prevent further CW motion.

At 2025-09-16T10:05:52Z, the next “TRK” command is issued to start the Juno pass. At this point, little additional information appears in the logs, but a few random errors begin to surface, likely due to cable damage caused by the over-wrap. Around this time, a member of the DSN team who was on break outside the antenna noticed water rushing out of the entrance door. The next logged event is the antenna being commanded to the stow position at 180 degrees CW. The stow command is likely issued because the operators believe the stow position is a safe location to put the antenna while the rushing water condition is assessed.

In reality, the antenna was at approximately 90 degrees CW and already over-wrapped—about 135 degrees beyond the CW hydraulic limit. In order to get to the stow position, it will drive an additional 90 degrees CW, pushing the over-wrap to approximately 235 degrees beyond the CW hydraulic limits. Damage was already occurring at this point, and the additional 90 degrees of rotation significantly amplified the over-wrap condition and causing further damage.

APPENDIX F: HYDRAULIC LIMIT SYSTEM DESCRIPTION

Hydraulic Limit System

The 70-meter Hydraulic Limit System (HLS) acts as a final line of defense to prevent overtravel of the azimuth axis, resulting in an over-wrap condition that can severely damage the antenna cabling, wiring, and plumbing routed up through the center of the antenna system. The cable wrap is a method used in many antenna systems of various sizes to account for rotation in azimuth without damaging the cables. It is commonly used in antenna systems used for tracking vehicles in space with very deterministic trajectories unlike many radar or telemetry systems tracking aircraft that may use more complete slip ring systems. It greatly simplifies the overall design of the system but does require the system to understand where it is in the wrap at all times and to implement safeguards to prevent over-wrap conditions. The HLS includes both CW and CCW limits that extend beyond the software and hardware pre- and final-limit switches. If these hydraulic limits malfunction, they will fail to stop antenna motion on the azimuth axis.

Overview

There are two hydraulic limit systems: one for CW and one for CCW. They are installed on separate circular paths—the CW system on the outer path and the CCW system on the inner path. Each system includes three key components: a hydraulic limit valve, a stepped pin, and a floor-mounted actuating mechanism (AM).

By default, the azimuth and elevation brakes are spring set. To move the antenna, hydraulic pressure is applied to release the brakes before motion begins. If pressure is lost, the brakes automatically engage to stop movement. The hydraulic limit valve and stepped pin are mounted on the rotating portion of the antenna. As the antenna rotates in azimuth, the stepped pin engages the floor-mounted AM, toggling a cam between disarm and arm positions. When the limit valve engages the cam in the armed position, hydraulic fluid is diverted from the brake line to the drain line, engaging the brakes. Once actuated, the antenna cannot be moved without intervention by a three-person technical team.

Description

[redacted]

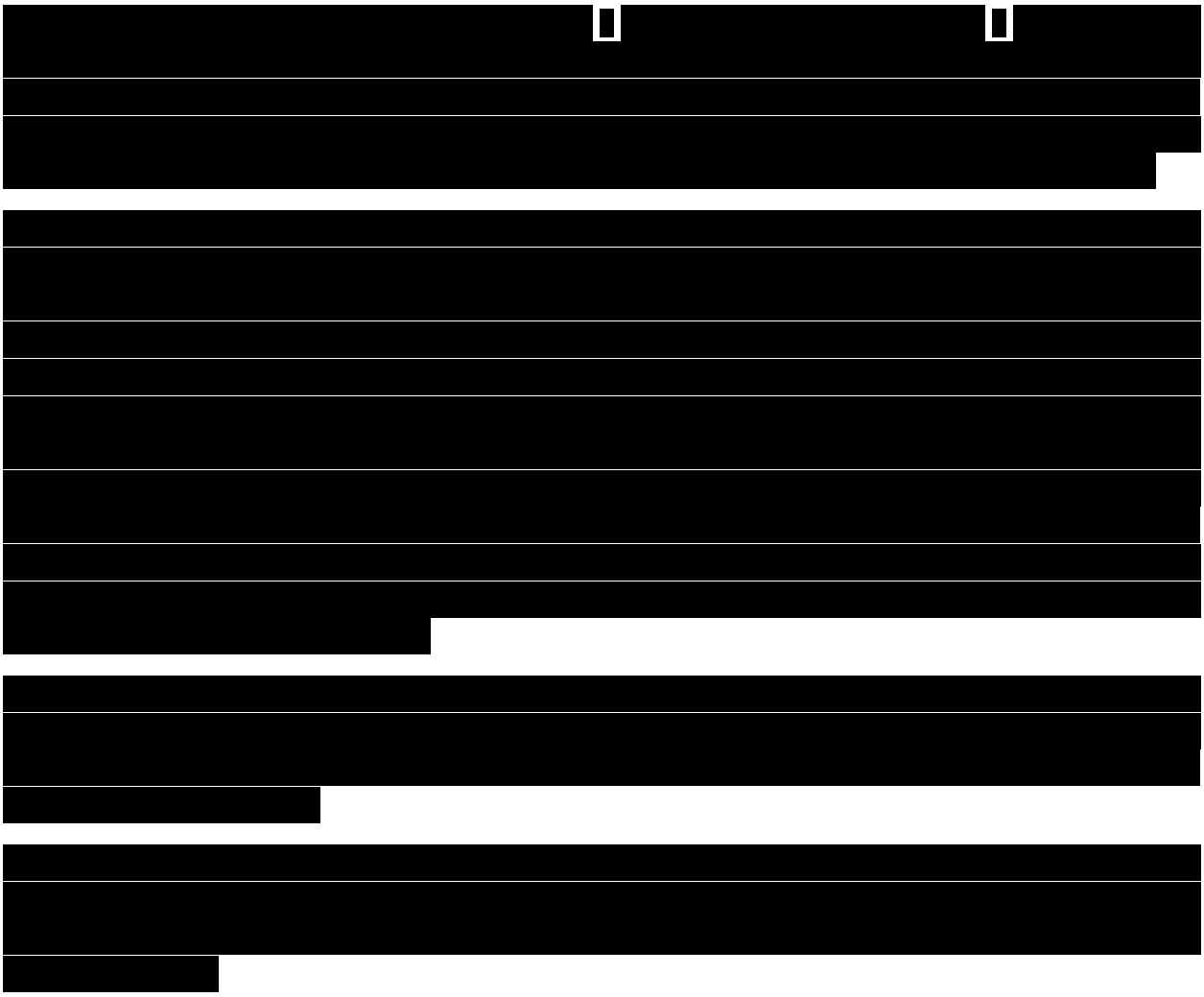


Figure 33 shows a representative actuating mechanism with each of the main components labeled (top diagram), as well as a photo of the CW unit installed on DSS-14.

[redacted]

Figure 35 below summarizes the primary failure modes that can occur with the actuator box.

[redacted]

APPENDIX G: HUMAN FACTORS ANALYSIS AND CLASSIFICATION SYSTEM (HFACS)

National Aeronautics and Space Administration

Deep Space Station 14 (DSS-14)
Azimuth Over-Rotation Mishap

Appendix G: Human Factors Analysis

CONTENTS

G.1 Introduction

A "Human Factors Analysis and Classification System (HFACS)" is required for high visibility, Type B, or Type A mishaps, per NPR 8621.1D. An MIB member was designated as the human-factors investigator, completed the required training specified in the standard, and conducted the human-factors investigations and analyses in support of the MIB's overall investigation.

Using a fault tree analysis, the MIB selected six critical adverse actions over the course of the extended duration of the mishap that had a direct impact on a proximate cause. Each of these actions was subjected to the HFACS analysis approach to identify and isolate any key human factors contributions to the action.

This appendix utilizes the HFACS taxonomy established in Version 1.4 of the Human Factors Handbook Procedural Guidance and Tools (NASA-HDBK-870925). Please refer to that document for a complete description and explanation of each human factor considered.

G.2 Approach

This Human Factors Analysis appendix is arranged in a manner that broadly conforms to the main report. As described in Section 3, six key actions were identified that caused significant state changes in the system and directly contributed to the undesired outcome. Each critical event is comprised of a discrete set of actions and decisions, and these decisions are the subject of HFACS analysis. For each event, a short narrative is provided in Section G.1.1.1. For full detail, please refer to Section 3 of the main report. Based on that narrative, each HFACS factor is evaluated and scored, and an accompanying narrative explains the scoring for each group of factors.

Scoring for human factors in this appendix broadly follow the guidance in the NASA Human Factors Handbook:

- A score of zero is applied if the factor was identified but cannot be shown to have a significant impact on the decisions in the event.
- A score of one is applied if the factor was identified and determined to have an impact but where eliminating the factor is unlikely to substantially mitigate the mishap.
- A score of two is applied if the factor was identified, is determined to have an impact, and where eliminating the factor would have some ameliorating effect on the mishap.
- A score of three is applied if the factor was identified, is determined to have an impact, and where eliminating the factor would have a clear mitigating effect on the mishap.
- A score of four is applied if the factor was identified, is determined to have an impact, and where eliminating the factor would have been sufficient to fully prevent the mishap.

Findings and observations are provided at the event level in Section G.2, but key findings that span multiple events are recapped in Section H.3. Recommendations specific to the human factors analysis are provided in Section H.4.

G.2.1 Critical Events

- **Hydraulic Limit Damage:** At an undetermined time, believed to be significantly prior to the mishap, the HLS — the final failsafe against antenna over-wrap — sustained significant damage. This damage was not noted during subsequent inspections, and there is no record of DSS-14 hydraulic limit testing. A detailed discussion of the nature of DSS-14 hydraulic limit damage is available in the main report and in Appendix F.

[redacted]

- **Hardware Pre-Limit Recovery:** On 2025-09-16, the antenna encountered its clockwise hardware pre-limit three times. Maintenance personnel and TSMs repeatedly moved the antenna out of the limit.

[redacted]

- **Return to Stow:** As the antenna rotated in an over-wrap condition, a hose carrying fire-suppression water was damaged, causing flooding into the antenna base. Personnel on break outside of the DSS-14 antenna noticed water coming through the surface-level doors and informed the GDSCC TSMs. The TSM stopped active tracking and commanded the antenna to the stow position. The antenna rotated further in the CW direction to reach stow, worsening the over-wrap and contributing to additional damage .

G.3 Analysis

G.3.1 Event 1: DSS-14 Hydraulic Limit System Rendered Inoperable

A full description of this event is available in Section 3.6.1 of the main report. From a human factors' perspective, the relevant consideration is the decision at GDSCC not to test the operation of the hydraulic limit at any point identified by the MIB in the past 10-plus years or implement a comprehensive inspection, nor implement a preventative maintenance process for the HLS. In its investigation, the MIB determined that both the MDSCC and CDSCC sites performed detailed testing of physical limits following major antenna modifications, as well as regular testing as part of preventative maintenance.

G.3.1.1 Organization Factors

Factor	Score
Climate and Culture	
Operations	
Organizational Structure (OP401)	2
Operational Risk Management (OP403)	2
Publications and Written Guidance (OP405)	3
Resources	
Design (OR405)	1
Operational Information (OR406)	1
Facilities (OR407)	2

G.3.1.1.1 Climate / Culture

Climate and culture factors were not considered for this event; information from interviews and discussions were not deemed viable given the elapsed time between the event and the investigation.

G.3.1.1.2 Operations

Work instruction records and employee recollections indicate that physical-limit testing is not required by work instructions. Both the MDSCC and CDSCC sites identified the need for site-specific requirements, including written guidance, for physical limit testing to reduce risk to antenna operations. Had GDSCC personnel adopted this approach and added physical-limit testing as a risk reduction, it would have identified issues in HLS operation. The MIB was unable to clearly determine who in the DSN project is ultimately accountable for ensuring proper procedures for testing; in practice it appeared that each site was responsible for their own determinations, but reference was also made to an operations engineer (OE) function that provided consistent guidance. The MIB found no clear guidance from the OE function associated with this event. There also appears to be a historical lack of safety documentation, such as Failure Modes and Effects Analysis, that would have indicated failure modes that could only have been assessed via test.

G.3.1.1.3 Resources

Resource considerations play a minor role in this event. The design and operational documentation of the HLS is sufficiently non-intuitive that it took engineers associated with the

MIB, FRB, DSN, GDSCC, and the NESC to fully characterize its operation, which may have contributed to personnel not recognizing the need to test the system. Discussions with GDSCC personnel also indicated that cosmetic damage to hydraulic-limit hardware had been noted but not repaired, which may have made it more difficult for a physical inspection to detect a more serious problem.

G.3.1.2 Supervision/Planning Factors

Factor	Score
Oversight	
Local Training (SO302)	1
Planning	
Local Training (SP306)	2
Accountability	
Supervisory Compliance	

G.3.1.2.1 Oversight

From discussions with personnel at MDSCC and CDSCC, contemporary local training for maintenance personnel appeared sufficient for personnel at those sites to consistently and accurately describe hydraulic limit operation and identify the criticality of testing. However, the MIB did not observe a similar level of training or system knowledge from GDSCC personnel. This lack of training on system functionality would likely have influenced decision-making if it persisted through the entire duration of Event 1.

G.3.1.2.2 Planning

Both CDSCC and MDSCC actions show that sufficient risk assessment could have identified the need for hydraulic limit testing. There is no evidence of similar assessment at GDSCC.

G.3.1.2.3 Accountability

Accountability was not considered for this analysis. There were multiple organizational changes in the elapsed time between the event and the investigation, making such an assessment infeasible.

G.3.1.2.4 Supervisory Compliance

There is no evidence of a compliance impact in this event. Historically, each site has had broad latitude in operational planning and site maintenance activities.

G.3.1.3 Environmental Factors

Factor	Score
Physical Environment	
Technological Environment	
System Condition (PT209)	1
Space Environment	
Information Environment	
Task Planning (PI202)	2

G.3.1.3.1 Physical Environment

The physical environment of the HLS is described in Appendix F of the report. There is no evidence indicating these conditions impacted the decision not to test the hydraulic limits.

G.3.1.3.2 Technological Environment

[redacted]

G.3.1.3.3 Information Environment

As referenced in Section 2.1.2, information that should have highlighted the need for testing (e.g., FMEAs) does not appear to be available. While it should be noted that other sites were able to determine the need for physical testing in an identical information environment, the additional context might have helped GDSCC personnel decide to perform similar testing. The MIB also notes that the DSN project should be the authority responsible for determining what testing is necessary.

G.3.1.4 Individual Factors

Individual factors were not considered; information from interviews and discussions were not deemed viable given the elapsed time between the event and the investigation.

G.3.1.5 Act

Factor	Score
Decision Making	
No Action Selection (AD102)	3
Skill-Based	
Perception	
Compliance	

G.3.1.5.1 Decision-Making

The decision relevant to this event is whether to physically test the hydraulic limit at any point in the past decade or more. The personnel at both the DSN and GDSCC incorrectly decided not to test the limits. Had they followed the MDSCC and CDSCC sites in making the correct decision to perform testing, the failure of the HLS would have been identified and resolved prior to the mishap. An effective hydraulic limit would have prevented the mishap.

G.3.1.6 Findings

G.3.1.6.1 GDSCC Teams Had Insufficient Documentation to Support Operations

The lack of safety documentation and network-level testing requirements significantly inhibited both project- level and complex-level understanding of why limit testing was necessary. At the same time, the lack of safety documentation indicates a level of organizational risk acceptance and a general lack of technical rigor that becomes clearly evident in subsequent events.

G.3.1.6.2 GDSCC Personnel Do Not Consistently Consider Risk before Acting

In part as a result of the insufficient documentation, it is clear that GDSCC personnel incorrectly assessed the risk to the antenna from an inoperable hydraulic limit and did not revisit the decision at any point in the following decade or more of antenna operations. A correct assessment of risk was possible, as demonstrated at the other DSN sites.

G.3.1.7 Observations

G.3.1.7.1 GDSCC Maintenance Does Not Fully Repair Damaged Hardware

Significant damage to the HLS was observed by the MIB and is described in the main body of the report. It should be noted that, in addition to the increased potential for system failure, the decision not to fully repair damaged systems inhibits effective physical inspection. During investigations and site tours, MIB personnel also identified several instances where repairs were made that were sufficient to restore functionality but did not return the antenna to a nominal state (e.g., fuse repairs that left blackened wires in place, sloppy caulking to prevent water intrusion). This observation is limited to GDSCC and generally to DSS-14. The 70-meter antennas at other sites did not exhibit similar maintenance issues, and the general state of repair of other antennas toured at GDSCC appeared generally adequate.

G.3.1.7.2 DSN and GDSCC Do Not Effectively Respond to Lessons Learned at Other Sites.

Due to the changes in personnel and the lack of data indicating when the limit was rendered inoperable, the MIB was unable to conclusively determine why the GDSCC site did not test its HLS, even after issues were discovered at the other sites in 2008. It should be noted that robust coordination and discussion between sites could have revealed the differences in operating modes and helped the GDSCC team identify the faulty limit in advance of the mishap.

G.3.2 Event 2: Troubleshooting

A detailed timeline of the troubleshooting efforts on 2025-09-15 to 12025-09-16 is available in the Section 3.6.2 of the main report. For the purpose of this analysis, the following information is considered relevant:

- The troubleshooting effort began with the identification of “ESTOP” faults. The E-stops prevent the movement of the antenna, and concurrent failures were observed across the entire E-stop system. As troubleshooting continued, additional faults appeared in multiple strings of pumps and hydraulic system subassemblies.

[redacted]

G.3.2.1 Organization Factors

Factor	Score
Climate and Culture	
Culture (OC401)	4
Climate (OC402)	1
Contractor Relations (OC403)	2
Operations	
Operational Tempo (OP402)	1
Resources	

G.3.2.1.1 Climate / Culture

The MIB observed, within GDSCC operations, the DSN project, and at the SCaN program level, a culture that places a strong emphasis on maintaining antenna uptime. While the objective of maximizing uptime is not inherently problematic and does not necessarily lead to adverse outcomes, interviews with all three sites (GDSCC, MDSCC, and CDSCC) revealed a shared focus on keeping their antennas operational.

Interviews with personnel at all three sites indicate that GDSCC staff seek to "keep the antennas green at all costs" (where "green" is the colloquial term for operational). In contrast, both MDSCC and CDSCC have indicated a willingness to "call the antenna red and wait for tomorrow" (where "red" is the colloquial term for an in-operational antenna).

Specific to the events surrounding the mishap, GDSCC maintenance personnel indicated during interviews that they felt responsible for working long overtime hours — even in the face of personal hardship — to return the antenna to operations. Estimates based on access logs indicate maintenance personnel were on-site for more than 12 hours before returning the antenna to a degraded operational status based on the repair of a lube pump.

G.3.2.1.2 Operations

During interviews, personnel involved with this mishap indicated that they were asked to troubleshoot multiple problems simultaneously and that context switching between these issues was challenging. It is possible that this simultaneous effort impacted analysis and engineering decision-making. Given the number of related issues on the antenna at the time, it is

unclear whether a reduction in operations tempo would have been feasible without extended downtime.

G.3.2.2 Supervision/Planning Factors

Factor	Score
Oversight	
Planning	
Proficiency (PF207)	1
Accountability	
Supervisory Compliance	

G.3.2.2.1 Planning

The MIB interviewed maintenance personnel associated with this mishap as well as personnel at both MDSCC and CDSCC, and asked personnel to describe the training that would be given prior to performing complex troubleshooting activities. At both MDSCC and CDSCC, maintenance staff described a clear elevation path for repair efforts and were able to quickly identify personnel from other disciplines who could be called in to support if a given repair exceeded their expertise or proficiency. In contrast, GDSCC personnel did not describe a hierarchy or elevation path and indicated that there was only one responsible engineer for the relevant discipline across the entire site. With additional support from personnel specifically proficient in the ALC, it is likely that the common-cause failure could have been identified and resolved more quickly and that the wrap inconsistency might have been discovered before the end of the maintenance shift.

G.3.2.3 Environmental Factors

Factor	Score
Physical Environment	
Technological Environment	
Instrument and Warning System (PT202)	3
Systems Automation (PT205)	3
Space Environment	
Information Environment	

G.3.2.3.1 Technological Environment

[redacted]

[redacted]

[redacted]

G.3.2.4 Individual Factors

Factor	Score
Psychological Environment	
Attention Management	1
Complacency (PP205)	3
Task Saturation (PP213)	1
Medical Environment	
Perceptual Environment	
Fitness	

G.3.2.4.1 Psychological Environment

[redacted]

G.3.2.5 Act

Factor	Score
Decision Making	
Incorrect Action Selection (AD101)	2
Ignored A Caution/Warning (AD104)	1
Skill-Based	
Perception	
Compliance	

G.3.2.5.1 Decision-Making

Maintenance personnel chose incorrect actions throughout the troubleshooting process by focusing on symptoms rather than identifying the root cause of the issues, and by failing to

respond to the repeated limit encounters. Discussions with DSN project personnel and TSMs at both MDSCC and CDSCC indicate that the set of cautions and warning observed clearly pointed to a control issue rather than a hardware issue indicated by the caution messages. Had the troubleshooting personnel correctly identified the root cause, they would have been better positioned to identify adverse results like the wrap status flip that contributed to the mishap.

G.3.2.6 Findings

G.3.2.6.1 System Automation Provides Inadequate Data on Wrap Status

[redacted]

misleading, and dangerous.

G.3.2.6.2 GDSCC Teams Provide Insufficient Documentation to Support Operations

[redacted]

G.3.2.6.3 GDSCC Personnel and Management Overemphasize Personal Heroics

Based on conversations with MDSCC and CDSCC personnel, it is clear the maintenance team at GDSCC worked to address the system errors far longer than was reasonable. This is especially true in the case where the same personnel are expected to serve as on-call advisors following an active shift. Accepting an extended downtime to allow for a methodical and comprehensive troubleshooting effort would have been the correct approach, aligned with the behaviors evidenced at other DSN sites, and ultimately safer for both personnel and the asset.

G.3.2.6.4 GDSCC Personnel Consistently Show Reduced Vigilance

While the primary fault lies with the system automation, it is notable that personnel did not see that the wrap state changed during the troubleshooting activity. Wrap inconsistency errors occurred throughout the troubleshooting effort, but the MIB found no evidence they were noticed or addressed. The MIB also was unable to find evidence that the TSMs questioned why the errors cleared without any action taken.

G.3.2.7 Observations

G.3.2.7.1 Concerning Response to Employee Life Events

While the technician in question had no causal relation to the mishap, the MIB learned during interviews that a servo technician on staff on 15 September had been given extraordinarily bad personal news that day but chose to remain at work. It was unclear during the interview whether that decision stemmed from the “hero mode” culture finding or for other reasons. Regardless,

personnel experiencing significant life events were not discouraged from remaining on the job, either for humanitarian reasons or to ensure personnel performing dangerous or complex operations were not unduly distracted.

G.3.2.7.2 Cautions and Warnings from Control Software Are Not Appropriately Distinguished

[redacted]

G.3.3 Event 3: Hardware Pre-Limit Recovery

G.3.3.1 Narrative

A detailed timeline of the hardware limit recovery event is provided in the main body of the report. For the purpose of this analysis, the following specific elements are relevant:

- After the end of the day shift at GDSCC, two TSMs assumed responsibility for GDSCC antennas. During operations, DSS-14 hit hardware pre-limits three times in quick succession without first encountering the software limits.
- In the first case, the TSM requested support from maintenance, in line with expected behavior. Maintenance staff were still on-site, having recently completed troubleshooting (Event 2), and were able to return to the antenna and recover it from the hardware limit. In the second and third case, one of the two TSMs entered DSS-14 and recovered the antenna from the hardware limit.
- An SOP exists that describes the approved process for recovering an antenna from hardware limits; it specifies multiple personnel to execute the procedure, one of whom is responsible for observing the wrap direction.
- A roles and responsibilities document defines the duties of a TSM and none of those duties require the TSM to physically enter an antenna. At the MDSCC site, TSMs are not permitted to enter the antenna. At both the CDSCC and GDSCC sites, TSMs are permitted to enter the antenna. From interviews with MDSCC and CDSCC personnel, it appears that GDSCC TSMs are more likely to exceed their enumerated duties — at times to a fault and, as seen in this mishap, in direction violation of procedures.
- At both MDSCC and CDSCC, TSMs expressed willingness to shut down the antenna rather than exceed their personal level of confidence in performing an operation. At GDSCC, TSMs expressed a willingness to do anything they can think of to return an antenna to service.

G.3.3.2 Organization Factors

Factor	Score
Climate and Culture	
Culture (OC401)	4
Contractor Relations (OC403)	2
Operations	
Organizational Structure (OP401)	2
Operational Risk Management (OP403)	1
Organizational Training (OP406)	2
Resources	

G.3.3.2.1 Climate / Culture

While a culture focused on uptime is unquestionably valuable and necessary for network operations, GDSCC personnel frequently referred to needing to be in "hero mode" to maintain operations. Similar language was used at the DSN project level and within the SCaN Program, always with positive intent. However, taken to the extreme shown at GDSCC, the culture clearly drove TSMs to take actions well outside of standard operating procedures, the enumerated roles of the TSM, and the individual TSM's proficiency and training. Interviews with personnel at MDSCC and CDSCC made clear that the decisions made at GDSCC would not have been acceptable in the cultures established at those sites. A degree of willingness on the part of the TSMs to take the antenna down once the hardware pre-limit was reached would have been in line with project-level SOPs and established roles.

While a direct contract mechanism was not identified, discussions with SCaN Program leadership indicate that uptime is a key consideration when assessing contract award fees. The MIB considers that focus entirely appropriate but notes that it may create the preconditions for a "hero mode" culture to develop. It also should be noted that the contract award mechanism does not exist at the other two sites.

G.3.3.2.2 Operations

The GDSCC organizational structure differs from the organization at other sites. At GDSCC, the TSM role is performed by a dedicated position on the contract. In contrast, the TSM role is assigned as a periodic "night shift" to link control operators at both MDSCC and CDSCC. This difference is significant: a separate cadre of overnight personnel will develop a separate psychological environment and will make decisions based on that separate shared experience, while splitting the shift among a large cadre of link operators will maintain a consistent psychological environment and generally consistent decision-making from day to night.

The "Follow the Sun" operational methodology distributes decision-making in a way not fully reflected in organizational structure; it is unclear whether SODs have oversight authority over TSMs operating in a different country and on a different contract. A lack of consistent organizational training across the three sites allows for site-specific assumptions about roles and responsibilities to persist.

Based on interviews with DSN-level training coordinators at CDSCC, the site-specific differences in the GDSCC organization prevented DSN project-level efforts to standardize training across the operations cadres at all three sites. As a result, training expectations vary significantly and unpredictably between the three sites.

Based on interviews with personnel at MDSCC, CDSCC, and the DSN, it appears that a factor contributing to this organizational difference may be the GDSCC sub-contractor and union negotiations on role definitions. Had TSMs been trained and organizationally aligned in a manner similar to MDSCC and CDSCC, the MIB believes the TSM on duty would likely have shut down the antenna at the first hardware limit and waited for an extraction team, per SOP, to recover the antenna and resume operations. This decision would likely have prevented the mishap.

G.3.3.3 Supervision/Planning Factors

Factor	Score
Oversight	
Planning	
Local Training (SP306)	3
Accountability	
Operations Management (SA302)	2
Supervisory Compliance	

G.3.3.3.1 Planning

There is no indication of any meaningful planning for the three limit recovery operations associated with this event. From a review of the caution and warning log, it is clear that cable wrap inconsistencies were correctly flagged by the software as warnings to console operators and TSMs during this event, yet the TSMs did not consider the potential risk to the hardware from continuing to drive the antenna into those limit states. Any degree of planning that involved the review of existing operating procedures would have provided clear instruction not to proceed without certified maintenance personnel involved.

G.3.3.3.2 Accountability

There is no indication of an operational management mechanism to review or approve the second and third attempts to back the antenna out of the hardware pre-limit. It appears the TSMs unilaterally decided to perform these actions, and that no process existed for the review and approval of those actions prior to the event; SODs did not request details or exercise judgement about proposed TSM actions. It is worth noting that review and approval processes are not in place at any of the sites, but TSMs at both MDSCC and CDSCC are significantly more restrained by management expectations and organizational culture and are therefore less likely to take actions for which a critical review might be necessary.

G.3.3.4 Environmental Factors

Factor	Score
Physical Environment	
Technological Environment	
Instrument and Warning System (PT202)	2
Visibility Restrictions (PT203)	1
Space Environment	
Information Environment	

G.3.3.4.1 Technological Environment

[redacted]

G.3.3.5 Individual Factors

Factor	Score
Psychological Environment	
Complacency (PP205)	3
Mental Fatigue (PP209)	2
Medical Environment	
Perceptual Environment	
Fitness	
Currency (PF208)	1

G.3.3.5.1 Psychological Environment

Interviews with GDSCC personnel associated with this event evidenced a significant degree of complacency — a lack of vigilance or willingness to ask questions about a given course of action. They did not attempt to diagnose the root cause of the pre-limit exceedances and either did not review or did not follow SOPs that would have been relevant to the actions taken.

In the case of the first pre-limit exceedance, maintenance personnel evidenced a similar false sense of security, believing that the actions taken were sufficient to resolve the issue and allow the antenna to operate. This complacency is particularly surprising, as data provided by the DSN shows that hardware pre-limit exceedances are quite rare. Mental fatigue likely helps to explain the complacency factor in this case; the maintenance personnel involved had worked a full shift and significant overtime on the troubleshooting activities described in Event 2. In any of the three cases, the involved personnel were overconfident in their abilities to respond to the system condition.

G.3.3.5.2 Fitness

The TSMs who performed the second and third pre-limit resets were operating outside their formal role when doing so. While the MIB was unable to identify a skills catalog or training plan that clearly indicated what training was expected for TSMs, interviews with GDSCC personnel and other control complexes indicated these kinds of tasks were not uncommon for GDSCC TSMs. It is likely that personnel were acting within their expertise (the things they knew how to do) but outside their currency (things they had been trained to do recently). It is unlikely that additional training in performing the task would have reduced the likelihood of this mishap.

G.3.3.6 Act

Factor	Score
Decision Making	
Incorrect Action Selected (AD101)	4
Ignored A Caution/Warning (AD104)	3
Skill-Based	
Perception	
Compliance	
Violation - widespread or routine (AC101)	2

G.3.3.6.1 Decision-Making

In this event, the correct action was to deem the antenna inoperable and hand it over to maintenance on their next day shift. This response is consistent with both the published SOP and with the enumerated roles and responsibilities of the TSM. During this event, both TSMs and maintenance personnel took incorrect actions and disregarded cautions specifically indicating a problem with the DSS-14 cable wrap. Removing the antenna from operations and passing it to maintenance would have permitted a team to work through the issues and identify the wrap inconsistency, preventing the mishap. Heeding the cautions about wrap inconsistency would

have prompted either TSMs or maintenance personnel to physically investigate the wrap direction, likely leading them to discover the wrap direction was incorrect and would likely have avoided taking actions that damaged the antenna.

G.3.3.6.2 Compliance

Both the enumerated roles for a TSM and the SOP for limit recovery were violated during this event. From interviews with personnel at all three sites, it is clear GDSCC routinely ignored that guidance during the night shift.

G.3.3.7 Findings

G.3.3.7.1 GDSCC Personnel did not Adhere to Standard Operating Procedures

The SOP for limit recovery clearly identifies the processes that require multiple qualified maintenance personnel to execute a limit recovery. The SOP also clearly identifies one member of the recovery team to observe wrap direction. Even loose adherence to this SOP would have significantly reduced the likelihood of the mishap.

G.3.3.7.2 GDSCC Personnel Did Not Plan before Executing Actions

Neither maintenance personnel nor TSMs involved in this event demonstrated any level of planning or preparation for the limit recovery actions performed. They did not appear to consider the risks involved, nor did they appear to identify or investigate why the antenna struck limits before attempting recovery This lack of planning was endemic to the mishap and made the selection of a correct action highly unlikely.

G.3.3.7.3 GDSCC Personnel Consistently Show Reduced Vigilance

Indications of wrap inconsistencies and general issues with antenna position knowledge were present. Cautions and warnings associated with the hardware pre-limit were clearly visible, and based on interviews with GDSCC TSMs, were unexpected and surprising. Even when faced with a clearly anomalous situation, both maintenance personnel and TSMs demonstrated a false sense of security in their ability to resolve the issue.

G.3.3.8 Observations

G.3.3.8.1 SCaN, DSN, and GDSCC provide no effective oversight of TSM actions.

In the review of the events surrounding Events 3 and 4, the MIB determined that no higher-level review or approval exists for non-standard actions (e.g., repeated limit recoveries). Based on the events of the mishap, it appears the TSMs are largely autonomous and can change the configuration or operation of an antenna in any way they see fit. When the antenna is in an anomalous state that differs significantly from their past experience, this lack of review places an undue burden on TSMs for planning and assessing off-nominal actions.

G.3.3.8.2 GDSCC Personnel Did Not Seek Root Causes for Either Positive or Negative Results

Throughout this mishap, the MIB observed a distinct lack of root cause analysis during troubleshooting and operations. The TSMs did not appear to understand why favorable or unfavorable things happened, even when they could accurately predict those outcomes. In interviews with the MIB, GDSCC personnel suggested “antennas have personalities,” and that

experience is the only way to develop an understanding of the antennas' behavior. It does not appear that personnel are expected to ask "why did this thing happen" before responding.

G.3.3.8.3 GSDCC TSMs Did Not Consistently Update Discrepancy Records

Significant data needed for the MIB to fully understand actions taken by TSMs during this event was missing from the DRs related to the mishap. Instead, this information was provided through photographs of handwritten notes made by TSMs or identified during reviews of voice loops and conversations between TSMs and remote operators. The reports did not accurately describe the discrepancies actually identified. Based on the information provided to the MIB, it is not clear if the DR process was used to capture relevant information or detail on the ongoing efforts. It does not appear to have been used to track steps taken, changes in antenna status, or to include information necessary for an outside observer (such as a remote SOD) to review or concur on significant configuration changes or troubleshooting actions.

G.3.4 Event 4: Sector Switch Toggling

G.3.4.1 Narrative

The full body of the report provides a timeline of this event. From a human factors perspective, the following information is relevant:

- Immediately following Event 3, the TSMs contacted the on-call maintenance personnel relevant to the failure. The on-call individual is the same person who worked the full prior day shift, the prior overtime, and responded to the first hardware pre-limit exceedance. The on-call maintenance personnel instructed the TSM to enter the antenna, go to the antenna bilge, and inspect the sector switches used by the antenna software to determine wrap state.
- While inspecting the sector switches, the TSM repeatedly toggled them from position to position. Reports differ on whether this action was directed by the on-call maintenance personnel. While the TSM states the switches were returned to their original position, log data indicates they were returned to the position corresponding with the faulty wrap indication generated by the software. Whether this was performed at the direction of maintenance personnel or unilaterally, the result was that the sector switches and the software limits agreed and were both incorrect at the end of this event.

G.3.4.2 Organization Factors

Factor	Score
Climate and Culture	
Culture (OC401)	4
Contractor Relations (OC403)	2
Operations	
Operational Risk Management (OP403)	3
Program Oversight or Management (OP404)	2
Resources	
Design (OR405)	1

G.3.4.2.1 Climate / Culture

The culture and contractor relations factors are identical to those found in Event 3. Please see H.3.3.2.1 for a full discussion.

G.3.4.2.2 Operations

There is no indication that the risks associated with toggling the sector switches were considered or mitigated. Any degree of mitigation or consideration would have logically included recording the initial switch position to ensure they were returned to the correct state. Had the sector switches been returned to the correct state, the subsequent hardware final limits would have prevented vehicle motion. The MIB was unable to determine the extent to which the decision to toggle the switches was directed or approved by an appropriate person; no documentation or record exists showing a review and approval of the activity. A systematic review of the plan would have involved sufficient risk management discussion and likely identified the need to record the initial switch position.

G.3.4.2.3 Resources

The design of the sector switches is convenient for operation but is configured in a way that is physically difficult to view. The switches are not well-labeled. It would not have been convenient or comfortable to toggle the switches, which may have led to a loss of focus or a lapse in memory about what position was correct.

G.3.4.3 Supervision/Planning Factors

Factor	Score
Oversight	
Policy (SO303)	3
Planning	
Led/Directed beyond experience (SP301)	3*
Local Training (SP306)	2
Authorized Unnecessary Hazard (SP307)	3*
Accountability	
Supervisory Compliance	

G.3.4.3.1 Oversight

No policy or method for developing, reviewing, and approving work plans for off-hours complex troubleshooting activities appears to exist. From interviews with personnel at each site, the only review occurs at the end of a TSM shift during handover to the next day shift. No project policy appears to exist that prohibits complex troubleshooting activities during off-hours. Personnel were operating in a "grey zone" in which the only relevant approval would have come from the person issuing the instruction. Had an approval process with higher-level review been in place, it is unlikely that the event would have occurred.

The TSM sent to the antenna bilge was operating significantly outside their experience and proficiency. During interviews with GDSCC personnel, it was indicated that TSMs travel to the bilge on the order of perhaps once every decade. The MIB was unable to determine whether the

TSM was directed to toggle the sector switches. If they were, no relevant training or guidance was identified that would have assisted the TSM in taking the correct actions. The action was risky both from a personnel-safety perspective —the area in which the switches are located contains physical hazards — and from an operational perspective, as toggling the switches had an unknown impact on system behavior.

G.3.4.4 Environmental Factors

Factor	Score
Physical Environment	
Technological Environment	
Systems Automation (PT205)	1
Space Environment	
Information Environment	

G.3.4.4.1 Technological Environment

Automation systems do not log changes in the positions of the sector switches. Had the system logged those position changes in a way easily available to the TSM, it may have been possible for them to confirm that the switches were returned to their original position. Given the overall context of this mishap, the MIB considers it unlikely that personnel performing troubleshooting would have used that information if it had been available.

G.3.4.5 Individual Factors

Factor	Score
Psychological Environment	
Expectancy or Pre-Conceived Notion (PP207)	3
Mental Fatigue (PP209)	2
Complacency (PP205)	2
Medical Environment	
Perceptual Environment	
Fitness	
Experience (PF206)	4
Currency (PF208)	2

G.3.4.5.1 Psychological Environment

[redacted]

[redacted]

G.3.4.5.2 Fitness

The TSM performing this action was not trained for it, had not routinely been in this area of the antenna, and was relying on instructions relayed via telephone during the event. The TSM role does not require training on this area of the antenna or on this operation because there is no reason for a TSM to be executing complex troubleshooting operations. The lack of experience and training contributed to a situation where the personnel performing the action were insufficiently prepared to understand what actions were allowable or appropriate.

G.3.4.6 Act

Factor	Score
Decision Making	
Incorrect Action Selected (AD101)	3
Skill-Based	
Perception	
Compliance	

G.3.4.6.1 Decision-Making

In this event, the correct action would have been for the TSM to refuse to perform tasks outside of their experience and role -- namely, entering the antenna bilge to inspect the sector switches. Modifying the position of the sector switches defeated both the hardware pre-limit and final limit, allowing the antenna to move into hydraulic limits. Avoiding this action would have prevented the mishap.

G.3.4.7 Findings

G.3.4.7.1 GDSCC Personnel and Management Promote Personal Heroics

This finding appears first associated with Event 2 and is addressed in more detail in Section 3. Regarding the sector switch toggling event, both the TSM and SSE took actions that failed to account for the qualifications and proficiencies of the on-site personnel, were unplanned and unreviewed, and were not supported by existing procedures or job plans. The actions were initiated and accepted by the team because they aligned with the overarching objective of "keeping the antenna operational at all costs," without any ameliorating objective focused on risk avoidance or asset safety.

G.3.4.7.2 GDSCC Personnel Do Not Consistently Consider Risk before Acting

Similar to the culture considerations above, the lack of deliberation before performing the limit recoveries included a lack of risk identification, assessment, or mitigation. This is clearly demonstrated by the failure to physically inspect the cable wrap to determine its current direction. Such an observation would have had almost no impact on response time, would have mitigated the risk associated with trusting the now-known-to-be-erroneous software data, would have required little to no physical movement to perform, and is required by SOP. A reasonable

degree of risk assessment and mitigation would have likely led the TSM to take that additional step and would have prevented the mishap.

G.3.4.7.3 GDSCC Personnel Consistently Show Reduced Vigilance

As described in Event 3, indications of wrap inconsistency and general issues with antenna position knowledge were available. Cautions and warnings associated with the hardware pre-limit were clearly visible and, based on interviews with GDSCC TSMs, were unexpected and surprising. Even when faced with a clearly anomalous situation, both maintenance personnel and TSMs demonstrated a false sense of security in their ability to resolve the issue.

G.3.4.7.4 GDSCC Personnel Did Not Plan before Executing Actions

As described in Event 3, neither maintenance personnel nor TSMs involved in this event demonstrated any level of planning or preparation for the troubleshooting actions performed. They did not appear to consider the risks involved, did not assess the antenna wrap, and did not appear to identify or investigate why the antenna struck limits before attempting a configuration change. The MIB also noted that the accounts of the TSM and the on-call maintenance lead differ as to whether the TSM was instructed to toggle the switches. A minimal amount of planning and documentation would have provided clarity to all parties on what actions were requested or permissible.

G.3.4.8 Observations

G.3.4.8.1 DSN and GDSCC Personnel Tend Towards Precipitous Action

In general, the MIB observed a consistent tendency toward immediate action from GDSCC personnel and, to a lesser extent, from the DSN project. Absent a correcting influence, DSN management, GDSCC management, and GDSCC personnel consistently proposed moving as quickly as possible, often without regard for their own safety or well-being. Troubleshooting teams stayed for hours after the end of their shift before driving long distances home. The TSMs and security personnel entered a flooded antenna without performing safety checks. Following the mishap, GDSCC conducted antenna-function tests without following chain-of-custody procedures, altering the antenna configuration for investigators. The MIB frequently found itself serving as a correcting influence, asking for work to performed during regular hours and for the team to develop plans and processes for complex operations like the antenna unwrap. If left uncorrected, this cultural tendency may continue to generate avoidable mishaps.

G.3.4.8.2 GDSCC Staffing Plans May Contribute to Impaired Decision-Making

The MIB was not provided with a staffing roster for maintenance or a clear explanation of how personnel are scheduled at GDSCC. Evidence clearly shows that the SSE on duty during the mishap performed a full day of work, logged a significant amount of overtime, and was still considered the on-call responsible engineer for TSM questions that evening. If this staffing model is a consistent part of GDSCC operations, it creates a situation where some personnel may never truly be off the clock within a 24-hour period. From a human factors perspective, this situation creates the preconditions for impaired judgement resulting from fatigue, personal concerns or considerations, or leisure activities.

G.3.4.8.3 GDSCC Culture Uniquely Enables Risky Behavior

The MIB traveled to both MDSCC and CDSCC to conduct interviews on the specific events of the mishap and on the technical, organizational, and cultural context necessary to generate findings and recommendations. Each site demonstrated a different culture: personnel at MDSCC described themselves as the least willing to act outside the enumerated roles and responsibilities of a given position, while personnel at CDSCC described a degree of willingness to exceed those roles in situations where they had relevant training or proficiency. Both the MDSCC and CDSCC teams clearly considered that TSMs should default towards abstaining from acting at the antenna and that TSMs should have refused a request to inspect the sector switches. Based on cultural factors and management expectations alone, this mishap would not have occurred at either of those sites.

G.3.5 Event 5: Return to Active Tracking

G.3.5.1 Narrative

As described in the main body of the report, at the conclusion of Event 4 the antenna had yet to sustain damage. This event contains the first actual damage to the antenna but is, from a human factors perspective, relatively straightforward. Event 1 defeated the hydraulic limit system. Event 2 defeated the software pre-limit. Event 4 defeated the hardware pre-limit and hardware final limit. At this point, the pre conditions necessary for an over-wrap were in place.

During this event, TSMs reviewed the console logs and determined the erroneous wrap error has been resolved. Closing this error allowed the antenna to be returned to service, and GDSCC TSMs sent it to track. The control software's erroneous understanding of the wrap state caused it to rotate in the CW direction past all four defeated limits and into the over-wrap condition.

G.3.5.2 Organization Factors

Factor	Score
Climate and Culture	
Culture (OC401)	4
Contractor Relations (OC403)	2
Operations	
Operational Risk Management (OP403)	1
Program Oversight or Management (OP404)	1
Resources	

G.3.5.2.1 Climate / Culture

In general, the discussion of climate and culture in Section 2.3.2.1 is relevant to this event as well. Interviews with GDSCC personnel indicated the culture and expectations of the organization emphasized returning an asset to service as quickly as possible. This cultural element was particularly problematic in the transition from Event 4 to Event 5, where the antenna was immediately placed back into service after the sector switch toggling. No effort was made to perform a cause analysis or diagnose why the wrap errors had taken place; the immediate response to eliminating the error was to resume operations.

G.3.5.2.2 Operations

The lack of review and approval surrounding the closeout of a problem and a return to operations contributed to the precipitous return to operations in this case.

G.3.5.3 Supervision/Planning Factors

Factor	Score
Oversight	
Policy (SO303)	2
Planning	
Local Training (SP306)	2
Accountability	
Supervisory Compliance	

G.3.5.3.1 Oversight

No policy exists for the review and approval surrounding discrepancy closeouts; in fact, SOP specifically identifies the lack of oversight as a positive step to increase efficiency. The TSMs considered themselves authorized to unilaterally return the antenna to service after toggling the sector switches, and the MIB was unable to find process documentation that contradicted the TSMs' view.

G.3.5.3.2 Planning

Lack of risk assessment continues to be a factor in the decision-making of GDSCC personnel. The MIB was unable to identify a risk assessment discussion or analysis at any point during the events surrounding the mishap.

G.3.5.4 Environmental Factors

Environmental factors were not found to have contributed to this event.

G.3.5.5 Individual Factors

Factor	Score
Psychological Environment	
Complacency (PP205)	3
Expectancy (PP207)	3
Medical Environment	
Perceptual Environment	
Fitness	

G.3.5.5.1 Psychological Environment

The GDSCC TSMs assumed the actions taken in Event 4 were sufficient to return the antenna to service, and no additional testing or assessment was necessary before resuming operations. This lack of testing reflects reduced vigilance regarding the hazards associated with modifying key system telemetry. Additionally, the TSM's response to the error resolving indicates they anticipated returning to service, even though it was unclear why the action taken would have solved the underlying problem.

G.3.5.6 Act

Factor	Score
Decision Making	
Inadequate real-time assessment (AD103)	4
Skill-Based	
Perception	
Compliance	
Violation - routine (AC101)	2

G.3.5.6.1 Decision-Making

The MIB found no evidence in interviews, voice logs, or command logs that GDSCC personnel assessed the risks associated with returning the antenna to service. This abrupt decision to resume operations directly resulted in damage to the antenna wrap.

G.3.5.6.2 Compliance

The TSMs did not follow the closeout and confirmation procedures in published limit recovery procedures. During interviews with MDSCC and CDSCC personnel, the MIB learned the published procedure was in disuse across the project and had been replaced by site-specific procedures at the other sites.

G.3.5.7 Findings

G.3.5.7.1 GDSCC Personnel and Management Promote Personal Heroics

This cultural factor is a consistent finding across decisions related to the mishap. In this case, the precipitous return to service is where the team could "be the hero" by recovering the antenna on their own and returning it to service with minimal disruption.

G.3.5.7.2 SCaN, DSN, and GDSCC did not provide effective oversight of TSM actions

The enumerated roles and responsibilities, along with the site-specific organizational and cultural factors at MDSCC and CDSCC, discourage TSMs from making decisions require oversight. At GDSCC, however TSMs appear to have unilateral authority to make any change to antenna function or configuration that they see fit. The lack of TSM activity oversight in areas where they are not trained, qualified, or sufficiently proficient, creates a significant risk to operations and places an undue burden of responsibility on the TSMs. Accountability for TSM actions is not clearly documented nor evident in the operations surrounding the mishap.

G.3.5.7.3 GDSCC personnel consistently show reduced vigilance

The continued lack of vigilance regarding the antenna state described in prior sections now culminates in serious consequences. After more than 16 hours of degraded antenna state knowledge and series of decisions unsupported by SOP, the antenna was placed directly back into service. This lack of caution is endemic to GDSCC culture and, in this case, directly contributed to the undesired outcome.

G.3.5.7.4 GDSCC personnel did not adequately assess the real-time situation

Personnel at GDSCC did not sufficiently consider the risks of exercising the sector switches. It is unclear from interviews and post-mishap reconstruction whether the TSM manually exercised the sector switches unilaterally or at the direction of the SSE. There is no evidence personnel considered the potential impact of the action. The TSM also placed their head within five feet of the antenna wrap while it was positioned at its extreme CW wrap limit, without noting that the wrap and the sector switches agreed. A reasonable degree of assessment before investigating the sector switches — or before instructing personnel on how to investigate the sector switches — would likely have prevented this mishap.

G.3.5.8 Observations

G.3.5.8.1 Site Personnel Generally Considered DSN Procedures Obsolete

Procedures relevant to this event and provided to the MIB for review were discussed with personnel at all three sites. All three sites noted that project-level procedures were rarely updated. Both MDSCC and CDSCC personnel described an increasing reliance on site-specific guidance to ensure processes and job plans accurately reflected antenna configurations, the staffing and organizational structures, changes in priority, or technological advancement. The DSN procedures reviewed by the MIB had last been updated in 2016 or earlier. Notably, these updates occurred before the significant changes introduced by the "Follow the Sun" operational paradigm. The procedures relevant to this mishap are considered barely adequate to prevent it and would likely require awareness of pre-"Follow the Sun" structures and approaches to implement effectively.

G.3.6 Event 6: Return to Stow

G.3.6.1 Narrative

As described in the main body of the report, GDSCC TSMs made the decision to return the antenna to the stowed position after fire suppression and cooling water had flooded the base of the antenna and was streaming out of the ground-level doors. This decision caused the antenna to move further into the over-wrap condition. As the antenna was moving to the stow position, personnel entered the antenna to investigate the source of the water. Under conditions that could easily have included a damaged 2400-V power line in the presence of standing water, both actions were unsafe; personnel should have used an emergency stop to halt antenna motion immediately and waited for qualified personnel to conduct the investigation.

Given that this event occurred after the over-wrap condition had already been applied and some damage had already occurred, the maximum score considered for this event was two.

G.3.6.2 Organization Factors

Factor	Score
Climate and Culture	
Culture (OC401)	2
Operations	
Written Guidance (OP405)	2
Resources	

G.3.6.2 Climate / Culture

The decision by the OE, two TSMs, and a security guard to enter an area of standing water in order to rapidly diagnose the damage reflected broader cultural expectation for TSM activities at GDSCC discussed in prior sections, but this action did not directly contribute to the mishap.

G.3.6.2.2 Operations

The MIB was unable to identify documentation or procedures that would have distinguished the appropriate circumstances to “return to stow” versus enacting an emergency stop. Had such procedures existed, and had the TSMs been trained on these procedures, it is likely that the antenna would have been stopped at the initial over-wrap. It remains unclear what damage would have been mitigated.

G.3.6.3 Supervision/Planning Factors

Factor	Score
Oversight	
Training (SO302)	2
Policy (SO303)	2
Planning	
Accountability	
Supervisory Compliance	

G.3.6.3.1 Oversight

In conversations with personnel at all sites, the MIB determined that the DSN does not have an expectation of, nor a practical mechanism for, training personnel on handling off-nominal scenarios. Personnel reported the primary mechanism available was on-the-job training; operators would need to be on console during an off-nominal condition to learn how to resolve it. The MIB was unable to identify any simulation capability that would allow for operators to train on scenarios other than currently active operations. The TSMs did not receive operational training on handling emergencies like water flooding the antenna because they had not been on console during a previous flooding incident. Had a training module existed, included emergency scenarios, and been levied on TSMs, it is likely that the TSM would have considered an emergency stop instead of a stow command.

The decision to enter a damaged facility containing both standing water and high-voltage electricity without appropriate safety considerations is a significant lapse in training that could

easily have resulted in the death of GDSCC personnel. Although the high-voltage lines were not damaged to the point of creating an actual hazard, the personnel involved had no way to verify that the flooded area was safe without testing. This decision did not further exacerbate the mishap, however, and therefore was not considered in the human factors scoring.

G.3.6.4 Environmental Factors

Factor	Score
Physical Environment	
Buildings (PE208)	1
Technological Environment	
Instrument and Warning System (PT202)	2
Space Environment	
Information Environment	
Local Training (SP306)	2

G.3.6.4.1 Physical Environment

At this point in the mishap, the antenna was in an over-wrapped state and water was actively flooding the base of the antenna. This situation would have contributed to an increased level of stress on the part of the personnel involved.

G.3.6.4.2 Technological Environment

Assuming a failure modes and effects analysis existed for DSS-14, the personnel responsible for the design of the antenna's instrument and warning systems would have been well aware of the potential for hose failures—whether caused by an overwrap or by other factors—and of the downstream effects that flooding could have on the antenna. However, there is no indication from a log review that cautions or warnings existed to cover this eventuality, and the monitoring software was silent on the failure. As a result, the first indication that a flood occurred came from direct observation.

G.3.6.4.3 Information Environment

In the context of HFACS, "risk assessment" is a factor at play when "a team members' ability to adequately communicate changes during mission execution and adjust their work accordingly contributes to an event". In this situation, the MIB did not identify an inhibitor to communication, but does note that TSMs failed to adjust their work accordingly based on their knowledge of the system state.

G.3.6.5 Individual Factors

Factor	Score
Psychological Environment	
Expectancy (PF206)	2
Complacency (PP205)	2
Medical Environment	
Perceptual Environment	

Fitness

G.3.6.5.1 Psychological Environment

The recurring complacency concerns associated with each event in this mishap continue into Event 6. An additional factor, expectancy, reflects an element noted during interviews with GDSCC personnel in which they anticipated a specific course of action (e.g., returning to stow) regardless of other cues. These factors contributed to the exacerbation of the mishap but removing them in the context of Event 6 alone would not have prevented it.

G.3.6.6 Act

Factor	Score
Decision Making	
No Action Selection (AD102)	2
Incorrect Action Selection (AD101)	2
Ignored A Caution/Warning (AD104)	1
Skill-Based	
Perception	
Compliance	

G.3.6.6.1 Decision-Making

Personnel entering the antenna to investigate the source of the water leak failed to hit an emergency stop before doing so. This lack of action, if corrected, would have placed the antenna into a hold. TSMs decided to put the antenna into a stow position once the leak was identified. This incorrect action exacerbated the damage and effectively ignored the critical alert announced by the OE that observed the leak. The correct action in either case was to impose an emergency stop and cease all motion until the antenna could be investigated by trained and qualified personnel.

G.3.6.7 Findings

In general, findings associated with this event mirror or extend findings from prior events.

G.3.6.7.1 GDSCC Personnel Acted Without Considering Risk

While the title is common to earlier events, in this case the lack of risk assessment also included potential hazards to personnel health and safety. The individuals who entered the antenna without developing a clear plan and safety assessment placed themselves in potentially life-threatening situation. While the low score for this event reflects the likelihood that the factor would have mitigated or eliminated the undesired outcome, it remains entirely possible that the incorrect action of entering the antenna unprepared would have resulted in the death of personnel. To a much lesser extent, TSMs operating the antenna did not consider the risk of further antenna movement on either the personnel inside the structure or to an asset in a clearly ambiguous and damaged state.

G.3.6.7.2 GDSCC Personnel Consistently Show Reduced Vigilance

Consistent with prior event analyses, both parties acting in Event 6 demonstrated a false sense of security in their understanding of antenna state, a false sense of security regarding their personal welfare, and a false sense of security about the antenna's ability to operate nominally in a severely off-nominal situation.

G.3.6.7.3 GDSCC Personnel Showed Insufficient Training for Observed Duties

Aside from the serious failure to consider the hazards associated with entering the antenna, both groups involved in this event demonstrated that they were insufficiently prepared to handle a severe antenna issue. The decisions they made, when compared to the correct actions of "hit an emergency stop and escalate the problem," were ill-advised and reflect a lack of effective training in both safety and off-nominal scenarios.

G.3.6.8 Observations

G.3.6.8.1 Training on Safety Does Exist at GDSCC (Green Light)

It should be noted that once a facilities lead arrived on scene, they implemented safety controls to determine the degree of hazard present and reduce the danger to personnel and assets. The MIB considers that the lack of safety training and tendency toward precipitous action is not uniform across the organization, and recommends that DSN and GDSCC use personnel who demonstrate sound judgement as the nucleus for developing their safety culture.

G.4 Key Findings

G.4.1 GDSCC Teams Provide Insufficient Documentation to Support Operations

[redacted]

G.4.2 GDSCC Personnel Do Not Consistently Consider Risk before Acting

Reference (2.1.7.2, 2.4.7.2) of this document for additional context.

In multiple areas and across multiple events, the MIB found GDSCC personnel evidenced poor risk assessment and response. The decision not to physically test the antenna rotation limits is the most direct evidence of this finding — this decision effectively accepted the risk that the hydraulic limit would not be operable when needed, and it was never reconsidered or reviewed. During the events immediately surrounding the mishap, the risks associated with toggling the sector switches do not appear to have been considered. Following the mishap, personnel entered the antenna and walked through standing water without considering electrical or fall hazards. While this lack of risk assessment can be partly explained by the fatigued mental state of the on-call personnel, the risks associated with making decisions while fatigued were also not considered. At no point does it appear that GDSCC personnel seriously evaluated what could go wrong as a result of their actions.

G.4.3 System Automation Imprecisely Tracks Wrap State

Reference (2.2.7.1) of this document for additional context.

[redacted]

G.4.4 GDSCC Personnel and Management Promote Personal Heroics

Reference (2.2.7.3, 2.4.7.1, 2.5.7.1) *of this document for additional details.*

Across the entirety of the mishap timeline, the MIB found consistent evidence that cultural factors at GDSCC had an adverse effect on the behaviors and decisions of on-site p ersonnel. Personnel described themselves — and were described by personnel at other sites — as "willing to do whatever it takes to keep the antenna running." This attitude was positively reinforced by GDSCC management, DSN management, and SCaN Program management. This attitude directly contributed to team members' willingness to work extended hours (increasing fatigue), troubleshoot during off-shifts, perform tasks outside their job descriptions and qualifications, operate outside SOPs, and skip tests or analyses that would have delayed the antenna's return to active operations. Personnel interviewed by the MIB described the primary objective of the GDSCC staff seemed to be "getting the antenna back up as quickly as possible." Both DSN project and GDSCC personnel took actions to test antenna systems that changed the configuration of the antenna during the active investigation in an effort to accelerate recovery and recommissioning activities. The cultural tendency to rush to action and to return the asset to active service acted in direct opposition to the correct behavior of thoughtful, safe, and risk-informed action. Had GDSCC personnel acted with greater caution or been more willing to leave the antenna in a failed state at any point during the mishap, the undesired outcome likely would not have occurred.

G.4.5 GDSCC Personnel Consistently Show Reduced Vigilance

Reference (2.2.7.4, 2.3.7.3, 2.4.7.3, 2.5.7.3) *of this document for additional details*.

Throughout the mishap timeline, personnel involved with critical events demonstrated complacency – a false sense of security that they understood the antenna's state, were sufficiently qualified to perform operations, and that the hazards associated with their actions were inconsequential or would not materialize. This factor also manifested in consistent decision-making bias toward believing information suggesting the antenna was nominal and discounting information that suggested the antenna was off-nominal. The MIB did not find evidence of reduced vigilance at MDSCC and CDSCC. Both sites demonstrated a healthy skepticism and attention to detail that would have caused them to critically evaluate potentially hazardous actions like those seen in Events 2-4. This lack of vigilance, combined with the "hero mode" culture, created ideal conditions for poor decision-making during this mishap.

G.4.6 GDSCC Personnel did not Adhere to Standard Operating Procedures

Reference (2.3.7.1) *of this document for additional details*.

The MIB identified a single SOP relevant to operations instead of maintenance — a procedure for recovering an antenna from hardware limits. The SOP specifies a team of qualified personnel, one of whom is responsible for physically observing the cable wrap and ensuring the limit recovery is safe. The procedure was volunteered to the MIB by personnel at both MDSCC and CDSCC and identified as the top-level guidance applicable to Event 3. Both sites described site-specific modifications to that guidance since it was last revised in 2014. The GDSCC TSMs would have been unable to recover the antenna from hardware limits had they adhered to the SOP, and the antenna would have remained in the hardware pre-limits until maintenance arrived the next day to investigate, likely preventing the mishap from occurring.

G.4.7 GDSCC Personnel Did Not Plan before Executing Actions

Reference (2.3.7.2, 2.4.7.4) *of this document for additional details.*

During both Events 3 and 4, the TSMs undertook novel and unorthodox actions to attempt to recover the antenna and return it to operations including ad-hoc tests of hardware functionality and attempts to recover the antenna from hardware limits while it was in an ambiguous state. There is no indication the TSMs or the on-call SSE developed any form of a work plan to cover the activity to identify likely hazards, required tools, test criterion, or key steps, like recording the initial position of sector switches before making changes. The MIB found no evidence that planning documentation was required, and believes such requirements do not exist because it was never anticipated that TSMs would attempt operations posing a high degree of system risk or lacking an established process. The TSMs interviewed at both MDSCC and CDSCC indicated that performing tasks outside of existing protocol would have been considered unacceptable by site management. The extraordinary degree of site-specific autonomy granted to GDSCC TSMs was not accompanied by site-specific expectations to perform the planning necessary to safely develop or execute complex and novel procedures.

G.4.8 SCaN, DSN, and GDSCC provide no effective oversight of TSM actions.

Reference (2.5.7.2) of this document for additional details.

A lack of effective oversight in the decision to return the antenna to operations is evidenced in Event 5, where the antenna was immediately returned to track even though the various discrepancies in antenna operation were unexplained and had not been analyzed or investigated by the maintenance team. A review of the logs shows multiple cautions and warnings requiring maintenance notification occurred prior to the return to service, yet maintenance had not reviewed or concurred with returning the antenna to service. Insufficient information was provided in DRs or in voice loop communications for SODs or other oversight personnel to make informed decisions. Furthermore, there is no evidence the TSM requested a decision or consultation from any outside party before returning the antenna to service. While the MIB cautions SCaN against unduly burdening operations with reviews or signature loops, any degree of review and oversight would have prevented the antenna from being returned to service in a dangerous and ambiguous state. Such oversight would relieve a TSM from the undue burden of simultaneously acting as the planner, reviewer, executor, and approver of antenna configuration changes.

G.4.9 GDSCC Personnel Did Not Adequately Assess The Real-Time Situation

Reference (2.5.7.4) *of this document for additional details.*

Given the apparent degree of autonomy given to GDSCC TSMs, it is incumbent upon those personnel to perform real-time risk assessments and exercise sound judgement when deciding whether to return the antenna to active operations. Subsequent events show that this judgment was incorrect. This is particularly evident in cases where TSM personnel were in close physical proximity to the cable wrap, investigating issues with wrap status, and failed to physically observe the wrap direction

to confirm the wrap direction. To a lesser extent, this finding also may apply to the decision to return the antenna to the stow position rather than simply stopping motion, as well as the observers' decisions not to hit an emergency stop at the first sign of flooding.

G.4.10 Training for GDSCC Personnel Is Insufficient for Observed Duties

Reference (4.6.7.3) of this document for additional details.

The key findings outlined above have a common through-line: each event involved actions or errors that could have been prevented through an effective training regimen. From interviews and site visits with personnel at all three sites, the MIB has learned that training programs are site-specific and vary significantly in completeness. The SCaN Program and the DSN project have not provided the capability to simulate off-nominal conditions and do not appear to perform simulations of off-nominal scenarios. There was no indication that GDSCC TSMs received the cross-training necessary to execute complex maintenance troubleshooting or that they were expected to maintain proficiency over time. The MIB considers many of the findings in this HFACS, many of the root causes of the mishap overall, and most of the key actions taken by personnel that contributed to this mishap to be exacerbated by a lack of training on off-nominal scenarios like those encountered during this mishap.

G.5 Recommendations

G.5.1 SCaN, DSN, and GDSCC Should Incentivize Technical Rigor over Personal Heroics

While availability of DSN assets for scheduled data collection is unquestionably important to the agency and humanity at large, the focus must be on consistent, reliable operations over the long term — not the next minute of uptime. A degree of technical rigor is critical to consistent and reliable operations, yet it was not evident in the events surrounding the mishap or its aftermath. The MIB identified evidence of this cultural factor at multiple levels: the SCaN Program, at the DSN project, and in the subcontract at GDSCC. It is therefore likely that the ultimate solution will require a culture change at the program level, in which the program intentionally and consistently prioritizes the technical management of network operations. To address this recommendation, the SCaN program manager should partner with OCE to define the types of technical change at the project level that should result in program-level oversight and approval and then issue directives as necessary to ensure that topics meeting those criteria are surfaced to the program for review. The program may utilize SCaN-internal and agency awards programs to recognize high-quality technical work. The program also may consider establishing and regularly reviewing performance metrics intended to incentivize technical excellence. The MIB recommends that SCaN and the DSN request support from NASA's OCE on other mechanisms for culture change.

G.5.2 DSN should Reform the TSM Role To Match Expected Training and Proficiency

The DSN control centers show markedly different implementations of the TSM role. At MDSCC, the role holds precisely to the enumerated roles laid out in DSN-level documentation. At CDSCC, TSMs are allowed to operate slightly outside those roles to the extent of their personal confidence and experience, but under a clear management expectation that they are always permitted to say no and with a reasonably-rigorous site-specific training plan. At GDSCC, the TSMs appear to be encouraged to act outside their enumerated roles and — based on the events of the mishap —outside their experience, training, and proficiency. Both a MDSCC-equivalent (no deviation from accepted roles) or a CDSCC-equivalent (small deviations with management support to decline) are feasible, as are other models. The DSN must clearly and consistently define the role across the sites, train the personnel on the information they need to execute it, and provide incentives for TSMs to stop before they exceed that training and proficiency.

G.5.3 SCaN and DSN Should Develop S&MA Products at All Levels

It is ultimately the responsibility of the SCaN Program to ensure that its own baseline, as well as the baselines for each of its projects, is relevant and provides accurate guidance on its technical and programmatic state. The MIB identified that the SCaN Program does not have an MPCP or a similar product that would guide program-level involvement in a mishap. Neither the DSN nor SCaN have the safety and mission assurance products necessary to develop a complete understanding of failure modes and effects or hazards. The MIB also identified that the SCaN Program has not established or enforced configuration management expectations on the DSN, and the DSN project has not prioritized ensuring that products exist and are up to date. These gaps must be addressed. The MIB

recommends that SCaN and the DSN engage OSMA to establish a list of needed products and a priority for development.

G.5.4 SCaN, DSN, and GDSCC Personnel Should Not Act Without Assessing Risk

Actions in this HFACS are related by a consistent lack of risk assessment. The TSMs and SSEs were given multiple opportunities to stop, consider the implications of their actions, and identify a way to proceed that limited or mitigated the risk to either the asset or personnel. In none of these cases did the MIB find evidence that personnel took those opportunities. Personnel should be trained in risk assessment and should explicitly develop plans to perform tasks that incur a risk to either the asset or personnel. The MIB acknowledges that this recommendation could be taken to an unhealthy extreme that impedes operations and therefore encourages the program and the project to find a reasonable balance between operational tempo and the health of both systems and personnel. The MIB additionally observes that the plans generated by the DSN and GDSCC during the unwrap procedure clearly showed that both groups are proficient in the type of risk assessment and consideration recommended here.

G.5.5 GDSCC Personnel Must Be Vigilant and Skeptical

Beginning as early as 2025-10-15, logs show that the system began to exhibit clear issues with the cable wrap. Personnel reported awareness that the antenna was in unusual positions and was responding in unexpected ways. Cautions and warnings associated with wrap direction changes, limits, and wrap inconsistencies occurred consistently through the multiple events in the mishap. At certain points, the wrap indication plots used by console operators were blank. In the MIB's judgement, there was clearly adequate information by Event 4 and 5 to warrant skepticism of data on console and to prompt personnel to reconsider their assumptions about the nature of the failures. All personnel, but especially personnel in a decision-making role, should be trained on a healthy level of skepticism of console data. The MIB recommends that SCaN and the DSN request support from NASA's Flight Operations Directorate on both console design and operator training with this factor in mind.

G.5.6 Antenna Control Software Must Accurately Inform Human Operators

[redacted]