National Aeronautics and
Space Administration

GRC-CONN-PLAN-0006 B
EFFECTIVE DATE: 10/07/2011

Communications, Navigation, and Networking reConfigurable Testbed (CoNNeCT) Project

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

CoNNeCT PROJECT

PRODUCT ASSURANCE PLAN (PAP)

AUTHORIZED by CM when under FORMAL Configuration Control	
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Distribution:

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Availability:

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PREFACE

National Aeronautics and Space Administration (NASA) is developing an on-orbit, adaptable, Software Defined Radios (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 Communications, Navigation, and Networking reConfigurable Testbed (CoNNeCT) 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 CoNNeCT Payload Operations Nomenclature is "SCAN Testbed" and this nomenclature will be used in all ISS integration, safety, verification, and operations documentation. 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 CoNNeCT 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 Space Assurance and Requirements Guideline (SARG).

DOCUMENT HISTORY LOG

Status (Preliminary/ Baseline/ Revision/ Canceled)	Document Revision	Effective Date	Description
Baseline	–	08/31/2009	Initial Release
Revision	A	02/16/2010	Incorporate Change Request CONN-CR-0025
Revision	B	10/07/2011	Incorporate Change Request CONN-CR-0506

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TABLE OF CONTENTS

TABLE OF TABLES

1.0 INTRODUCTION

The Communications, Navigation and Networking reConfigurable Testbed (CoNNeCT) is a fast-track payload intended for flight to the International Space Station (ISS), aboard the Express Logistics Carrier (ELC). The CoNNeCT Product Assurance Plan provides instruction and guidelines that upon implementation will assure the NASA Glenn Research Center (GRC) that CoNNeCT will be safe and will perform as intended. Standard Assurance Requirements are addressed in ten main sections: Project Management, Assurance Reviews, Verification, System Safety, EEE and Mechanical Parts Control, Materials and Processes, Reliability, Availability and Maintainability, Quality Assurance, Continuous Risk Management, and Software Assurance.

1.1 Purpose

The purpose of this Plan is to provide clear instruction to Project personnel on their responsibilities to implement the safety and mission assurance activities through the use of formal processes and methodologies. Furthermore, this Plan defines the personnel responsibilities, documentation requirements, and general verification methodologies for accomplishing the product assurance requirements on CoNNeCT.

1.2 Applicability and Scope

This plan applies to the CoNNeCT Flight System, and Ground System hardware and software. The CoNNeCT project is classified as a Class D payload per NPR 8705.4 and CONNECT-MEMO-0002, CoNNeCT SARG Compliance Matrix. Furthermore, CoNNeCT is Category 3 per 7120.5D.

1.3 Implementation Approach

As a fast-track payload, the CoNNeCT project must apply resources in a careful manner to obtain maximum return on the applied resources. Duplicate activities must be eliminated or reduced to a minimum. With respect to the implementation of the Safety and Mission Assurance activities, many of the assurance requirements identified in the GRC Space Assurance Requirements and Guidelines (SARG) are imposed upon the CoNNeCT project by the carrier integration process for the ELC, the HTV (H-II Transfer Vehicle), and/or the Shuttle/ISS payload safety process. Where external programmatic requirements and/or processes meet the intent of the SARG requirements, these external programmatic requirements, and/or processes will be employed by the CoNNeCT Project Team.

For SARG requirements that are not enveloped by external programmatic requirements and/or processes, the CoNNeCT project will implement appropriate processes or activities or will provide a rationale for not implementing the requirement.

1.4 Overall Requirements

1.4.1 Description of Overall Requirements

The CoNNeCT Project will plan and implement an organized Safety and Mission Assurance (SMA) Program that encompasses all flight hardware and software from project initiation through flight operations.

The CoNNeCT Project Manager (PM) has primary responsibility for ensuring assurance requirements are satisfactorily accomplished. The assurance task will be designed for effective interaction among all elements of the project, regardless of organization.

1.4.2 Roles and Responsibilities

Responsibility for developing, planning and implementing CoNNeCT product assurance falls upon the following personnel: GRC Project Manager, GRC Chief Safety and Mission Assurance Officer, Technical Team (Flight & Ground Systems Leads, Discipline Engineering Leads, and Project Engineers & Technicians).

These personnel have the following specific responsibilities:

1.4.2.1 CoNNeCT Project Manager

The Project Manager (PM) has primary responsibility for ensuring assurance requirements are accomplished. The PM is responsible for establishing the specific content of product assurance and securing GRC management approval.

1.4.2.2 GRC CoNNeCT Safety and Mission Assurance Lead

The GRC CoNNeCT Safety and Mission Assurance Lead (the Multi-Center Lead for CoNNeCT) together with the Chief Safety and Mission Assurance Officer will assist the PM in developing project specific product assurance.

1.4.2.3 CoNNeCT Technical Team

The Technical Team in support of the Project Manager is responsible for developing project specific safety and mission assurance procedures and plans, maintaining SMA training current, creating and maintaining SMA verification status data products, implementing product assurance across the flight and ground systems development activities, submitting assurance status reports to the PM, implementing specific SMA plans, performing and documenting SMA-required analyses, ensuring that all hardware and software designs meet applicable SMA requirements, ensuring that proper materials are selected for space flight usage, and ensuring that all as-built hardware and software meet applicable SMA requirements, adhering to project developed plans and procedures, ensuring that all as-built hardware and software meet applicable drawing call out requirements, performing tests and procedures for SMA verification.

1.4.3 Product Assurance Plan

This Product Assurance Plan addresses the requirements of the Space Assurance Requirements and Guidelines (SARG), GLM-QE.8700.2. It details the performing organizations and deliverables. Any non-compliance or modifications to the requirements of the SARG are detailed in this document.

When the term "shall" is used in the SARG, a specific delivery item or Verification Data Sheet (VDS) is generated to provide a formal documented closure of a requirement. When the terms "will or must" are used, the condition is recognized as a requirement, but no formal verification will be provided. An audit can be scheduled per the governing contract or a particular area addressed on a case-by-case basis to validate requirements not formally addressed.

The ten main sections contain references to "Controlling and Applicable Documents," "Reference Documents," and "Impacted Documents." The "Controlling and Applicable Documents" are applicable to the CoNNeCT Project to the extent specified herein. The "Reference Documents" are provided only as reference material for background information and are not imposed as requirements in this Product Assurance Plan. The "Reference Documents" link this PAP to the other pertinent CoNNeCT documents.

1.5 Use of Previously Designed, Fabricated, or Flown Hardware

CoNNeCT will not use previously flown hardware or systems, so the items in the SARG that pertain to this topic are not applicable to CoNNeCT. CoNNeCT does not rule out the use of previously designed, or fabricated hardware. CoNNeCT may utilize previously conducted tests or analyses to show compliance with qualification requirements. Re-verification will be performed as necessary where new design hardware differs or may differ from previously verified hardware and where compliance with mission specific requirements has not yet been demonstrated. The Project Manager will provide documented evidence as to how the flight worthiness and integrity of previously designed and/or fabricated hardware intended for reuse has been maintained.

1.6 Assurance Status Reports

The CoNNeCT development team will prepare and submit periodic Safety Mission Assurance status reports to the PM. These assurance status reports include items such as verification matrix status reports, corrective and preventive action status reports, request for action status reports, lists of open safety verifications, and hazard reports.

1.7 Contractor Surveillance

The work activities, operations, and documentation performed on CoNNeCT may be subject to review by external auditors, internal auditors and/or Safety and Mission Assurance Directorate (SMAD) personnel, including any government agencies or entities delegated by the SMAD.

2.0 ASSURANCE REVIEW REQUIREMENTS

2.1 General Requirements

CoNNeCT will implement the programmatic review requirements defined in NPR 7120.5D and NPR 7123.1A as tailored in the CoNNeCT Project Plan (GRC-CONN-PLAN-0004) and the SEMP (GRC-CONN-PLAN-0005).

2.2 Controlling and Applicable Documents

The following documents, of the latest revision issued, direct, mandate, or control the content and impact of, or are required to understand the content of this document.

2.3 Impacted Documents

The following documents, of the latest revision issued, are used in the execution of this plan to the extent specified herein.

Document Number	Document Title
GRC-CONN-BSD-0017	CoNNeCT Baseline System Description
GRC-CONN-DOC-0025	CoNNeCT Science and Technology Requirements Document
GRC-CONN-PLAN-0002	CoNNeCT Configuration Management Plan
GRC-CONN-PLAN-0007	CoNNeCT Risk Management Plan
GRC-CONN-PLAN-0024	CoNNeCT Software Configuration Management Plan
GRC-CONN-PLAN-0085	CoNNeCT Software Assurance Plan
GRC-CONN-SRD-0013	CoNNeCT System Requirements Document

CoNNeCT product assurance is derived from the generic program defined in Section M of GLM-QE.8700.2. Section M provides a complete listing of all GRC safety and mission requirements for space flight hardware/software development activities. The requirement applicability for each class of payload, as a function of carrier, is also defined.

CoNNeCT product assurance is defined by listing each requirement from Section M of GLM-QE.8700.2 and providing a project implementation response. The implementation response will define how the project intends to meet the requirement. For those requirements that the CoNNeCT project will not be compliant with, a rationale for the non-compliance is provided.

Table D-1 identifies the responsible organization with respect to the requirements defined in Section M of GLM-QE.8700.2. For classification purposes, CoNNeCT is defined as a Class D payload, per NPR 8705.4 and CoNNeCT-DOC-008, and is Category 3, per NPR 7120.5D.

2.4 GRC Assurance Review Requirements

For each review presented, CoNNeCT will a) develop and organize material for oral presentation to the review team and submit copies of visual aids and other supporting material pertinent to the review in accordance with the Project Schedule; b) support splinter review meetings resulting from the major review; and c) produce written responses to recommendations and Requests for Action (RFA) resulting from the review, as required.

2.5 GRC Flight Assurance Review

CoNNeCT will implement the programmatic review requirements defined in NPR 7120.5D and NPR 7123.1A as tailored in the CoNNeCT Project Plan (GRC-CONN-PLAN-0004) and the SEMP (GRC-CONN-PLAN-0005).

2.5.1 Preliminary Design Review

CoNNeCT will implement the preliminary design review requirements defined in NPR 7120.5D and NPR 7123.1A as tailored in the CoNNeCT Project Plan (GRC-CONN-PLAN-0004) and the SEMP (GRC-CONN-PLAN-0005).

2.5.2 Critical Design Review

CoNNeCT will implement the critical design review requirements defined in NPR 7120.5D and NPR 7123.1A as tailored in the CoNNeCT Project Plan (GRC-CONN-PLAN-0004) and the SEMP (GRC-CONN-PLAN-0005).

2.5.3 Verification Readiness Review

CoNNeCT will implement the verification readiness review requirements defined in GLM-QE-8700.2 as tailored in the CoNNeCT Project Plan (GRC-CONN-PLAN-0004) and the SEMP (GRC-CONN-PLAN-0005).

2.5.4 System Acceptance Review

CoNNeCT will implement the system acceptance review requirements defined in NPR 7120.5D and NPR 7123.1A as tailored in the CoNNeCT Project Plan (GRC-CONN-PLAN-0004), the SEMP (GRC-CONN-PLAN-0005), and the System Acceptance Review Plan (GRC-CONN-PLAN-0773).

2.5.5 Operational Readiness Review

Although CoNNeCT will not implement the formal the pre-ship review requirements defined in GLM-QE-8700.2, an operational readiness review will be conducted as specified in the CoNNeCT Project Plan (GRC-CONN-PLAN-0004) and the SEMP (GRC-CONN-PLAN-0005).

2.6 System Safety

System safety will be addressed at all CoNNeCT reviews. CoNNeCT will implement the programmatic review requirements defined in NPR 7120.5D and NPR 7123.1A as tailored in the CoNNeCT Project Plan (GRC-CONN-PLAN-0004) and the SEMP (GRC-CONN-PLAN-0005).

3.0 VERIFICATION

3.1 General Requirements

CoNNeCT will implement a verification program that tracks adherence of all experiment, engineering, carrier integration, HTV and ISS safety, and other assurance and verification requirements (i.e. program/science, safety, assurance, interface and operational). All flight products will undergo prescribed verification activities in accordance with the defined verification program.

3.2 Controlling and Applicable Documents

Document Number	Document Title
GLM-QE.8700.2	Space Assurance Requirements and Guidelines (SARG)
GLM-QSA-1700.1	NASA Glenn Safety Manual
GLPR 7120.5.20	GRC Project Deviation/Waiver Process
KHB 1700.7	Payload Ground Safety Handbook
MIL-HDBK-1811	Mass Properties Control for Space Vehicles
MIL-STD-1540 Rev E	Test Requirements for Launch, Upper-Stage, and Space Vehicles
NASA-SSP-41172 Rev U	Qualification and Acceptance Environmental Test Requirements
NASA-SSP-SSP30237 Rev F	Space Station Electromagnetic Emission and Susceptibility Requirements
NASA-SSP-SSP30238 Rev E	Space Station Electromagnetic Techniques
NASA-STD-5001	Structural Design and Test Factors of Safety for Space-flight Hardware
NASA-STD-5002	Load Analyses of Spacecraft and Payloads
NASA-STD-5003	Fracture Control Requirements for Payloads Using the Space Shuttle
NASA-STD-5005	Ground Support Equipment
NASA-STD-7001	Payload Vibroacoustic Test Criteria
NSTS 1700.7B	Safety Policy and Requirements for Payloads Using the Space Transportation System
NSTS/ISS 18798	Interpretations of NSTS/ISS Payload Safety Requirements
SSP 30558	Fracture Control Requirements for Space Station
SSP 52005	Payload Flight Equipment Requirements and Guidelines for Safety-Critical Structures

3.3 Impacted Documents

The following documents, of the latest revision issued, are used in the execution of this plan to the extent specified herein.

Document Number	Document Title
GRC-CONN-BSD-0017	CoNNeCT Baseline System Description
GRC-CONN-DOC-0025	CoNNeCT Science and Technology Requirements Document
GRC-CONN-DOC-0092	Mass Properties Report
GRC-CONN-PLAN-0002	CoNNeCT Configuration Management Plan
GRC-CONN-PLAN-0012	Verification and Validation Plan
GRC-CONN-PLAN-0018	Software Verification & Validation Plan
GRC-CONN-PLAN-0024	CoNNeCT Software Configuration Management Plan
GRC-CONN-PLAN-0056	Fastener Control plan
GRC-CONN-PLAN-0062	Fracture Control Plan
GRC-CONN-PLAN-0072	Electromagnetic Compatibility Control Plan
GRC-CONN-PLAN-0083	Structural Verification Plan
GRC-CONN-RPT-0060	Thermal Analysis report
GRC-CONN-SRD-0013	CoNNeCT System Requirements Document
JHX-2009142	Communication, Navigation and Networking Re-configurable Testbed (CoNNeCT) Payloads Interface Control Document H-2 Transfer Vehicle (HTV)

3.4 Overall Verification Program

CoNNeCT will create and maintain a Verification Plan that is compliant with the verification tracking requirements of the ELC carrier integration process, HTV and ISS safety program and the Spaceflight Systems Directorate. In addition, all project derived engineering requirements will be tracked to closure. The plan will specify the necessary analyses, inspections, and tests for demonstrating compliance with traceability to original requirements. This plan will be prepared and released in accordance with the CoNNeCT defined configuration management approach. Some of the safety verifications will flow down from the CoNNeCT Hazard Reports.

The verification plans will include a summary of analyses, inspections, and tests in matrix format that will be performed on the overall experiment, as well as a matrix that specifies necessary verification activities to be performed on each component and subsystem. The verification plan will contain the following information:

- Requirements document reference.
- Paragraph reference from requirements document.
- Requirement title.
- Method(s) of verification.
- Verification/validation approach summary.
- Closure documentation.
- Safety closure reference (if applicable).

CoNNeCT personnel will update the verification matrix throughout product development activities and as verification activities have been completed.

Verification procedures will be prepared for each functional and environmental test activity at the component, subsystem, and experiment levels. These procedures will describe the configuration of the article, specific environmental parameters, and how each activity contained in the verification plan will be implemented. These procedures will be prepared and released in accordance with the CoNNeCT defined configuration management approach.

Reports will be compiled by the responsible CoNNeCT personnel. These reports will be prepared and released in accordance with the CoNNeCT defined configuration management approach.

3.5 Electrical Verification Requirements

CoNNeCT will comply with SSP 57003-ELC and NSTS 1700.7B and the associated verification programs by inspection, demonstration, similarity, analysis or tests, in order to meet the intent of this Product Assurance (PA) requirement.

Performance tests will be conducted before, during, and after environmental tests, as defined in the verification plan.

3.6 Structural and Mechanical Requirements

CoNNeCT will comply with SSP 57003-ELC and NSTS 1700.7B and the associated verification programs by inspection, demonstration, similarity, analysis or tests in order to meet this PA requirement (refer to NASA TM X-73305 and NSTS 08307).

3.6.1 Safety Critical and Fracture Critical Structures

CoNNeCT will comply with SSP 57003-ELC and NSTS 1700.7B and the associated verification programs to meet the intent of this PA requirement. All structural elements including associated interfaces, fasteners, and welds in the primary load path are considered safety critical and will be analyzed per the guidelines of NASA-STD-5003 and SSP 52005. The extensive verifications required for Safety-Critical Structures (SCS) are due to the critical flight safety concern of the structural integrity of International Space Station (ISS) payloads.

Fracture Critical components are a subset of SCS and are defined as ones whose failure would present catastrophic hazards, i.e. they are not fail-safe. These components will be shown through analysis, inspection, and/or test to be safe from failure throughout the mission.

3.6.2 Structural Loads

CoNNeCT will comply with SSP 57003-ELC and NSTS 1700.7B and the associated verification programs to meet the intent of this PA requirement. CoNNeCT will demonstrate compliance with structural loads requirements by conducting the appropriate inspections, analyses, and/or tests. Flight hardware will be designed to maintain structural integrity and functionality during all phases of the expected life cycle. Verification of the structures and systems will consider static and dynamic loads encountered during assembly, testing, transportation, launch, ascent, and space operations. NASA-STD-5002 will be utilized for defining methodologies, practices, and requirements for conducting load analyses in the verification plan.

3.6.3 Factors of Safety

CoNNeCT will comply with SSP 57003-ELC and NSTS 1700.7B and the associated verification programs to meet the intent of this PA requirement. NASA-STD-5001 and SSP 52005 will be used to establish design and test factors, as well as service life factors, to be used for flight hardware development and verification.

3.6.4 Margins of Safety

CoNNeCT will comply with SSP 57003-ELC and NSTS 1700.7B and the associated verification programs to meet the intent of this PA requirement. All structural elements critical for safety and mission assurance will be shown by analysis to have positive margins of safety or, in the case of containment devices, be structurally adequate against penetration. The minimum margins of safety for all credible failure modes will be determined.

3.6.5 Fracture Control

CoNNeCT will comply with SSP 57003-ELC and NSTS 1700.7B and the associated verification programs to meet the intent of this PA requirement. A Fracture Control Program will be implemented to meet the requirements of NASA-STD-5003 and SSP 30558.

3.6.6 Pressurized Systems

CoNNeCT will comply with SSP 57003-ELC and NSTS 1700.7B and the associated verification programs to meet the intent of this PA requirement.

3.6.7 Strength Testing

CoNNeCT will comply with SSP 57003-ELC and NSTS 1700.7B and the associated verification programs to meet the intent of this PA requirement. Strength Testing criteria and rationale will be reviewed and approved by the Verification Readiness Review Panel and by the Payload Carrier/Integrator (refer to NASA-STD-5001 and SSP 52005).

3.6.8 Vibroacoustics

CoNNeCT will comply with SSP 57003-ELC and NSTS 1700.7B and the associated verification programs to meet the intent of this PA requirement. NASA-STD-7001 will be used in conjunction with carrier/integrator mission requirements (HTV Cargo Standard Interface Requirements Document NASDA-ESPC-2857 Rev A and IRD-SSP50835) to define the random vibration test environment. The random vibration environments may be tailored to prevent the over-test of components that are vibration sensitive.

3.6.8.1 Component Random Vibration Testing

Where it is practical, random vibration testing will be performed on electrical, electronic, and electromechanical components and mechanisms at the component level in order to identify latent defects and manufacturing flaws. The minimum workmanship level is provided in NASA-STD-7001. For highly vibration-sensitive components that could be damaged by these levels, other methods of verifying workmanship may be employed such as by inspection, vendor data, or a tailored vibration spectrum.

3.6.9 Shock (Mechanical and Pyro)

CoNNeCT systems do not generate mechanical or pyro shock, so those items in this section of the SARG are not applicable to CoNNeCT. The CoNNeCT Project will perform shock testing per carrier/integrator requirements if they subject the payload to mechanical or pyro shock.

3.6.10 Mechanical Function

CoNNeCT will comply with SSP 57003-ELC and NSTS 1700.7B and the associated verification programs to meet the intent of this PA requirement. A kinematics analysis will be performed on all experiment mechanical operations to show that each mechanism can perform satisfactorily and has adequate design margin under worst-case conditions; satisfactory mechanical component clearance exists for stowed and operational configurations, and all mechanical elements are capable of withstanding the worst-case loads that may be encountered.

3.6.10.1 Flight Acceptance Testing

Verification testing will be performed to demonstrate that the installation of each mechanical device is correct and that no problems exist that will prevent the proper operation of the mechanism during mission life.

3.6.11 Pressure Profile

CoNNeCT will comply with SSP 57003-ELC, NSTS 1700.7B and HTV Cargo Standard Interface Requirements Document NASDA-ESPC-2857 Rev A and IRD-SSP50835, i.e. the associated verification programs, to meet the intent of this PA requirement.

3.6.12 Fastener Integrity

CoNNeCT will comply with SSP 57003-ELC and NSTS 1700.7B and the associated verification programs to meet the intent of this PA requirement. The CoNNeCT Fastener Control Plan will detail the activities to maintain fastener traceability, perform fastener testing (mechanical and physical) and provide controlled fastener storage for all safety critical or fracture critical fasteners only. Examples of acceptable Fastener Control Plans are listed in the SARG.

3.6.13 Mass Properties

CoNNeCT will develop and maintain a mass properties report and will status this report at each design review and other appropriate review venues. Payload mass properties will meet SSP 57003-ELC and SSP 57294 CoNNeCT unique Interface Control Document. CoNNeCT will develop a Mass Properties Control Plan.

3.7 Electromagnetic Compatibility (EMC) Requirements

EMC verifications will be demonstrated via test to the levels required by the Carrier/integrator. CoNNeCT will comply with SSP 57003-ELC and NSTS 1700.7B and the associated verification programs to meet the intent of this PA requirement. Two basic criteria will be met: first, the equipment will not generate electromagnetic interference that interferes with its own mission objectives or the operation and safety of concurrently operating systems, i.e., the launch vehicle, ISS, or other payloads; secondly, the system will be designed to operate in the mission's defined electromagnetic environment, containing both conducted, and radiated interference sources.

3.7.1 EMC Guidance

The method of achieving EMC is through a process called EMI control, and is managed with an EMI Control Plan. The power distribution system, control functions, signal, data processing, and distribution function must be managed through careful attention to electrical isolation, grounding, filtering, and shielding.

Commercial off-the-shelf (COTS) equipment may not meet these requirements. The EMI control process must address how these non-compliant components will be managed in the integrated system such that they will meet the system objectives before procurement of these items is allowed. For COTS equipment the following should be considered: isolation, bonding, shielding, and filtering.

3.8 Radiation Requirements

Exposure of electronic components to radiation causes three different types of effects: Total Ionizing Dose (TID), Displacement Damage Dose (DDD), and Single Event Effects (SEE). TID manifests itself as charge being trapped in nonconductive regions of the component as a result of absorbed charged particles or the scattering of electrons by high-energy electromagnetic radiation (gamma rays), which leads to parametric degradation. DDD manifests itself as atoms being knocked out of lattice structure of the component by charged or uncharged particles, which also leads to parametric degradation. SEE manifests itself as bit-flips, transients, functional interrupts, latch-ups, stuck bits, burn-outs, and gate ruptures as a result of ionization caused by high-energy protons or cosmic rays. The radiation environment and tests to determine the extent of these three effects on electronic components is discussed in Section 5.4.6.

When radiation testing of modules or individual EEE parts is required, CoNNeCT should test items that are similar to the actual flight unit, where 'similar' is defined below:

- Both EEE parts must be the product of the same approved Qualified Parts List, Qualified Manufacturer List and/or ISO 9000 manufacturer.
- Both parts must have been manufactured on the same line.
- The processing of both parts must have been identical, especially the critical parameters of oxide growth, temperature of the oxide process and final oxide thickness
- The two parts must be similar in function and identical in technology including the same mask design, identical feature size, deposition and doping.
- The same foundry, off shore or on shore, must have produced both wafers.

- Allowable technologies for Radiation Similarity consideration are DMOS, CMOS, VMOS, diffused junction and alloy junction.

3.8.1 Test Methods

The purpose of the SEE testing is to determine the MTBF (Mean Time Between Failure) of various electronic components due to SEE. Components will be monitored during exposure to radiation to determine when an error occurs as well as what type of error.

3.9 Vacuum, Thermal, and Humidity Requirements

CoNNeCT will comply with Section 3.7.2 in the SARG. CoNNeCT will perform thermal testing with the flight system hardware. CoNNeCT will test to the Protoflight levels defined in table 3.7.2-1 in the SARG.

3.9.1 Compliance with Requirements

Prior to the start of system environmental testing, CoNNeCT will prepare a formal environmental test plan as per GRC-CONN-PLAN-0012, the CoNNeCT Verification, and Validation Plan.

3.9.2 Testing Levels

Refer to 3.9 above.

3.9.3 Description of Applicable Testing

Refer to 3.9 above.

3.9.4 Description of Applicable Analysis

The CoNNeCT project will perform Thermal Analysis on all systems and identify the following:

a. Heat sources and their magnitude
b. Methods employed to dissipate the heat from the sources
c. List of operating temperature ranges of the components
d. Environmental conditions and design criteria
e. An assessment of the thermal design and identification of additional analysis needed.
f. An evaluation of the susceptibility to humidity extremes.
g. Identification of any special testing requirements or conditions.

This minimum analysis will be completed by PDR

3.10 Flight System Performance Acceptance Test Requirements

3.10.1 Burn-In Tests

Systems under test that contain electronic (EEE) parts will be burned-in to stimulate infant mortality failures. A minimum of one hundred hours of failure-free operation is required for CoNNeCT components and subsystems prior to system level burn-in of another one hundred hours. Therefore the flight system will have a total of 200 hours of burn-in before hardware turnover. These two hundred hours includes operational time accumulated during the thermal-cycle testing and any functional testing.

3.10.2 Primary Path Functional Performance Test (Integration Test)

The integrated flight and ground system will be tested for function, performance, and requirement fulfillment. Commands from the CCC will be sent to the ELC simulator then onto the Avionics Command and Data Handling unit and vice versa back to the CCC. Operational tests of command execution, which exercises all equipment and software commands, is a critical part of this verification. A test plan for the scope and duration of this test will be coordinated by the V&V Team with the Principal Investigator(s) to verify the correct experiment operations.

3.10.3 End-to-End Verification Test

An end-to-end compatibility test will be conducted on the complete operational system in the final mission configuration, as closely as possible. This test would include the flight system, the flight operational software, the ELC Simulator, and the CCC system, including the ground processing equipment and software in order to fully demonstrate operational compatibility. The verification of Tracking and Data Relay Satellite System (TDRSS) communication for "Link Forward" data is accomplished via: CCC to White Sands Complex (WSC), via the NASA Information Services Network (NISN), through the Compatibility Test Van's TDRSS link to the Flight System. The verification of TDRSS communication for "Return Link" data is accomplished via: the Flight System to the SDRs to the Van-TDRSS to WSC to CCC (via NISN).

3.10.4 Spectrum Compatibility Test

A spectrum compatibility test will be conducted on the Flight system, ELC Simulator, and the CoNNeCT Control Center (CCC). TDRSS specific compatibility testing will be performed with the TDRSS Van supplied by Goddard Space Flight Center. The objective of this test is to verify S-Band and Ka-band TDRSS through the actual satellite. "Link Forward" data verification is accomplished via: CCC to Van to the SDRs to the Flight System. "Return Link" data verification is accomplished via: Flight System to the SDRs to the Van to the CCC.

3.11 Ground Support Equipment (GSE)

CoNNeCT will design Ground Support Equipment (GSE) using NASA-STD-5005 as a guideline. All GSE to be used at the Glenn Research Center will also meet the requirements of the NASA Glenn Safety Manual, GLM-QSA-1700.1.

3.11.1 CoNNeCT Project Policy for Ground Support Equipment (GSE) and Test Support Equipment (TSE)

3.11.1.1 Commercial Off the Shelf (COTS) GSE

The following activities will be performed for the certification of COTS GSE:

1. Vendor documentation is evaluated for acceptability from a materials and processes (M&P) and a safety standpoint
2. Vendor test results are evaluated for acceptance
3. A post shipment inspection is performed upon arrival at GRC for packaging and appropriate paperwork
4. A GRC acceptance test is performed.
5. All certification evidence including vendor documentation is compiled into a certification package which is reviewed by Engineering and S&MA for completeness. The package is then entered into the CoNNeCT Configuration Management System.
6. Certified COTS GSE will be tagged with a green label that states it is CoNNeCT certified GSE.

3.11.1.2 CoNNeCT designed GSE

The following activities will be performed for the certification of GSE:

The technical requirements of 5005C are reviewed and approved by engineering for applicability to the specific piece of GSE. Per project implementation of NASA-STD-5005C as a guideline, the physical characteristic requirement 4.2.2.3, Color, is not applicable to any of the CoNNeCT GSE as it has no impact on technical or programmatic risk.

1. Qualification testing of the GSE is performed and documented
2. The applicable technical requirements are verified by the cognizant/responsible engineer
3. The materials and processes, safety, and quality requirements are verified by the S&MA
4. All certification evidence is compiled into a certification package which is reviewed by Engineering and S&MA for completeness. The package is then entered into the CoNNeCT Configuration Management System.
5. Certified GSE will be tagged with a green label that states it is CoNNeCT certified GSE.

3.11.1.3 TSE

TSE is non-flight COTS equipment that may physically or functionally interface with the flight hardware during the testing phases of the project (i.e. spectrum analyzer, multi-meter, oscilloscope, signal generators, power supplies, power meters, etc). The following three items will be reviewed as applicable prior to the TSE being approved for use with the CoNNeCT flight hardware.

1. In the case of TSE for which calibration is applicable, up to date calibration data will available for review by quality assurance (QA) during QA inspections of the test setups.
2. In the case of TSE for which a UL listing is applicable, it will be verified.
3. A GIDEP Alert search will be performed by QA prior to approving the use of the TSE.
4. Certified TSE will be tagged with a green label that states it is CoNNect certified TSE. For those TSE requiring annual calibration the label will also state to verify calibration date prior to use.

3.11.1.4 GSE Cables

In-house cables (GRC built) Certification of the in house cables is completed when the as manufactured cable process plan has been closed with engineering and quality assurance signatures. The cable process plans include and document closure of all cable build and test requirements.

3.11.1.5 COTS Cables

Certification of COTS cables is completed when the as completed pin to pin test is documented and approved with quality assurance and engineering signoffs.

The above certifies the cables for use. Safe to mate procedures must be used at all times when making any connection to flight hardware or GSE.

3.11.1.6 Laptops and Computers

Certification of COTS Laptops and PC's used as GSE or as part of GSE systems includes the review and completion of the following four activities.

1. COTS Laptops and PC's shall undergo a GIDEP Alert search by QA to verify there are no known recalls or hardware defects.
2. Software shall be reviewed by Software Assurance to verify it is acceptable for use in GSE. The software assurance activities required are dependent on the category of software. Categories and software assurance activities are listed below in this policy.
3. COTS Laptop and PC's, COTS software, and GRC coded software shall be scanned for viruses prior to use with flight hardware using Norton Antivirus. Every three months the antivirus definitions will be updated and a new scan performed for all certified computers or laptops.
4. The laptop or PC equipment shall be evaluated for acceptability from a performance standpoint.
5. Certified GSE will be tagged with a green label that states it is CoNNeCT certified GSE.

In accordance with NPR 2810.1A, certified laptops and computers may not be connected to an external network. Certified laptops or computers may be connected to each other in an internal/local network. All media used to install new software, software changes or to transfer data to or from a certified computer or laptop must undergo a virus scan prior to use. All software changes and updates must be recorded in the log book for the GSE and coordinated with software assurance, so that the required software assurance activities are completed. This process must be followed to maintain the GSE laptop or PC configuration and certification.

3.11.1.7 Categories and Software Assurance Activities for Software on GSE

Listed below are the five categories (1-5) of software that may be used on the CoNNeCT Ground Support Equipment (GSE) and Software Assurance activity related to each category. Listed under each category are examples (lower case letters, a, b, etc) and the associated software assurance activities (lower case roman numerals, i, ii, iii, etc). Software of differing categories may be used on the same GSE.

1. Purchased Software (COTS) that's loaded one time on a GSE laptop or PC.
    a. Example; OS like Microsoft XP, Windows 7, MS Word, Norton Ant-Virus etc

i. Come from a licensed source CD or factory loaded (License on back of PC).
ii. Any open source tool requires special consideration.

2. In house developed software that aids in testing (not verification) used on GSE laptop or PC connected to flight hardware.
    a. Example; Tools written to help loading waveform software.
    b. Example; Tools written to collect data for later analysis not used in verification.
        i. Meet Class E requirements
        ii. Indicate testing that was done to verify correct operation
        iii. Version controlled in a CM system
        iv. SA verify version loaded on GSE laptop or PC from CM system
3. In house developed software used on GSE equipment that is part of verification.
        i. Meets Class C requirements including verification before use.
        ii. Version controlled in CM system
        iii. SA verify loaded from CM system
4. Outsider developed software tools to simulate components (GSE) that connect to flight hardware
    a. Example; ELC Simulator Software (GSFC)
    b. Example; KaTSIM Software
        i. Identify who and how software was obtained.
        ii. Identify history of software. Document any known problems.
        iii. Version controlled in CM system
        iv. SA verify version loaded from CM controlled system
5. Unreleased Development Software used on or with current SDS#3/GIU/EM
    a. Payload Avionics Software
    b. JPL SDR S-Band Waveform Software
    c. GD SDR Software
    d. Harris SDR Software
    e. CTAD (Trek) Ground Software (GSE laptop or PC)
        i. Controlled by software or communication groups.
        ii. Loaded from CM system (No SA activity)

4.0 SYSTEM SAFETY

CoNNeCT will comply with system safety requirements imposed by SSP 57003-ELC, NSTS 1700.7 (Main Vol and ISS addendum), and JSX-2001015 HTV (HTV Cargo Safety Requirements).

4.1 General Requirements

CoNNeCT will comply with system safety requirements imposed by SSP 57003-ELC and NSTS 1700.7 (Main Vol and ISS addendum). CoNNeCT will prepare Safety Data Packages (per GRC Work Instruction GLWI-QE-8715.2) and will obtain concurrence from the GRC Safety & Mission Assurance Directorate (per GRC Work Instruction GLWI-QE-8715.4) on final documents. The objectives of the S&MA Program are to ensure that hazards involving personnel, equipment, or hardware have been identified and are either eliminated, controlled, or managed as an accepted risk in accordance with established engineering practices. These objectives are accomplished by a risk assessment methodology including: safety and trade studies; design, documentation and procedure reviews; System Safety analyses; training; safety & quality audits and inspections, surveillance, and monitoring activities. The specific objectives of the CoNNeCT S&MA program are to assure the following:

a. Safety consistent with requirements is designed into the system.

b. Appropriate controls over identified hazards are established to protect personnel, equipment, and property.

c. Minimum risk is involved in the acceptance and use of new materials and production techniques.

d. Hazards associated with each system, subsystem, and equipment, are identified, and are either eliminated or controlled in accordance with recognized standards.

e. Relevant safety factors and provisions are included in the initial engineering and design efforts to minimize retrofit actions required by hazards which could be present if safety design principles were not considered.

f. System safety engineering considerations are integrated into all design development, quality assurance, maintainability, reliability, maintenance engineering, and test and evaluation efforts.

g. Inherent safety is not compromised during any phase of the effort.

h. Safe operating procedures are established in the project.

4.2 Controlling and Applicable Documents

Document Number	Document Title
GRC-M0510.002	Space Assurance Requirements and Guidelines (SARG)
GRC-W0510.074	Shuttle/ISS Payload Safety Data Package Review
JSX-2001015 HTV	HTV Cargo Safety Requirements
KHB 1700.7	Space Shuttle Payload Ground Safety Handbook
NSTS/ISS 13830	Payload Safety Review and Data Submittal Requirements

4.3 Impacted Documents

The following documents, of the latest revision issued, are used in the execution of this plan to the extent specified herein.

Document Number	Document Title
GRC-CONN-BCD-0014	CoNNeCT Baseline Concept Description
GRC-CONN-DOC-0025	CoNNeCT Science and Technology Requirements Document
GRC-CONN-DOC-0092	Mass Properties Report
GRC-CONN-PLAN-0002	CoNNeCT Configuration Management Plan
GRC-CONN-PLAN-0004	CoNNeCT Project Plan
GRC-CONN-PLAN-0012	Verification and Validation Plan
GRC-CONN-PLAN-0018	Software Verification & Validation Plan
GRC-CONN-PLAN-0024	CoNNeCT Software Configuration Management Plan
GRC-CONN-PLAN-0056	Fastener Control plan
GRC-CONN-PLAN-0062	Fracture Control Plan
GRC-CONN-PLAN-0072	Electromagnetic Compatibility Control Plan
GRC-CONN-PLAN-0083	Structural Verification Plan
GRC-CONN-SRD-0013	CoNNeCT System Requirements Document
JHX-2009142	Communication, Navigation and Networking Re-configurable Testbed (CoNNeCT) Payloads Interface Control Document H-2 Transfer Vehicle (HTV)

4.4 Project Safety Planning and Implementation

CoNNeCT will comply with system safety requirements imposed by SSP 57003-ELC and NSTS 1700.7 (Main Vol and ISS addendum).

4.4.1 System Safety Criteria

A System Safety program will be implemented whereby the application of engineering and management principles, criteria, and techniques are employed to optimize personnel and equipment safety within the constraints of operational effectiveness, time, and cost throughout all phases of the system life cycle.

4.4.2 System Safety Design Requirements

System safety design requirements criteria will be specified after review of pertinent standards, specifications, regulations, design handbooks, safety design checklists, and other sources of design guidance for applicability to the design of the system. Safety design criteria will be derived from all applicable data including the preliminary hazard analyses if available. This criterion will be the basis for developing system specification safety requirements. The procedures as outlined in GRC procedure GLP-QE-8715.1 will be followed. Some general system safety design requirements are:

a. Eliminate identified hazards or reduce associated risk through design, including material selection or substitution. When potentially hazardous materials must be used, select those with least risk throughout the life cycle of the system.

b. Isolate hazardous substances, components, and operations from other activities, areas, personnel, and incompatible materials.

c. Locate equipment so that access during operations, servicing, maintenance, repair, or adjustment minimizes personnel exposure to hazards (e.g., hazardous chemicals, high voltage, electromagnetic radiation, cutting edges, or sharp points).

d. Minimize risk resulting from excessive environmental conditions (e.g., temperature, pressure, noise, toxicity, acceleration, and vibration).

e. Design to minimize risk created by human error in the operation and support of the system.

f. Consider alternate approaches to minimize risk from hazards that cannot be eliminated. Such approaches include interlocks, redundancy, fail safe design, system protection, fire suppression, and protective clothing, equipment, devices, and procedures.

g. Protect the power sources, controls, and critical components of redundant subsystems by physical separation or shielding.

h. When alternate design approaches cannot eliminate the hazard, provide safety and warning devices and warning and caution notes in assembly, operations, maintenance, and repair instructions, and distinctive markings on hazardous components and materials, equipment, and facilities to ensure personnel and equipment protection. These will be standardized in accordance with commonly accepted practice to help minimize the severity of personnel injury or damage to equipment in the event of a mishap.

i. Design software controlled or monitored functions to minimize initiation of hazardous events or mishaps.

j. Review design criteria for inadequate or overly restrictive requirements regarding safety. Recommend a new design criterion supported by study, analyses, or test data.

4.4.3 Hazard Reduction Precedence

The order of precedence for satisfying system safety requirements and resolving identified hazards will be as follows:

a. **Design for minimum risk** - From the first, design to eliminate hazards. If an identified hazard cannot be eliminated, reduce the associated risk to an acceptable level through design selection.

b. **Incorporate safety devices -** If identified hazards cannot be eliminated or their associated risk adequately reduced through design selection, that risk will be reduced to a level acceptable through the use of fixed, automatic, or other protective safety design features or devices. Provisions will be made for periodic functional checks of safety devices when applicable.

c. **Provide warning devices -** When neither design nor safety devices can effectively eliminate identified hazards or adequately reduce associated risk, devices will be used to detect the condition and to produce an adequate warning signal to alert personnel of the hazard. Warning signals and their application will be designed to minimize the probability of incorrect personnel reaction to the signals and will be standardized within like types of systems.

d. **Develop procedures and training -** Where it is impractical to eliminate hazards through design selection or adequately reduce the associated risk with safety and warning devices, procedures and training will be used. Procedures may include the use of personal protective equipment.

4.4.4 Hazard Severity Classification

Hazard severity categories are defined to provide a qualitative measure of the worst credible mishap resulting from personnel error; environmental conditions; design inadequacies; procedural deficiencies; or system, subsystem, or component failure or malfunction as shown at Table 4-1.

Table 4-1—Hazard Severity Categories

	Technical	Safety
Very High (5)	Performance requirement and/or other mission objectives cannot be met. Major new technology or hardware/software development is required.	A condition that may cause death or permanently disabling injury, facility destruction, loss of crew, loss of major systems, or loss of space vehicle/spacecraft (Catastrophic)
High (4)	Significant impact to meeting performance requirement and/or other mission objectives. Moderate new technology or hardware/software development is required.	A condition that may cause severe injury or occupational illness, major damage to facilities, equipment, or flight hardware (Critical)
Moderate (3)	Moderate impact to meeting performance requirement and/or other mission objectives. May require some new technology or hardware/software development.	A condition that may cause minor injury or occupational illness, damage to facilities, systems, equipment, or flight hardware (Moderate)
Low (2)	Minor impact to meeting performance requirement and/or other mission objectives. No new technology or hardware/software development required. May require minor modifications to existing technologies.	A condition that may cause some insignificant injury that would not adversely affect personnel safety or health (Negligible)
Very Low (1)	No impact to meeting performance and/or other mission objectives. No technology development or modifications required.	No safety impact

	Cost (estimate to complete)	Schedule
Very High (5)	> 10% increase over allocated funding and/or exceeds available reserves.	Any slip on any element on the critical path. Any slip that affects the launch date or delays scheduling to other segments on the critical path.
High (4)	≥ 7% but ≤ 10% increase over allocated level funding, and/or threatens to reduce reserves below prudent levels.	Any slip in non-critical path elements of ≥ one-quarter or non-critical path elements entering the critical path.
Moderate (3)	≥ 4% but ≤ 7% increase over allocated level funding, and can be handled within available reserves.	Any slip in non-critical path elements of ≥ half-quarter ≤ one-quarter.
Low (2)	≥ 2% but ≤ 4% increase over allocated funding, and can be handled within available reserves.	Any slip in non-critical path elements of ≥ 1 month ≤ half-quarter.
Very Low (1)	< 2% increase over allocated funding, and can be handled within available reserves.	Minimal or no slip in non-critical path elements.

4.4.5 Hazard Probability

The probability that a hazard will be created during the planned life expectancy of the system can be described in potential occurrences per unit of time, events, population, items, or activity. Assigning a quantitative hazard probability to a potential design or procedural hazard is generally not possible early in the design process. A qualitative hazard probability may be derived from research, analysis, and evaluation of historical safety data from similar systems. Supporting rationale for assigning a hazard probability will be documented in hazard analysis reports. An example of a qualitative hazard probability ranking is shown at Table 4-2.

Table 4-2—Hazard Probability Levels

Very High (5)	**Qualitative**: Occurrence is almost certain, and may not be controlled by following existing processes, procedures, and plans. **Quantitative**: 80 - 100%
High (4)	**Qualitative**: Occurrence is very likely, and may not be entirely controlled by following existing processes, procedures, and plans. **Quantitative**: 60 – 80%
Moderate (3)	**Qualitative**: Occurrence is possible, and may not be entirely controlled by following existing processes, procedures, and plans. **Quantitative**: 40 – 60%
Low (2)	**Qualitative**: Occurrence is unlikely, and may not be entirely controlled by following existing processes, procedures, and plans. **Quantitative**: 20 – 40%
Very Low (1)	**Qualitative**: Occurrence is very unlikely, and is generally controlled by following existing processes, procedures, and plans. **Quantitative**: 0 – 20%

4.4.6 Technical Analysis Requirements

Qualitative analyses are performed to identify hazardous conditions for the purpose of their elimination or control.

4.4.6.1 Preliminary Hazard Analysis

A Preliminary Hazard Analysis will be performed to obtain an initial risk assessment of a concept or system. Based on the best available data, including mishap data (if assessable) from similar systems and other lessons learned, hazards associated with the proposed design or function will be evaluated for hazard severity, hazard probability, and operational constraint. Safety provisions and alternatives needed to eliminate hazards or reduce their associated risk to an acceptable level will be included. The PHA will consider the following for identification and evaluation of hazards as a minimum:

a. Hazardous components (e.g., fuels, propellants, lasers, explosives, toxic substances, hazardous construction materials, pressure systems, and other energy sources).

b. Safety related interface considerations among various elements of the system (e.g., material compatibility, electromagnetic interference, inadvertent activation, fire/explosive initiation and propagation, and hardware and software controls). This will include consideration of the potential contribution by software (including software developed by other contractors/sources) to subsystem/system mishaps. Safety design criteria to control safety-critical software commands and responses (e.g., inadvertent command, failure to command, untimely command or responses, inappropriate magnitude) will be identified and appropriate action taken to incorporate them in the software (and related hardware) specifications.

c. Environmental constraints including the operating environments (e.g., drop, shock, vibration, extreme temperatures, noise, exposure to toxic substances, health hazards, fire, electrostatic discharge, lightning, electromagnetic environmental effects, ionizing and non-ionizing radiation including laser radiation).

d. Operating, test, maintenance, built-in-tests, diagnostics, and emergency procedures (e.g., human factors engineering, human error analysis of operator functions, tasks, and requirements; effect of factors such as equipment layout, lighting requirements, potential exposures to toxic materials, effects of noise or radiation on human performance; explosive ordnance render safe and emergency disposal procedures; life support requirements and their safety implications in manned systems, crash safety, egress, rescue, survival, and salvage). Those test unique hazards, which will be a direct result of the test and evaluation of the article or vehicle.

e. Facilities, real property installed equipment, support equipment (e.g., provisions for storage, assembly, checkout, proof testing of hazardous systems/assemblies which may involve toxic, flammable, explosive, corrosive or cryogenic materials/wastes; radiation or noise emitters; electrical power sources) and training (e.g. training and certification pertaining to safety operations and maintenance).

f. Safety related equipment, safeguards, and possible alternate approaches (e.g., interlocks; system redundancy; fail safe design considerations using hardware or software controls; subsystem protection; fire detection and suppression systems; personal protective equipment; heating, ventilation, and air-conditioning; and noise or radiation barriers).

g. Malfunctions to the system, subsystems, or software. Each malfunction will be specified, the causing and resulting sequence of events determined, the degree of hazard determined, and appropriate specification and/or design changes developed.

4.4.6.2 Subsystem Hazard Analysis

A Subsystem Hazard Analysis will be performed to identify all components and equipment that could result in a hazard or whose design does not satisfy contractual safety requirements. This will include government-furnished equipment, non-developmental items, and software. Areas to consider are performance, performance degradation, functional failures, timing errors, design errors or defects, or inadvertent functioning. The human will be considered a component within a subsystem, receiving both inputs and initiating outputs, during the conduct of this analysis.

The analysis will include a determination:

a. Of the modes of failure including reasonable human errors as well as single point and common mode failures, and the effects on safety when failures occur in subsystem components.

b. Of potential contribution of hardware and software (including that which is developed by other contractors/sources) events, faults, and occurrences (such as improper timing) on the safety of the subsystem.

c. That the safety design criteria in the hardware, software, and facilities specification(s) have been satisfied.

d. That the method of implementation of hardware, software, and facilities design requirements and corrective actions has not impaired or decreased the safety of the subsystem nor has it introduced any new hazards or risks.

e. Of the implementation of safety design requirements from top level specifications to detailed design specifications for the subsystem. The implementation of safety design requirements developed, as part of the PHA will be analyzed to ensure that it satisfies the intent of the requirements.

f. Of test plan and procedure recommendations to integrated safety testing into the hardware and software test programs.

g. Those system level hazards attributed to the subsystem are analyzed and that adequate control of the potential hazard is implemented in the design.

4.4.6.3 System Hazard Analysis

A system hazard analysis will be performed to identify hazards and assess the risk of the total system design, including software, and specifically of the subsystem interfaces. This analysis will include a review of subsystem interrelationships for:

a. Compliance with specified safety design criteria.

b. Possible independent, dependent, and simultaneous hazardous events including system failures; failures of safety devices; common cause failures and events; and system interactions that could create a hazard or result in an increase in mishap risk..

c. Degradation in the safety of a subsystem or the total system from normal operation of another subsystem.

d. Design changes that affect subsystems.

e. Effects of reasonable human errors.

f. Determination:

1 Of potential contribution of hardware and software (including that which is developed by other contractors/sources, or Commercial Off-The-Shelf hardware or software) events, faults and occurrences (such as improper timing) on safety of the system.

2 That the safety design criteria in the hardware, software, and facilities specification(s) have been satisfied.

3 That the method of implementation of the hardware, software, and facilities design requirements and corrective actions have not impaired or degraded the safety of the system nor have introduced any new hazards.

4.4.6.4 Operating and Support Hazard Analysis

An Operating and Support Hazard Analysis (O&SHA) will be performed to examine procedurally controlled activities. The O&SHA identifies and evaluates hazards resulting from the implementation of operations or tasks performed by persons, considering: the planned system configuration/state at each phase of activity; the facility interfaces; the planned environments (or ranges thereof); the supporting tools or other equipment, including software controlled automatic test equipment, specified for use; operational/task sequence, concurrent task effects and limitations; biotechnological factors, regulatory or contractually specified personnel safety and health requirements; and the potential for unplanned events including hazard introduced by human errors. The human will be considered an element of the total system, receiving both inputs and initiating outputs during the conduct of this analysis. The O&SHA must identify the safety requirements (or alternatives) needed to eliminate or control identified hazards, or to reduce the associated risk to a level which is acceptable under either regulatory or contractually specified criteria.

The analysis will identify:

a. Activities, which occur under hazardous conditions, their time periods, and the actions, required to minimize risk during these activities/time periods.

b. Changes needed in functional or design requirements for system hardware/software, facilities, tooling, or support/test equipment to eliminate or control hazards or reduce associated risks.

c. Requirements for safety devices and equipment, including personnel safety and life support equipment.

d. Warnings, cautions, and special emergency procedures (e.g., egress, rescue, escape, render safe, explosive ordnance disposal, back-out, etc.), including those necessitated by failure of a computer software-controlled operation to produce the expected and required safe result or indication.

e. Requirements for packaging, handling, storage, transportation, maintenance, and disposal of hazardous materials.

f. Requirements for safety training and personnel certification.

g. Effects of non-developmental hardware and software across the interface with other system components or subsystems.

h. Potentially hazardous system states under operator control.

4.4.6.5 Safety Assessment

All CoNNeCT Team members (i.e. NASA GRC, GDAIS, Harris Corp, JPL, and SpaceDev) will perform and document a safety assessment to identify all safety features of the hardware, software, and system design elements they are developing and to identify procedural, hardware and software related hazards that may be present in the system being acquired including specific procedural controls and precautions that should be followed.

The safety assessment will summarize:

a. The safety criteria and methodology used to classify and rank hazards, plus any assumptions on which the criteria or methodologies were based or derived.

b. The results of analyses and tests performed to identify hazards inherent in the system, including:

    1 Those hazards that still have a residual risk, and the actions that have been taken to reduce the associated risk, to a level contractually, specified as acceptable.

    2 Results of tests conducted to validate safety criteria, requirements, and analyses.

c. The results of the safety program efforts. Include a list of all significant hazards along with specific safety recommendations or precautions required to ensure safety of personnel, property, or the environment. Categorize the list of hazards as to whether or not they may be expected under normal or abnormal operating conditions.

d. Any hazardous materials generated by or used in the system, including:

    1 Identification of material type, quantity, and potential hazards.

    2 Safety precautions and procedures necessary during use, packaging, handling, storage, transportation, and disposal (e.g., explosive ordnance disposal). Include all explosives hazard classifications.

    3 A copy of the Material Safety Data Sheet (OSHA Form 174, or equivalent manufacturer's format).

e. Conclude with a signed statement that all identified hazards have been eliminated or their associated risks controlled to levels contractually specified as acceptable, and that the system is ready to test or operate or proceed to the next acquisition phase. In addition, the contractor will make recommendations applicable to hazards at the interface of his system with the other system(s) as contractually.

4.4.7 Action Taken on Identified Hazards

Action will be taken to eliminate identified hazards or reduce the associated risk to a previously defined level. Catastrophic, critical, and other hazards will not rely solely on warnings, cautions, or procedures/training for control of risk. If this is impossible or impractical, alternatives will be recommended.

4.4.7.1 Risk Impact

The risk impact will be assessed, as necessary, to discriminate between hazards having the same hazard risk index. This impact consists of the effect and cost of an identified risk in terms of mission capabilities, and social, economic, and political factors. (Example- Release of small amount of radioactive material may not cause direct physical damage or equipment damage, but can cause extreme damage socially and politically to a program.)

4.4.7.2 Residual Hazards

Those catastrophic and critical hazards which have not been eliminated or controlled will be identified to CoNNeCT Program Management and closed as accepted risks. Continuation of effort to eliminate or reduce such hazards will be accomplished throughout the program by maintaining awareness of new safety technology or devices being developed and their application. Justification for the closure of catastrophic or critical hazards as accepted risks will be documented.

4.4.7.3 Hazard Analysis Closure Criteria

A hazard analysis will be considered closed when approved by CoNNeCT Program Management and:

a. The hazard has been eliminated by a confirmed design change.

b. The hazard has been reduced to an acceptable level (controlled hazard), and this reduction has been verified by way of a successful completion of the required verification program, analytical study and/or training program.

c. The hazard has been assessed and the risk has been accepted by CoNNeCT Program Management.

4.4.8 Specific System Safety Requirements

The CoNNeCT Program System Safety Requirements are as follows:

4.4.8.1 NASA

NASA will be responsible for:

a. Oversight of System Safety effort
b. Review of all System Safety Analysis from contractors
c. Communicating Risk level to NASA management
d. Providing System Safety insight/management for CONNECT Program Management
e. Identifying any additional System Safety tasks required

4.4.8.2 Contractors

CoNNeCT contractors (i.e. GDAIS, Harris Corp, JPL, and SpaceDev) will be responsible for:

a. Develop a System Safety Plan and forward to the CoNNeCT Project
b. Communicating Subassembly Risk level to CoNNeCT management

4.5 Safety Surveillance

Safety will perform Inspections and Audits to verify conformance to program safety requirements. These surveillance measures are performed periodically throughout the program life cycle. The basis for these surveillance measures is recognized federal codes, NASA standards, and any existing local standards in existence.

4.5.1 Safety Inspection and Monitoring

Safety personnel observe project related activities, to include construction and hazardous tests/operations to insure adherence to safety principles and compliance with safety requirements and checklists. Safety Inspection/Walkthroughs will be conducted on a periodic basis. Construction Safety reviews will be conducted (with the same frequency). Additionally, construction contractors will submit a safety plan describing their program to insure a safety and healthful work environment

4.5.1.1 Safety Audits

Program Level Safety Audits will be conducted on a periodic basis. The scheduling of audits is usually in conjunction with other internal audits with the results documented and published by the primary audit group. A log is maintained for follow-up and closeout of safety findings. The frequency of audit is tailored to program requirements governed by the performance of the subcontractor or facility being audited.

4.5.1.2 Code Requirements Analysis and Surveys

A determination of code requirements is oftentimes necessary to lay a foundation for future compliance activity orchestration. The analysis provides an underpinning for code compliance audits to come. Initial evaluation of project plans indicates the need for compliance to applicable codes and consequently safety representative undertakes an analysis of all potentially code requirements. The analysis will determine the specific code sections which apply and the effect of these requirements on project tasks, schedules, and human resources planning. Results of this analysis will be documented and submitted to provide guidance in project planning and management functions. Code compliance surveys are developed when a working knowledge is gained of the applicable codes, and a schedule can be developed for performing the surveys. The Ht survey team in a report documents discrepancies between project activities and identified codes. Follow-up and closeout procedures for recommended corrective actions will be described in the survey plan.

4.5.1.3 Hazard Tracking

When hazards are identified which require additional action for reduction to an acceptable level, safety hazard tracking is performed. Hazard tracking applies to all identified hazards requiring resolution that are identified by hazard analysis, audits, or mishap investigation. Hazard Tracking will be accomplished through the Projects System Safety Engineer/Analyst. The objectives of hazard tracking are to:

a. Ensure that all unresolved hazards and safety concerns are appropriately tracked for resolution.

b. Provide a record of all identified hazards requiring additional action for resolution.

c. Provide management with visibility of open hazard status.

4.6 Procedure Review

Procedure review will be conducted to identify potential hazards inherent in the operation of the system/facility and to recommend risk reduction alternatives to the project manager. The review will incorporate all phases of the project to ensure that when hazardous activities occur, the following actions will be taken:

a. Active steps will be taken to minimize the risk associated with the hazardous operation.

b. Requirements for safety feature, devices, and equipment will be generated.

c. Warnings, cautions, and special procedures will be generated

4.7 Safety Training

Safety, in conjunction with program management will identify specific tasks on the CoNNeCT program that require training and certification. The identification of these tasks results from the Hazard Analysis Program and from program associated mishaps, i.e. the task must be significantly more difficult than routine tasks of the same or similar type, or failure to perform the task properly will result in a potential hazardous event. When such conditions are present, personnel assigned to the task must be specifically trained or skilled for the task, with the ability to demonstrate the necessary skills. Safety assures that:

a. The hazardous tasks are identified

b. Procedures restrict task performance to skilled personnel trained for the task

c. Only individuals with current certification status perform the task

d. Proper training is provided where requirement from a safety standpoint.

4.8 Operational Readiness inspection/Safety Review

The purpose of the ORI/SR is to ensure, for the CoNNeCT Program, that prior to the first operation adequate measures have been taken to ensure the safety of the system and its operator over the designed operating range of the system. As opposed to the programmatic reviews stated in Section 2.5 of this plan, this is a GRC operational review. Safety participation generally consists of evaluation of the facility redesign and / or presentation of the hazard analysis for the test hardware including results, conclusions, and resolution status of the hazards. The ORI/SRT will be orchestrated in accordance with the appropriate NASA Standards. The ORI/SR is intended to demonstrate that for a given system the following tasks have been completed, documented, and reviewed for safety concerns:

a. Any project related Safety/Reliability/Maintainability concerns are evaluated and the associated risks are accepted.

b. Operating procedures have been prepared and are complete and clear

c. Operating crews are properly trained and certified.

4.9 Test Readiness Review

Safety considerations will form a major part of the test planning during the test and evaluation phase of the CONNECT program. Existing safety analysis reports and other safety data will be provided and all safety requirements for both hardware and software testing will be identified. Test Plans are reviewed by System Safety to ensure recognition and control of potential hazards; and identify verification that will provide substantiation of the effectiveness of designs, safety devices, warnings, or procedures implemented to reduce hazards

4.10 Safe Alerts

Problems with parts, materials, or equipment which are mutual concern to NASA and associated contractors will be reported by using the appropriate NASA form. CoNNeCT Team members (i.e. NASA GRC, GDAIS, Harris Corp, and JPL) will develop a systematic approach to evaluate and respond to all NASA Alerts and to investigate, resolve, and document parts and materials problems.

4.11 Mishap Reporting and Investigation

A mishap is any unplanned occurrence, event, or sequence of events that results in one or more of the following: Injury and/or death to employees or visitors, and/or other loss of resources. CoNNeCT complies with the requirements of NPR 8621.1B, NASA Procedural Requirements for Mishap and Close Call Reporting, Investigating, and Recordkeeping, and GLPR 1720.1, GRC Center Mishap Preparedness and Contingency Plan. All mishaps will be reported and investigated in compliance with this chapter, NASA Standards, and specific processes called out in the Mishap Preparedness and Contingency Plan, contained within the CoNNeCT Project Plan, GRC-CONN-PLAN-0004. Reportable mishaps include fatalities, injuries/illnesses requiring more than first aid treatment; damage to or loss of NASA equipment/property equal to or greater than $2000.00; and mission failures where less than majority of stated objectives are met (dollar value is not a criterion); and close calls with high severity potential Mishap reporting and investigation consists of reporting CoNNeCT mishaps involving personnel, hardware or resources, providing prompt investigation and follow-up to minimize adverse effects, and providing adequate and timely corrective action. The appropriate NASA form will be filled out for all reportable mishaps. CoNNeCT Team members (i.e. NASA GRC, GDAIS, Harris Corp, and JPL) will use their own forms for documenting and transmitting to the Project Team. The initial notification via either the appropriate NASA form or the Contractor's form will be made within 24 hours of the mishap.

4.12 Lessons Learned Information System

NASA GRC, GDAIS, Harris Corp, JPL, and SpaceDev will contribute to the Lessons Learned Information System (LLIS). Safety lessons learned during the performance of management and technical functional activities will be developed and disseminated to program managers and throughout NASA Field Installations and Headquarters by cognizant personnel to improve understanding of hazards, prevent the occurrence of accidents, and suggest better ways of implementing system safety programs. In addition to contributing appropriate information to the LLIS, safety managers will include this information in program, procurement, and Field Installation newsletters to communicate more effectively with management. Lessons learned that indicate the need to revise source documents (e.g., Instructions, Handbooks, specifications, and standards) will be submitted directly to the preparer of the document. The LLIS will provide a library of lessons learned data for use by Program Managers, design engineers, and safety personnel.

4.13 Hazardous Material Control

An effective program that allows for safety and efficient use and control of hazardous or exotic substances will be developed. Policies and specific procedures will be developed for the proper use of such substances. Contractor will provide a Hazard Communication program for their personnel.

4.14 Specific Operational/Industrial Safety Requirements

The Specific Operational/Industrial Safety Requirements are as follows:

4.14.1 NASA

NASA will be responsible for:

a. Providing oversight of Operational/Industrial Safety effort

b. Reviewing of all Operating and Support Hazard Analysis performed System Safety Analysis from contractors

c. Communicating Risk level to NASA management

d. Providing Operational/Industrial Safety insight/management for CONNECT Program Management

e. Assuring participation in NASA Safety Alerts System

f. Assuring participation in IRIS

g. Assuring participation in LLIS

h. Assuring the conduct of HAZMAT program

i. Assuring the conduct of a Safety Training/Certification program

j. Reviewing Procedures

k. Assuring the conduct and contractor participation in Operational Readiness Inspection Activities (ORI)

l. Assuring the conduct and contractor participation in Test Readiness Review

m. Identifying any additional Operational/Industrial Safety tasks required

4.15 ISS Payload Safety Data Package Preparation

CoNNeCT will comply with system safety requirements imposed by SSP 57003-ELC and NSTS 1700.7 (Main Vol and ISS addendum).

4.16 HTV Payload Safety Data Package Preparation

In addition to complying with system safety requirements imposed by SSP 57003-ELC and NSTS 1700.7 (Main Vol and ISS addendum), CoNNeCT will comply with JAXA HTV Cargo Safety Requirements, JSX-2001015.

5.0 EEE AND MECHANICAL PARTS CONTROL

The purpose of this section is to provide requirements covering the selection and usage of electrical, electronic, and electromechanical (EEE) parts and assemblies and mechanical parts used in the CONNECT project. This plan applies to GRC in-house designed EEE parts and assemblies throughout all phases of design and manufacturing. Additionally, requirements herein apply to procurements of non-GRC designed and Commercial Off-The-Shelf (COTS) EEE parts and assemblies for evaluation and approval of selection as well as incoming inspection and acceptance.

5.1 Documents

This section lists specifications, models, standards, guidelines, handbooks, and other special publications. These documents have been grouped into two categories: applicable documents and reference documents.

5.1.1 Applicable Documents

In the event of a conflict between this document and other documents referenced herein, the requirements of this document will apply. Nothing in this document supersedes applicable laws and regulations unless a specific exemption has been obtained.

The documents in these paragraphs are applicable to the CONNECT Project to the extent specified herein.

Document Number	Document Title
EEE-INST-002	Instructions for EEE Parts Selection, Screening, Qualification, and Derating
NASA TM 102179	Selection of Wires and Circuit Protective Devices for STS Orbiter Vehicle Payload Electrical Circuits
NPD 8730.2	NASA Parts Policy
NPSL	*NASA Parts Selection List (NPSL)* via the NASA Electronic Parts and Packaging (NEPP) web site
SSP 30312	Electrical, Electronic, and Electromechanical (EEE) and Mechanical Parts Management and Implementation Plan for Space Station Program
SSP 30423	Space Station Approved Electrical, Electronic, and Electromechanical Parts List
SSP 30512	Space Station Ionizing Radiation Design Environment
SSP 57003	Attached Payload Interface Requirements Document
SSP 57003-ELC	Attached Payload Interface Requirements Document - EXpedite the PRocessing of Experiments to Space Station (EXPRESS) Logistics Carrier (ELC) Cargo Interface Requirements International Space Station Program

5.2 Reference Documents

The documents in this paragraph are provided only as reference material for background information and are not imposed as requirements.

Document Number	Document Title
GEIA-STD-0005-2	Standard for Mitigating the Effects of Tin Whiskers in Aerospace and High Performance Electronic Systems

5.3 Impacted Documents

The following documents, of the latest revision issued, are used in the execution of this plan to the extent specified herein.

Document Number	Document Title
GRC-CONN-PLAN-0007	CoNNeCT Risk Management Plan

5.4 EEE Parts Selection and Screening

EEE parts will be selected in order to meet project reliability and availability requirements over mission life. In addition, parts selection will be driven by safety requirements, performance requirements, worst case environmental conditions (e.g. radiation, thermal, high oxygen concentration), and maintenance allocations defined by the equipment specification. Grade 2 or higher parts are expected to meet these requirements and will be used if available. However, Grades 3 and 4 parts, including COTS parts and assemblies, are acceptable to meet budget and schedule considerations provided these safety, reliability, and environmental requirements are met. The selection and use of EEE parts for CONNECT will be based on the requirements of the NASA Parts Policy, NPD 8730.2.

5.4.1 EEE Parts Management and Control

The EEE parts management and control will fall under the jurisdiction of the Engineering Review Board (ERB). The ERB will meet on an as-needed basis to review all parts that do not meet the requirements of this plan. The following will require review and approval by the ERB:

- Selection of a part from a lower grade level than specified for safety critical circuits
- Use of parts outside de-rating limits as demonstrated in the derating stress analysis
- Procurement of a part from a source other than the manufacturer or the manufacturer's authorized distributor
- Selection of an electronic circuit board, assembly, or equipment not fabricated at GRC as required in Section 5.4.10
- Selection of parts with prohibited materials such as pure tin
- Any other deviation or waiver from the EEE parts requirements herein

5.4.2 EEE Parts Grades

Electrical, electronic, and electromechanical (EEE) parts are components such as capacitors, circuit breakers, connectors, crystals, discrete semiconductor devices, filters, fuses, hybrid, and monolithic microcircuits, inductors, photonic devices, relays, resistors, switches, transformers, wire and cable, etc. The risk associated with a given part is related to the grade level of the part, with the highest-grade parts (e.g. Level 1 or Class S) having the lowest risk. Higher grade parts will have higher reliability due to the manufacturer's quality assurance procedures and practices, including screening. Parts manufactured on a qualified manufacturing line will tend to be the most reliable. The following list ranks various parts grades according to their associated risk level from lowest risk to highest risk:

1 **Grade 1 parts** include Level 1 parts contained in the NASA Parts Selection List (NPSL) or EEE-INST-002 or Grade 1 parts contained in SSP 30423. These include Class S/Class V microcircuits, Class K hybrids, JANS semiconductor devices, established reliability passive parts with failure rate levels S and R, and parts procured to source control drawings (SCDs) that meet the Level 1/Grade 1 requirements of the NPSL or SSP 30312.

2 **Grade 2 parts** include Level 2 contained in the NPSL or EEE-INST-002 or Grade 2 parts contained in SSP 30423. These include Class B/Class Q microcircuits, Class H hybrids, JANTXV and JANJ semiconductor devices, established reliability passive parts with failure rate level P, and parts procured to SCDs that meet the Level 2/Grade 2 requirements of the NPSL or SSP 30312.

3 **Grade 3 parts** include Level 3 parts contained in EEE-INST-002 as well as all military specification parts that are not Grade 1 or Grade 2. They include Class M/Class N/Class T microcircuits; Class D/Class E hybrids; MIL-STD-883 compliant microcircuits; JANTX and JAN semiconductor devices; established reliability passive parts with failure rate levels M and L; parts procured to DSCC Standard Military Drawings but not military specifications; parts procured to SCDs with requirements equivalent to Grade 3 military parts, and vendor high reliability flow parts.

4 **Grade 4 parts** include all parts that are not Grade 1, Grade 2, or Grade 3. They include industrial and commercial parts. For such parts, risk must be assessed on a case-by-case basis. These parts are usually of higher risk than qualified military parts. Ceramic packages are preferred over plastic.

The NPSL has been developed to serve as a parts selection tool for NASA space flight programs. In general, parts listed in the NPSL have established procurement specifications, have available source(s) of supply, are capable of meeting a wide range of application needs, and have been assessed for quality, reliability, and risk. Parts listed in the NPSL will be used in space flight hardware when they meet the project's needs.

5.4.3 Safety Critical Circuits

Grade 1 parts will be used in safety critical circuits. If the required grade parts are not available, the next lower grade may be used with the review and approval of the ERB. Upgrade screening will be considered for lower grade parts in safety critical circuits. Safety critical EEE parts will be determined by the safety analysis and Failure Modes and Effects Analysis, FMEA.

5.4.4 Flight EEE Parts Screening

Individual parts will be screened as specified in the appropriate military specification or source control drawing. Screening of Grade 4 parts, including individual parts in COTS assemblies, at the piece part level is not required; however the parts must pass environmental testing at the assembly level as described in this section. When upgrade screening of Grades 3 and 4 is required by the ERB, microcircuits and semiconductor devices will receive a burn-in at a minimum of 100 hours at maximum rated temperature with a lot percent defective allowable (PDA) of no more than 10%, and passive components will receive twenty thermal cycles from –55 to 125 ^{o}C with a lot PDA of no more than 10%. This upgrade screening may be performed at the subassembly or assembly level.

Assemblies containing EEE parts will be subjected at the system, subsystem, box or board level to the following environmental tests as specified in SSP 57003-ELC and this Plan:

a. Thermal cycling (refer to Section 3.9)

b. Operational burn-in (refer to Section 3.10.1)

c. Vibration (refer to Section 3.6.8)

5.4.5 De-rating

5.4.5.1 De-rating of Parts

EEE parts will be de-rated in accordance with the requirements of SSP 30312 Appendix B. Wire de-rating criteria for loads at and downstream of the Attached Payload Port Interface will be per NASA TM 102179 as specified in SSP 57003. For equipment procured from outside vendors, other de-rating plans are acceptable with the approval of the CoNNeCT Project.

A parts stress/de-rating analysis will be performed to demonstrate that the EEE parts are not stressed beyond the maximum de-rated values. The ERB must approve the application of any parts that are stressed above their maximum de-rated limits. Evaluation of individual components used in COTS hardware will not be required.

5.4.5.2 De-rating Assemblies (Thermal Stress)

All assemblies will be de-rated for thermal stress in their intended operating environment. The de-rating will verify that the actual stresses are substantially less than the design maximum ratings of the assembly or its critical components. This verification activity will be started as soon as practical during the design and development phases of the project since thermal issues are a critical factor in the evolution of the design.

5.4.6 Radiation Hardness

EEE parts will be selected that are able to function in the ISS radiation environment as defined in SSP 30512. Preference should be given to devices that are inherently not susceptible or have been hardened to operate in a specified environment. Radiation hardened components will be selected when it has been determined by engineering that particular environmental conditions warrant it. The risk of failure due to radiation effects will be mitigated by one of the following:

- Selection of parts that are radiation hardened, or analysis showing that parts are sufficiently radiation tolerant for the expected environment based on available test data
- Testing of parts or assemblies to determine level of susceptibility. For single event effects susceptibility high energy proton testing is recommended.
- Software and procedures to deal with upsets and functional interrupts
- Design methods such as protection circuits, redundant circuits, current limiting, additional power de-rating to mitigate displacement damage, and additional voltage de-rating to mitigate single event effects.
- Additional shielding to mitigate total ionizing dose.

5.4.6.1 Total Ionizing Dose

When shielded by an equivalent aluminum thickness as given in the first column of the table below, all the CoNNeCT EEE parts must be able to withstand the TID given in the second column of the table below. (Ref. SSP 30512 for more detailed data).

Equivalent Aluminum Thickness, in	CoNNeCT 2 year mission TID, rads (Si)
0.01	61320.0
0.04	5712.0
0.1	1345.8
0.2	256.4
0.4	92.5
2	38.8
4	18.9

5.4.6.2 Displacement Damage

The majority of displacement damage in a low earth orbit is due to protons. The CoNNeCT EEE parts will be subjected to an equivalent displacement damage of about 6×10^{11} one MeV equivalent neutrons/cm^2. This damage is due to about 1.1×10^9 protons/cm^2. Since all EEE parts can withstand this level of displacement damage dose, no testing of CoNNeCT devices is anticipated solely for displacement damage.

5.4.6.3 Single Event Effects

Single event effects are classified as nondestructive (single event upsets, including bit errors and functional interrupts; single event transients; and nondestructive single event latch-ups) or destructive (single event burnouts, single event gate ruptures, and destructive single event latch-ups). Nondestructive single event effects may be mitigated through error detection and correction software or special procedures as an alternative to using parts that are hard for single event effects.

For the CoNNeCT EEE parts the single event effects are caused mostly by protons and to a lesser extent by cosmic rays. The linear energy transfer (LET) associated with the protons is about 36 MeV-cm^2/g, and that associated with the cosmic rays is about 36 MeV-cm^2/mg. Because the CoNNeCT mission cosmic ray encounters with this LET is less than 0.1/cm^2 of chip sensitive area, single event effects testing to this LET will only be required for EEE parts in safety critical circuits to a fluence of 10^6 ions/cm^2 without undergoing destructive single event effects. All other CoNNeCT EEE parts and modules that require SEE testing will be 200 MeV proton tested to a fluence of 10^{10} protons/cm^2 without undergoing destructive single event effects. Total pass/fail criteria for all radiation testing are given in Section 5.4.6.6.

5.4.6.4 Radiation Test Report

All radiation tests on EEE parts and assemblies will be documented in a CoNNeCT Radiation Test Report containing as a minimum:

- Type and energy of particles being used in the test
- Fluence of particles
- Identification of articles under test
- Pass/fail criteria
- Test results

All CoNNeCT Radiation Test Reports will be made a part of the Acceptance Data Package.

5.4.6.5 Radiation Design Margin (RDM)

Because EEE parts can exhibit variations in their response to TID and SEE, a design margin must be applied to test data. Such variations can be due to changes in wafer design or processing, different date lot codes, or radiation test variances. Also the variations of EEE parts in response to radiation environment are greater for COTS than for Grade 1 or 2 devices. The following radiation design margins will be applied to CoNNeCT devices:

Quality Grade	RDM
Grade 1 or 2	1.2
Grade 3 or COTS	1.5

5.4.6.6 Radiation Test Pass/Fail Criteria

At least three individual devices or one module/assembly will be subjected to a radiation test. The device will be considered acceptable for use on the CoNNeCT Program if its test satisfies the following pass/fail criteria.

Radiation Test	Pass/Fail Criteria
TID	Less than 10% shift in critical parameters such as zener, forward, or gate threshold voltage; gain; etc.
DDD	
SEE	No latch-up, gate rupture, burnout, stuck bits, etc. (non-recoverable events). Less than 10 upsets, incorrect executions, minor transients, functional interrupts, etc. (recoverable events).

5.4.7 Electric Motors

CoNNeCT will utilize non contact motors.

5.4.8 Corona and Arcing

CoNNeCT will not operate during ascent or descent. Requirements for corona and arcing in the external ISS environment are defined in SSP 57003-ELC.

5.4.9 Inspection Prior to Assembly

EEE parts will be inspected prior to their assembly into flight hardware to ensure they are free of any debris, defects, or other manufacturing faults that would interfere with their form, fit, and function. With respect to the CoNNeCT contractors (i.e. GDAIS, Harris, JPL, and SpaceDev) inspections by GRC may consist of one or all of the following: audits, document review, and/or surveillance.

5.4.10 Selection of Assemblies

Assemblies containing EEE parts, including circuit boards and self-contained modules, will be selected in order to meet project reliability and availability requirements over mission life. In addition, selection will be driven by safety requirements, performance requirements, worst case environmental conditions (e.g. radiation, thermal, high oxygen concentration), and maintenance allocations defined by the equipment specification. The following order of precedence will be used when selecting assemblies:

1 Heritage assemblies populated with similar EEE parts as defined in Section 3.8 or military qualified assemblies with space qualified heritage.

2 Heritage assemblies populated with non-similar EEE parts as defined in Section 3.8 or military qualified assemblies without space qualified heritage, subject to ERB review, and assembly level screening of Section 5.4.4 and proton testing for SEE as defined in Section 5.4.6.3.

3 Commercial Off-The-Shelf (COTS) assemblies. COTS assemblies are populated circuit boards or self contained modules that were designed and manufactured for commercial applications. As a minimum these assemblies will receive the assembly level screening of Section 5.4.4 and proton testing for SEE as defined in Section 5.4.6.3.

If selection of a COTS assembly is required because of functionality or part availability considerations, the part selection will be submitted along with justification to the ERB for approval. Refer to Section 7.4.1.1 for more details. With respect to the CoNNeCT contractors (i.e. GDAIS, Harris, JPL, and SpaceDev) in addition to the above ERB approval process, the selection of assemblies' criteria will be presented to the Project at the major design reviews.

5.5 Mechanical Parts Selection and Screening

CoNNeCT will select mechanical parts and components that meet the defined mission life and reliability requirements.

5.5.1 Mechanical Parts Control

Safety and Fracture critical components and fastener requirements will be tracked and verified through the hazard reports generated through the NSTS 1700.7B safety process.

5.5.2 Inspection Prior to Assembly

Mechanical parts will be inspected prior to their assembly into flight hardware to ensure they are free of any debris, defects, or other manufacturing faults that would interfere with their form, fit, and function. All mechanical parts that provide rotational, transitional, or other movements will be tested for full range of motion, and inspected for freedom of motion prior to assembly into flight hardware.

5.6 Parts Storage Control

A bonded storage control plan will be developed and implemented. CoNNeCT flight system hardware parts and assemblies will be stored in a bonded storage area.

Incoming inspection of parts and assemblies will include quantity verification, inspection for proper identification, verification that parts received are supplied with the required certification, and are free of external defects. Recording of manufacturer, part number, and lot date codes will be required. Plastic encapsulated parts are to be handled in such a way as to minimize moisture absorption and ionic contamination from direct contact with hands. Refer to Section 8.8.4 for further details.

5.7 Parts Age Control

The requirements of this section of the SARG are not applicable to CoNNeCT.

5.8 Parts Procurement

EEE parts will be procured from the manufacturer or the manufacturer's authorized distributor. Lists of authorized distributors can be found in the manufacturer's literature or web site or, for passive military parts, in the applicable Qualified Manufacturers List or Qualified Parts List.

Procurement of parts from unauthorized distributors or brokers introduces the risk of obtaining counterfeit or discrepant parts. If parts are not available from the manufacturer or a manufacturer's authorized distributor, they may be procured from other sources only with the approval of the ERB, which will verify that steps have been taken to mitigate the risk of purchasing counterfeit parts.

5.9 Parts Lists and Traceability

5.9.1 As-Designed Parts List

The as-designed parts list will be prepared before flight hardware is fabricated to identify the parts intended for use in the flight hardware. The list will contain as a minimum the following:

- Part number to which the part will be procured (This will be the military specification part number if it is a military part, a source/specification control drawing (SCD) part number if it is manufactured to the requirements of such a drawing, or the manufacturer's part number otherwise.)
- Generic part number if different from the procurement part number
- Part name or brief description
- Name or CAGE code of the preferred manufacturer
- Quantity
- Drawing number and name of the assembly, subassembly, or circuit board where the part is located

5.9.2 As-Built Parts List

The as-built parts list will be prepared to identify the parts actually used in fabricating the flight hardware. The list will have the same data requirements as the as-designed parts list, except that the name or CAGE code of the actual manufacturer of the parts will be included.

5.9.3 Traceability

Traceability by part number, manufacturer, and lot date code will be maintained for all parts assembled into flight or flight-like hardware. Procurement information/records and any Certificates of Compliance or Conformance from vendors will be kept on file.

5.10 Parts Risk Evaluation

CoNNeCT employs continuous risk management which includes assessment of usage of COTS parts and/or part application. Specific risks will be documented and worked per GRC-CONN-PLAN-007, Risk Management Plan.

5.11 Parts Subject to Metal Whisker Growth

The use of parts with metals subject to the formation of tin whiskers, including pure tin, zinc, and cadmium, is prohibited. This pertains to surface coating(s) used on the leads/lead frames and terminations of EEE parts used in high reliability electrical space flight parts, components and assemblies. This also includes, but is not limited to, the metal coating(s) applied to electrical bus-bars, heat-sinks, standoffs, printed circuit boards (PCBs), the internal surfaces of metal case hermetically sealed components, and the termination finishes of separable connectors such as bolted-on lug connectors including associated washers and threaded fasteners. Acceptable surface finishes on leads and lead frames are:

- Tin alloy with 3% Pb (Lead) minimum
- Ni/Pd (Nickel Palladium)
- Ni/Au (Nickel Gold)
- Ni/Pd/Au

Parts with prohibited materials may be used with the approval of the ERB only if their use cannot be avoided. Criteria for acceptance may include one or more of the following; however it should be noted that all except the first will reduce but not eliminate the risk of whiskers:

- Strip and re-plate with tin-lead alloy
- Mitigation through solder dipping, a suitable conformal coating, or reflow tin
- Verify use of matte tin, post plating annealing, or nickel underplating
- Risk analysis based on lead spacing

Guidance for the mitigation of the risk of metal whiskers can be found in the following references:

- *NASA Tin Whisker (and Other Metal Whisker) Homepage*
- GEIA-STD-0005-2

Standard notes will be utilized from the GRC Drafting Standards and Guidelines for drawings controlling parts or assemblies with the potential for prohibited coatings, and for identifying the use of solders that do not contain pure tin.

6.0 MATERIALS AND PROCESSES REQUIREMENTS

6.1 General Requirements

CoNNeCT will comply with SSP 57003-ELC and NSTS 1700.7B and the associated verification programs to meet the intent of this PA requirement. The objective of the materials and processes (M&P) activity is to ensure the materials selected for space flight hardware meet safety requirements per NPR 8715.3C. This is accomplished through the proper selection, application, processing, inspection, and testing of the chosen materials for the project subsystems and equipment.

Materials will be selected based upon functional design needs. Material selections will be evaluated according to ratings provided in NASA/Marshall Space Flight Center's Materials and Processes Technical Information System (MAPTIS). CoNNeCT will consider potential problem areas when selecting materials to anticipate and minimize materials problems during hardware development and operation. CoNNeCT will consider the problem areas of thermal cycling, stress corrosion cracking, galvanic corrosion, lubrication, useful life, flammability, toxicity, fracture toughness, and oxygen safety, as needed. Metallic materials will be evaluated for resistance to corrosion and stress corrosion cracking. Nonmetallic materials will be evaluated for flammability and off-gassing. The results of pertinent nondestructive testing, chemical composition, and mechanical and physical properties will be required for material that will be used in the fabrication of assemblies and subassemblies that are deemed fracture- and/or safety-critical. It is intended that closeout photographs will be taken of final sub/assemblies before they are covered or inaccessible during the build process.

CoNNeCT will compile a Material Identification Usage List (MIUL) during the design process and maintain its current to the as-built configuration. The MIUL will identify individual material applications specified in design drawings; their respective pertinent material ratings; and other pertinent material application features essential for evaluation of the material application. All materials not "A" rated per MSFC-HDBK-527 or MAPTIS will require an MUA (Materials Usage Agreement) and supporting documentation of the test results or analysis.

CoNNeCT will prepare the appropriate materials-related information, including a certification letter for the acceptance of flight payload materials that will support NASA/GRC's material certification of the experiment hardware. All manned space flight hardware certified from GRC will be per the M&P Inter Center Agreements (ICA) established with Marshall Space Flight Center (MSFC), Johnson Space Flight Center (JSC), and Goddard Space Flight Center (GSFC). An M&P certification letter is approved and issued by the GRC Certifying Official to document compliance with the ICA.

6.2 Controlling and Applicable Documents

Document Number	Document Title
ASTM Manual 36 (superseding NSS 1740.15)	Safe Use of Oxygen and Oxygen Systems: Guidelines for Oxygen Systems Design, Materials Selection, Operations, Storage, and Transportation
GLM-QE.8700.2	Space Assurance Requirements and Guidelines (SARG)
JSC 29353	Flammability Configuration Analysis for Spacecraft Applications (major revision and update of NSTS 22648)
JSC SP-R-0022A	Vacuum Stability Requirements of Polymeric Materials for Spacecraft Application
MSFC-HDBK-527	Materials Selection List for Space Hardware Systems
MSFC-SPEC-250	Protective Finishes for Space Vehicle Structures and Associated Flight Equipment, General Specification for
MSFC-STD-3029	Guidelines for the Selection of Metallic Materials for Stress Corrosion Cracking Resistance in Sodium Chloride Environments
NASA-STD-5003	Fracture Control Requirements for Payloads Using the Space Shuttle (Same as NHB 8071.1)
NASA-STD-6001	Flammability, Odor, Offgassing, and Compatibility Requirements and Test Procedures for Materials in Environments that Support Combustion (Formerly NHB 8060.1C)
NASA TM 104823	Guide for Oxygen Hazard Analyses on Components and Systems
NPR 8715.3C	NASA General Safety Program Requirements
NSTS 1700.7B	Safety Policy and Requirements for Payloads Using the Space Transportation System (STS)
SAE/ARP 5316	Storage of Elastomer Seals and Seal Assemblies Which Include an Elastomer Element Prior to Hardware Assembly
SSP 30233	Space Station Requirements for Materials and Processes
SSP 30558	Fracture Control Requirements for Space Station

6.3 Impacted Documents

The following documents, of the latest revision issued, are used in the execution of this plan to the extent specified herein.

Document Number	Document Title
GRC-CONN-BCD-0014	CoNNeCT Baseline Concept Description
GRC-CONN-DOC-0025	CoNNeCT Science and Technology Requirements Document
GRC-CONN-PLAN-0002	CoNNeCT Hardware Configuration Management Plan
GRC-CONN-PLAN-0007	CoNNeCT Risk Management Plan
GRC-CONN-SRD-0013	CoNNeCT System Requirements Document

6.4 Specific Requirements

CoNNeCT roles and responsibilities are defined in the Product Assurance Plan. Drawing review process incorporates a materials review check. The Engineering Change Orders (ECO) process incorporates a materials review check. Carrier and safety M&P processes are levied by SSP 57003-ELC and NSTS 1700.7B. This document addresses the M&P requirements needed to assure all mission success and safety related areas are addressed. This will include but is not limited to:

1 Organizational roles and responsibilities for meeting the M&P PAP requirements will be written and implemented through the Configuration Management (CM) Plan (Ref. Section 8.5). All M&P documentation is submitted to the Project Manager for approval as a deliverable item and included in the Acceptance Data Package (ADP). It is recognized that approval of MUAs is required from the Quality Management Office outlined in GRC-W0510.041. Generally the Project Manager directs the project to work interactively with Quality Management Office representatives on a consulting basis from the beginning of a project to prepare the MIUL and MUAs.

2 The CM Plan provides for a drawing review approval process that assures the engineer designated as having responsibility for materials has reviewed all materials selected.

3 The CM plan provides for review and approval of ECO for materials issues by a qualified engineer as part of the drawing release process. The engineer designated as having responsibility for materials provides input to the Lead Mechanical engineer and/or the Project Manager regarding the appropriateness of the as-designed materials based on this review process.

4 Specific M&P requirements will be based on the applicable payload carrier or location.

5 The engineer designated as having responsibility for materials will be involved with any materials testing.

6 A Fracture Control Plan will meet NASA-STD-5003. Additionally, all International Space Station elements and payloads will meet SSP 30558.

7 Nondestructive Inspection used will include accept/reject criteria.

8 Closeout photographs will be taken during assembly of subsystems to show materials and configurations hidden after assembly.

6.4.1 Reporting Requirements for M&P Assessment and Verification

CoNNeCT Lead engineers are responsible for ensuring materials are compatible with project usage. All project drawings will be reviewed by the CoNNeCT Engineering Control Board for materials usage and cross reference to Materials and Process Technical Information System (MAPTIS) ratings. The CoNNeCT engineer designated as having responsibility for materials will assess metallic materials for corrosion resistance (CORR), stress corrosion cracking (SCC) and Thermal vacuum stability (TVS).

6.4.1.1 Corrosion (Internal and External Environments)

All project drawings will be reviewed by the CoNNeCT Engineering Control Board for proper materials finish call outs. MAPTIS - A rated materials will not require further finishes unless required by project need. Materials not rated "A" in MAPTIS will have the required protection specified by the CoNNeCT project and verified by the CoNNeCT quality assurance lead.

For materials exposed to environments other than salt water, seacoast, or mild industrial environments, specific evaluations will be conducted and verified to determine the compatibility of materials utilized. The M&P representative will be consulted regarding the specific evaluation(s) required.

6.4.1.2 Stress Corrosion (Internal and External Environments)

All safety and fracture critical parts will be review for proper use of stress corrosion resistant materials. All project flight drawings will be reviewed by the CoNNeCT Engineering Control Board for proper materials call outs. The CoNNeCT project will use only metallic materials which meet the requirements that prevent stress corrosion cracking per MSFC-STD-3029 Guidelines for the Selection of Metallic Materials for Stress Corrosion Cracking Resistance in Sodium Chloride Environments.

Any alloy or weldment that is utilized and not listed in Table I of MSFC-STD-3029 will require the completion of a Stress Corrosion Evaluation Form (Appendix C of MSFC-STD-3029), which is then attached to a MUA, and sent to the GRC M&P engineer for approval prior to use.

Non-"A" rated materials used in safety critical or fracture critical applications will be referenced in the structural failure hazard report.

6.4.1.3 Outgassing (applicable to Exterior Areas of Vehicle Only)

These requirements are Applicable to CoNNeCT. All materials used in non-habitable areas will meet the outgassing requirements of JSC SP-R-0022A that establishes the outgassing requirements and test guidelines for materials used in the space thermal vacuum environment. Organic materials used in vacuum applications will exhibit a Total Mass Loss (TML) of less than 1% and a Collected Volatile Condensable Material (CVCM) of less than 0.1%. An MUA will be submitted to the M&P engineer for all materials that do not meet the TML and CVCM requirements. Commercial off-the-shelf items (black boxes) that incorporate materials not specifically identified on a materials list or drawing will be vacuum baked per test conditions listed in JSC SP-R-0022A. Sealed pressurized containers are exempt from testing.

6.4.1.4 Flammability (applicable to All Vehicle Areas)

CoNNeCT will comply with system safety requirements, imposed by SSP 57003-ELC and NSTS 1700.7B. Electrical wire insulation will be made of Teflon-based materials and meet the requirements of JSC 29353. The M&P representative will be contacted regarding utilization of any wires or cables that do not meet of these specifications.

Electrical wiring cable ties will be made from ECTFE (Halar) material to provide an efficient means of hazard reduction. This is in preference to expending resources on verifying the spacing of flammable cable tie materials allowed by JSC 29353.

6.4.1.5 Fluid Compatibility (applicable to All Vehicle Areas)

CoNNeCT has no hazardous fluids as defined by NSTS 1700.7B, para 209.1. Therefore the requirements in this section of the SARG are not applicable.

6.4.1.6 Materials Offgassing in Habitable Areas

The requirements in this section of the SARG are not applicable to CoNNeCT.

6.4.1.7 Fungus

The requirements in this section of the SARG are not applicable to CoNNeCT.

6.4.1.8 Atomic Oxygen

The requirements in this section are applicable. When evaluations of atomic oxygen erosion rates are needed, ASTM E2089 "Standard Practices for Ground Laboratory Atomic Oxygen Interaction Evaluation of Materials for Space Applications" is the current industry-testing standard that should be used.

7.0 RELIABILITY, AVAILABILITY AND MAINTAINABILITY

7.1 General Requirements

CoNNeCT will not prepare a formal R&M program due to the fast-track nature of the payload. Reliability analyses will be performed concurrently with design to indicate areas of risk, promote design improvements, and increase system reliability; however, no formal documents will be required.

Reliability risks will be identified by the project team in conjunction with the Project Manager. All decisions for acceptance of reliability risk will be the responsibility of the Project Manager.

All non-conformances that occur during build-up or testing of flight hardware will be reported and tracked to completion (refer to Section 8).

7.2 Controlling and Applicable Documents

Document Number	Document Title
GLM-QE.8700.2	Space Assurance Requirements and Guidelines (SARG)
SSP 30234	Failure Modes and Effects Analysis and Critical Items List Requirements for Space Station
SSP 30309	Safety Analysis and Risk Assessment Requirements
SSP 57000	Pressurized Payload Hardware Interface Requirements Document

7.3 Impacted Documents

The following documents, of the latest revision issued, are used in the execution of this plan to the extent specified herein.

Document Number	Document Title
GRC-CONN-BCD-0014	CoNNeCT Baseline Concept Description
GRC-CONN-DOC-0025	CoNNeCT Science and Technology Requirements Document
GRC-CONN-PLAN-0001	CoNNeCT Software Configuration Management Plan
GRC-CONN-PLAN-0002	CoNNeCT Configuration Management Plan
GRC-CONN-PLAN-0007	CoNNeCT Risk Management Plan
GRC-CONN-SRD-0013	CoNNeCT System Requirements Document

7.4 Reliability Requirements

CoNNeCT is conducting R&M analysis to quantify expected reliability, but a formal program with R&M allocations and flow-downs will not occur in view of the aggressive schedule & acceptable risk level of the payload. Therefore, although this section is applicable, CoNNeCT will not comply with all of the SARG requirements.

7.4.1 Reliability Allocation and Prediction Analysis

CoNNeCT will not prepare a formal R&M program plan in view of the fast-track status and acceptable risk level of the payload. The system level reliability goal, as defined in CONNECT-MEMO-0001, "CONNECT Project Approach to EEE Parts", is 0.9 for the 2 year CoNNeCT mission duration. Processes as outlined in GRC work instruction GLWI-QE-8720.3 will be followed to strive towards that goal.

When using a commercial off-the-shelf (COTS) component, CoNNeCT will attempt to procure the optimal reliability component. The selection will be based on the following:

1 Acceptable vendor screening program to the project requirements (burn-in, thermal cycle and vibration levels)

2 Acceptable vendor quality control program

3 A Mean-Time Between Failure (MTBF) which supports the system reliability allocation

4 Radiation hardness and minimized EMI susceptibility, as determined by the PM and the EEE Parts Review Board.

In supporting the parts data acquisition requirements of Section 5.5.1, Section 5.5.6, and Section 5.5.11 for COTS components, CoNNeCT will request MTBF reliability data. If MTBF is not available, MTBF from a similar part/process may be used or standard values from MIL-HDBK-217 and other available sources such as NPRD 95 and IEEE STD 500. In the unlikely event that a bill of materials for the component is supplied by the vendor, the project can perform a reliability analysis to estimate the component MTBF. Designers will replace high failure rate commercial parts with higher quality space grade or industrial parts if necessary to meet project and mission requirements.

7.4.1.1 Commercial Off-The-Shelf Components

The impact on safety and reliability of lower grade COTS assemblies must be considered before they are approved for flight use. When procuring COTS assemblies the following are typical attributes that the EEE Parts Review Board will request:

1 Procure the highest reliability unit available. Check on the availability of military or high reliability grades or ruggedized units, increased derating of parts and/or increased derating of operating temperatures.

2 Radiation hardness* and minimized EMI susceptibility

3 Request additional testing or screening options from the vendor (burn-in, thermal cycle, and vibration levels).

4 Obtain reliability data such as Mean Time Between Failures (MTBF).

5 Obtain parts and materials lists for reliability analysis and materials certification (i.e., vendor's quality control data).

6 Obtain all available supporting documentation such as circuit diagrams.

* Radiation hardness means the ability to perform the intended functions when exposed to the radiation levels in the space environment for the mission.

7.4.2 Burn-In Periods

CoNNeCT will conduct burn-in testing for all flight hardware. Total burn-in period will be 200 hours for all flight system hardware. One hundred hours of the 200 will be at the subsystem/component level, and another one hundred hours at the system level.

7.4.3 Failure Modes and Effects Analysis and Critical Items List

CoNNeCT will prepare an assessment of hardware elements determined to have higher risk of failure. The processes as outlined in GRC work instruction GLWI-QE-8720.2 will be followed. The assessment will focus on analysis of the hardware elements to ensure that hardware is used in a manner well within its design limitations; a Critical Items List (CIL) will be prepared.

7.4.4 Single Point Failure List

As a fast track payload, CoNNeCT accepts the risk of single point failures in all areas except Safety Critical. Thus, the CoNNeCT project will provide a list of single point failures that would lead to loss of life and/or the payload.

7.4.5 Failure Detection

CoNNeCT will provide a description of the automatic or manual failure detection, isolation and recovery methods at CDR (Critical Design Review).

7.4.6 Fault Tree Analysis

The processes as outlined in GRC work instruction GLWI-QE-8720.2 on Fault Tree Analysis will be followed.

7.4.7 Parts Stress Analysis

If indicated, parts stress analysis will be performed for parts at the most stressful (conservative) values that result from specified performance and environmental requirements (e.g. temperature, voltage, vibration, and shock) on the assembly or component.

7.4.7.1 Thermographic Mapping

CoNNeCT will conduct infrared thermographic mapping of safety critical components (per CIL). The results will be provided at CDR. It is at the project's discretion as to how to determine the worst-case operating environment in order to derate non-safety critical components found in the CIL.

7.4.8 Worst Case Analysis

This section of the SARG is applicable to CoNNeCT. A WCA (Worst Case Analysis) will be completed and documented for circuits and mechanical systems affecting system performance (Mission or Science parameters that are subject to variations could degrade performance) to verify that sufficient operating margin exists for performance requirements under the proposed operating conditions (electrical, thermal, shock, vibration, vacuum, aging, and radiation).

7.4.9 Trend Analysis

The CoNNeCT Team will fully utilize data from testing and information during the test program to assess flight system performance and identify problems. CoNNeCT will evaluate performance, PRACA or CPARS data to detect deteriorating trends in order to take corrective action and avoid mission failure.

7.4.10 Performance Trending

During the assembly process those components that require performance monitoring will be identified. Performance measurements for the selected components will be monitored and graphically displayed to detect trends. When a monitored parameter indicates out of specification performance, the project will take corrective action to avoid failure during the mission.

7.4.11 Problem Trending

This trend analysis includes the tracking and categorization of problems over time in order to identify trends in failures or non-conformances. These problems may be at any indenture level of the system.

7.5 Availability Requirements

7.5.1 Availability Allocation and Prediction

As a fast track payload, CoNNeCT will not perform an availability allocation and prediction analysis. Furthermore, CoNNeCT will have no provisions for maintenance or repair, so the definition of availability is not applicable to CoNNeCT. Thus CoNNeCT will not comply with all of the SARG requirements.

7.5.2 Sparing and Logistics Planning

CoNNeCT will have no provisions for maintenance or repair, so sparing and logistics are not applicable to CoNNeCT.

7.6 Maintainability Requirements

CoNNeCT will have no provisions for maintenance or repair, so the definition of maintainability is not applicable to CoNNeCT.

7.6.1 Maintainability Allocation and Prediction Analysis

As a fast track payload, CoNNeCT will not perform a maintainability allocation and prediction analysis. The requirements in this section of the SARG are not applicable.

7.6.2 Limited-Life Items

CoNNeCT will identify flight hardware elements with limited life and maintain records of flight hardware element usage. The processes as outlined in GRC work instruction GLWI-QE-8720.5 will be followed. Limited-life items are divided into two categories, limited operating life and limited storage life. This section constitutes the CoNNeCT plan for controlling both types of limited life items. Limited operating life items will be identified and listed. Operational life will be determined either from manufacturer's data or from engineering life testing.

Limited operating life items are hardware items whose expected operational life is less than 125% of the total required operating time. (The additional 25% of the required operating time has been added to provide some margin since there is inherent uncertainty in operating life estimates.)

Records will be maintained that allow evaluation of the cumulative stress (time and/or number of cycles). Records will indicate the date and time when the useful life period begins for the limited-operating life items, and indicate the accrued operating time and operating conditions. The use of an item, who's expected life is less than its required mission design-life, must be approved by the Project Manager.

Limited storage life items have a specified storage time limit (shelf-life), which is less its planned storage time. Examples of limited storage-life items are solid chemicals, chemical mixtures and/or solutions, solvents, lubricants, epoxies, or even hardware devices. The project controls limited storage-life items by the expiration date indicated on any limited storage-life item. Whether dated by the manufacturer or by the project at receiving/creation, any expiration date is checked before use and recorded in the process plan or log book. For safety critical operations, this is validated by a Quality Assurance (QA) sign-off.

7.6.3 Maintainability Task Analysis

CoNNeCT will have no provisions for maintenance or repair, so the definition of maintainability is not applicable to CoNNeCT. The requirements in this section of the SARG are not applicable to CoNNeCT.

7.6.4 Provisions for Failure Detection

The premise that CoNNeCT has no safety critical failure modes will be confirmed in the System Safety and the Reliability Analyzes. If so, then this section in the SARG will not be applicable, and CoNNeCT will not comply with the SARG requirements. If CoNNeCT does have safety critical failure modes, then the following must be provided:

a. Capability to detect and isolate failures that could manifest a catastrophic or critical hazard

b. Confirmation of a restored function

8.0 QUALITY ASSURANCE REQUIREMENTS

This section defines the CoNNeCT Project QA approach to implement and assure that quality requirements are met through processes, procedures, and inspection. The CoNNeCT QA Project will meet the intent of the following documents: NPD 1280.1, NPD 8070.6 and for ISS elements and payloads, SSP 41173, Space Station Quality Assurance Requirements.

8.1 General Requirements

These Quality Assurance requirements are applicable to all CoNNeCT suppliers, NASA Field Centers, prime contractors, subcontractors, and any organization that provides, processes, or has custody of CoNNeCT hardware for use on the International Space Station (ISS).

These quality requirements are applicable to all ISS hardware and software designated as flight components, subsystems, systems, and/or equipment including Flight Support Equipment (FSE). These quality requirements are also applicable to Ground Support Equipment (GSE) that: 1) either physically or functionally interfaces with flight hardware/software; 2) could by its malfunction cause loss of life or loss/damage to flight, GSE, or facilities hardware/software; and/or 3) generated data used in determining flight worthiness/certification and acceptance of deliverable items.

If the CoNNeCT Ground Integration Unit (GIU) does not satisfy the above definitions of FSE, GSE, or data used in flight worthiness and acceptance, these QA requirements may be applied as a precursor check of the Flight Model (FM) QA requirements.

CoNNeCT Project will have a Quality System which is compliant with SSP 41173, Space Station Quality Assurance Requirements, or American National Standards Institute/American Society for Quality Control (ANSI/ASQC) Q9001-1994, American National Standard Quality Systems Model for Quality Assurance in Design, Development, Production, Installation and Servicing, (or its corresponding International Standard (registration not required). It will be the responsibility of CoNNeCT Project to allocate applicable requirements based on the payload (or HW) classification.

8.2 Controlling and Applicable Documents

The following are the Applicable and Reference Documents that relate to this plan. Applicable Documents are those that directly tie into this plan and the Reference Documents are those that can provide additional background or reference information to help clarify the plan.

Document Number	Document Title
ANSI/ESD S20.20	ESD Association Standard for the Development of an Electrostatic Discharge Control Program
ASME Y14.5	Dimensioning and Tolerancing
GLM-QE.8700.2	Space Assurance Requirements and Guidelines (SARG)
GLPR 1270.1	Corrective and Preventative Action
NASA-STD-8739.7	Electrostatic Discharge Control
NPD 8730.1	Metrology and Calibration
NPR 8735.1	Procedures For Exchanging Parts, Materials, and Safety Problem Data Utilizing the Government-Industry Data Exchange Program and NASA Advisories
NPR 8735.2	Management of Government Safety and Mission Assurance Functions for NASA Contracts
SAE/ARP 5316	Storage of Elastomer Seals and Seal Assemblies Which Include an Elastomer Element Prior to Hardware Assembly
SSP 41170	ISS Configuration Management (CM) Requirements
SSP 41173	Space Station Quality Assurance Requirements
SSP 52054	ISS Program Payloads Certification of Flight Readiness Implementation Plan, Generic
SSP 57000	Pressurized Payloads Interface Requirements Document

8.3 Reference Documents

The documents in this paragraph are provided only as reference material for background information and are not imposed as requirements.

Document Number	Document Title
SSP-30695	Acceptance Data Package Requirements Specification

8.4 Impacted Documents

The following documents, of the latest revision issued, are used in the execution of this plan to the extent specified herein.

Document Number	Document Title
GRC-CONN-BCD-0014	CoNNeCT Baseline Concept Description
GRC-CONN-DOC-0025	CoNNeCT Science and Technology Requirements Document
GRC-CONN-PLAN-0001	CoNNeCT Software Configuration Management Plan
GRC-CONN-PLAN-0002	CoNNeCT Configuration Management Plan
GRC-CONN-PLAN-0007	CoNNeCT Risk Management Plan
GRC-CONN-SRD-0013	CoNNeCT System Requirements Document

8.5 Quality Assurance Organization

The CoNNeCT PM is responsible for implementation of the quality program. The CoNNeCT Project will delegate authority for managing the quality assurance program to an organization not responsible for the cost or schedule of performing NASA work and who is responsible for directing and managing the Quality Assurance Program. The CoNNeCT Project will make functional assignments to implement each element of the quality program. Personnel performing quality program functions will have sufficient, well-defined responsibilities and the organizational freedom to identify and assess problems, and to recommend, track and review solutions. The effectiveness of quality program functions and the ability of assigned personnel to objectively assess, document and report findings will be maintained during all phases of the project and will not be reduced by other considerations, such as the influence of engineering changes, rework, or rescheduling.

Government quality assurance organizations are to ensure that contractors implement quality system requirements and deliver conforming product in accordance with Federal Acquisition Regulations (FAR), the NASA FAR Supplement, and NPR 8735.2, Management of Government Safety and Mission Assurance Functions for NASA Contracts, Chapters 1 and 2.

8.6 Configuration Management and Verification

CoNNeCT has prepared and implemented Configuration Management Plans, GRC-CONN-PLN-0001 and GRC-CONN-PLN-0002. All documents, drawings and revisions, which define and verify the system, will be kept under configuration control. A Configuration Management Plan will specify responsibilities and, as a minimum, address the following:

a. Identification of configuration items, which will be base-lined and controlled, including specifications and procedures.

b. Formation of a CoNNeCT Control Board (CCB) to review base lined items, and to review changes to controlled items.

c. The completion of an as-built parts list, which will document the final versions of the components contained in the flight system, along with verification that all testing and changes have been properly completed in both documentation and the system.

d. Records of all changes made to the system once the configuration controlled items have been base-lined.

The system configuration items will be placed under configuration control and base-lined at the earliest possible time. This will occur at the time an assembly is considered to be in a flight-like configuration.

CoNNeCT Project configuration control personnel will assure that documents are kept current, and when changes are made, they are made promptly and include changes to all associated documentation and the system. Configuration control personnel will assure that only the latest drawings, including all changes, are used for the fabrication, assembly, testing and inspection of all components. Inspection records will indicate the revision level with which the item has been fabricated, inspected and/or tested. Evidence will be provided specifying compliance with the as-built documentation as a basis for acceptance.

8.7 Identification and Traceability

All CoNNeCT flight hardware will be marked with unique part numbers and serial numbers. The CoNNeCT Project will have a system in place to ensure identification of all flight materials/products and spares, whether separately produced discrete items or material produced in batches, to ensure traceability to the original source/manufacturer and to determine verification status. This system will be maintained throughout the life of the project, including material/product receipt, all stages of production, delivery, installation, etc. Commercial Off-The-Shelf (COTS) hardware that cannot provide material certifications, traceable parts, or workmanship processes will be evaluated for further testing and the results will be used to supplement the acceptance testing for that hardware.

A documented identification and data retrieval system will be developed, implemented, and maintained for: rapid retrieval of information to facilitate ground and on-orbit anomaly resolution, experiment phase, preventive maintenance and logistical planning. CoNNeCT Project will use identification numbers (e.g., part numbers, lot numbers, and serial numbers, etc.), related to the engineering design, as required by engineering documentation and SSP 41170. This system will provide traceability to the related manufacturer's lot or batch number and/or date code for parts and materials. Controls will be included to assure serial numbers are assigned in a consecutive manner, and gaps in serial numbers are not permitted.

8.8 Procurement Requirements

CoNNeCT will utilize process plans as appropriate for all flight hardware elements.

8.8.1 Government Source Inspection

All purchase orders will include a statement, which assures that the Government has the right to inspect any or all of the work included in the purchase order. When a NASA representative elects to perform inspection at a procurement source, the following statement will be included in the procurement document: "Work on this order is subject to inspection and test by NASA or its designated representatives at any time or place. The NASA QA representative who has been delegated the QA functions on this procurement will be notified immediately upon receipt of this order. NASA or its designated representatives will also be notified 48 hours in advance of the time articles or materials are ready for inspection or test." Procurements, which do not require GSI, will include the following statement: "The Government reserves the right to inspect the work included in this order at the supplier's plant."

8.8.2 Receiving Inspection

A receiving inspection system will be developed and implemented which ensures purchased components comply with procurement documents. The receiving inspection system will verify that:

a. Documentation is reviewed to verify that components comply with purchase requirements.

b. Inspections and/or tests are performed in accordance with written procedures for selected components to verify performance.

c. Identification of acceptance or nonconformance status of components and records is maintained. All nonconforming items will be segregated for disposition.

d. Receiving inspection and test records are maintained.

e. Protective measures for cleanliness, electrostatic discharge, handling, packaging, and shipping are implemented.

8.9 Control of Fabrication Activities

CoNNeCT will utilize process plans as appropriate for all flight hardware elements. A Fabrication and Assembly Flow Process will be developed and implemented that covers operations from start of fabrication to end item completion. Inspection and test points and all special processes to be used will be included. Controls will ensure that only conforming components are released and used during fabrication.

8.9.1 Fabrication and Inspection Requirements

CoNNeCT procurement process approval cycle ensures that only properly released drawings are used in the fabrication of flight hardware. Suitable fabrication and inspection requirements will be used based on the complexity and expected environment of the project. All drawings will meet the requirements of ASME Y14.5. Only released prints, approved in accordance with the configuration control plan, will be used for the manufacture of the qualification and flight hardware.

QA will support fabrication operations, including assembly and test, to verify that critical characteristics of the design are identified and their conformance to engineering specifications are maintained in all articles produced. Critical characteristics will be selected by quality, manufacturing, and engineering personnel and will be derived from drawings, specifications, Failure Modes and Effects Analysis/Critical Items List (FMEA/CIL), Hazard Analysis, etc. Critical characteristics will be designated as inspection points that must be verified by QA personnel. Identification of these characteristics, definition of methods, and sequence of operation will be consistent with the criteria, methods, and plans developed during product development and reviewed at design reviews.

8.9.1.1 Control of Assembly, Inspection, and Test Procedures

CoNNeCT Project will plan and conduct an assembly, inspection and test program, which controls fabrication, assembly and testing of flight systems, and demonstrates that drawing and specification requirements are met. The assembly, inspection, and test plans will be approved prior to work being performed on flight articles. Inspections and performance tests will be performed on components and subassemblies when they cannot be fully inspected or tested in the next level of assembly. Each inspection and test will be traceable to the person performing the task. CoNNeCT Project and/or developer QA organization will verify that all manufacturing documentation, processes, procedures, and specifications are available prior to the build.

8.9.1.2 Assembly, Inspection, and Test (AIT) Procedures

All work and inspections performed on flight hardware/software will be conducted with approved procedures. Proper planning will be done to ensure orderly and timely inspections are performed at all levels of assembly and tests.

AIT procedures will be written for all flight system operations. The degree of detail in the procedures will be commensurate with the complexity of the operation. Drawings may stand alone as assembly procedures as appropriate. Any deviations from these procedures must be properly approved and recorded.

Procedures will include, as applicable, revision level of the document, the nomenclature of the article, instructions for qualified personnel to perform the work, characteristics to be inspected or tested, accept/reject criteria, and special considerations regarding handling, measuring, testing, equipment, standards, safety, and environment. CoNNeCT Project and or developer's QA organization will verify that proper inspection and testing criteria are included in the procedures during the QA review of processes, procedures, and specifications. Prior to any testing or inspection QA will assure that all applicable procedures are available, test/inspection equipment is calibrated and properly configured, and the facility is properly configured.

Procedures will require the recording of equipment identification and calibration due dates for all calibrated instruments used. During testing QA assures the testing/inspection is performed with the approved procedures. After testing/inspection, QA assures the results and data are complete and traceable to the appropriate test article. The logbooks of this activity must be kept in sufficient detail to verify and evaluate the status of all articles and materials tested/inspected.

8.9.2 Training for Personnel

The CoNNeCT PM is responsible for implementation of quality training program. A Training plan will be developed and appropriate records will be maintained for all training conducted with the team. CoNNeCT Project will establish and maintain documented procedures for identifying training needs and provide for the training of all personnel performing activities affecting quality. Personnel performing specific assigned tasks will be qualified based on appropriate education, training, and/or experience, as required.

8.9.3 Evaluation and Control of Process Specifications and Procedures

The requirements in this section are Applicable to CoNNeCT. QA will participate in product and process development activities to ensure that fabrication quality requirements are defined in concert with product requirements. QA will assure criteria for material, and process controls are developed consistent with these requirements. Special processes, with which the quality cannot be ensured by inspection alone, will be given special attention as to the controls and methods of verifying the adequacy of the process. The developer's QA organization will assure all processes are adequate for the stated purpose. Product and process activities include, but are not limited to development of mockups, engineering models, qualification/protoflight units, development test units, and development of processes and fabrication methods. QA will develop methods and plans for verification of these requirements with particular emphasis on early identification of critical characteristics.

The following list of special process and inspection documents are requirements for all NASA GRC flight hardware: NASA-STD-8739.1, NASA-STD-8739.2, NASA-STD-8739.3, NASA-STD-8739.4, NASA-STD-8739.5, IPC-2221, and IPC-2222. Other requirements will be imposed by the project as deemed necessary.

8.9.4 Bonded Storage

CoNNeCT will use bonded storage for all flight system hardware. A bonded storage control plan will be developed and implemented. CoNNeCT Project will maintain a controlled bonded storage area, which is capable of storing flight material, parts and assemblies. The level and type of environmental control will be defined based on the specifics of the flight material, parts, and assemblies being stored. The environmental control will minimally protect the flight items from excessive temperatures and humidity, and from contamination. Electrostatic discharge (ESD) control will be implemented for ESD sensitive parts as defined in Section 3.7.

The area will have controlled access applicable to the type of system being held, and will have a documentation system adequate to identify and track the flow of parts in and out of bonded storage. Bonded storage will be capable of segregating materials, assemblies, qualified components, accepted systems, limited-life items, and nonconforming components. Traceability by part number, manufacturer, serial numbers, and lot date code will be maintained for parts and components in controlled storage.

8.9.5 Records of Inspection and Tests

The requirements in this section of the SARG are Applicable to CoNNeCT. Records and data of all inspections and tests performed will be prepared and maintained in sufficient detail to verify and evaluate the status of articles and materials. The record retrieval system will be organized so that these records and the related articles and materials may be rapidly located and retrieved for project use and to support ground and on-orbit assembly and operations.

Records will be maintained of all inspections and tests as evidence that all operations have been performed, objectives have been met, and the end-item is fully verified. Logbooks will be kept for each component, subassembly, and assembly, based on their complexity. As the product is integrated, the next higher-level assembly documentation will reference all integrated subassemblies or subsystems by positive configuration identification. The logbooks will document all actions taken on the component, and will provide for easily accessible total operating time of the component under control

8.10 Contamination Control

CoNNeCT Project will assure compliance to the contamination requirements during all phases of the program or project. QA will verify that requirements for articles and materials to be fabricated, processed, inspected, or tested in a temperature, humidity, ESD, or contamination controlled environment are properly implemented. Contaminants include all materials of molecular or of particulate nature, whose presence degrades system performance. The source of the contaminant materials may be the system itself, the test facilities, and the environments to which the system is exposed.

CoNNeCT Project will define contamination allowances for performance degradation of contamination-sensitive systems such that, even in the degraded state, the system will meet its mission objectives. Allowable contamination levels are either those necessary to ensure that the system will meet its performance requirements or those necessary to meet mission contamination control considerations, whichever is more stringent. These levels will serve as a basis for the measurements to be taken to control contamination. The contamination allowable will be assessed in a timely fashion such that results can be used to assess the adequacy of and, if necessary, to modify the design of the system.

The contamination potential of material and equipment used in cleaning, handling, packaging, tent enclosures, shipping containers, and bagging (e.g., antistatic film materials), will be considered. Clean room standards and personnel training will also be included in the processes.

QA will assure that contaminant-sensitive items are cleaned and controlled in accordance with documented procedures to the levels specified in the applicable technical documents and are maintained to these cleanliness levels. These procedures will cover hardware, equipment, personnel, and control of such areas as fabrications, assembly, inspection, test, and storage. Specific cleanliness levels to be maintained for systems, subsystems, and major components will be indicated on drawings, specifications, or other documents controlling the manufacture and test of those items. QA will assure that clean-room disciplines and procedures are properly implemented and monitored to assure continuing compliance with requirements.

8.10.1 Contamination Control Plan

The requirements in this section of the SARG are applicable to CoNNeCT.

8.11 Electrostatic Discharge Prevention

The requirements in this section of the SARG are applicable to CoNNeCT. The CoNNeCT Project will plan, implement, and maintain a program to prevent Electrostatic Discharge (ESD) damage to any susceptible parts or components in accordance with ANSI/ESD S20.20. Personnel who handle ESD sensitive parts or components will be trained in ESD prevention methods.

8.12 Nonconformance and Problem Reporting and Control

CoNNeCT will implement a PRACA-type system (i.e. CPAR) prior to testing of flight or flight-like hardware. CoNNeCT Project will report failures and nonconformance through a documented problem reporting and corrective action (PRACA) system. In-House Projects will handle PRACA through the GRC Corrective and Preventive Action Reporting System (CPARS). (Ref. GLPR 1270.1). An outside contractor may maintain its own PRACA system with approval of CoNNeCT Project and Chief Safety Officer (CSO). The project will implement the PRACA system during the Development Phase within the project Team. The PRACA review board (via the Material Review Board, MRB) and Review Process will be initiated prior to subsystem testing and system level assembly for the prototype, protoflight, and flight systems prior to system level testing. The PRACA system will include documentation of problem, traceability of material or part, disposition of problem, root cause corrective action, segregation of discrepant material, verification of corrective action, and trending to help prevent similar discrepancies. The Product Assurance Plan (PAP) will describe the problem review process including any review boards and the problem report tracking and distribution process. NASA will be informed of any reportable problem within 48 hours of occurrence.

A reportable problem is any nonconformance, which is, or is suspected of being, a failure, an unsatisfactory condition, an unexplained anomaly, or an overstress occurring during or subsequent to production acceptance testing or qualification testing (i.e. after manufacturing or development).

The problem report should include as a minimum: 1) description of problem; 2) analysis of root cause of problem; 3) description of corrective action; and 4) corrective action follow-up.

MRBs will be conducted within 4 hours after all the pertinent failure/non-conformance data is gathered.

8.12.1 Review Boards

A review board will be operated with the responsibility of reviewing all problem reports. The board will include the following:

a. Quality or reliability representative (chair).
b. Engineering representative.
c. Project manager or his representative (optional member at their discretion, necessary for Failure Review Board, FRB, only).
d. Government representative, if other members are contractor personnel.

The board will have the authority and responsibility to:

a. Determine the disposition of the submitted problem.
b. Approve all standard repair procedures.
c. Ensure that remedial and preventative actions are properly addressed.
d. Ensure that excessive repairs do not compromise the component's reliability and quality.

8.12.2 Waivers and Deviations

The acceptance of any nonconformance affecting flight acceptance, safety, or mission success will require an approved waiver or deviation. For CoNNeCT's Product Assurance purposes, the CoNNeCT Configuration Management Plan, GRC-CONN-PLAN-0002, will describe the process for submission, review, and disposition of a request for a waiver or deviation.

CoNNeCT Project shall follow the process stipulated in GLPR 7120.5.20 "GRC Project Deviation/Waiver Process"

8.13 Alert Information

The requirements in this section of the SARG are applicable to CoNNeCT. The project will review NASA Parts Advisories and Government-Industry Data Exchange Program (GIDEP) Failure Experience reports according to the requirements of NPR 8735.1 and respond to System Safety, Quality & Reliability Division (SSQRD) and project review teams as to the applicability to project systems, location of affected system, criticality identification from the FMEA/CIL and disposition for design reviews. GIDEP Failure Experience reports include GIDEP Alerts, Problem Advisories, and Agency Action Notices. CoNNeCT Project will report discrepant parts and/or components that are within the scope of the GIDEP Failure Experience system or NASA Parts Advisory system to the GRC GIDEP Representative (Assurance & Risk Management Branch), who will prepare and submit the Failure Experience report to GIDEP or issue the NASA Parts Advisory per NPR 8735.1. A contractor may use its own GIDEP Representative to prepare and submit the GIDEP Failure Experience report but will inform the GRC Project Manager and CSO of the problem and provide them with an advance copy of the report.

8.14 Inspection and Test of Stored Limited Life Hardware

The requirements in this section of the SARG are applicable to CoNNeCT. A plan will be developed which assures that limited-life items stored or stocked have not been degraded or damaged during storage. The plan will address proper handling, including environmental conditions, to mitigate damage or prolong life, and testing to assure the stored items meet required specifications. Limited-life items not meeting the requirements set forth in the plan will be considered nonconforming, and handled in accordance with paragraph 3.7. Limited life items will be identified on a list and a log of their remaining life maintained.

8.15 Metrology

The requirements in this section of the SARG are applicable to CoNNeCT. CoNNeCT Project will establish and implement a documented metrology system in accordance with NPD 8730.1. Only properly calibrated instruments and tools will be used to assemble, test, inspect, and verify flight hardware. Individual records of measurement standards and equipment will be maintained. Records include identification of standard use, identification of equipment calibrated, identification of calibration procedure used, calibration time interval to next calibration, results of calibration, and individuals performing the calibration.

A documented metrology system will be established and maintained to ensure that measurement standards and equipment provide objective evidence that articles and materials produced or procured comply with specifications, drawings, and program and contractual requirements. All new or repaired measurement standards and equipment will be inspected and/or tested prior to use. Documentation of this effort will be maintained and made available for review by the designated Program QA representative.

8.16 Handling, Preservation, Marking, Packaging, Packing, and Transportation

The requirements in this section of the SARG are applicable to CoNNeCT. The CoNNeCT Project will develop and implement procedures for handling, preservation, marking, packaging, packing, and transportation to properly protect and identify all flight systems and ground support equipment during build-up, handling, storage, testing, shipping, and turn-over at integration. The developer's QA organization will verify that the articles and materials have been prepared and packaged in accordance with applicable procedures and requirements and have been properly identified and marked.

QA will review and approve, prior to their release, all technical documents pertaining to handling, storage, preservation, marking, labeling, packaging, and shipping operations.

Handling equipment used to handle program critical hardware (as defined in the ISS Program Reliability & Maintainability Critical Items List) will be marked to indicate the maximum load capacity. Handling equipment used for handling non-program critical hardware does not require maximum load capacity marking.

In the absence of special packing and marking requirements, packing and marking will comply with SSP 41173, Paragraph 3.10 Requirements. Also all accompanying documents will have been properly identified as to inspection status with the appropriate inspection stamps.

8.16.1 Control of Government Property by Contractors

When supplied in accordance with the provisions of the contract, government property will be controlled and accounted for by the contractor. The contractor will be responsible for, as a minimum:

a. Upon receipt, examine components to detect damage that may have occurred in transit.

b. Inspect for quantity, completeness of shipment and proper shipping documents.

c. Provisions for protection, maintenance, calibration, periodic inspection, and controls necessary to prevent damage or deterioration during handling, storage, installation, or shipment.

Any property that is found damaged, malfunctioning, or otherwise unsuitable for use will be processed in accordance with government procedures and paragraph 3.8. The property will not be disposed of, repaired, reworked, replaced, or in any way modified unless such actions are authorized by or prior approval of Glenn Research Center's Project Manager and the Contracting Officer.

8.17 Configuration Verification

CoNNeCT has prepared and implemented Configuration Management Plans, GRC-CONN-PLAN-0001 and GRC-CONN-PLAN-0002. The Project Manager will perform periodic audits to ensure that configuration management is applied as intended. CoNNeCT Project Configuration Management (CM) System will be capable of assuring that as-built hardware conforms to the design documentation. CoNNeCT Project QA organization will provide assessment of the CM system during construction of the engineering and flight systems. Formal verification and sign-off that flight as-built systems conform to as-designed documentation will be the responsibility of the CoNNeCT Project, unless otherwise stated in the PAP.

The PM will prepare Certificate of Flight Readiness (CoFR) as required after the PSR has been successfully completed. It is recommended that the CoFR Check List be prepared for PSR.

8.18 Acceptance of Flight Systems

The requirements in this section of the SARG are applicable to CoNNeCT. Prior to the Pre-ship Review, the Developer will assure that, all deliverable end-items including the Acceptance Data Package are in accordance with CoNNeCT Project requirements. SSP 41173 may be used to guide the preparation of Acceptance Data Packages. The Acceptance Data Package will be submitted for approval and is suggested to include the following:

a. As-built Configuration List in accordance with Paragraph 3.2c.

b. List of as-built parts used.

c. List of Materials and Processes used.

d. Log Books, including total operating and repair times, and cycle records.

e. Status of all verification items with a list of open items and rationale for the items being open.

f. Listing, status, and remaining life of Limited-Life items.

g. Results of Flight Acceptance Tests.

h. Listing and status of all nonconformance, failure, or problem reports.

i. Listing of waivers and deviations affecting flight acceptance, safety, and mission success.

j. Cleanliness certification

k. Certification of flight software acceptance.

l. A comparison of as designed versus as-built configuration listings and rationale for any differences from approved baseline designs.

m. The test procedure and test data for all end item acceptance tests including strip charts, deviations, and other data applicable to evaluate test records.

n. Radiation test data.

Appendix F contains the more detailed, Project approved, tabular format of the ADP. An ADP Dictionary follows the ADP list in Appendix F.

QA will conduct and participate in Acceptance Reviews (ARs) to assure compliance with documentation requirements. Supplier will ensure that the following information will be provided for review at the AR:

a. A summary of test and checkout operations and results with anomalies encountered, failure history, remedial actions, and recurrence control.

b. The status of any open work, including open items from previous reviews, shortages, nonconformance, unincorporated engineering changes, etc., and constraints on further activities.

c. Identification of waivers/deviations and objective evidence of appropriate approvals.

d. Identification of limited life components and their remaining life.

e. Completed deliverable Acceptance Data Package (ADP).

f. A form DD250 or other contractually authorized document(s) prepared for signature.

g. Records of all open non-conformances occurring during manufacturing and test of the end-item.

h. Handling, shipping, storage, preservation, packing, and packaging instructions, including environmental constraints, identification of hazards, and maintenance requirements and user manuals.

i. In addition, all supporting documentation, which may be required to establish equipment acceptability, should be readily retrievable. This includes, but is not limited to, engineering drawings, schematics, supplier ADPs, test specifications, closed nonconformance, fabrication and inspection test records, etc.

   Staged subsystem acceptance reviews can be performed as long as the final acceptance data products meet the ADP requirements stated in the SARG.

8.19 Quality Program Audits

The requirements in this section of the SARG are applicable to CoNNeCT. Quality Assurance will conduct audits of task performance, procedures, and operations, which implement the quality program. Assessments will be conducted periodically as appropriate with program maturity and will be performed by personnel not having specific line responsibilities in those areas. Each audit will include an examination of operations and documentation, evaluation of actual operations as compared with each established requirement, documentation of discrepancies and deficiencies, and recommendations for corrective action, as appropriate. A corrective action plan, which addresses measures, to be taken to correct the discrepancies/deficiencies will include reviews to ensure that measures required by the corrective action plan are being implemented properly.

The results of audits will be documented in a report to management. Management action will be taken to ensure correction of the reported deficiencies. Follow-up reviews will be made to ensure that required corrections have been implemented.

8.20 Control of Quality Records

The requirements in this section of the SARG are applicable to CoNNeCT. The Developer will establish and maintain documented procedures for identification, collection, indexing, access, filing, storage, maintenance, and disposition of quality records. Quality records will be maintained to demonstrate conformance to specified requirements and the effective operation of the quality system. Pertinent quality records from the subcontractor will be an element of these data. All quality records will be legible and will be stored and retained in such a way that they are readily retrievable in facilities that provide a suitable environment to prevent damage or deterioration and to prevent loss. Retention times of quality records will be established and recorded. Where agreed contractually, quality records will be made available for evaluation by the Project or the Project Assurance Representative for an agreed period. Records may be in the form of any type of media, such as hard copy or electronic media.

Records will not be destroyed unless authorized by the CoNNeCT Program's contracting officer. Record systems will ensure that records are identified and related to the applicable articles and materials. The record retrieval system will be organized so that these records and the related articles and materials may be rapidly located and retrieved for Project use and to support ground and on-orbit assembly and operations.

Records and data of all inspections and tests performed will be prepared and maintained in sufficient detail to verify and evaluate the status of articles and materials.

The overall Project Acceptance Data Package will be prepared and maintained for all government, contractor, or bilateral agreement requirements. SSP 30695, Acceptance Data Package Requirements Specification, may be used as a guide. QA will ensure the organization responsible for accountability of the hardware or software prepares and maintains ADPs to reflect current status of the product throughout the life of the hardware/software.

9.0 CONTINUOUS RISK MANAGEMENT

Continuous Risk Management activities will be completed as addressed in the CoNNeCT Continuous Risk Management Plan, GRC-CONN-PLAN-0007.

10.0 SOFTWARE ASSURANCE

Software Assurance activities will be completed as addressed in the CoNNeCT Software Assurance Plan, GRC-CONN-PLAN-0085.

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

ADP	Acceptance Data Package
AIT	Assembly, Inspection and Test
ANSI	American National Standards Institute
ANSI/ESD	American National Standard Institute/Electrostatic Discharge
AR	Acceptance Review
ASME	American Society of Mechanical Engineers
ASQC	American Society for Quality Control
ATI	Assembly, Inspection and Test
CCB	CoNNeCT Control Board
CCC	CoNNeCT Control Center
CDR	Critical Design Review
CE	Complex Electronics
CHCI	Computer Hardware Configuration Item
CIL	Critical Items List
CM	Configuration Management
CoFR	Certificate of Flight Readiness
CoNNeCT	Communications, Navigation & Networking Configurable Test-bed
CORR	Corrosion Resistance
COTS	Commercial Off-the-Shelf
CPARS	Corrective and Preventive Action Reporting System
CSO	Chief Safety Officer
CVCM	Collected Volatile Condensable Material
ECB	Engineering Control Board
ECO	Engineering Change Order
EEE	Electrical, Electronic, Electromechanical
ELC	Express Logistics Carrier
EMC	ElectroMagnetic Compatibility
EMI	ElectroMagnetic Interference
EPRB	EEE Parts Review Board
ERBs	Engineering Review Boards
ESD	ElectroStatic Discharge
EXPRESS	Expedite the Processing of Experiments to Space Station
FAR	Federal Acquisition Regulations
FCA	Functional Configuration Audit
FM	Flight Model
FMEA	Failure Mode Effects Analysis
FRB	Failure Review Board
FSE	Flight Support Equipment

GDAIS	General Dynamics Advanced Information Systems
GIDEP	Government-Industry Data Exchange Program
GOTS	Government Off-the-Shelf
GRC	Glenn Research Center
GSE	Ground Support Equipment
GSI	Government Source Inspection
HW	Hardware
ICA	Inter Center Agreements
IEEE	Institute of Electrical and Electronics Engineers
LET	Linear Energy Transfer
LLIS	Lessons Learned Information System
M&P	Materials and Processes
MAPTIS	Materials and Processes Technical Information System
MIUL	Material Identification Usage List
MOTS	Modified Off-the-Shelf
MRB	Material Review Board
MTBF	Mean Time Between Failure
MUA	Materials Usage Agreement
NISN	NASA Information Services Network
NPD	NASA Policy Directive
NSTS	National Space Transportation System
ORI/SR	Operational Readiness Inspection/Safety Review
PA	Product Assurance
PAP	Product Assurance Plan
PCB	Printed Circuit Board
PHA	Preliminary Hazard Analysis
PRACA	Problem Reporting, Analysis and Corrective Action
PSR	Pre-Ship Review
QA	Quality Assurance
RFA	Request For Action
RMIT	Risk Management Implementation Tool
SA	Software Assurance
SARG	Standard Assurance Requirements and Guidelines
SCC	Stress Corrosion Cracking
SCD	Source/Specification Control Drawing
SCS	Safety Critical Structures
SEE	Single Event Effects
SEMP	System Engineering Management Plan
SMA(D)	Safety and Mission Assurance (Directorate)
SR&QA	Safety, Reliability and Quality Assurance
SSP	Space Station Program
SSQRD	System Safety, Quality & Reliability Division
TDRSS	Tracking and Data Relay Satellite System
TID	Total Ionizing Dose
TML	Total Mass Loss
TVS	Thermal Vacuum Stability
V&V	Verification and Validation
VDS	Verification Data Sheet
WCA	Worst Case Analysis
WSC	White Sands Complex

APPENDIX B DEFINITIONS

B.1 Scope

This appendix lists the definitions used in this document.

B.2 List of Definitions

Table B-1—Definitions

Activity: (1) Any of the project components or research functions that are executed to deliver a product or service or provide support or insight to mature technologies. (2) A set of tasks that describe the technical effort to accomplish a process and help generate expected outcomes.

Advanced Technology Development: ATD is one of four interrelated NASA product lines. ATD programs and projects are investments that produce entirely new capabilities or that help overcome technical limitations of existing systems. ATD is seen as a bridge between BAR and actual application in NASA, such as FS&GS projects or elsewhere. ATD projects typically fall within a Technology Readiness Level (TRL) range of 4 to 6.

Architecture and Design: A description of the mission elements, their interfaces, their logical and physical layout, and the analysis of the design to determine expected performance and margins. Includes System Design Synthesis, System Design Analysis, and System Design Validation products.

Baseline: An agreed-to set of requirements, designs, or documents that will have changes controlled through a formal approval and monitoring process.

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.

Contractor: Per NPR 7123.1, a "contractor" is an individual, partnership, company, corporation, association, or other service having a contract with the Agency for the design, development, manufacture, maintenance, modification, operation, or supply of items or services under the terms of a contract to a program or project within the scope of this NPR. Research grantees, research contractors, and research subcontractors are excluded from this definition.

Customer: The organization or individual that has requested a product and will receive the product to be delivered. The customer may be an end user of the product, the acquiring agent for the end user, or the requestor of the work products from a technical effort. Each product within the system hierarchy has a customer. A subset of "stakeholders." (Refer to Stakeholder.)

Decision Authority: The Agency's responsible individual who authorizes the transition at a KDP to the next life-cycle phase for a program/project.

Designated Governing Authority: The management entity above the program, project, or activity level with technical oversight responsibility.

Entry Criteria: Minimum accomplishments each project needs to fulfill to enter into the next life-cycle phase or level of technical maturity.

Exit Criteria: Specific accomplishments that should be satisfactorily demonstrated before a project can progress to the next product-line life-cycle phase.

Expectation: Statements of needs, desires, capabilities, and wants that are not expressed as a requirement (not expressed as a "shall" statement) is to be referred to as an "expectation." Once the set of expectations from applicable stakeholders is collected, analyzed, and converted into a "shall" statement, the "expectation" becomes a "requirement." Expectations can be stated in either qualitative (nonmeasurable) or quantitative (measurable) terms. Requirements are always stated in quantitative terms. Expectations can be stated in terms of functions, behaviors, or constraints with respect to the product being engineered or the process used to engineer the product.

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.

Formulation Phase: The first part of the NASA management life cycle defined in NPR 7120.5 where system requirements are baselined, feasible concepts are determined, a system definition is baselined for the selected concept(s), and preparation is made for progressing to the Implementation phase.

I**mplementation Phase**: The part of the NASA management life cycle defined in NPR 7120.5 where the detailed design of system products is completed and the products to be deployed are fabricated, assembled, integrated, and tested; and the products are deployed to their customers or users for their assigned use or mission.

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

Key Decision Point: The event at which the Decision Authority determines the readiness of a program/project to progress to the next phase of the life cycle (or to the next KDP).

Level 1 Requirement: A Project's fundamental and basic set of requirements levied by the Program or Headquarters on the project.

Logical Decomposition: The decomposition of the defined technical requirements by functions, time, and behaviors to determine the appropriate set of logical models and related derived technical requirements. Models may include functional flow block diagrams, timelines, data control flow, states and modes, behavior diagrams, operator tasks, and functional failure modes.

Measure of Effectiveness: A measure by which a stakeholder's expectations will be judged in assessing satisfaction with products or systems produced and delivered in accordance with the associated technical effort. The MOE is deemed to be critical to not only the acceptability of the product by the stakeholder but also critical to operational/mission usage. An MOE is typically qualitative in nature or not able to be used directly as a "design-to" requirement.

Measure of Performance: A quantitative measure that, when met by the design solution, will help ensure that an MOE for a product or system will be satisfied. These MOPs are given special attention during design to ensure that the MOEs to which they are associated are met. There are generally two or more measures of performance for each MOE.

Other Interested Parties: A subset of "stakeholders," other interested parties are groups or individuals that are not customers of a planned technical effort but may be affected by the resulting product, the manner in which the product is realized or used, or have a responsibility for providing life-cycle support services. A subset of "stakeholders." (Refer to Stakeholder.)

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.

Peer Review: Independent evaluation by internal or external subject matter experts who do not have a vested interest in the work product under review. Peer reviews can be planned, focused reviews conducted on selected work products by the producer's peers to identify defects and issues prior to that work product moving into a milestone review or approval cycle.

Product: A part of a system consisting of end products that perform operational functions and enabling products that perform life-cycle services related to the end product or a result of the technical efforts in the form of a work product (e.g., plan, baseline, or test result).

Product-Based WBS Model: Refer to WBS model.

Product Realization: The act of making, buying, or reusing a product, or the assembly and integration of lower level realized products into a new product, as well as the verification and validation that the product satisfies its appropriate set of requirements and the transition of the product to its customer.

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.

Realized Product: The desired output from the application of the four Product Realization Processes. The form of this product is dependent on the phase of the product-line life cycle and the phase exit criteria.

Relevant Stakeholder: Refer to Stakeholder.

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.

Risk: The combination of the probability that a program or project will experience an undesired event (some examples include a cost overrun, schedule slippage, safety mishap, health problem, malicious activities, environmental impact, failure to achieve a needed scientific or technological breakthrough or mission success criteria) and the consequences, impact, or severity of the undesired event, were it to occur. Both the probability and consequences may have associated uncertainties. (Reference 7120.5.)

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

Specification: A document that prescribes, in a complete, precise, verifiable manner, the requirements, design, behavior, or characteristics of a system or system component.

Stakeholder: A group or individual who is affected by or is in some way accountable for the outcome of an undertaking. The term "relevant stakeholder" is a subset of the term "stakeholder" and describes people or roles that are designated in a plan for stakeholder involvement. Since "stakeholder" may describe a very large number of people, a lot of time and effort would be consumed by attempting to deal with all of them. For this reason, "relevant stakeholder" is used in most practice statements to describe the people identified to contribute to a specific task. There are two main classes of stakeholders. Refer to "customers" and "other interested parties."

Success Criteria: Specific accomplishments that must be satisfactorily demonstrated to meet the objectives of a technical review so that a technical effort can progress further in the life cycle. Success criteria are documented in the corresponding technical review plan.

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 Approach: The application of a systematic, disciplined engineering approach that is quantifiable, recursive, iterative, and repeatable for the development, operation, and maintenance of systems integrated into a whole throughout the life cycle of a project or program.

Systems Engineering Engine: The SE model provides the 17 technical processes and their relationship with each other. The model is called an "SE engine" in that the appropriate sets of processes are applied to the products being engineered to drive the technical effort.

Systems Engineering Life-Cycle: Concept Studies (Phase A), Preliminary Analysis and Definition (Phase B), Design (Phase C), Development (Phase D), Mission Operations (Phase E) and Disposal (Phase F) are the systems engineering life-cycle phases. Development includes Acquisition, Fabrication, and Integration; Verification and Preparation for Deployment; and Deployment and Operations Verification.

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.

System Structure: A system structure is made up of a layered structure of product-based WBS models. (Refer to WBS definition.)

Technical Performance Measures: The set of critical or key performance parameters that are monitored by comparing the current actual achievement of the parameters with that anticipated at the current time and on future dates. Used to confirm progress and identify deficiencies that might jeopardize meeting a system requirement. Assessed parameter values that fall outside an expected range around the anticipated values indicate a need for evaluation and corrective action. Technical performance measures are typically selected from the defined set of Measures of Performance (MOPs).

Technology Readiness Level: Provides a scale against which to measure the maturity of a technology. TRLs range from 1, Basic Technology Research, to 9, Systems Test, Launch, and Operations. Typically, a TRL of 6 (i.e., technology demonstrated in a relevant environment) is required for a technology to be integrated into an SE process.

Technical Risk: Risk associated with the achievement of a technical goal, criterion, or objective. It applies to undesired consequences related to technical performance, human safety, mission assets, or environment.

Validation (of a product): Proof that the product accomplishes the intended purpose. Validation may be determined by a combination of test, analysis, and demonstration.

Validated Requirements: A set of requirements that are well-formed (clear and un-ambiguous), complete (agrees with customer and stakeholder needs and expectations), consistent (conflict free), and individually verifiable and traceable to a higher-level requirement or goal.

Verification (of a product): Proof of compliance with specifications. Verification may be determined by test, analysis, demonstration, and inspection.

Waiver: A documented agreement intentionally releasing a program or project from meeting a requirement. (Some Centers use deviations prior to Implementation and waivers during Implementation).

WBS Model: Model that describes a system that consists of end products and their subsystems (perform the operational functions of the system), the supporting or enabling products (for development; fabrication, assembly, integration, and test; operations; sustainment; and end-of-life product disposal or recycling), and any other work products (plans, baselines) required for the development of the system. Refer to the example product-based WBS for an aircraft system and one of its subsystems (navigation subsystem) below:

APPENDIX C TBDs AND TBRs

C.1 Scope

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

C.2 List of TBDs

Table C-1—TBDs

TBD Number	Description	Document Paragraph
	NONE	

C.3 List of TBRs

Table C-2—TBRs

TBR Number	Description	Document Paragraph
	NONE	

APPENDIX D RESPONSIBILITY MATRIX

The following Responsibility list was applicable at the start of the Project; it may change with Project maturity.

Table D–1—Responsible Organization

SARG Section	Requirement Title	CoNNeCT Responsible Organization (with respect to WBS)
1.1	Overall Requirements	1,2
1.2	Product Assurance Plan	3
1.3	Use of Previously Designed, Fabricated or Flown Systems	N/A
1.4	Assurance Status Reports	3
1.5	Contractor Surveillance	3
2.1	Assurance Review General Requirements	2,3
2.2	GRC Assurance Review Requirements	2,3
2.3	GRC Assurance Review Program	3
2.3.1	Preliminary Design Review	1,2,3
2.3.2	Critical Design Review	1,2,3
2.3.3	Verification Readiness Review	1,2,3
2.3.4	Pre-Ship Review	1,2,3
2.4	System Safety	3
3.1	Verification General Requirements	1,2
3.2	Overall Verification Program	1,2
3.3	Electrical Verification Requirements	2,5
3.4	Structural and Mechanical Requirements	2,5
3.4.1	Safety Critical Structures and Fracture Control	3,5
3.4.2	Structural Loads	5
3.4.3	Factors of Safety	3,5
3.4.4	Margins of Safety	3,5
3.4.5	Fracture Control	3,5
3.4.6	Pressurized Systems	3,5
3.4.7	Strength Testing	2,5
3.4.8	Vibroacoustics	2,5
3.4.9	Shock (Mechanical and Pyro)	2,5
3.4.10	Mechanical Function	2,5
3.4.11	Pressure Profile	2,5
3.4.12	Fastener Integrity	3,5
3.4.13	Mass Properties	2,5
3.4.14	Ground Support Equipment (GSE)	5
3.5	Electromagnetic Compatibility (EMC) Requirements	2,5
3.6	Vacuum, Thermal, and Humidity Requirements	2,3,5
4.1	System Safety Requirements	2,3
4.1.2	Project Safety Planning and Implementation	1,3
4.1.3	Shuttle/ISS Payload Safety Data Package Preparation	1,2,3,4,5,6,7
4.1.4	Shuttle/ISS Payload Safety Data Package Review and Approval	1,3
5.1	Parts General Requirements	2,3,5
5.2	EEE Parts Selection and Screening	3,5

SARG Section	Requirement Title	CoNNeCT Responsible Organization (with respect to WBS)
5.2.1	EEE Parts Control Plan	3,5
5.2.2	EEE Parts Grades	3,5
5.2.3	Flight EEE Parts Screening	3
5.2.4	De-rating	3
5.2.5	Radiation Hardness	3,5
5.2.6	Electric Motors	5
5.2.7	Corona and Arcing	2,5
5.2.8	Inspection Prior to Assembly	3,5
5.3	Mechanical Parts Selection and Screening	3,5
5.3.1	Mechanical Parts Control Plan	5
5.3.2	Inspection Prior to Assembly	3,5
5.4	Parts Storage	3,5
5.5	Parts Age Control	5
5.6	Parts Identification List	5
5.7	Parts Risk Evaluation	3
6.1	M&P General Requirements	1,3
6.4	Specific Requirements	3
6.4.1	Reporting Requirements of M&P Assessment and Verification	3
6.4.1.1	Corrosion	3,5
6.4.1.2	Stress Corrosion	3,5
6.4.1.3	Outgassing	3,5
6.4.1.4	Flammability	3,5
6.4.1.5	Fluid Compatibility	3,5
6.4.1.6	Material Offgassing in Habitable Areas	N/A
6.4.1.7	Fungus	3,5
6.4.1.8	Atomic Oxygen	3,5
7.1	Reliability, availability, and maintainability (R&M) General Requirements	1,2,3
7.2	Reliability Requirements	3
7.2.1	Reliability Allocation and Prediction Analysis	1,3
7.2.2	Burn-In Periods	1,3,5
7.2.3	Failure Modes and Effects Analysis and Critical Item List	3
7.2.4	Single Point Failure List	3
7.2.5	Failure Detection	2,3
7.2.6	Fault Tree Analysis	3
7.2.7	Parts Stress Analysis	3,5
7.2.8	Worst Case Analysis	3,5
7.2.9	Analysis of Test Data	2,3,5
7.3.1	Availability Allocation and Prediction	N/A
7.3.2	Sparing and Logistics Planning	2
7.4.1	Maintainability Allocation and Prediction	N/A
7.4.2	Limited Life Items	3
7.4.3	Qualitative Maintainability Analysis	N/A
7.4.4	Provision For Failure Detection	2,3,6
7.4.5	Maintainability Assessment Report	N/A
7.4.6	Preventive Maintenance Analysis	2
8.1	Quality Assurance General Requirements	1,3

SARG Section	Requirement Title	CoNNeCT Responsible Organization (with respect to WBS)
8.2	Quality Assurance Organization	3
8.3	Configuration Management and Verification	1,3
8.4	Identification and Traceability	1,2,3,5
8.5	Procurement Requirements	1,2,3,5
8.5.1	Government Source Inspection	3
8.6	Control of Fabrication Activities	2,3,5
8.6.1	Fabrication and Inspection Requirements	2,3,5
8.6.2	Training for Personnel	1,2,3
8.6.3	Evaluation and Control of Process Specifications and Procedures	2,3,5
8.6.4	Bonded Storage	3,5
8.6.5	Records of Inspection and Tests	2,3,5
8.7.1	Contamination Control Plan	3,5
8.8	Electrostatic Discharge Prevention	3,5
8.9	Nonconformance and Problem Reporting and Corrective Action (PRACA)	3
8.10	Alert Information	3,5
8.11	Inspection and Test of Stored Limited Life Hardware	2,3,5
8.12	Metrology	1,2,5
8.13	Handling, Preservation, Marking, Packaging, Packing, and Transportation.	1,2,3,5
8.13.1	Control of Government Property by Contractor	1,2,5
8.14	Configuration Verification	1,2,5
8.15	Acceptance of Flight System	1,2,3,5
8.16	Quality Program Audits	3
8.17	Control of Quality Records	3
9.3	Risk General Requirements	1,3
10.1	Software General Requirements	1,2,6
10.3	Software Safety	3,6
10.4	Software Reliability	3,6
10.5	Software Configuration Management	1,6
10.6	Software Problem Reporting and Corrective Action	3,6
10.7	Software Verification and Validation	2,3,6
10.7.1	Software Reviews	6
10.7.2	Inspections	3,6
10.7.3	Software Testing	2,6
10.7.4	Software Audits	3
10.7.5	Software Acceptance	2,3,6

APPENDIX E LIST OF PANELS, REVIEW BOARDS, LISTS, AND PLANS

Note: Not all the following panels/boards will necessarily be active. For example if no failures occur then there will be no need to gather an FRB. Also, most panels are non-exclusive, i.e. the same people may serve on multiple panels.

E.1 List of Panels and Boards

#	Panel and Board	Section in PAP
1	Verification Readiness Review Panel	3.6.7
2	EEE Parts Review Board (EPRB)	7.4.1
3	Engineering Control Board (ECB)	6.4.1
4	Engineering Review Board (ERB)	5.4.1, 5.8, 5.11
5	CoNNeCT Control Board (CCB)	8.6
6	Material Review Board (MRB)	8.12
7	Failure Review Board (FRB)	8.12.1

Furthermore, all the above Boards are in Appendix D and in Appendix F.

Note: Many of the following lists and plans are not mandated or required, they are listed simply as a suggestion to help the Project organize information. It is up to the reader to refer to the specific section of the PAP for a specific situation to determine if a particular list is required or mandated.

E.2 List of Lists and Plans

#	List and Plan	Section in PAP
1	Qualified Parts List	3.8
2	Qualified Manufacturer List	3.8
3	Space Station Approved Electrical, Electronic, and Electromechanical Parts List	5.1.1
4	NASA Parts Selection List (NPSL)	5.1.1
5	As-designed Parts List	5.9.1
6	As-built Parts List	5.9.2
7	Material Identification Usage List (MIUL)	6.1
8	Critical Items List (CIL)	7.4.3, 8.9.1
9	Single Point Failure List (SPFL)	7.4.4
10	CoFR (Certificate of Flight Readiness) Check List	8.17
11	As-built Configuration List	8.18
12	List of Materials and Processes	8.18
13	List of verification open items	8.18
14	List of Limited-Life items	8.18
15	List of nonconformance, failure or problem reports	8.18
16	Listing of waivers and deviations affecting flight acceptance, safety, and mission success	8.18
17	Fastener Control Plan	3.6.12
18	EMI Control Plan	3.7.1
19	Environmental Test Plan	3.9.1
20	ISS Program Reliability & Maintainability Critical Items List	8.16
21	Electrical, Electronic, and Electromechanical (EEE) & Mechanical Parts Management & Implementation Plan for Space Station Program	5.1.1
22	Bonded Storage Control Plan	5.6, 8.9.4
23	Configuration Management (CM) Plan	6.4, 8.6, 8.12.2, 8.17
24	Fracture Control Plan	6.4
25	Fabrication and Assembly Flow Process Plan	8.9
26	Assembly, Inspection and Test Program Plan	8.9.1.1
27	Training Plan	8.9.2
28	Contamination Control Plan	8.10.1
29	Corrective Action Plan	8.19
30	End-To-End Compatibility Test Plan	3.10.3
31	Mass Properties Control Plan	3.6.13

APPENDIX F ACCEPTANCE DATA PACKAGE LIST

The following list is applicable for all deliverables across CoNNeCT, i.e. government and contractor packages. **Note:** The letter "H" stands for an ADP entry that is applicable to hardware, whereas the letter "S" represents an ACP entry that is more applicable to software. The checkmark signifies an entry that is not easily applied across all deliverables and so may be optional or customizable per discussions with the Project.

	H/S	Item	Customizable /Optional
		ADP Documentation:	
1	H/S	Copy of Shipped/Delivery Document (DD250 or DD1149) or other recognized government shipping document	
2	H/S	Index Page: identifies deliverable item name, type of hardware, content of package, & appropriate deliverable data package approval	
3	H/S	Certification of Safety Compliance	
4	H	Material Certifications (including MIULs)	
5	H	Cleanliness Certification	√
6	H/S	Certificate of Conformance	
7	H/S	Verification Closure	
		Documentation of Deliverable	
8	H/S	As-Designed vs. As-Built List (includes serialization/revisions, date codes, lot numbers)	
9	H	Final Drawing Package (including rework instructions, if any)	
10	H	Assembly procedures/processs plans	
11	H	Non-flight hardware/temporary installations	
12	H	Weight and CG	
13	H	Shortages	
14	H	Photograph Documentation (Pre-Closure and Closed)	√
		Documentation of Anomalies	
15	H/S	Notes/Comments/Unexplained Anomalies	
16	H/S	Problem/anomaly reporting (complete copies of report)	
17	H/S	Waiver/Deviation Records (affecting integration, safety)	
		Documentation of Life, Cycles, Reliability	
18	H	List, status, & historical logs of all identified Age Sensitive/Life-Limited Item Component/Equipment	
19	H	Flight connector mate/demate log (Flight Unit only)	
20	H	Log of total operating time	
21	H	Calibration Data	
		Documentation of Software	
22	S	Overview of Software	
23	S	Version Description	
		Documentation of Open Items	
24	H/S	Open/Preplanned Work	
25	H/S	Open/Unplanned/Deferred Work	
		H = Hardware S = Software	

The following **ADP Dictionary Table** is intended to further clarify, and give examples of, the above deliverables.

ADP Entry		Top Level Definition	Definition Specifics/Examples
Certifications	=	Documented evidence attesting to the fact the delivered hardware meets specified requirements (i.e., proof load, proof pressure, cleanliness, flight, etc.). Supporting documentation [e.g. Verification Completion Notices (VCNs)], shall be available for review.	
Developer Certification	=	Documented evidence that delivered hardware/software meets specified requirements.	This is a table. Each row of the table has columns for Requirement, Req. Description, Verification Method (I,A,T,D), Verification Procedure, Section of Verification Procedure, Status (Open, Closed, Waived, Failed,), and the Verification Test Report. This is fed from the Verification Matrix
Material Certifications (including MIULs)	=	Materials Certification is based on Certificate of Compliance stating that material meets the requirements of the applicable specifications MIUL = Material Identification Usage List	
Cleanliness Certification	=	Certificate identifing the cleanliness level to which the specified deliverable was cleaned and verified	
Certificate of Conformance	=	Certificate stating flight system compliance with the contract, drawings, standards, specifications and any other applicable documentation	
Indentification - As Designed/As-Built Listing	=	An indentured parts list which provides a comparison of the as–designed/as–built configuration of the hardware being delivered. The configuration listing consists specifically of the following: a. System assembly and subsystem assemblies (traceable and non–traceable); b. Parts procured to a Specification Control Drawing (traceable only). The as–designed/ as–built configuration excludes specification control drawing parts and standard usage hardware which are exempt from traceability (e.g., nuts, bolts, washers, shims, pins).	
As-Designed vs. As-Built List (includes serialization/revisions, date codes, lot numbers)	=	A parts list which provides a comparison of the as–designed/as–built configuration of the hardware being delivered.	
As-Designed Configuration	=	A configuration formally approved & released by NASA or contractor engineering release authority	
Final Drawing Package	=	SCaN Testbed Assembly (080911MFA100) CoNNeCT Flight Drawing Tree (GRC-CONN-TREE-0039)	
Assembly procedures/process plans	=	A. Assembly procedures/process plans that may be required after delivery or during during ground processing. B. Integration procedures/process plans for the primary subsystems	A. Assembly procedures that may be required after delivery or during integration. B. Assembly of subsystems/component plan C. Integration procedures and testing procedures that are performed during integration. D. Workmanship/Cleaniness/ESD/Inventory Control documentation
Certification of Safety Compliance	=	A. PSRP provided memo stating CoNNeCT is approved for safe operations B. Ground/Launch safety approval	
Weight and CG	=	Weight and Center of Gravity	Inspection form documenting the flight payload weight and center of gravity
Shortages	=	Listing of physical hardware shortages	Identification of physical hardware shortages existing at the time of delivery and copy of inspection and test/retest requirements documentation received upon shortage installation.
Instructions (both operating and post shipment verification checkout procedures)	=	Self explanatory	A. Post shipment verifications B. Check-out Procedures C. Operating Procedure - safe to mate, initialization procedures, command list, D. Mini FMEA - Failure weak points
Photograph Documentation (Pre-Closure and Closed)	=	Closeout photos of hardware (to include internal just prior to final closure of the payload, external closeout, pre and post shipment)	Photos of hardware at all stages of development/integration.
Non-conformances /Unexplained Anomalies	=	Problems that occur during system integration and verification activities. Provide a record of any Unexplained Anomalies (UAs) noted during fabrication and/or testing and use of the deliverable hardware item and any open problem reports.	
Notes/Comments/Unexplained Anomalies	=	An unexplained anomaly is an anomaly (ghost or phantom) which cannot be repeated or for which a cause cannot be determined.	This is a summary spreadsheet of all flight payload CPARs that are unexplained anomalies, with each row having the PRACA ID# (CPAR#), Problem description, Interim action, SMA response and Date Closed
Problem/anomaly reporting	=	This is a summary spreadsheet statusing all flight payload CPARs that are not unexplained anomalies . Actual copies of CPAR record for open CPARs.	This is all Inspection, Demostration, Analysis & Testing. Possible refer to the anomaly disposition plan. Actual copies of open PRACAs.
Waiver/Deviation Records	=	Approved waivers and deviations to the contract and/or other requirements authorizing hardware use or variations as applicable to the physical/functional parameters of the item being delivered (i.e., form, fit, function).	Summary listing of all system level Waivers & Deviations
List, status, & historical logs of all identified Age Sensitive/Life-Limited Item Component/Equipment	=	Limited life items having a maximum life limit which are subject to replacement when the specified limit is reached or exceeded. Included are time action control items having a minimum periodic functional operating limit which are subject to replacement when one or more specified limits are exceeded A. Deliverable item P/N and S/N B. Age sensitive or time action part name, P/N & S/N, manufacture date, expiration date (action due date), & type of action required (i.e. replace, service, inspect, etc.	List, status, & historical logs of all identified Age Sensitive/Life-Limited Item Component/Equipment
Non-flight hardware/temporary installations	=	A listing of installed hardware, which is not part of the deliverable item configuration and must be removed prior to subsequent operations or flight, shall be provided.	A. Hat Couplers, GSE equipement (DVM), instrumentation, simulators, etc.... B. Summary list of all temporary installations that must be removed prior to subsequent operation or flight
Flight connector mate/demate log (Flight Unit only)	=	Accumulated times a connector has been mated & demated	Mate/demate log
Log of total operating time	=	Status at time of delivery of accumulated operating time and/or cycles of parts designated as time/cycle critical. This includes maintenance activities which are required based on operating time/cycle.	A. Status at time of delivery of accumulated operating time and/or cycles of parts designated as time/cycle critical. B. System operating time
Calibration	=	Table of any items on the Deliverable that has calibration requirements	Summary spreadsheet documenting any items in the flight payload with calibration requirements.
Overview of Software	=	Full description of what the currently delivered version does (The term software applies to all new & existing software (for example, reuse, legacy, & heritage software) developed, acquired, modified, or maintained for CoNNeCT. This includes all open source software, firmware, data, computer programs for Complex Electronics Government off-the-shelf (GOTS) software, modified off-the-shelf (MOTS) software, & commercial off-the-shelf (COTS) software when included)	SW Overview documentation.
Software Version Description	=	Current version identification. This includes a list of CSCIs covered by this ADP and their versions. There's an ECO list of each ECO affecting baselined software. (Each version required an ECO). There's an ECO history for documentation. For Each CSCI there's a directory listing of all software files that make up the CSCI (including file sizes). There's a Software configuration Management list of each file showing its existence in SCM	SW Version Release documentation for the flight and ground software (including all firmware version control information), and the SDR software version information.
Verification Closure	=	Documented evidence that delivered hardware/software meets specified requirements.	Verification Closure Matrix documenting the closure status and associated VCN/CoC for each requirement.
Open/Preplanned Work	=	Description of work from manufacturing and/or test authorized for accomplishment after item turnover because of a Program decision to ship prior to completion, or deferral of work completion because of authorized shortages or constraints. Provide a copy of inspection and test/reject requirements documentation required to complete Preplanned/Assigned Work.	Procedures/Process Plans required for planned work to be performed post final turnover.
Unplanned/Deferred Work	=	Unaccomplished fabrication, test, inspection, or installation activities remaining to be completed at time of acceptance because of parts shortages, lack of schedule time, etc., including open Material Review actions, open nonconformance reports, open recurrence control actions, unincorporated engineering changes, mod kits, and other open work applicable to the hardware being delivered and copy of inspection and test/retest requirements per appropriate documentation to complete Unplanned/Deferred Work.	A. Summary listing of any system level hardware deferred work B. Summary listing of any system level software deferred work