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Space Communications and Navigation (SCaN) Testbed Project

National Aeronautics and Space Administration
John H. Glenn Research Center at Lewis Field, OH 44135

SCaN TESTBED PROJECT

PAYLOAD OPERATIONS HANDBOOK

AUTHORIZED by CM when under FORMAL Configuration Control	
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PREFACE

National Aeronautics and Space Administration (NASA) is developing an on-orbit, adaptable, Software Defined Radio (SDR)/Space Telecommunications Radio System (STRS)-based testbed facility to conduct a suite of experiments to advance technologies, reduce risk, and enable future mission capabilities on the International Space Station (ISS). The Space Communications and Navigation (SCaN) Testbed Project will provide NASA, industry, other Government agencies, and academic partners the opportunity to develop and field communications, navigation, and networking technologies in the laboratory and space environment based on reconfigurable, software defined radio platforms and the STRS Architecture. The project was previously known as the Communications, Navigation, and Networking reConfigurable Testbed (CoNNeCT). Also included are the required support efforts for Mission Integration and Operations, consisting of a ground system and the Glenn Telescience Support Center (GRC TSC). This document has been prepared in accordance with NASA Glenn's Configuration Management Procedural Requirements GLPR 8040.1 and applies to the SCaN Testbed configuration management activities performed at NASA's Glenn Research Center (GRC). This document is consistent with the requirements of SSP 41170, Configuration Management Requirements, International Space Station, and GLPR 7120.5.30 Space Assurance Requirements (SAR).

This document provides guidance to the SCaN Testbed Mission Operations Team to define interfaces, plan and execute operations, and perform additional tasks required to conduct payload operations.

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1.0 INTRODUCTION

1.1 Purpose

The purpose of this plan is to provide a description of the various aspects of SCAN Testbed operations.

1.2 Scope

The scope of this plan covers SCAN Testbed operations on ISS. It does not cover the operational protocols for the experimenters.

2.0 APPLICABLE DOCUMENTS

This section lists the NASA/Government and non-NASA/Government specifications, standards, guidelines, handbooks, or other special publications applicable to this document.

2.1 Applicable Documents

Applicable documents are those documents that form a part of this document. These documents carry the same weight as if they were stated within the body of this document.

Document Number	Applicable Document
GRC-CONN-DOC-0906	Software Avionics Error Codes
GRC-CONN-DOC-0908	Flight Software Squawk Messages
GRC-CONN-DOC-0915	Ground Software Errors and Recovery
GRC-CONN-OPS-0176 VI	Console Handbook Volume I ISS Interfaces
GRC-CONN-OPS-0176 VII	Console Handbook Volume II SN/NEN Interfaces
GRC-CONN-OPS-0912	Mission Operations Modules
GRC-CONN-OPS-0913	Mission Operations Off-Nominal Procedures
GRC-CONN-PLAN-0130	Data Management Plan
GRC-CONN-PLAN-0900	SCaN Testbed SN-NEN Planning Guide
GRC-CONN-PLAN-5006	Experimenters Handbook
GRC-CONN-RPT-0227	Fault Detection, Isolation, and Recovery (FDIR)
GRC-CONN-SDP-0753	Flight Safety Data Package (includes Hazards Reports)
n/a	Mission Operations Planning Schedule (MOPS)

2.2 Reference Documents

Reference documents are those documents that, though not a part of this document, serve to clarify the intent and contents of this document.

Document Number	Reference Document
GRC-CONN-ICD-0067	CCC to TSC Interface Control Document
GRC-CONN-ICD-0427	CCC to CEC Interface Control Document
<TBD 2-1>	SFEP User's Guide
n/a	LynxCAT SK Toolbox User's Guide
<TBD 2-2>	SCAN Testbed Trajectory, Attitude and Antenna Modeling Plan

2.3 Order of Precedence for Documents

In the event of a conflict between this document and other documents specified herein, the requirements of this document shall apply. In the event of a conflict between this document and higher level documents, the higher level documents shall take precedence over this document.

All documents used are to be the approved versions released as of the CoNNeCT Project Plan (GRC-CONN-PLAN-0004) baseline date. All document changes issued after the baseline establishment shall be reviewed for impact on the scope of work. Nothing in this document supersedes applicable laws and regulations unless a specific exemption has been obtained.

3.0 OPERATIONS DOCUMENT TREE

The following sections list the relevant documents that the Operations Team has either created or referenced to prepare for on-orbit operations. A document tree is presented in Figure 3-1.

3.1 SCaN Documents

Document Number	Document Title
GRC-CONN-DOC-0906	Software Avionics Error Codes
GRC-CONN-DOC -0908	Flight Software Squawk Messages
GRC-CONN-DOC-0915	Ground Software Errors and Recovery
GRC-CONN-OPS-0176 VI	Console Handbook Vol I ISS Interfaces
GRC-CONN-OPS-0176 VII	Console Handbook Vol II SN/NEN Interfaces
GRC-CONN-OPS-0429	Mission operations Scenario Timelines (outdated)
GRC-CONN-OPS-0911	Payload Operations Handbook
GRC-CONN-OPS-0912	Mission Operations Modules
GRC-CONN-OPS-0913	Mission Operations Off-Nominal Procedures
GRC-CONN-PLAN-0130	Data Management Plan
GRC-CONN-PLAN-0133	Mission Operations Plan (outdated)
GRC-CONN-PLAN-0900	SCaN Testbed SN-NEN Planning Guide
GRC-CONN-PLAN-5006	Experimenters Handbook
GRC-CONN-RPT-0227	Fault Detection, Isolation, and Recovery (FDIR)
GRC-CONN-SDP-0753	Flight Safety Data Package (includes Hazards Reports)
<TBD 2-1>	SFEP User's Guide
<TBD 2-2>	SCAN Testbed Trajectory, Attitude and Antenna Modeling Plan
n/a	LynxCAT SK Toolbox User's Guide
n/a	Mission Operations Planning Schedule (MOPS)

3.2 Mission Operations Directorate (MOD) and Payload Operation Integration Function (POIC) Documents

Document Owner	Document Title
MOD	Flight Rules
MOD	Operational Control Agreement Database (OCADS)
MOD	Operational Interface Procedures (OIPs)
POIC	POIC Payload Operations Handbook (POH)
POIC	Payload Regulations
POIC	Ground Command Procedures (GCP)
POIC	Payload Planning Overview
POIC	Ground Rules &Constraints (Gr&Cs)

3.3 Space Network (SN) and Near Earth Network (NEN) Documents

Document Number	Document Title
453-NENUG	Near Earth Network Users Guide
450-NOSP-SCaN Testbed	Network Operations Support Plan for SCaN Testbed
450-NRD-SCAN Testbed	Network Requirements Document
450-PSLA-SCAN Testbed	Project Service Level Agreement
450-RFICD-SCAN Testbed/SN/NEN	Radio Frequency Interface Control Document
450-SNUG	Space Network Users Guide
n/a	SNAS User's Guide (help menu in SNAS)

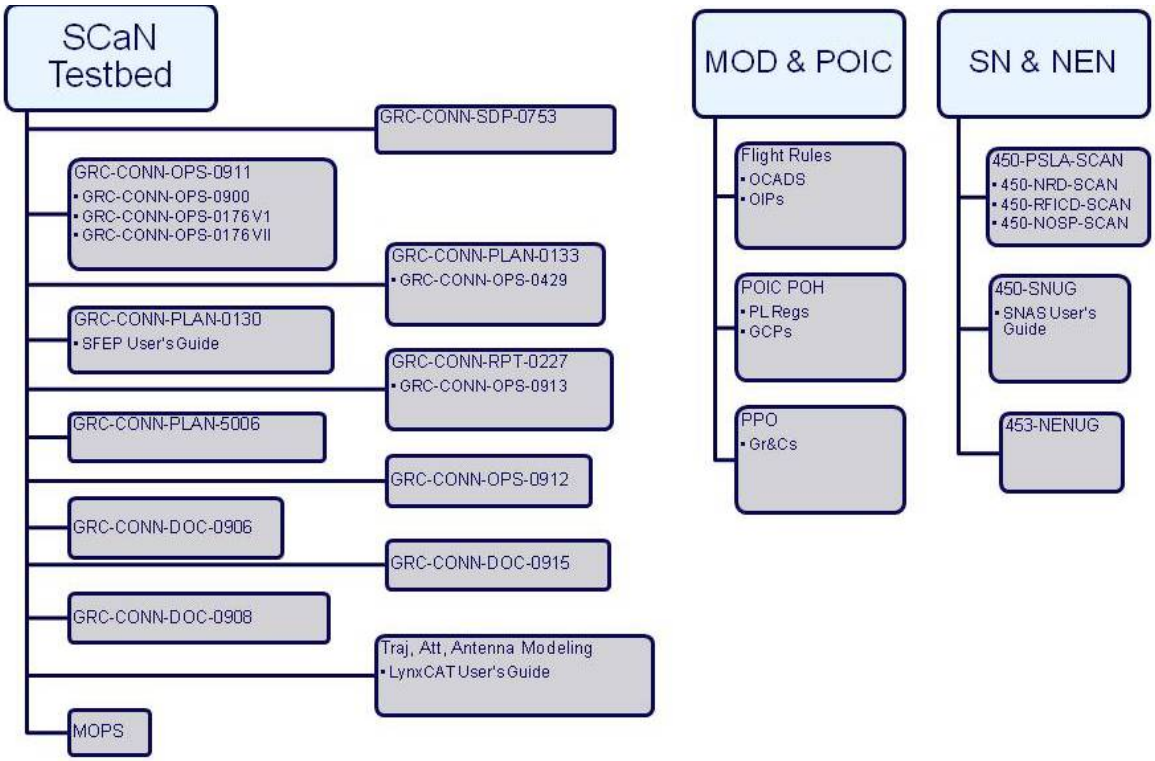

Figure 3-1—Document Tree

4.0 OPERATIONS TEAM ROLES AND RESPONSIBILITIES

The roles and responsibilities of the Operations Team are described in GRC-CONN-OPS-0860 Connect Training and Certification Plan. The off-line responsibilities are covered in GRC-CONN-PLAN-5006 Experimenter's Handbook.

4.1 Mission Operations Manager

The Mission Operations Manager (MOM) manages the Operations Team and is responsible for all aspects of mission success, including configuration management, payload planning and integration, and ground and on-orbit operations. The position of the MOM is not a console position and does not require certification. However, the MOM will approve the certification of all operations team members, in conjunction with the Training Manager.

The MOM can also direct various troubleshooting activities. In case of on-orbit anomalies, the MOM will focus attempts to reproduce the event or condition on the ground by utilizing the Ground Integration Unit (GIU) and Ground Support Equipment (GSE) available in the high bay of Building 333 at GRC.

4.2 Controller – Console Position

The Controller has the overall responsibility for coordinating all flight system activities. Based on the various plans (e.g., Short-Term Plan (STP), the SN and NEN schedules) and any Operations Change Requests (OCRs) written against those plans. The Controller conducts payload operations. The Controller will monitor telemetry, keep the console log, initiate SCAN Testbed OCRs as required, and review/approve POIC OCRs.

4.3 Commander – Console Position

The Commander, in accordance with the specific procedures, transmits all of the commands to the payload, manages command validation, and monitors telemetry from the SCAN Testbed. Prior to experiment runs, the Commander verifies that flight system resources are sufficient to capture the anticipated science data. The Commander has the responsibility to verify that all data requested for downlink is received and complete, including science data generated by the SDRs. After a data set has been received, the Commander will ensure that the data has been appropriately stored on the Data Storage Server.

4.4 Scheduler – Console Position

The Scheduler has the responsibility of coordinating and defining the planned operations of the payload, tracking resources, and scheduling activities for the ISS, Space Network (SN), and Near Earth Network (NEN). The Scheduler is not directly involved in commanding or operating the payload, but is cross trained to conduct those activities if needed.

4.5 SCAN Testbed Front End Processor Operator – Console Position

The SCAN Testbed Front End Processor (SFEP) Operator has the responsibility to configure the SFEP for SN and NEN contacts. The SFEP Operator verifies that data is flowing to / from the payload in the uplink / downlink direction as applicable via the experiment path. The SFEP Operator must configure the front end processor such that data is converted to the proper protocol for transmission over the experiment path. The SFEP Operator is also responsible for configuring the White Sands Ground Terminal (WSGT) and Second TDRSS Ground Terminal (STGT), in addition to the White Sands Complex Software Defined Radio (WSC SDR).

4.6 APS Operator – Console Position

The APS (Antenna Pointing System) Operator is responsible for developing inputs and generating the antenna tracking files, preparing APS pre-simulation, preparing XML configuration files and post-processing APS performance. The APS Operator will ensure that the LYX state matrix data and the antenna and gimbal telemetry is logged, gathered, and post processed. The APS Operator is also required to verify proper operation and tracking of the antenna pointing system and to identify anomalous behavior in-situ to the experiment and decide on immediate corrective action, as well as developing remediation methods for future tracking cases given past performance (such as CPU drops during high data rates).

4.7 Off-line Responsibilities

The Operations Team will be involved in the integration of experiments into the SCaN Testbed Experiment Process Flow (see Section 5.0). Upon selection, each experiment will be assigned two Operations Team members, a primary and a back-up, to follow them through the process. During the development of the Experiment Plan, the experiment's requirements will be assessed and resources will be negotiated. If updates to SN/NEN or ISS products are required, the Operations Team will initiate the changes. During the Development and Test phase, the assigned Operations Team members will help develop procedures, support testing, and start building the mission operation timeline.

5.0 OPERATIONS PLANNING

Operations planning will be implemented during the overall course of the experiment integration process, though it will have a higher focus after the verification test. Initial operations data will be obtained from Experiment Plan and subsequent reviews of this data. Additionally, the functional testing on the GIU will provide opportunity to confirm early assessments of the experiment time line.

5.1 Experiment Integration Activities

GRC-CONN-PLAN-5006 Experimenter's Handbook describes the processes and schedules to be followed to progress from an approved experiment through utilizing the SCAN Testbed on the International Space Station (ISS). An Experiment Plan will be developed which serves as a means for specifying resources/support to be provided from the SCaN Project to the Experimenter. Elements of the plan will be used by the Project to (a) identify Experimenter developing testing needs on the Engineering Development System (EDS) and GIU, (b) experiment-unique support requirements, (c) establish initial schedules, and (d) begin mission planning.

It is at this point that the Experimenter makes requests that are outside the nominal resources available such as a higher data rate line. Each request will be evaluate for technical feasibility. If the request is viable, it will be brought to the Engineering Review Board (ERB) for a decision.

5.1.1 Functional Testing

Functional testing on the GIU will begin after the Experimenter has completed development on the EDS (approximately 6 months from real-time operations). The assigned Operations Team member will assist the Experimenter in writing and performing procedures. One outcome of this testing is to confirm that the original requirements and resource requests are still valid. If changes are necessary, the Experiment Plan must be updated.

5.1.2 Verification Testing

After a successful Experiment Readiness Review (ERR), the Experimenter will be approved for verification testing on the GIU (approximately 3 months prior to operations). The verification test will be conducted by the assigned Operations Team member, using the flight mission operation procedures. Experimenters will support the test in a fashion analogous to ISS mission operations. The Operations Team will use the verification test as a key familiarization of experiment operations in preparation for flight.

5.1.3 Experimental Operations Review

The purpose of the Experiment Operations Review is to validate that the Experimenter team, the Operations Team, and other SCaN Testbed team members are prepared to conduct flight experiment operations. The Operations Team will ensure that the flight procedures are prepared, training is completed, and the experimenter's requirements are reflected in the POIC and MOD products as necessary.

5.2 Ground System Requirements Assessment

As the Experiment Plan is developed, the Operations Team evaluates the requirements and requests of the Experiment Team. The Experiment may ask for additions to the nominal resource set, such as a new NEN ground station, or a modification to an existing resource, such as a more capable SFEP.

5.3 SN and NEN Databases

The SN, NEN and NASA Integrated Services Network (NISN) data networks all have defined planning protocols and schedules. The Operations Team will compile and translate the Experimenter's operational requirements into discrete data inputs for each of these organizations.

Approximately 6-3 months prior to operations, based upon experiment new waveform parameters the Scheduler will work with the Network Integration Manager (NIM) at Goddard Space Flight Center (GSFC) on any necessary updates to the RFICD (450-RFICD- SCAN Testbed/SN/NEN). The Scheduler will also develop the Service Specification Codes (SSCs) for Tracking and Data Relay Satellite (TDRS) contact operations and incorporate them into the Network Control Center Data System (NCCDS) and SNAS operations database (databases at WSC) and will also provide the experiment waveform parameters to the NEN MCE for the Configuration/Telemetry Rate (TR) code development for NEN contact operations. The experiment communication code development and integration to the SN and NEN processes will take at least 2 weeks to 1 month depending on the numbers of codes introduced. Refer to GRC-CONN-PLAN-0900 SCAN Testbed SN-NEN Planning Guide for more details.

5.4 Flight Rules Assessment

As part of the integration process, the flight rules will be reviewed with respect to the new experiment's requirements and planned operations. This assessment will occur after the Experiment Plan has been developed, approximately 8 months prior to operations. If changes to flight rules are required, the Operations Team will initiate them. Additional analysis for Radio Frequency (RF) Interference may also be necessary as well as Power Flux Density analysis which could impact the Flight Rules.

5.5 POIC Planning Assessment

In addition to the flight rules, the POIC planning documents will also be reassessed. In most cases the existing SCAN Testbed planning products (the User Requirements Collection (URC) data set, Ground Rules and Constraints, Payload Activity Requirements Document (PARD), Payload Planning Overview (PPO)) will encompass the Experimenter's operations. If a modification is required, the SCAN Testbed Payload Activity Requirements Coordinator (PARC) will work with the Operations Team to incorporate the change.

6.0 PROCEDURE DEVELOPMENT PROCESS

6.1 Configuration Data Sheet

The Configuration Data Sheet (CDS) is a form that collects information pertinent to the Operations Team. The details are contained in GRC-CONN-PLAN-0130 Data Management Plan. The CDS has two parts – the first is for static experiment information, the second is for on-orbit information that changes for each experiment run. A CDS is developed for each Experimenter.

The CDS is populated from information in the Experiment Plan. As the Experimenter works through the process flow, the CDS is updated as needed. After the ERR, the first part of the CDS should be in its final state.

When the Experimenter is ready for On-Orbit operations, the CDS will be updated as required. After an experiment run, the second part of the CDS is filled in with the relevant data (such as filenames, SFEP configurations, etc.). If two experiments are run on the same day, they will each have an independent CDS.

6.2 Modules

The procedures to operate each subsystem have been broken down into component modules. These modules cover the basic functions of the subsystem such as power up, power down, telemetry checks, configuring waveforms, etc. They have been performed on the GIU to ensure their accuracy and usability.

These modules have been collected into GRC-CONN-OPS-0912 Mission Operations Modules which is configuration controlled. This document will provide the basis for flight procedure development. A read-only copy will be placed on the Connect Data Base server (CONDB) for use by the Operations Team to generate procedures.

6.3 Scripts

For each day of operations, a script will be prepared using the SCaN Testbed Script Builder. This script will provide an ordered list of tasks that need to occur for that day's operations. It will include modules for ISS tasks, steps for SFEP and Experimenter Front End Processor (EFEP) configuration, and the timing of data flows. The script will start with a configuration page that summarizes the planned event windows, the SDRs and their Waveforms, the forward and return data rates, and the track files to be used.

The SCaN Testbed Script Builder allows the user to select baselined module titles from a menu list. The module titles are then placed in the correct slots in the ordered task list. Additional steps are added to the list as needed. This script will be saved on CONDB.

During flight operations, the APS Operator and the SFEP Operator will have the script to follow. The Science Team will also have a script.

6.4 Procedures

Once the script is prepared, the expanded procedure can be created. Directing the SCaN Testbed Procedure Creator to run, it retrieves the full modules and places them in a new document in the order they are to be performed. The non-modules steps are also placed in the correct order in the new document. The program will prompt for known inputs such as track file names and the Jet Propulsion Laboratory (JPL) SDR stripe number.

Once the procedure has been created, it will be saved on CONDB. This is the procedure that will be used during GIU testing prior to flight operations. If changes are needed, the script will be reworked and the procedure recreated.

During flight operations, the Commander and Controller will have the expanded procedures. The Commander will have the official copy that will be become the As-Run.

6.5 As-Run Procedures

Upon completion of a procedure, the marked-up hard copy will be placed in an As-Run folder in the SCAN Test Control Center (STCC). The CDSs are considered part of the As-Run and will be the cover sheets. Configuration Management (CM) will collect the As-Run procedures, scan them into PDF files, and place them in CMTS. The paper copies will be stored at Zin.

7.0 GENERAL OPERATIONS

The operational philosophy for SCAN Testbed is the STCC will be manned when power is applied to the flight system.

7.1 Critical Commands

Due to RF safety considerations, the commands to apply power to Avionics, the Traveling Wave Tube Amplifier (TWTA), and the 3 SDRS, are considered critical. These commands cannot be sent by the Operations Team and have been removed from the SCAN Testbed command database. They have been moved to the POIC database so that the Payload Rack Officer (PRO) can send them. The PRO must receive approval from the Payload Operations Director (POD) prior to sending a critical command.

7.2 Shift Operations

The nominal work week will be 5 shifts of approximately 8 hours per shift. The actual times will be based on that day's On-Orbit Short Term Plan (OSTP).

At the start of the shift,

- Open the appropriate programs and tools such as the Connect Telemetry and Display System (CTADS), EHS Web Launch Pad, EPC, On-Orbit Short Term Plan Viewer (OSTPV), Command Track, Payload Information Management System (PIMS), the GSE Displays, and the Console Log. Most of these will be run on Telescience Resource Kit (TReK) computers. The procedures are given in GRC-CONN-OPS-0176 Console Handbook.

- Verify that GSE Packet 555, which contains ISS pointing information and the Resistance Temperature Detector (RTD) temperatures, is still active. If not, it should be configured to run for 99 days. The procedure is given in GRC-CONN-OPS-0176 Console Handbook.

- Open SNAS. Verify the SN events have not changed.

- Verify that NEN events have not changed.

- Verify the link to White Sands with the SFEP. Configure the SFEP for the first event of the shift.

- Check the PIMS To-Do List for actions assigned to SCAN Testbed such as OCR reviews.

- Verify all positions have the current script and procedure as needed.

- The Controller should inform the Operations Controller (OC) that SCAN Testbed is on-console and ready to support operations. The Controller should brief the OC on the day's activities including the time of the event windows, the SDRs being used, and the verification that no RF hazard constraints are present.

At the end of the shift,

- Verify safety inhibits are in place prior to deactivation
- Inform the OC that SCAN Testbed is going off-console
- Close the appropriate programs and tools. The GSE Packet 555, which contains ISS pointing information and RTD temperatures, should be left to run.
- Move the User Performance Data (UPD) log files from SN and NEN to CONDB
- Close SNAS
- Move files from SFEP to SFEP Mass Storage (GRC-CONN-DOC-0891 SFEP User's Guide)
- Close the SFEP terminal windows
- Retrieve NEN raw data files and place on CONDB (GRC-CONN-PLAN-0900 SN-NEN Planning Guide)
- Copy any files (CTADs logs, flight system logs, APS files) to CONDB
- Ensure the console log is current with the shift's activities

7.3 Console Logs

The console log is a MySQL database accessed through the Connect website (see GRC-CONN-OPS-0176 Console Handbook).

The console log will have pre-defined categories and subcategories to make the entry of information more efficient. The entries can be searched by various categories such as date, category, or text in the description.

Log entries should be made during the shift as they occur. Typical entries will include power on times of the various subsystems, RF switch commanding, name of the script/procedure that is being used, OCR activity, anomalies and Payload Anomaly Report (PAR) activity, verification of safety inhibits, and power down of the subsystems. Each command does not need to be entered in the log. That information is captured in the As-Run procedure and the CTADs command log.

Limited life items will also be tracked by the console log. Specifically, these items are TWTA power cycles and the APS sweep cycles. An APS sweep cycle is defined by the full motion from hard stop to hard stop. The typical APS motion will not be this extensive but it will be tracked in the console log. One TDRS pass equals one sweep.

7.4 Experiment Scorecard

In order to insure that the experimenters' objectives are met during the course of their operations, a scorecard will be developed during their integration process. This will be used to plan operations and to track accomplishments.

7.5 PAS/Kernel Uploads

An update of the Payload Avionics Software (PAS) or Kernel is a crucial activity which requires precise procedures to accomplish. Due to the in-depth knowledge needed for an update, the Software Team will provide the necessary procedures to the Operations Team. Each new update will have its own procedure.

8.0 FLIGHT SAFETY

The signed Hazard Reports can be access from the Payload Safety Review Panel (PSRP) Data Management System (http://psrp.jsc.nasa.gov/pgReports/Home.aspx). The rest of the documents can be accessed from the Mission Control Center - Houston (MCC-H) Gateway, under References (https://ops1.jsc.nasa.gov/gateway/). There will also be hardcopies in binders in the STCC.

8.1 Hazard Reports

During the Payload Safety process, a number of hazards were identified. After negotiation with the PSRP, the hazards and their controls were documented in Hazard Reports and approved. A summary of each hazard follows:

- Standard Hazards (SCANTB-FLT-001): This is a standardized list of common hazards such as structural failure, sharp edges, rotating equipment, batteries, and lasers. Not all of these apply to SCAN Testbed. The items that do apply have safety controls listed or a reference to a standalone Hazard Report.
- Radiation - RF Energy (SCANTB-FLT-002): When an SDR is transmitting, it emits RF energy. This is a hazard during Extravehicular Activity (EVAs), Extravehicular Robotics (EVRs), and Visiting Vehicles (VV) but only under certain conditions such as when the Space Station Remote Manipulator System (SSRMS) brakes are off (documented in Flight Rule B19-X).
- Structural Failure (SCANTB-FLT-004): This is a general hazard covering the structural integrity of the payload design to prevent damage to the ISS.
- Rotating Equipment (SCANTB-FLT-005): The APS contains a gimbaled assembly which tracks TDRSS. The hazard is if the gimbals exceed their design limits and break apart, creating debris outside of the ISS.
- EVA Contact Hazard (SCANTB-FLT-006): The concern here is sharp edges or protrusions on SCAN Testbed if the crew is working in the vicinity.
- Electrical Shock (SCANTB-FLT-007): The concern here is incidental contact with high voltage if the crew is working in the vicinity.

8.2 Flight Rules

A subset of signed Hazard Reports required flight rules to ensure the controls were in place during operations. B19-XX SCAN TESTBED RADIATION MANAGEMENT WITH ISS is the overarching flight rule that describes when SCAN Testbed must be inhibited. The other rules are complementary.

These flight rules have been approved:

B19-18 ISS PAYLOAD POWER INTERRUPTION CONSTRAINTS
B19-28 SCAN TESTBED EVA MAINTENANCE INHIBITS
B19-29 SCAN TESTBED POWER FLUX DENISTY CONFORMANCE LIMITS
B11-127 HTV/ATV/DRAGON/CYGNUS S-BAND COMMUNICATION CONSTRAINTS
B15-15 EVA KEEPOUT ZONES

These flight rules are in work:

B19-25 PAYLOAD KU-BAND INTERRUPTION CONSTRAINTS
B19-XX SCAN TESTBED RADIATION MANAGEMENT WITH ISS
B12-107 MSS STAY-OUT ZONES

8.3 Operational Control Agreement Database (OCAD)

There are five Operational Control Agreement Database (OCAD) records in place for SCAN Testbed. Two of them address EVA concerns and are an outcome of SCANTB-FLT-004 and SCANTB-FLT-006. Three of them address RF concerns and are an outcome of SCANTB-FLT-002.

OCAD ID 92348 Structural Failure of the SCAN Testbed. To protect the payload from EVA kick loads, the control is to designate the hardware above the Flight Releasable Attachment Mechanism (FRAM) interface as a No-Touch Area.

OCAD ID 92349 EVA Contact Hazards. To protect the EVA crew from the SCAN Testbed hardware, the control is to designate the hardware above the FRAM interface as a No-Touch Area.

OCAD IDs 102194, 102195, and 102196 RF- Radiation Energy. The first of these OCADs describes the keep-out zones for non-stationary elements such as EVAs, EVRs, and VVs to protect them from exposure to excessive RF energy. The second OCAD places power inhibits on the Harris SDR, the TWTA, and the ELC EMC 120V main switch power prior to EVA/EVR/VV proximity operations to protect from inadvertent Ka-Band activation. The third OCAD places power inhibits on the General Dynamics (GD) SDR, the JPL SDR, and the ELC EMC 120V main switch power prior to EVA/EVR/VV proximity operations to protect from inadvertent S-Band activation.

8.4 Operational Interface Procedures (OIPs)

The purpose of the ISS Operations Interface Procedures (OIPs) is to document real-time operational interfaces and procedures used between the control centers. SCAN Testbed requires a unique coordination between MOD at Johnson Space Center (JSC) and POIC at Marshall Space Flight Center (MSFC). MOD has insight into systems that POIC does not normally monitor.

There will be one generic OIP and three specific ones. The generic OIP "Inhibit Notification Planning Process for SCAN Testbed" will be an umbrella procedure with pointers to the specific OIPs as well as the notification process for activities that need to be inhibited (EVAs, VVs).

The first specific OIP is C7.13.4.3 Ground Coordination of Reflected Radiation Constraints Due To Japanese Experiment Module Remote Manipulator System (JEMRMS) Loaded Configuration <TBR 8-1>. It describes the notification process for implementing a Ku-Band mask or SCAN Testbed Shutdown for when the JEMRMS or the Small Fine Arm (SFA) grapples any payload.

The second specific OIP is <TBD 8-1> TDRS and NEN Scheduling Process for SCAN Testbed. It defines how SCAN Testbed Planners and ISS Pointers interact to request TDRS and NEN resources to support SCAN Testbed operations.

The third specific OIP is <TBD 8-2>. It describes the coordination of the Mobile Base System/ Space Station Remote Manipulator System/Special Purpose Dexterous Manipulator (MBS/SSRMS/SPDM) inhibit periods with the POIC.

9.0 ANOMALY COORDINATION

9.1 Anomaly Process

GRC- CONN-OPS-0897 SCaN Testbed Anomaly Resolution Process defines the process by which anomalies will be addressed and resolved. The scope of the Anomaly Resolution Process (ARP) includes the SCaN Testbed (including the Avionics, SDRs, RF subsystem, and APS), STCC, SFEPs, SN, NEN, ISS, and NISN.

There are two distinct phases of anomaly resolution: Real-Time Operations and Sustaining Engineering. Real-Time Operations is limited to using approved procedures and to working with the allocated ISS resources, timelines, and operational constraints. Sustaining Engineering is open to detailed engineering analysis and development and validation of new processes, software or hardware.

9.2 ISS System Anomalies

The following subsections describe several possible ISS System anomalies. ISS System events that affect SCAN Testbed should be entered into the console log.

9.2.1 Payload Multiplexer/Demultiplexer (PLMDM) Failure

A Payload Multiplexer/Demultiplexer (PLMDM) failure results in the loss of commanding, low rate data and Health & Status. The high rate data will continue to be downlinked. The PLMDM can fail over to the back-up PLMDM. This typically takes 30 minutes.

The high rate data provides insight into the status of the flight system. If a transmitter is on, the POD should be informed but emphasize that there is no safety issue. When the PLMDM has been restored and if the timeline allows, request a commanding window to prepare the flight system for the next event. If the end of shift is near, prepare for deactivation.

9.2.2 Extended Ku-Band Antenna Outage

In the event of an unplanned Ku-Band Antenna outage that is predicted to last less than 3 hours, there are no actions to be taken. It will be handled like a normal LOS period. If a transmitter is on, the POD should be informed but emphasize that there is no safety issue.

If the unplanned outage is expected to last more than 3 hours, then the Flight Rule B19-25 PAYLOAD KU-BAND INTERRUPTION CONSTRAINTS is enacted. This rule allows SCAN Testbed to be deactivated by commanding in the blind. It also allows for S-Band Normal Data Dumps which will provide snapshots of SCAN Testbed or ExPRESS Logistics Carrier-3 (ELC3) telemetry to verify inhibits or temperature status depending on the situation. Inhibits will be verified only if there is an inhibit event planned within 24 hours of the outage. Temperatures will be gathered every 2 hours on a best effort basis.

9.2.3 Unplanned Power Interruption

As an external payload, SCAN Testbed is highly susceptible to changes in the thermal environment. For planned power outages, the flight system can be preheated to survive the period without heaters.

For unplanned power outages, the Flight Rule B19-18 ISS PAYLOAD POWER INTERRUPTION CONSTRAINTS is enacted. It provides guidance on how long the flight system has before the temperatures fall below the non-operating survival limit. Depending on the Beta Angle and the initial conditions, the system could have as little as 30 minutes before potential damage would occur.

9.3 SCAN Testbed Hardware Anomalies

The document GRC-CONN-RPT-0227 Fault Detection, Isolation, and Recovery (FDIR) defines responses that can be handled autonomously by the flight avionics software onboard SCAN Testbed as well as responses that require action from the mission operations personnel on the ground. GRC-CONN-OPS-0913 Mission Operations Off-Nominal Procedures has been written to provide the recommended courses of action for FDIR anomalies.

In the event of a hardware anomaly that is not covered by the FDIR, the general approach is to turn off any transmitters, gather log files, deactivate subsystems as necessary, and assess the telemetry. A power cycle of a subsystem is an expected remedy for some anomalies. If a power cycle is needed, the PRO should be informed because of the critical commands needed for activation. The PRO will seek approval from the POD and a PAR will likely be assigned.

Every anomaly should be entered into the console log. In some cases, the POD will assign a PAR for the anomaly.

9.4 Software Error Messages

GRC-CONN-DOC-0906 Software Avionics Error Codes lists the errors defined by the flight avionics software. These errors are reported in one or more of the following ways: the avionics log that resides on the flight system, in telemetry on a CTADS screen, or in a squawk message. This document does not include errors generated by the operating system, VxWorks.

There are 40 categories of error defined by the area of code. Each error has a description and in most cases a recommended course of action. The courses of action range from resending a command after checking some parameters to power cycling the entire flight system. If the error code can be cleared by simple actions, then these should be taken immediately to try to preserve the planned operations. If the error code suggests a reboot or power cycle of a radio or the avionics, the PRO should be informed because of the critical commands needed for activation. The PRO will seek approval from the POD and a PAR will likely be assigned.

Every error code received should be entered into the console log. In some cases, the POD will assign a PAR for the anomaly.

9.5 Squawk Message

GRC-CONN-DOC-0908 Flight Software Squawk Messages lists the avionics squawk messages sent in telemetry and reported in the ground software CTADS squawk screen display. Many of the squawk messages are informational and require no further action. Some of the squawk messages have a suggested course of action. Some of the messages also have a corresponding error code. Like the error codes, the actions can range from verify the state of certain parameters to power cycling a subsystem. If the actions are simple, they should be performed immediately to try to preserve the planned operations. If the action is a reboot or power cycle of a radio or the avionics, the PRO should be informed because of the critical commands needed for activation. The PRO will seek approval from the POD and a PAR will likely be assigned.

The squawk messages received that have associated actions should be entered into the console log. In some cases, the POD will assign a PAR for the anomaly.

9.6 Ground Software Errors

GRC-CONN-DOC-0915 Ground Software Errors and Recovery describes error messages that can be generated from the CTADS ground software and the possible remedies to the problem. Errors will generally be reported in one of three methods: Logging, Message or Error window output, or Windows style pop up messages. The recommended courses of action frequently call for a reboot of the workstation or a restart of the CTADS program.

The ground software errors should be entered into the console log. Neither the PRO nor the POD needs to be informed of these issues unless they impact an upcoming event.

10.0 GROUND SYSTEM DESCRIPTION

Experimenters access the SCAN Testbed through the ground system, operated by Mission Operations personnel, by exchanging data with the SCAN Testbed Control Center (STCC) which is located within the Telescience Support Center (TSC) at GRC. Experimenters operate from within the SCAN Testbed Experiment Center (STEC), which is adjacent to the STCC. Communication between SCAN Testbed and ground systems for command and telemetry occurs through established ISS paths, which is called the Primary Path. The Primary Path includes the STCC, Payload Operations Integration Center (POIC) which is part of the Huntsville Operations Support Center (HOSC) at MSFC, the NASA Space Network (SN) S-band and Ku-band services to the ISS, the ISS MDMs, EXPRESS Logistics Carrier (ELC), and the SCAN Testbed.

The Experimental Path, which includes the RF links used by the SDRs in SCAN Testbed, is predominantly used to transmit and receive experimental data. The SN Experimental Path includes the STCC and SN S-band and Ka-band services to the SCAN Testbed. On the Forward Link, data travels from the Experimenter Front End Processor (EFEP), to the Mission Operation's Front End Processor (SFEP), through the TSC network, through NISN Ground Network to White Sands (which includes either White Sands Complex (WSC) SFEP and possibly the WSC SDR) to Tracking and Data Relay Satellite System (TDRSS) and onto the SCAN Testbed. The Return Link reverses the path originating with SCAN Testbed to TDRSS to White Sands through the NISN Ground Network to the STCC SFEP and ending at the STEC EFEP. The Near Earth Network (NEN) Experimental Path includes the STCC and NEN S-band services from Wallops to the SCAN Testbed. The Uplink starts with the GRC TSC through the NISN Ground Network to the Wallops Ground Station (WGS) and onto the SCAN Testbed. The Downlink goes from the SCAN Testbed to the WGS through NISN Ground Network to the GRC TSC. These data paths are shown in Figure 10-1.

The drawing, SCAN Testbed System Overview, lays out the ground system architecture in great detail. It shows how the telemetry flows from the Flight System to the TSC Server Room, the STCC, and the STEC through both the primary and experimental path. It also shows the path commands follow from the STCC to the Flight System. This drawing is kept on CONDB.

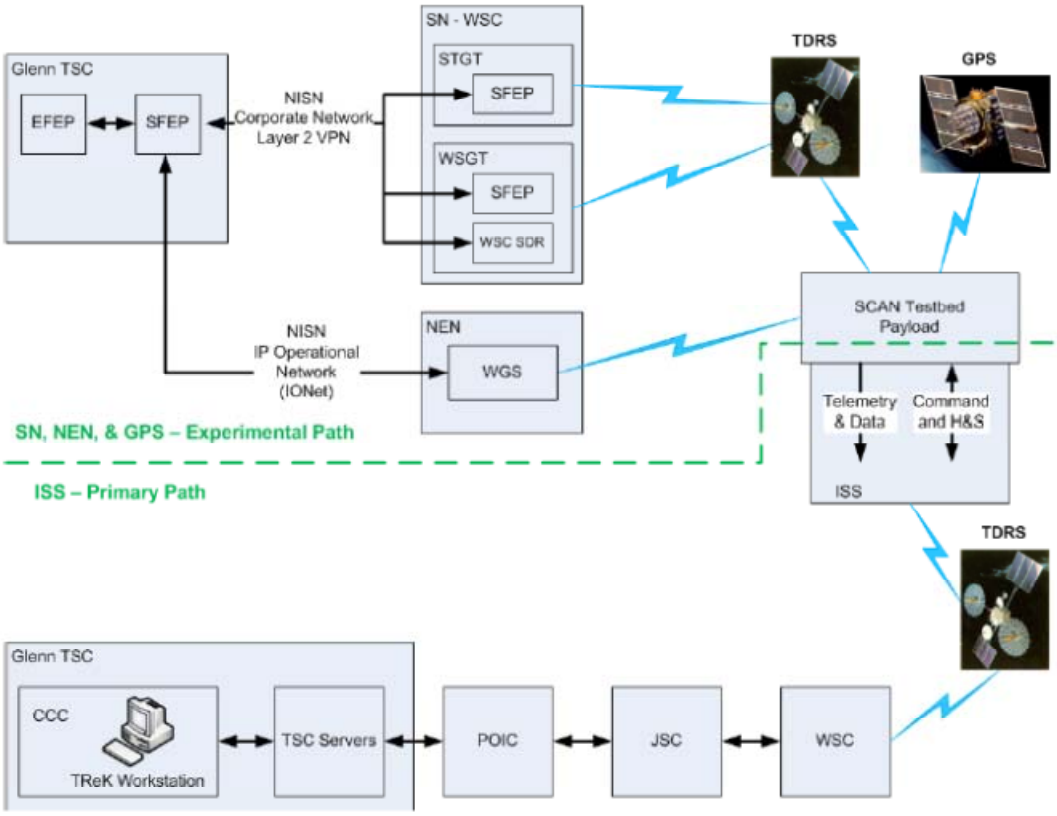

Figure 10-1—SCAN Testbed Data Paths

11.0 DATA MANAGEMENT

Data management for the SCaN Testbed Project is the process of controlling the data flow, storage, distribution, retrieval, and archival of science and mission data associated with the SCaN Testbed tests and experiments. The details are contained in GRC-CONN-PLAN-0130 Data Management Plan.

Data is created at and retrieved from many locations within the SCaN Testbed flight and ground systems. The data travels along different networks and at different points in the hardware paths, these networks intersect. Precautions must be taken to ensure that access to one network such as the Internet does not compromise the other networks such as NISN and the Mission Network. As part of these precautions, care is taken to ensure that the different storage servers are isolated from one another where necessary, either through the use of firewalls or by physical isolation. There are two storage servers and three files repositories.

11.1 Mission Operations Data Storage Server

The Mission Operations data storage server, CONDB, is located in the SCaN Testbed Mission Operation rack in the TSC Server Room. The TReK recordings along with other data from the Flight System, as well as data from the GIU are copied directly from the Connect Mass Storage server (CONMS) and the TReKs to CONDB. Files that are transferred to and from the Flight System, including experiment data files, are stored on CONDB. Data retrieved from the Internet such as performance data from SN and NEN are manually transferred from the GRC supplied computers to the TReK workstations to be copied to CONDB. This includes data from prelaunch and flight phases. Remote access to selected science and Mission Operations data, stored on CONDB, is provided through a secure web server.

11.2 GRC SFEP Mass Storage Server

The SFEP Mass Storage Server is housed in the SFEP rack, located in the TSC Server Room. The raw experiment data returned using either the SN or NEN is stored here, after being copied post-pass from the WSC SFEP and WGS file server respectively. NEN data files from WGS are retrieved via the GRC computers and are manually copied to the SFEP. The data can be used to run the experiment through the GRC SFEP to the Experimenter equipment, in playback mode. Details on the operation of the SFEPs and the usage of the SFEP Mass Storage Server can be found in the SCAN Testbed Front End Processor (SFEP) Users Guide, GRC-CONN-DOC-0891

11.3 File Repositories

All software updates to the PAS, SDR Operating Environments (OEs) or SDR Waveforms, which are uploaded to the Flight System, must be stored under configuration control in the SCaN Testbed configuration management system to maintain control and integrity of the SCaN Testbed flight hardware, ISS systems and the network services.

All waveforms and OEs are submitted to the SCaN Testbed Waveform Repository and STRS Repository, both of which are maintained by GRC Communication's personnel. Details of the STRS Repository are available in STRS Application Repository Design and Analysis Document, STRS-SWL-00001 and STRS Application Repository Implementation Document, STRS-SWL-00002.

All PAS updates are kept in the SCaN Testbed Software Repository which is maintained by SCaN Testbed Sustaining Engineering. Details of the SCaN Testbed Software Repository can be found in The Software Configuration Management Plan, GRC-CONN-PLAN-0001.

APPENDIX A ACRONYMS AND ABBREVIATIONS

A.1 Scope

This appendix lists the acronyms and abbreviations used in this document.

A.2 List of Acronyms and Abbreviations

Table A-1—Acronyms

APS	Antenna Pointing Subsystem
ARP	Anomaly Resolution Process
CDS	Configuration Data Sheet
CM	Configuration Management
CONDB	CoNNeCT Data Base server
CONMS	CoNNeCT Mass Storage server
CPU	Computer Processing Unit
CTADS	CoNNeCT Telemetry and Display System
EDS	Engineering Development System
EFEP	Experimenter Front End Processor
ELC3	ExPRESS Logistics Carrier-3
ERB	Engineering Review Board
ERR	Experiment Readiness Review
EVA	Extravehicular Activity
EVR	Extravehicular Robotics
FDIR	Fault Detection, Isolation, and Recovery
FRAM	Flight Releasable Attachment Mechanism
GCP	Ground Command Procedure
GD	General Dynamics
GIU	Ground Integration Unit
GRC	Glenn Research Center
Gr&Cs	Ground Rule and Constraints
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
Harris	Harris Corporation
HOSC	Huntsville Operations Support Center
ICD	Interface Control Document
ISS	International Space Station
JEMRMS	JEM Remote Manipulator System
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
MBS	Mobile Base System
MCC-H	Mission Control Center - Houston

MOD	Mission Operations Directorate (JSC)
MOM	Mission Operations Manager
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
NCCDS	Network Control Center Data System
NEN	Near Earth Network
NISN	NASA Integrated Services Network
OC	Operations Controller
OCAD	Operational Control Agreement Document
OCR	Operation Change Request
OE	Operating Environment
OIP	Operational Interface Procedures
OSTP	On-Orbit Short Term Plan
OSTPV	On-Orbit Short Term Plan Viewer
PAR	Payload Anomaly Report
PARC	Payload Activity Requirements Coordinator
PARD	Payload Activity Requirements Document
PAS	Payload Avionics Software
PIMS	Payload Information Management System
PLMDM	Payload Multiplexer/Demultiplexer
POD	Payload Operations Director
POH	Payload Operations Handbook
POIC	Payload Operation Integration Function
PPO	Payload Planning Overview
PRO	Payload Rack Officer
PSRP	Payload Safety Data Package
RF	Radio Frequency
RTD	Resistance Temperature Detector
SCaN, SCAN	Space Communications and Navigation
SCANTB	SCaN Testbed
SDR	Software Defined Radio
SFA	Small Fine Arm
SFEP	SCAN Testbed Front End Processor
SN	Space Network
SPDM	Special Purpose Dexterous Manipulator
SSC	Service Specification Code
SSRMS	Space Station Remote Manipulator System
STCC	SCaN Testbed Control Center
STGT	Second TDRSS Ground Terminal
STP	Short-Term Plan
STRS	Space Telecommunications Radio System
TBD	To Be Determined
TBR	To Be Resolved

TDRS	Tracking and Data Relay Satellite
TDRSS	Tracking and Data Relay Satellite System
TR	Telemetry Rate
TReK	Telescience Resource Kit
TSC	Telescience Support Center
TWTA	Traveling Wave Tube Amplifier
UPD	User Performance Data
URC	User Requirements Collection
VV	Visiting Vehicle
WGS	Wallops Ground Station
WSC	White Sands Complex
WSGT	White Sands Ground Terminal

APPENDIX B DEFINITIONS

B.1 Scope

This appendix lists the definitions used in this document.

B.2 List of Definitions

Table B-1—Definitions

Configuration Management: A systematic process for establishing and maintaining control and evaluation of all changes to baseline documentation, products (Configuration Items), and subsequent changes to that documentation which defines the original scope of effort. The systematic control, identification, status accounting, and verification of all Configuration Items throughout their life cycle.

Flight Systems and Ground Support: FS&GS is one of four interrelated NASA product lines. FS&GS projects result in the most complex and visible of NASA investments. To manage these systems, the Formulation and Implementation phases for FS&GS projects follow the NASA project life-cycle model consisting of phases A (Concept Development) through F (Closeout). Primary drivers for FS&GS projects are safety and mission success.

Interface Control Document (ICD): A specification of the mechanical, thermal, electrical, power, command, data, and other interfaces that system elements must meet.

Operations Concept: A concept that defines how the mission will be verified, launched, commissioned, operated, and disposed of. Defines how the design is used to meet the requirements.

Program: A strategic investment by a mission directorate (or mission support office) that has defined goals, objectives, architecture, funding level, and a management structure that supports one or more projects.

Project: (1) A specific investment having defined goals, objectives, requirements, life-cycle cost, a beginning, and an end. A project yields new or revised products or services that directly address NASA's strategic needs. They may be performed wholly in-house; by Government, industry, academia partnerships; or through contracts with private industry. (2) A unit of work performed in programs, projects, and activities.

Requirement: The agreed upon need, desire, want, capability, capacity, or demand for personnel, equipment, facilities, or other resources or services by specified quantities for specific periods of time or at a specified time expressed as a "shall" statement. Acceptable form for a requirement statement is individually clear, correct, feasible to obtain, unambiguous in meaning, and can be validated at the level of the system structure at which stated.

Software: As defined in NPD 2820.1, NASA Software Policy.

System: (a) The combination of elements that function together to produce the capability to meet a need. The elements include all hardware, software, equipment, facilities, personnel, processes, and procedures needed for this purpose. (Refer to NPR 7120.5.) (b) The end product (which performs operational functions) and enabling products (which provide life-cycle support services to the operational end products) that make up a system. (Refer to WBS definition.)

Systems Engineering Management Plan (SEMP): The SEMP identifies the roles and responsibility interfaces of the technical effort and how those interfaces will be managed. The SEMP is the vehicle that documents and communicates the technical approach, including the application of the common technical processes; resources to be used; and key technical tasks, activities, and events along with their metrics and success criteria.

System Safety Engineering: The application of engineering and management principles, criteria, and techniques to achieve acceptable mishap risk, within the constraints of operational effectiveness and suitability, time, and cost, throughout all phases of the system life cycle.

APPENDIX C TBDs AND TBRs

C.1 Scope

This appendix lists all items in this document that need to be determined (TBD) and that need to be resolved (TBR).

C.2 List of TBDs

Table C-1—TBDs

TBD Number	Description	Section Number	Closure Date/Event
2-1	Document number of the SFEP User's Guide	2.2	Baseline of document
2-2	Document number of SCAN Testbed Trajectory, Attitude and Antenna Modeling Plan	2.2	Baseline of document
8-1	Number of OIP for TDRS and NEN Scheduling Process for SCAN Testbed	8.4	Baseline of OIP
8-2	Number and Title of OIP that addresses the coordination of MBS/SSRMS/SPDM inhibit periods with the POIC	8.4	Baseline of OIP

C.3 List of TBRs

Table C-2—TBRs

TBR Number	Description	Section Number	Closure Date/Event
8-1	Title of OIP C7.13.4.3	8.4	Baseline of OIP