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AIRBORNE INSTRUMENTS

QUALITY ASSURANCE PLAN

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1. SCOPE

1.1 Purpose

The purpose of this document is to identify minimum safety and quality approaches taken to develop airborne instruments that are flown on a crewed aircraft in a manner consistent with the NASA Risk Based Tailoring Philosophy as negotiated and described in the JPL Aircraft Operations Implementation Plan (AOIP) addendum to the NASA/Caltech Prime contract, with referenced command media.

The Flight Project Practices (FPP), DocID 58032, classifies airborne instruments as Type III projects, which are those that do not go into space, including sounding rockets, balloons, aircraft payloads, and ground-based projects. The FPP further states that Type III projects are required to comply with any applicable legal or contractual requirements such as International Traffic in Arms Regulations (ITAR) and human safety requirements. This document lays out the approach that JPL takes to tailor the safety and mission assurance (SMA) program that airborne instruments use to **ensure human and aircraft safety**.

1.2 Applicability

This document provides the basic quality requirements for the life cycle of JPL-developed airborne instruments, including ground and flight-test hardware that interface with the aircraft. The entire project life cycle includes instrument development, fabrication, integration, verification and validation (ground and flight testing), operations, modifications, and data processing activities as related to a quality assurance (QA) program.

2. AIRBORNE INSTRUMENT QUALITY MANAGEMENT

Airborne instrument quality and safety are governed by the JPL Office of Safety and Mission Success (OSMS), which serves multiple roles that support JPL's missions. The various disciplines within OSMS are resources provided for aircraft tasks with the goal of ensuring airworthiness, safety of employees/public, protection of the environment and preventing damage to properties/facilities. In this section we specify the requirements for airborne instrument quality for the following disciplines: quality assurance (QA), component engineering and assurance, mission environmental assurance, document control, and configuration management.

2.1 Quality Assurance (QA)

The QA Section will provide oversight and support for hardware deemed to be Airborne Quality Critical Items (AQCI). AQCI will focus on those items that need to be built correctly in order to ensure the "Do No Harm" principle. These are the items that, if damaged or came loose, could jeopardize personnel or aircraft safety and egress.

2.1.1 AQCI Hardware

The following items that are part of the load path which ultimately interface directly with the aircraft airframe or systems, or present identified hazards such as cryogenic vessels and pressurized systems used for containing pressurized fluids or gases, are AQCI hardware:

- Parts and materials for load-carrying structures, including fasteners and straps for equipment racks
- Wires, connectors, and fuses that are parts of systems that interface directly with the aircraft systems
- Cryogenic vessels
- Pressurized vessels
- Internal hardware that could escape vessel enclosure and associated safety devices (burst discs, pressure relief valves, regulators)
- Hazardous material containers

The instrument cognizant engineer is responsible for coordinating with the System Safety Program Office (SSPO) and aircraft provider to conduct a preliminary hazard analysis to identify AQCI hardware as early as possible to ensure the proper procurement of AQCI hardware.

2.1.2 AQCI Procurement

All JPL aircraft instruments **shall** procure AQCI parts and materials from

- Sources listed on the JPL **Approved Supplier List** (ASL) per JPL DocID 61974
- **JPL QCI Common Stores**, which stocks aircraft grade fasteners, wires, connectors, main payload breakers, and straps for equipment racks
- OEM suppliers who are able to produce parts traceability; a Quality Clause Requirements Document (QCRD) will be utilized and flowed down to suppliers

AQCI hardware should be inspected upon receipt at JPL to verify traceability of hardware. Inspection reports (IR) or traceability documentation **shall** be retained for recordkeeping and made available for airworthiness oversight. In the event that IR and traceability report is missing for AQCI hardware/material, additional safety margin **shall** be applied in structural analysis or load tests.

2.1.3 Workmanship standards

Hardware development involving AQCI **shall** utilize personnel that have been trained for applicable workmanship standards including:

- Requirements for Soldered Electrical and Electronic Assemblies (IPC J-STD 001G)
- Crimping, Interconnecting Cables Harnesses, and Wiring (NASA STD 8739.4)
- Polymeric Application of Electrical Assemblies (NASA STD 8739.1)
- Electrostatic Discharge (ESD) (see JPL DocID 34906, which meets the requirements of ANSI/ESD S20.20-2014)

2.1.4 Procedures for Build and Test

The build, assembly, and test of all AQCI hardware assemblies **shall** be done with Cognizant Engineer-approved procedures such as IBATs. A JPL or aircraft Quality Assurance Engineer **shall** review and approve procedures used for instrument/aircraft integration to ensure that requirements for airworthiness and personnel safety are met. All procedures and As-Built documentation **shall** be archived for tracking AQCI hardware build and instrument/aircraft configuration (see 2.5 regarding Document Control).

2.1.5 Facilities and Equipment

AQCI hardware development **shall** use certified facilities and calibrated equipment for fabrication, assembly, and test. The assembly, modification, and repair of AQCI EEE parts or systems **shall** be performed in an ESD-protected area in accordance with JPL DocID 34906.

2.1.6 Drawing Standards

All instrument assembly, cabling block diagram, and aircraft interfaces **shall** be documented in drawings using JPL drawing format templates that include title block, revision history, parts list when appropriate, and identification of AQCI hardware (see JPL DocID 35596).

2.2 Component Engineering

COTS components **shall** be assessed for their specification regarding the ability to withstand the environmental requirements of the host aircraft, such as expected temperature range at operational altitudes, vibrational environments, and failure modes when exposed to maximum operational altitude pressures. Many COTS items are only certified up to pressure altitudes of ~10,000 ft; therefore, the JPL Component Engineering and Assurance Office should be consulted for any potential required modifications.

COTS hardware and software are often combined with one-of-a-kind sensors during the airborne instrument development and assembly. Programmatic risks (e.g., loss of data during a flight, marginal performance) may be traded against the extra costs of extensive ground testing and/or rigorous component certification and documentation, such as might be expected in a one-shot, spaceflight opportunity.

2.3 Mission Environmental Assurance

2.3.1 Electromagnetic Compatibility

JPL-provided payload **shall** demonstrate via a Combined System Test and/or analysis that the payload's radiated emissions and conductive emissions do not interfere with the host aircraft's radio-frequency instrumentation to ensure the safe operation of the aircraft.

2.3.2 Mechanical Assurance

The JPL-provided payload **shall** be designed to prevent itself from incurring damage to the host aircraft at the aircraft's maximum specified load, shock, and vibration environment for all expected flight events, including turbulence (gust inertial loads) and hard landing (crash landing).

2.3.3 Fault Containment Region

The JPL-provided payload **shall** be a fault-containment region, and not propagate payload-internal failures to the host aircraft by any means, including via the Payload-to-Aircraft electrical and/or mechanical interfaces where they could potentially damage aircraft systems. Areas of concern include (but are not limited to) payload conditions that may cause a transient on the aircraft power bus, over or under-volt conditions, and/or result in catastrophic overheating of a sensitive payload-aircraft electrical or mechanical interface,

2.4 Configuration Management

All interface drawings and assembly drawings/models **shall** reflect the latest configuration.

2.5 Document Control

All drawings/documents used for configuration management, Commercial Aircraft Services subcontracts, Airworthiness Approval process, System Safety, and Occupation Safety **shall** be stored in JPL EPDM or uploaded to the designated project repository for safekeeping and for future reference and airworthiness oversight. All documentation associated with the acquisition of AQCI hardware and material **shall** be archived similarly for future reference and airworthiness oversight.

ACRONYMS

AOIP	Aircraft Operations Implementation Plan
AQCI	Airborne Quality Critical Item
ASL	Approved Supplier List
Cog E	Cognizant Engineer
COTS	Commercial Off-the-Shelf
EPDM	Engineering Product Data Management
ESD	Electrostatic Discharge
FPP	Flight Project Practices
HR	Hazard Report
HQA	Hardware Quality Assurance
IBAT	Instructions for Build, Assemble, and Test
ICD	Interface Control Document
IR	Inspection Report
ISO	International Organization for Standardization
ITAR	International Traffic in Arms Regulations
JPL	Jet Propulsion Laboratory
NASA	National Aeronautics and Space Administration
OSMS	Office of Safety and Mission Success (JPL)
QA	Quality Assurance
QCI	Quality Critical Item
SMA	Safety and Mission Assurance
SSPO	System Safety Program Office

REFERENCES

DocID 34906	Electrostatic Discharge Requirements
DocID 35412	Safety Requirements for Mechanical Support Equipment for JPL Critical Items Equipment
DocID 35596	Engineering Drawing Practices
DocID 61974	Approved Supplier List
DocID 79011	Airborne Instrument Development and Deployment
TBD	JPL Airborne Instruments Guidebook, 20220214
DocID 79026	Independent Assessment of Type III Projects and Non-Space Flight Activities
IPC J-STD 001G	Requirements for Soldered Electrical and Electronic Assemblies
NASA STD 8739.1	Polymeric Application of Electrical Assemblies
NASA STD 8739.4	Crimping, Interconnecting Cables Harnesses, and Wiring
AS 9100	Quality Management Systems -- Requirements