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Chapter 2. Airworthiness and Maintenance

2.1 Purpose

2.1.1 This chapter establishes policy to ensure the airworthiness and maintenance of NASA aircraft/UASs and non-NASA aircraft used to perform NASA missions. It also establishes policy for safety and flight readiness reviews performed in conjunction with the acceptance or modification of aircraft.

2.2 Airworthiness General Requirements

2.2.1 NASA aircraft shall be operated in an airworthy condition as certified by a formal NASA airworthiness review board (ARB), under the authority of a NASA Center Director, using a NASA Certificate of Airworthiness process. [52] All NASA aircraft shall possess and maintain a NASA Certificate of Airworthiness (appendix E) approved by the Center Director. [53] Additionally, all aircraft used for MMA purposes shall possess a "Normal" or "Transport" category FAA Certificate of Airworthiness. [54] When NASA aircraft are transferred between Centers, a new NASA Certificate of Airworthiness approved by the receiving Center Director shall be obtained. [55]

2.2.2 Airworthiness, flight safety, and mission readiness reviews, including configuration control, shall be conducted for all aircraft modifications, with the exception of those noted in 2.4.2.4 that are cleared through an airworthiness review process (ARP) or configuration control process. [56] These review processes are to clear unique or nonstandard internal or external payloads or stores configurations for flight and to review

nonstandard flight operations--those other than normal aircraft operations for the specific aircraft. The purpose of these reviews is to identify hazards so as to minimize risks to persons and property and to enhance the likelihood of mission and program success. Formal review requirements will be appropriate for the types of modifications incorporated, the specific mission or project requirements, and the operational risks involved.

2.2.3 The ARP may include several levels of review. Each Center shall clearly identify the appropriate airworthiness review process for experimental, research, and operational configurations and nonstandard ground or flight operations for all aircraft operated by the Center. [57]

2.3 Airworthiness Responsibilities

2.3.1 The Chief, Safety and Mission Assurance formulates NASA safety policy and provides independent oversight of NASA aviation safety and safety procedures or guidelines.

2.3.2 Center Directors shall establish airworthiness, flight safety, mission readiness, and configuration control review processes and procedures to identify any hazards, to manage the risks associated with flight programs, to ensure safe flight operations, to manage and thoroughly document aircraft configurations, and to ensure that flight objectives satisfy programmatic requirements. [58] Center Directors shall ensure that these procedures are incorporated into the contracts of those who operate and maintain NASA aircraft. [59]

2.4 Airworthiness, Flight Readiness, and Safety Reviews

2.4.1 Center Directors shall establish procedures to ensure that airworthiness and safety reviews are conducted for flight operations or missions. [60]

2.4.1.1 Reviews shall ensure that hazards associated with aircraft experimental modifications, research, or unique internal or external payloads and nonstandard operations are identified and that risks are adequately managed to enhance the likelihood of mission and program success for all aircraft missions or operations and to minimize the risks to persons or property. [61]

2.4.1.2 Program managers shall review flight programs early in the development cycle to identify the need and schedule for additional safety-related resources, procedures, or reviews. [62] Managers shall ensure that aircraft modifications are accomplished with sufficient time for engineers and technicians to safely complete required tasks. [63]

2.4.1.3 Center Directors shall establish configuration control procedures to ensure that the configuration of each NASA aircraft is fully documented and reviewed. [64] A minimum equipment list (MEL) shall be established for all non-test-related equipment for all aircraft operations. [65] Test-related equipment will be handled through the flight test planning process. If test equipment remains on the aircraft for non-test-related missions, then such equipment shall be addressed in the aircraft MEL. [66] Waivers to a MEL may be granted by the Chief of Flight Operations but may not be delegated to a lower office/position.

2.4.2 The ARP is the process by which an engineering and safety analysis is performed to determine that an aviation system or its component parts meets minimum design

criteria, standards, and configuration for the conduct of safe flight operations. The ARP also includes a review of the operations of NASA aircraft when those operations are nonstandard for that aircraft type, place the aircraft into a more hazardous environment than normal, or involve experimental internal or external payloads, configurations, or noncertified external stores, including the dropping of uncertified stores, which may affect the airworthiness of the aircraft.

2.4.2.1 An ARP is required prior to an aircraft commencing its first or subsequent test or research flights in nonstandard configurations or operating envelopes. An ARP approval is valid only for the specific configurations and flight envelopes and operations specified in the approval. Any change to the specified configuration or flight operation requires issuance of a separate or amended ARP approval per individual Center procedures.

2.4.2.2 Examples of configuration and envelope changes requiring an ARP approval include, but are not limited to:

- a. Structural and material changes that alter the basic aircraft design configuration.
- b. Modification of the exterior contour or mold line of the aircraft to an experimental configuration (e.g., addition/removal of wing fence, ventral fin, vortex generator, air induction system, auxiliary inlets, and nonstandard antenna configurations or locations).
- c. Modification to the flight control system, including software revisions, to nonstandard configurations.
- d. A new or modified propulsion system or its control system, including software revisions, that is nonstandard for the aircraft.
- e. Modification of the displays or annunciation affecting critical information presented to the aircrew (e.g., situational awareness, aircraft control, air vehicle launch) that are nonstandard for the aircraft.
- f. Modification of any subsystem interfacing with and affecting flight or propulsion systems (e.g., mission computer, navigation, and warning and caution systems) that are nonstandard.
- g. Modification of the aircrew life support systems to nonstandard configurations.
- h. Evaluation of crosswind landing or wet runway landing limits, emergency procedures, structural or flight control limits, wind envelopes, or helicopter external lift, cargo hook system, or tow limits that are outside the normal limits for the aircraft.
- i. Flight test instrumentation that interfaces with normal aircraft systems or that may affect the operation of those systems.
- j. Intentional operation in a degraded mode for test purposes (e.g., simulation of partial loss or malfunction of flight control system, engine, and avionics).
- k. Dropping of uncertified stores or objects.
- l. Any other modifications, payloads, or operations that are nonstandard according to established flight manuals, procedures, or FAA certification requirements (if operated under an FAA airworthiness certificate).

2.4.2.3 Minor aircraft system modifications that do not interface with or affect the standard operation of aircraft systems or alter aircraft aerodynamic characteristics may

be reviewed through a configuration control process. Examples of modifications that might fall into this category include such systems as:

- a. Additions of C-band tracking beacons.
- b. Addition of onboard video-recording equipment.
- c. Addition of global positioning system (GPS) recording or tracking systems.

2.4.2.4 The following aircraft modifications may not require airworthiness certification, flight safety, or mission readiness reviews:

- a. Airworthiness Directives (ADs), commonly issued by FAA.
- b. Maintenance Advisories, which are issued by multiple sources, such as the U.S. Navy, the U.S. Air Force, and manufacturers.
- c. One Time Inspections (OTIs), which may be issued by multiple sources.
- d. Service Bulletins/Service Instructions (SB/SI), which may be issued by manufacturers.
- e. Service Information Letters, which may be issued by multiple sources.
- f. Time Compliant Technical Orders (TCTOs), issued by the U.S. Air Force.
- g. Technical Orders (TOs).
- h. Technical Directives (TDs), issued by the U.S. Navy.
- i. Power Plant Bulletins/Power Plant Changes (PPB/PPCs).
- j. Supplemental Type Certificates (STCs) issued by the FAA.

2.4.2.5 Modifications to aircraft, such as avionics upgrades, that meet FAA certification requirements according to applicable FAA regulations may be handled through a configuration control process.

2.5 Staffing for Airworthiness Review Process

2.5.1 Each Center Director shall ensure that the ARP is staffed with personnel possessing the appropriate scientific, engineering, operational, maintenance, and managerial expertise. [67] At least one member of the ARP shall be a NASA pilot. [68] The ASO also shall be a member. [69] The process reviews project or mission hazards, aircraft modifications, project processes, and procedures related to safety and mission assurance. In addition, the process approves appropriate risk mitigation procedures/techniques and provides oversight for all planned operations. Additionally, each Center Director is responsible for establishing a list of senior managers and/or senior engineers who are responsible for conducting the ARP and approving projects or missions for flight, including appointing personnel responsible for managing and executing the Center ARP review board and maintaining records of airworthiness approvals.

2.5.2 The ARP review board may be broken down into several subpanels to facilitate the overall review process. For instance, separate reviews of technical issues and safety hazards may facilitate a detailed review of specific aspects of the project or mission by discipline experts, who then advise the Center review board. Any cockpit or cabin modifications that might interfere with aircrew egress shall be reviewed by a subpanel

including aircrew and life support personnel. [70]

2.5.3 The ARP approval for flight may be for an entire test or research program or be restricted to a certain number of flights or missions and require additional review once defined project or mission goals are achieved.

2.5.4 The ARP shall be continual throughout the course of a project. [71] The Center Director may establish periodic reviews of projects to review project progress subsequent to defined project events (including successes or failures) or at other points in the project to review the overall airworthiness of the aircraft for the intended mission and the progress of the project.

2.5.5 Each Center shall establish the content of the ARP based on the aircraft mission, complexity of the modifications, and the inherent hazards associated with the operation. [72] Content for ARP approvals shall be documented in Center-level ARP procedures. [73] The following are typical of the information required for an ARP to approve an aircraft modification or flight operation for a specific aircraft configuration:

2.5.5.1 A description of the aircraft modifications including aircraft configuration, loads, flight envelope, aircraft weight and balance data, reference to applicable mechanical and electrical design documents, reference to applicable software version description documents, and a listing of associated computer software configuration. The ARP reviews each of these items as applicable for the specific aircraft or subsystems under review.

2.5.5.2 Applicable engineering analysis that describes design criteria, aircraft loads and safety limits, external pod loads, electrical or mechanical system vibrations, aero-elastic vibrations (flutter), aero-servo-elastic effects, thermal loads, electrical system loads, and other abnormal environmental conditions and their effects on aircraft performance, stability, and control or aircraft systems operation. The results of tests conducted to verify the engineering analysis also shall be considered. [74]

2.5.5.3 A description of the required flight operations, including operating procedures, test conditions, maneuvers, required instrumentation, mission control operations, mission rules and flight limitations, nonstandard operation or inspection criteria, and associated checklists. Actions to be taken in the event of in-flight malfunctions or emergency conditions associated with the aircraft modifications or nonstandard operations also shall be described. [75]

2.5.5.4 A safety hazard analysis of systems and operations, including risk assessment and risk reduction actions and the methodology used to reduce the risks to acceptable levels (design, safety devices, warnings, procedure or training, or other methods).

2.5.6 ARP approval is based on the results of a Center-approved engineering and safety analysis. The final approval shall contain a description of the configuration of the aircraft, operating instructions and procedures, operating limitations and restrictions, and specific maneuvers or operations for which the aircraft is cleared. [76]

2.6 Maintenance Program

2.6.1 NASA aircraft shall be maintained in accordance with an established and documented maintenance program, using standards of quality in workmanship, materials, and support equipment that will ensure airworthiness of aircraft for safety of flight. [77] Each Center shall develop written guidance for maintenance practices and

procedures that include aircraft-specific (manufacturer, NASA, or Department of Defense [DoD]) maintenance practices. [78]

2.6.2 All NASA aircraft, specifically designated ground support equipment, and aircraft operated by NASA flight and ground crews shall be maintained under an approved airworthiness program. [79] The program/process/ARP shall comply with applicable FAA-approved Original Equipment Manufacturer (OEM) standards, DoD technical standards, or NASA standards in material quality and workmanship. [80] NASA aircraft maintenance and quality assurance inspection programs shall address, at a minimum, the following activities:

2.6.2.1 Calendar, depot, periodic, phase, pre-flight, and post-flight inspections, and provisions for inspection and certification procedures of specific maintenance actions. [81]

2.6.2.2 Determination of the serviceability, authenticity, traceability, and airworthiness of parts, components, accessories, and assemblies by subjecting them to inspections, tests, or operational checks. [82]

2.6.2.3 A configuration control process to ensure compliance with applicable airworthiness, service and safety bulletins, or other pertinent requirements, such as those from FAA, DoD, or OEMs. The process shall allow for documentation of alternate procedures or inspections if they are substituted. [83]

2.6.2.4 A program for trend analysis and investigation of recurring discrepancies, high-failure-rate components, and high-usage materials. [84]

2.6.2.5 Documentation consisting of aircraft logs and records, accessory change records, weight and balance records, and aircraft property accountability records, as well as documentation required by NPR 4100, NASA Materials Inventory Management Manual. [85]

2.6.3 Quality Assurance

2.6.3.1 A comprehensive aircraft maintenance quality assurance program shall be established at each NASA Center that is responsible for the maintenance of NASA aircraft. [86]

2.6.4 Training

2.6.4.1 The Center Director shall ensure that quality assurance inspectors and maintenance personnel are trained, qualified, and assigned to implement a comprehensive maintenance and quality assurance program for Center Flight Operations. [87]

2.6.5 Depot-Level or Major Aircraft Modifications

2.6.5.1 Center Flight Operations shall maintain continuous onsite oversight of vendors and facilities performing aircraft depot-level overhauls or major aircraft modifications to ensure quality of workmanship, maintenance of NASA standards, and schedule and cost control. [88]

2.6.5.2 Individuals assigned onsite responsibilities shall have expertise and experience in aircraft airworthiness standards and requirements. [89]

2.6.6 Tool Control and Foreign Object Damage (FOD) Control

2.6.6.1 Each Center shall have a documented tool control program. [90]

2.6.6.2 Each Center shall have a documented FOD control program. [91]

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