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DEPARTMENT OF DEFENSE HANDBOOK

AIRCRAFT STRUCTURAL INTEGRITY PROGRAM GENERAL GUIDELINES FOR

THIS HANDBOOK IS FOR GUIDANCE ONLY.
DO NOT CITE THIS DOCUMENT AS A REQUIREMENT.

AMSC N/A

FSC 15GP

FOREWORD

1. This handbook is approved for use by the Department of the Air Force and is available for use by all Departments and Agencies of the Department of Defense.

2. This handbook is for guidance only. This handbook cannot be cited as a requirement. If it is, the contractor does not have to comply.

3. This handbook provides guidance for programmatic tasks for the conceptual definition, development, acquisition, maintenance, and modification of the primary and secondary structures of crewed and unmanned flight vehicles and external stores, to ensure their structural integrity while affordability of these Air Force systems is maintained throughout their period of use. Structural deficiencies must be identified and corrected as early as possible to minimize repairs, modifications, and life cycle costs while cost and schedule risks are managed. The Aircraft Structural Integrity Program (ASIP) consists of a series of disciplined, time-phased actions; procedures; analyses; tests; etc.; which, when developed and applied in accordance with the guidance of this handbook; will ensure reliable, affordable, and supportable flight vehicle primary and secondary structures, thus contributing to the enhancement of total systems mission effectiveness and operational suitability while minimizing cost and schedule risks.

4. This handbook is available to promote implementation and provide guidance which concerns implementation of Air Force Policy Directive (AFPD) 63-10 and Air Force Instruction (AFI) 63-1001. Both documents, AFPD 63-10 and AFI 63-1001, contain policy directives which ensure the safe operation of the U.S. Air Force airframe structures. These constraints are not repeated in higher-level policy (e.g., DoD-5000 series) and have no commercial equivalent (e.g., FAA regulations). In addition, these peculiar ASIP constraints evolve from durability considerations and individual tracking and data gathering which are part of AFI 63-1001.

5. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: ASC/ENOI, 2530 LOOP ROAD WEST, WRIGHT-PATTERSON AFB OH 45433-7101; by use of the Standardization Document Improvement Proposal (DD Form 1426) that appears at the end of this document, or by letter.

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1. SCOPE

1.1 Scope. This handbook contains general guidelines for the U.S. Air Force Aircraft Structural Integrity Program (ASIP). These guidelines describe the processes proven successful in achieving structural integrity of USAF air vehicles while the cost of ownership is minimized, and cost and schedule risks managed through a series of disciplined, time-phased tasks. This handbook is for guidance only. This handbook cannot be cited as a requirement. If it is, the contractor does not have to comply.

1.1.1 Application. This handbook provides guidance to contractors in the development of an airframe for a particular weapon or support system and to government personnel in managing the development, production, and operational support throughout the life cycle or a particular structures program and air vehicle system, as follows:

a. Type of air vehicle. This handbook is directly applicable to manned air vehicles which have fixed or adjustable fixed wings and to those portions of manned helicopter and Vertical/Short Takeoff and Landing (V/STOL) air vehicles which have similar structural characteristics. Helicopter-type power transmission systems—including lifting and control rotors and other dynamic machinery; power generators, engines, and propulsion systems—are not covered. For unmanned vehicles, some guidelines of this handbook are generally not applicable commensurate with sufficient structural safety and durability to meet the intended use of the airframe.

b. Type of program. This handbook should be applied to new air vehicle systems, to air vehicle systems procured by the U.S. Air Force but developed under the auspices of other government agencies or departments (such as the Federal Aviation Administration or United States Navy), and air vehicles modified or directed to new missions. Procurement of off-the-shelf, new or used air vehicles for military use presents somewhat different problems than procurement of air vehicles developed under the auspices of the military services. Although the ASIP process still applies, additional tailoring is needed to optimize these programs. Appendix A provides additional guidance for procurement of off-the-shelf air vehicles. Appendix B provides additional guidance for aging air vehicle programs.

c. Type of structure. This handbook should be applied to metallic and nonmetallic structures.

1.1.2 Tailoring. This handbook may not need to be invoked on a blanket basis. It should be tailored to the specific program, with each guideline assessed in terms of need. The degree of applicability of the various portions of this handbook will vary among programs.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand fully the information provided by this handbook.

2.2 Government documents

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the latest issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto.

SPECIFICATIONS

Department of Defense

JSSG-2006	Aircraft Structures

HANDBOOKS

Department of Defense

MIL-HDBK-5	Metallic Materials and Elements for Aerospace Vehicle Structures
MIL-HDBK-17	Plastics for Flight Vehicles
MIL-HDBK-23	Structural Sandwich Composites (*cancelled*)
MIL-HDBK-6870	Inspection Program Requirements, Nondestructive, for Aircraft and Missile Materials and Parts

(Unless otherwise indicated, copies of the above specifications, standards, and handbooks are available from the Standardization Document Order Desk, 700 Robbins Avenue, Bldg 4D, Philadelphia PA 19111-5094; [215] 697-2179; http://assist.daps.mil. MIL-HDBK-23 is listed for reference; it has been cancelled and copies are not available.)

2.2.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein.

U.S. AIR FORCE DIRECTIVES/INSTRUCTIONS

Air Force Policy Directive AFPD 21-1	Managing Aerospace Equipment Maintenance
Air Force Policy Directive AFPD 63-10	Aircraft Structural Integrity
Air Force Instruction AFI 21-105	Aerospace Equipment Structural Maintenance
Air Force Instruction AFI 63-1001	Aircraft Structural Integrity Program
Air Force Materiel Command Instruction AFMCI 21-102	Analytical Condition Inspection (ACI) Programs

(Copies of Directives and Instructions are available from the US Air Force Publications Distribution Center, 2800 Eastern Blvd, Baltimore MD 21220-2898; [410] 687-3330; http://afpubs.hq.af.mil.)

U.S. AIR FORCE TECHNICAL ORDERS

T.O. 1-1B-40	Weight and Balance Data
T.O. 1-1B-50	Basic Technical Order for USAF Aircraft Weight and Balance

(Copies of T.O.s are available from Oklahoma City Air Logistics Center (OC-ALC/TILUB), 7851 Arnold St Ste 209; Tinker AFB OK 73145-9147; [405] 736-5468; http://wwwmil.robins.af.mil/imweb/IMP.htm.)

TECHNICAL REPORTS

WL-TR-94-40152/3/4/5/6	Damage Tolerance Design Handbook

(Copies of TRs are available from the Defense Technical Information Center [DTIC], 8725 John J. Kingman Road, Suite 0944, Fort Belvoir VA 22060-6218; [703] 767-8274; http://www.dtic.mil.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the latest issue of the DoDISS, and supplement thereto.

MCIC-HDBK-01	Damage Tolerance Design Handbook

(Copies are available from Metals and Ceramics Information Center, Battelle Memorial Institute, 505 King Avenue, Columbus OH 43201-2681.)

RP #7	Society of Allied Weight Engineers

(Copies are available from Society of Allied Weight Engineers, P O Box 60024, Terminal Annex, Los Angeles CA 90060-0024.)

2.4 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS

3.1 Damage tolerance. Damage tolerance is the attribute of a structure that permits it to retain its required residual strength for a period of unrepaired usage after the structure has sustained prescribed levels of fatigue, corrosion, and accidental or discrete source damage such as (a) unstable propagation of fatigue cracks, (b) unstable propagation of initial or service induced damage, and/or (c) impact damage from a discrete source.

3.2 Design service goal. The design service goal is the period of time (in flight cycles/hours) established at design during which the structure will be reasonably free from significant structural degradation.

3.3 Durability. Durability is the ability of the airframe to resist cracking (including stress corrosion and hydrogen-induced cracking), corrosion, thermal degradation, delamination, wear, and the effects of foreign object damage for a prescribed period of time.

3.4 Economic life. This is the operational service period during which there is no significant departure from the cost burden associated with the Force Structural Maintenance Plan for a newly-manufactured air vehicles, based on an evaluation of data developed during full-scale development. The economic life is indicated by the results of the durability test program; i.e., test performance interpretation and evaluation in accordance with JSSG-2006. The economic life should be evaluated with the incorporation of U.S. Air Force-approved and committed production or retrofit changes and the supporting application of the force structural inspection and maintenance documentation in accordance with this handbook. In general, production or retrofit changes will be incorporated to correct local design and manufacturing deficiencies disclosed by test. It will be assumed that the economic life of the test article has been attained with the occurrence of fatigue cracking which could be uneconomical to repair and, if not repaired, could cause functional problems which affect operational readiness. This may sometimes be characterized by a rapid increase in the number of damage locations or repair costs as a function of cyclic test time.

3.5 Fail-safe. Fail-safe is that attribute of the structure that permits it to retain its required residual strength for a period of unrepaired usage after the failure or partial failure of a Principal Structural Element (PSE).

3.6 Initial quality. Initial quality is a measure of the condition of the airframe relative to flaws, defects, or other discrepancies in the basic materials or introduced during manufacture of the airframe.

3.7 Multiple load path. Multiple load path is identified with redundant structures in which the applied loads would be safely distributed to other load-carrying members in the event of failure of individual elements.

3.8 Onset of widespread fatigue damage. Onset of widespread fatigue damage in a structure is characterized by the simultaneous presence of cracks at multiple structural details which are of sufficient size and density whereby the structure will no longer meet its damage tolerance requirement (e.g., maintaining required residual strength after partial structural failure).

3.9 Principal structural element (PSE). A PSE is an element of structure which contributes significantly to carrying flight, ground, and pressurization loads, and whose integrity is essential to maintenance of the overall structural integrity of the air vehicle.

3.10 Single load path. Single load path is where the applied loads are eventually distributed through a single member, the failure of which would result in the loss of the structural capability to carry the applied loads.

3.11 Structural operating mechanisms. Structural operating mechanisms are those operating, articulating, and control mechanisms which transmit structural forces during actuation and movement of structural surfaces and elements.

4. GENERAL GUIDELINES

4.1 ASIP goals. The effectiveness of any military force depends in part on the operational readiness of weapon systems. One major item of an air vehicle system that affects its operational readiness is the condition of the structure. The complete structure, herein referred to as "the airframe," includes the fuselage, wing, empennage, landing gear, control systems and surfaces, engine section, nacelle, air induction, weapon mount, engine mounts, structural operating mechanisms, and other components as described in the contract specification. The capabilities, condition, and operational limitations of the airframe of each air vehicle weapon and support system must be established to maintain operational readiness. Potential structural or material problems must be identified early in the life-cycle to minimize their impact on the operational force, and a preventive maintenance program must be determined to provide for the orderly scheduling of inspections and replacement or repair of life-limited elements of the airframe. The overall program to provide USAF air vehicles with the required airframe structural characteristics is referred to as the Aircraft Structural Integrity Program, or "ASIP." The primary purposes of the ASIP are to:

a. establish, evaluate, and substantiate the structural integrity (airframe strength, rigidity, damage tolerance, and durability) of air vehicle structures;

b. acquire, evaluate, and apply operational usage data to provide a continual update of the structural integrity of operational air vehicles;

c. provide quantitative information for decisions on force structure planning, inspection, modification priorities, and relate operational and support decisions; and

d. provide a basis to improve structural criteria and methods of design, evaluation, and substantiation for future air vehicle systems and modifications.

4.2 Primary tasks. ASIP consists of the following five, interrelated functional tasks as delineated in table I and on figures 1, 2, 3, and 4:

a. Task I (design information). Task I is development of those criteria which must be applied during design so the overall program goals will be met.

b. Task II (design analysis and development tests). Task II is development of the design environment in which the airframe must operate and the response of the airframe to the design environment.

c. Task III (full-scale testing). Task III is flight and laboratory tests of the airframe to assist in determination of the structural adequacy of the analysis and design.

d. Task IV (force management data package). Task IV is the generation of data required to manage force operations in terms of inspections, maintenance, modifications, and damage assessments when an air vehicle is flown in a manner that differs from that for which is was designed.

e. Task V (force management). Task V are those operations which must be conducted by the U.S. Air Force during force operations to ensure damage tolerance and durability throughout the useful life of individual air vehicles.

5. DETAIL GUIDELINES

5.1 Design information (Task I). The design information task encompasses those efforts required to apply the existing theoretical, experimental, applied research, and operational experience to specific criteria for materials selection and structural design for the air vehicle. The objective is to ensure the appropriate criteria and planned usage are applied to an air vehicle design so that the specific operational requirements will be met. This task begins as early as possible in the conceptual phase and is finalized in subsequent phases of the air vehicle life cycle.

5.1.1 ASIP Master Plan. The ASIP manager will translate the requirements of AFI 63-1001 into a program for each air vehicle and document these in the ASIP master plan. This plan will be integrated into the Integrated Master Plan and Integrated Master Schedule. The purpose of the ASIP master plan is to define and document the specific approach to accomplish the various ASIP tasks throughout the life-cycle of each, individual flight vehicle. The plan should depict the time-phased scheduling and integration of all required ASIP tasks for design, development, qualification, and tracking of the airframe. The plan should include discussion of unique features, exceptions to the guidance of this handbook and the associated rationale, and any problems anticipated in the execution of the plan. The development of the schedule should consider all interfaces, the impact of schedule delays (e.g., delays due to test failure), mechanisms for recovery programming, and other problem areas. The plan and schedules should be updated annually and when significant changes occur.

5.1.2 Structural design criteria. Detailed structural design criteria for the specific air vehicle should be established in accordance with the requirements of the applicable contracts. These should include design criteria for strength, damage tolerance, durability, flutter, vibration, sonic fatigue, mass properties, and weapons effects. Detailed structural design criteria guidance is provided in JSSG-2006.

5.1.2.1 Damage tolerance and durability design criteria. The airframe structure should incorporate materials, stress levels, and structural configurations which:

a. allow routine in-service inspection;

b. minimize the probability of loss of the air vehicle due to propagation of undetected cracks, flaws, or other damage; and

c. minimize cracking (including stress corrosion and hydrogen-induced cracking), corrosion, delamination, wear, and the effects of foreign object damage.

Damage tolerance design approaches should be used to ensure structural safety since undetected flaws or damage can exist in critical structural components despite design, fabrication, and inspection efforts to eliminate their occurrence. Durability structural design approaches should be used to achieve USAF weapon and support systems with low in-service maintenance costs and meet operational readiness throughout the design service goal.

5.1.2.1.1 Damage tolerance. The damage tolerance design guidance is provided in JSSG-2006 and should be applied to the principal structural elements and mission-essential structure. Damage tolerance designs are categorized into two general concepts:

a. fail-safe concepts where unstable crack propagation is locally contained through the use of multiple load paths or crack arrest structures in multiple-load-path structures, and

b. slow crack growth concepts where flaws or defects are not allowed to attain the size required for unstable, rapid propagation in single-load-path structures.

Either design concept should assume the presence of undetected flaws or damage, and should have a described residual strength-level both during and at the end, of a prescribed period of unrepaired service usage. The initial damage size assumptions, damage growth limits, residual strength requirements, and the minimum periods of unrepaired service usage depend on the type of structure and the appropriate inspectability level.

5.1.2.1.2 Durability. The durability design guidelines are provided in JSSG-2006. The airframe should be designed such that the economic life is greater by the desired margin than the design service goal when subjected to the design service loads/environment spectrum. The design service goal and typical design usage requirements will be described by the U.S. Air Force in the contract specifications for each new air vehicle. The design objective is to minimize cracking or other structural or material degradation which could result in excessive maintenance problems or functional problems such as fuel leakage, loss of control effectiveness, or loss of cabin pressure.

5.1.2.1.3 Corrosion control and prevention. Corrosion control and prevention guidelines are provided in JSSG-2006, AF Policy Directive 21-1, and AF Instruction 21-105. The goals are to control the maintenance cost burden associated with corrosion and ensure that it does not cause a safety-of-flight problem. These goals are attainable if corrosion control and prevention are addressed early in the design. Materials and processes, finishes, coatings, and films which have been proven in service or by comparative testing in the laboratory should be the basis for choices to meet the goals. Corrosion prevention should also be a primary consideration in the development and implementation of the durability and damage tolerance control process and the fleet management process.

5.1.2.2 Battle damage criteria. Where applicable, specific battle damage criteria will be provided by the U.S. Air Force. These criteria will include the threat, flight conditions, and load-carrying capability and duration after damage is imposed, etc. The structure should be designed to these criteria and to other criteria as described in JSSG-2006.

5.1.2.3 Repairability. Repairability must be designed into the air vehicle from the beginning and must be a design influence throughout the design process. Repairability is required to support production, maintain the fleet, and maximize operational readiness by repairing battle damage. High- or moderate-maintenance items and items subject to wear must be repairable. The structure should be designed to these criteria as described in JSSG-2006.

5.1.3 Durability and damage tolerance control. The System Program Office (SPO) and the contractor should prepare durability and damage tolerance control processes and conduct the resulting programs in accordance with this handbook and JSSG-2006. These processes should identify and define all the tasks necessary to ensure compliance with the damage tolerance requirements as described in 5.1.2.1.1 and JSSG-2006, and the durability requirements as described in 5.1.2.1.2 and JSSG-2006. The disciplines of fracture mechanics, fatigue, materials selection and processes, environmental protection, corrosion prevention and control, design, manufacturing, quality control, and nondestructive inspection are involved in damage tolerance and durability control. The corrosion prevention and control process should also use the guidelines in JSSG-2006. These processes should include the requirement to perform durability and damage-tolerance design concepts, material, weight, performance, cost trade studies during the early design phases to obtain low weight, and cost-effective designs which comply with the requirements of Durability, Damage tolerance, and Durability and damage tolerance control (3.11, 3.12, and 3.13; respectively) in JSSG-2006.

5.1.4 Selection of materials, processes, and joining methods. Materials, processes, and joining methods should be selected to result in a lightweight, cost-effective airframe that meets the strength, durability, and damage tolerance requirements of the applicable specifications. New materials and/or processes should have been subjected to a technology transition criteria based on: 1.) stabilized materials and processes, 2.) producibility, 3.) characterized mechanical properties, 4.) prediction of structural performance, and 5.) supportability. A primary factor in the final selection should be the results of the design concept/material/weight/cost trade studies performed as a part of the durability and damage tolerance control.

5.1.4.1 Structural materials, processes, and joining methods selection criteria. In response to the Request For Proposal (RFP), prospective contractors should identify the proposed materials, processes, and joining methods to be used in each of the structural components and the rationale for the individual selections. After contract award and during the design activity, this rationale should include all pertinent data upon which the selections were based—including the database, previous experience, and trade study results. The requirement and verification for Materials and processes (3.2.19 and 4.2.19) in JSSG-2006 should be used for material requirements and processes, respectively.

5.1.5 Design service goal and design usage. The U.S. Air Force will provide the required design service goal and typical design usage as part of the contract specifications. These data should be used in the initial design and analysis of the airframe. The design service goal and design usage will be established through close coordination between the procuring activity and the advanced planning activities (i.e., Headquarters U.S. Air Force, Headquarters Air Force Materiel Command, and using Commands). Design mission profiles and mission mixes which are realistic estimates of expected service usage will be established using requirement and verification guidelines for Service life and usage (3.2.14 and 4.2.14) in JSSG-2006. It is recognized that special force management actions will probably be required (i.e., early retirement, early modification, or rotation of selected air vehicle) if the actual usage is more severe than the design usage.

5.1.6 Nondestructive testing and inspection (NDT/I). NDT/I guidelines are provided in JSSG-2006 and MIL-HDBK-6870. Nondestructive testing and inspection requirements should be considered early in the design development and the appropriate tools and methods integrated into the overall risk management process.

5.2 Design analyses and development tests (Task II). The objectives of the design analyses and development tests task are to: 1.) determine the environments in which the airframe must operate (load, temperature, chemical, abrasive, and vibratory and acoustic environment), 2.) perform preliminary and final analyses and tests based on these environments, and 3.) size the airframe to meet the strength, rigidity, damage tolerance, and durability requirements.

5.2.1 Material and joint allowables. Materials and joint allowables data in MIL-HDBK-5, MIL-HDBK-17, MIL-HDBK-23, MCIC-HDBK-01, and WL-TR-94-40152/3/4/5/6 may be used to support the use of existing materials in various design analyses. Other data sources may also be used, but should be reviewed by the concerned SPO and contractor elements. For new materials and those existing materials for which there are insufficient data available, experimental programs to obtain the data and generate analysis test data should be formulated and performed using the requirement and verification guidelines for Materials (3.2.19.1 and 4.2.19.1) in JSSG-2006.

5.2.2 Loads analysis. Loads analysis should determine the magnitude and distribution of significant static and dynamic loads which the airframe may encounter when operated within the envelope established by the structural design criteria. This analysis consists of a determination of the flight loads, ground loads, powerplant loads, control system loads, and weapon effects. When applicable, this analysis should include the effects of temperature, aeroelasticity, and dynamic response of the airframe.

5.2.3 Design service loads spectra. Detail guidance for design service loads spectra are established in JSSG-2006 and in the contract specifications. The purpose of the design service loads spectra is to develop the distribution and frequency of loading that the airframe will experience based on the design service goal and typical design usage. The design service loads spectra and the design chemical/thermal environment spectra as defined in

5.2.4 will be used to develop design flight-by-flight stress/environment spectra as appropriate to support the various analyses and test tasks described herein.

5.2.4 Design chemical/thermal environment spectra. Detail guidance for design chemical/thermal environment spectra is in JSSG-2006. These environmental spectra should characterize the intensity, duration, frequency of occurrence, etc.

5.2.5 Stress analysis. A stress analysis should consist of the analytical determination of the stresses, deformation, and margins-of-safety which result from the external loads and temperatures imposed on the airframe. In addition to verification of strength, the stress analysis should be used as a basis for durability and damage-tolerance analyses, selection of critical structural components for design development tests, material review actions, and selection of loading conditions to be used in the structural strength tests. The stress analysis is also used as a basis to determine the adequacy of structural changes throughout the life of the air vehicle and to determine the adequacy of the structure for new loading conditions which result from increased performance or new mission requirements. The stress analysis should be revised to reflect any major changes to the airframe or to the loading conditions applied to the airframe.

5.2.6 Damage tolerance analysis. Detail guidance for damage tolerance analysis is contained in the requirement and verification for Damage tolerance (3.12 and 4.12) in JSSG-2006. The purpose of this analysis is to substantiate the ability of the structural components to comply with the detail requirements for damage tolerance. The design flight-by-flight stress/environment spectra based on the requirements of 5.2.3 and 5.2.4 should be used in the damage growth analysis and verification tests. The calculations of critical flaw sizes, residual strengths, safe crack growth periods, and inspection intervals should be based on existing fracture test data and basic fracture allowables data generated as a part of the design development test program. The effect of variability in fracture properties on the analytical results should be accounted for in the damage tolerance design.

5.2.7 Durability analysis. Detail guidance for durability is contained in the requirement and verification for Durability (3.11 and 4.11) in JSSG-2006. The purpose of this analysis is to substantiate the ability of the structure to comply with the detail requirements for durability. The design flight-by-flight stress/environment spectra based on the requirements of 5.2.3 and 5.2.4 should be used in the durability analysis and verification tests. The analysis approach should account for those factors which affect the time for cracks or equivalent damage to reach sizes large enough to cause uneconomical functional problems, repair modification, or replacement. These factors should include initial quality and initial quality variations, chemical/thermal environment, load sequence and environment interaction effects, material property variations, and analytical uncertainties. In addition to providing analytical assurance of a durable design, the durability analysis will provide a basis for development of test load spectra to be used in the design development and full-scale durability tests.

5.2.8 Aeroacoustic durability analysis. Utilize the verification guidance for Vibration and aeroacoustics, Aeroacoustic disability, Structures, and Analyses (4.4.3, 4.5, 4.5.1, and 4.5.1.1; respectively) in JSSG-2006 to comply with the requirements for sonic durability of the contract. The objective of the sonic durability analysis is to ensure the airframe is resistant to sonic durability cracking throughout the design service goal. The analysis should define the intensity of the acoustic environment from potentially critical sources and should determine the dynamic response, including significant thermal effects. Potentially-critical sources include but are not limited to powerplant noise, aerodynamic noise in regions of turbulent and separated flow, exposed cavity resonance, and localized vibratory forces.

5.2.9 Vibration analysis. Utilize the verification guidance for Ramps, Vibration, and Analyses (4.3.3, 4.6, and 4.6.1; respectively) in JSSG-2006 to comply with the requirements for vibration analysis specified in the contract. The analysis should predict the resultant environment in terms of vibration levels in various areas of the air vehicle such as the crew compartment, cargo areas, equipment bays, etc. The vibration analyses, in conjunction with the durability analyses of 5.2.7, should show that the structure in each of these areas is resistant to cracking due to vibratory loads throughout the design service goal. In addition, the analyses should show that the vibration levels are suitable for the reliable performance of personnel and equipment throughout the design-life of the air vehicle.

5.2.10 Flutter analysis. Utilize the verification guidance for Aeroelasticity (4.7) in JSSG-2006 to comply with the detail requirements for aeroelastic (flutter divergence and other related aeroservoelastic or aeroservoelastic instabilities) analyses. These analyses should determine the characteristics of the air vehicle for flutter, divergence, and other related aeroelastic or aeroservoelastic instabilities. The primary objective of the analyses is to substantiate the ability of the air vehicle structure to meet the specified flutter (including divergence and other related aeroelastic or aeroservoelastic instabilities), airspeed margins, and damping requirements for all design conditions. Analyses for design failure conditions should also be conducted.

5.2.11 Mass properties analysis. A Mass Properties Control and Management Process (MPCMP) should be implemented and the results provided to the U.S. Air Force. Vehicle mass properties estimates should be established based on the Initial Operational Capability (IOC) air vehicle. Analysis should continue throughout this task and be provided to the U.S. Air Force. Detail guidance may be found in JSSG-2006 and Society of Allied Weight Engineers (SAWE) Recommended Practice number 7 (RP #7).

5.2.12 Nuclear weapons effects analyses. Detail requirements for nuclear weapons effects analyses are contained in the requirement and verification for Required structure survivability - nuclear (3.8 and 4.8) in JSSG-2006. The objectives of the nuclear weapons effects analyses are to:

a. verify the design of the airframe will successfully resist the described environmental conditions with no more than the described residual damage, and

b. determine the structural capability envelope and crew radiation protection envelope for other degrees of survivability (damage) as may be required.

These criteria and nuclear weapons effects analyses should be conducted for transient thermal, overpressure, and gust loads and provide the substantiation of allowable structural limits on the structures critical for these conditions. The nuclear weapons effects capability envelope—including crew radiation protection, for a specified range of variations of weapon delivery trajectories, weapon size, air vehicle escape maneuvers, and the resulting damage limits—should also be defined.

5.2.13 Nonnuclear weapons effects analysis. Guidance for nonnuclear weapons effects analysis is contained in the requirement and verification for Required structure survivability - nonnuclear (3.9 and 4.9) in JSSG-2006.

5.2.14 Design development tests. Detail guidance for design development tests are contained in JSSG-2006. The objectives of the design development tests are to establish material and joint allowables; to verify analysis procedures; to obtain early evaluation of allowable stress levels, material selections, fastener systems, and the effect of the design chemical/thermal environment spectra; to establish flutter and loads characteristics through wind tunnel tests; and to obtain early evaluation of the strength, durability (including aeroacoustic and vibration durability), and damage tolerance of critical structural components and assemblies. Examples of design development tests are tests of coupons; small elements; splices and joints; panels; fittings; control system components and structural operating mechanisms; and major components such as wing carry through, horizontal tail spindles, wing pivots, and assemblies thereof. The scope of the proposed test program should be included in the response to the request for proposal and should be included in the ASIP Master Plan which is included in the Integrated Master Plan (IMP) and Integrated Master Schedule (IMS). The plans should consist of information such as rationale for selection of scope of tests; description of test articles, procedures, test loads and test duration; and analysis directed at establishing cost and schedule trade-offs used to develop the program.

5.3 Full-scale testing (Task III). The objective of this task is to assist in the determination of the structural adequacy of the basic design through a series of ground and flight tests.

5.3.1 Static tests. Detail verification guidance is contained in Static strength (4.10.5) in JSSG-2006. The test plans, procedures, and schedules should be reviewed by the SPO and the contractor prior to test initiation. The static test program should consist of a series of laboratory tests conducted on an instrumented airframe that simulate the loads which result from critical flight and ground handling conditions. Thermal environment effects should be simulated, along with the load application on airframes where operational environments impose significant thermal effects. The primary purpose of the static test program is to verify the static strength analyses and the design ultimate strength capabilities of the airframe. Full-scale static tests to design ultimate loads should be conducted except:

a. where it is shown that the airframe and its loading are substantially the same as that used on previous air vehicles where the airframe has been verified by full-scale tests, or

b. where the strength margins (particularly for stability critical structure) have been demonstrated by major assembly tests.

When full-scale ultimate load static tests are not performed, it should be a program requirement to conduct a strength demonstration proof test. Deletion of the full-scale ultimate load static tests is generally unacceptable. Functional- and inspection-type proof test requirements should be developed with the guidance of JSSG-2006.

5.3.1.1 Schedule requirement. Full-scale static tests should be scheduled such that the tests are completed in sufficient time to allow removal of the 80-percent limit restrictions on the flight test air vehicle and allow unrestricted flight within the design envelope to be performed on schedule. The guidance of JSSG-2006 is recommended.

5.3.2 Durability tests. The detail verification guidance for Durability tests (4.11.1.2.2) in JSSG-2006 should be utilized. Prior to initiation of testing, the test plans, procedures, and schedules should be reviewed by the SPO and the contractor. Durability tests of the airframe should consist of repeated application of the flight-by-flight design service loads/environment spectra. The objectives of the full-scale durability tests are to:

a. demonstrate that the economic life of the test article is equal to or greater than the design service goal by the desired margin,

b. identify critical areas of the airframe not previously identified by analysis or component testing, and

c. provide a basis for special inspection and modification requirements for force air vehicles.

5.3.2.1 Selection of test articles. The test article should be an early System Development & Demonstration-phase test airframe and should be as representative of the operational configuration as practical. If there are significant design, material, or manufacturing changes between the test article and production air vehicle, durability tests of an additional article or selected components and assemblies thereof should be required.

5.3.2.2 Test scheduling. The full-scale airframe durability test should be scheduled according to the verification guidance of Durability tests - Duration (4.11.1.2.2.f) in JSSG-2006. One lifetime of durability testing plus an inspection of critical structural areas should be completed prior to a full production go-ahead decision. Two lifetimes of durability testing plus an inspection of critical structural areas should be scheduled to be completed prior to delivery of the first production air vehicle. If the economic life of the test article is reached prior to two lifetimes of durability testing, sufficient inspection in accordance with 5.3.2.3.a, 5.3.2.3.b, and data evaluation should be completed prior to delivery of the first production air vehicle to estimate the extent of required production changes and retrofit. In the event the original schedule for the production decision and production delivery milestones become incompatible with the above schedule requirements, a study should be conducted to assess the technical risk and cost impacts of changing these milestones. An important consideration in the durability test program is that it be completed at the earliest practical time, but after Critical Design Review (CDR).

5.3.2.3 Inspections. Inspection programs should be conducted as an integral part of the full-scale airframe durability test. The inspection programs should be reviewed by the SPO and the contractor. These inspection programs should consist of:

a. monitored progress of the durability test and verification or redefinition of the analytically-defined critical areas,

b. design inspections in accordance with verification of Durability tests - Inspections (4.11.1.2.2.e) in JSSG-2006, and

c. special inspections to monitor the status of critical areas and to support the milestone schedule of 5.3.2.2.

5.3.2.4 Test duration. The minimum durability test duration should be defined per the verification guidance of Durability tests (4.11.1.2.2) in JSSG-2006. It may be advantageous to the U.S. Air Force to continue testing beyond the minimum requirement to: 1.) determine life-extension capabilities, 2.) validate design-life capability for usage that is more severe than design usage, 3.) validate repairs, modifications, and changes, and 4.) support damage tolerance requirements.

5.3.3 Damage tolerance tests. Verification guidance for damage tolerance tests is contained in subparagraph b of Residual strength and damage growth limits (4.12.2.b) in JSSG-2006. Prior to initiation of testing, the test plans, procedures, and schedules should be reviewed by the SPO and the contractor. The intent should be to conduct damage tolerance tests on existing test hardware. This may include use of components and assemblies of the design development tests as well as the full-scale static and durability test articles. When necessary, additional structural components and assemblies should be selected, fabricated, and tested.

5.3.4 Flight and ground operations tests. Verification guidance for detail planning for flight and ground operations tests is found in Ground loading conditions (4.4.2) in JSSG-2006. An air vehicle in the early System Development & Demonstration phase should be used to perform the flight and ground operations tests. Load measurements should be made by the strain gage or pressure survey methods commensurate with the latest state-of-the-art, usually installed during production buildup. An additional air vehicle, sufficiently late in the production program to ensure obtainment of the final configuration, should be the backup air vehicle for these flight tests and should be instrumented similarly to the primary test air vehicle. These tests should include a flight and ground loads survey and dynamic response tests.

5.3.4.1 Flight and ground loads survey. The flight and ground loads survey program should consist of an instrumented and calibrated air vehicle operated within and to the extremes of its limit structural design envelope to measure the resulting loads and, if appropriate, to also measure pertinent temperature profiles on the air vehicle structure. The objectives of the loads survey should be as follow:

a. Verify the structural loads and temperature analysis used in the design of the airframe.

b. Evaluate loading conditions which produce the critical structural load and temperature distribution.

c. Determine and define suspected new critical loading conditions which may be indicated by the investigations of structural flight conditions within the design-limit envelope.

5.3.4.2 Dynamic response tests. The dynamic response tests should consist of an instrumented and calibrated air vehicle operated to measure the structural loads and inputs while flown through atmospheric turbulence and during taxi, takeoff, towing, landing, refueling, store ejection, etc. The objectives should be to obtain flight verification and evaluation of the elastic response characteristics of the structure to these dynamic load inputs so the loads analysis, fatigue analysis, and interpretation of the operational loads data can be substantiated or corrected.

5.3.5 Aeroacoustic durability tests. Utilize the verification guidance for sonic durability tests of Vibration and aeroacoustics, Aeroacoustic durability, Structure, Tests (4.4.3, 4.5, 4.5.1, 4.5.1.2; respectively), and subparagraphs in JSSG-2006. Prior to initiation of testing, the test plans, procedures, and schedules should be reviewed by the SPO and the contractor. Measurements should be made of the acoustic environments on a full-scale air vehicle to verify or modify the initial design aeroacoustic loads/environment. The sonic durability test should be conducted on a representative air vehicle (or its major components) to demonstrate structural adequacy for the design service goal. Sonic durability tests are normally accomplished by ground testing of the complete air vehicle with the power plants operating at full power for a time sufficient to assure design service goal. However, testing of major portions of the air vehicle in special non-reverberate ground test stands using the air vehicle propulsion system as the noise source, or in high-intensity noise facilities, may be acceptable.

5.3.6 Flight vibration tests. Utilize the verification guidance for flight vibration tests of Vibration and Aeroacoustics, Vibration, and Tests (4.4.3, 4.6, and 4.6.2; respectively), and subparagraphs in JSSG-2006. Prior to initiation of testing, the test plans, procedures, and schedules should be reviewed by the SPO and the contractor. These tests should be conducted to verify the accuracy of the vibration analysis. In addition, the test results should be used to demonstrate that vibration control measures are adequate to prevent cracking and to provide reliable performance of personnel and equipment throughout the design service goal.

5.3.7 Flutter tests. Verification guidance for flutter-related tests is in Aeroelasticity (4.7) in JSSG-2006. Flutter-related tests should include such tests as ground vibration tests, aeroservoelastic ground tests, stiffness tests, control surface free play and rigidity tests, and flight flutter tests.

5.3.7.1 Ground vibration tests and aeroservoelastic ground tests. Ground vibration tests consist of the experimental determination of the natural frequencies, mode shapes, and structural damping of the airframe or its components. The objectives of these ground tests are to obtain data to validate, and revise if required, the dynamic mathematical models which are used in dynamic analyses, aeroelastic (including flutter), and aeroservoelastic stability analyses.

5.3.7.2 Structural rigidity tests. Thermoelastic tests, stiffness tests, and control surface free play and rigidity tests consist of the experimental determination of the structural elastic and free play properties of the airframe and its components. The objective of these tests is to verify supporting data used in aeroelastic analyses and dynamic model design.

5.3.7.3 Flight flutter tests. Flight flutter tests are conducted to verify the airframe is free from aeroelastic instabilities and has satisfactory damping throughout the operational flight envelope.

5.3.8 Mass properties testing. The air vehicle should be weighed to verify the air vehicle weight and balance are as predicted and within limits for all design conditions. The results of this test should be documented and provided to the U.S. Air Force. Guidance may be found in JSSG-2006 and Society of Allied Weight Engineers (SAWE) Recommended Practice number 7 (RP #7).

5.3.9 Interpretation and evaluation of test results. Each structural problem (failure, cracking, yielding, etc.) that occurs during the tests described by this handbook should be analyzed to determine the cause, corrective actions, force implications, and estimated costs. The scope and interrelations of the various tasks within the interpretation and evaluation effort are illustrated on figures 2 through 4. The results of this evaluation should define corrective actions required to demonstrate that the strength, rigidity, damage tolerance, and durability design requirements are met. The cost, schedule, and other impacts which result from correction of deficiencies will be used to make major program decisions such as major redesign, program cancellation, awards or penalties, and production air vehicle buys. Structural modifications or changes derived from the results of the full-scale test to meet the specified strength, rigidity, damage tolerance, and durability design requirements should be substantiated by subsequent tests of components, assemblies, or full-scale article, as appropriate (see figure 3).

5.4 Force management data package (Task IV). Maintenance of strength, rigidity, damage tolerance, and durability is dependent on the capability of the appropriate U.S. Air Force Commands to perform specific inspection, maintenance, and possibly modification or replacement tasks at specific intervals throughout the service goal (i.e., at specified depot- or base-level maintenance times and special inspection periods). The U.S. Air Force must have detailed knowledge of the required actions to perform these tasks properly. Additionally, experience has shown the actual usage of military air vehicles may differ significantly from the assumed original design usage. It is necessary that the U.S. Air Force have the technical methods and actual usage data to assess the effect of these changes in usage on air vehicle damage tolerance and durability. Task IV describes the minimum required elements of a data package so the U.S. Air Force can accomplish the force management tasks as described in 5.5.

5.4.1 Final analyses. Preliminary design analyses should be revised as appropriate to account for significant differences revealed between analysis and test during the full-scale tests, and later during the loads/environment spectra survey.

5.4.1.1 Initial update of analyses. The design analyses as described in 5.2 should be revised when the results of the design development and full-scale tests as described in 5.2.14 through 5.3.8 are available. These initial updates will be used to identify the causes of problems, corrective actions, and production and force modifications required by the interpretation and evaluation of test results task as described in 5.3.9.

5.4.1.2 Final update of analyses. The initial update of the damage tolerance and durability analyses should be revised to reflect the baseline operational spectra as described in 5.4.4.2. These analysis updates should form the basis for preparation of the updated force structural maintenance documentation as described in 5.4.3. The documentation should identify the critical areas, damage growth rates, and damage limits required to establish the damage tolerance and durability inspection and modification requirements and economic life estimates.

5.4.1.3 Development of inspection and repair criteria. The appropriate analyses (stress, damage tolerance, durability, etc.) should be used to develop a quantitative approach to inspection and repair criteria. Allowable damage limits and damage growth rates established by the analyses should be used to develop inspection and repair times for structural components and assemblies. These analyses should also be used to develop detailed repair procedures for use at field or depot level. Special attention should be placed on defining damage acceptance limits and damage growth rates for components utilizing bonded, honeycomb, or advanced composite types of construction. These inspection and repair criteria should be incorporated into the force structural maintenance documentation as described in 5.4.3.

5.4.2 Strength summary. A strength summary and operating restrictions document should summarize the final analyses and other pertinent structures data into a format which will provide rapid visibility of the important structures characteristics, limitations, and capabilities in terms of operational parameters. It is desirable that the summary be primarily in a diagrammatic form that shows the air vehicle structural limitations and capabilities as a function of the important operational parameters such as speed, acceleration, center-of-gravity location, and gross weight. The summary should include brief descriptions of each major structural assembly, also preferably in diagrammatic form, that indicates structural arrangements, materials, critical design conditions, damage tolerance and durability critical areas, and minimum margins of safety. Appropriate references to design drawings, detail analyses, test reports, and other back-up documentation should be indicated.

5.4.3 Force structural maintenance documentation. Force structural maintenance documentation should be created to identify inspection and modification requirements and the estimated economic life of the airframe. Complete detailed information (when, where, how, and cost data as appropriate) should be included in the documentation. It is intended that the U.S. Air Force will use this plan to establish budgetary planning, force structure planning, and maintenance planning. To support documentation changes to account for operation beyond the design service goal, repairs, corrosion, or potential of loss of fail-safety from the onset of widespread fatigue damage, the following information should be included:

a. finite element models of the structure

b. loads and spectrum generation database

c. materials database

d. crack growth analysis procedures.

5.4.4 Loads/environment spectra survey. The objective of the loads/environment spectra survey is to obtain time history records of those parameters necessary to define the actual stress spectra for the critical areas of the airframe. It is envisioned that 100-percent of the operational air vehicle will be instrumented to measure such parameters as velocity, accelerations, altitude, fuel usage, temperature, strains, etc. Ten- to twenty-percent of the data will be captured by the U.S. Air Force as part of the force management task as described in 5.5 and should be used to construct the baseline operational spectrum as described in 5.4.4.2. Data acquisition should start with delivery of the first operational air vehicle. The data would also be available to detect when a significant change in usage occurs to require an update in the baseline operational spectra. If the individual air vehicle tracking program as described in 5.4.5 obtains sufficient data to develop the baseline operational spectra and detect significant usage changes, a separate survey program (or continuation thereof) as described herein may not be required.

5.4.4.1 Data processing provisions. Data processing provisions (including reformatting) and computer analysis methods should be compatible with the U.S. Air Force data analysis system. It is envisioned that facilities and personnel, except for reformatting/transcribing and other data processing and analysis functions for which capabilities exist within the U.S. Air Force and are approved for use, will be used to process data collected during a defined period beginning with delivery of the first production air vehicle. Plans for transfer of data processing provisions to U.S. Air Force facilities including training of U.S. Air Force personnel should be determined prior to contract signature.

5.4.4.2 Analysis of data and development of baseline operational spectra. These flight data will be used to assess the applicability of the design and durability test loads/environment spectra and to develop baseline operational spectra. The baseline operational spectra should be used to update the durability and damage tolerance analyses as described in 5.4.1.2 when a statistically-adequate amount of data has been recorded. Subsequent revisions of the baseline operational spectra may be required when mission requirements change.

5.4.5 Individual air vehicle tracking program. The objective of the individual air vehicle tracking program is to predict potential flaw growth in critical areas of each airframe which are key to verification damage growth limits of Sensitivity analysis (4.14) in JSSG-2006, inspection times, and economic repair times. It is envisioned that 100-percent of the fleet will be instrumented with a goal that 100-percent of the data will be captured. In practice, capture of 90- to 95-percent of the data is considered reasonable. Data acquisition should start with delivery of the first operational air vehicle. The program should include serialization of major components (e.g., wings, horizontal and vertical stabilizers, landing gears, etc.) so component tracking can be implemented by the U.S. Air Force.

5.4.5.1 Tracking analysis method. An individual air vehicle tracking analysis method should be developed to establish and adjust inspection and repair intervals for each critical area of each airframe, based on the individual air vehicle usage data. Damage tolerance and durability analyses and associated test data will be used to establish the analysis method. These analyses will provide the capability to predict crack growth rates, time to reach the crack size limits, and the crack length as a function of the total flight time and usage. The computer analysis method should be compatible with the U.S. Air Force data analysis system.

5.4.5.2 Data acquisition provisions. The recording system should be as simple as possible and should be the minimum required to monitor those parameters necessary to support the analysis methods as described in 5.4.5.1. Instrumentation and flight data recording equipment should be available to accomplish the necessary functions outlined above for individual air vehicle usage and to recognize changes in operational mission usage.

5.5 Force management (Task V). Task V includes those actions which must be conducted by the U.S. Air Force during force operations to ensure the damage tolerance and durability of each air vehicle. Task V will be primarily the responsibility of the U.S. Air Force and will be performed by the appropriate Commands, which will utilize the data package supplied in Task IV.

5.5.1 Loads/environment spectra survey. The ASIP manager will be responsible for the overall planning and management of the loads/environment spectra survey and will:

a. establish data collection procedures and transmission channels within the U.S. Air Force;

b. train squadron-, base-, and depot-level personnel as necessary to ensure the acquisition of acceptable quality data;

c. maintain and repair the instrumentation and recording equipment; and

d. ensure the data are of acceptable quality and are obtained in a timely manner to analyze the data, develop the baseline spectrum (see 5.4.4.2), and update the analyses (see 5.4.1.2) and force structural maintenance documentation (see 5.4.3).

The ASIP manager will also be responsible to ensure survey data are obtained for each type of usage that occurs within the force (training, reconnaissance, special tactics, etc.). Subsequent to completion of the initial data-gathering effort, the U.S. Air Force will elect whether or not to continue to operate either all or a portion of the instrumentation and recording equipment aboard the survey air vehicle to support additional updates of the baseline spectra and inspection and maintenance information to update the -6 and -36 Technical Orders.

The initial survey period would typically last three to five years after Initial Operating Capability (IOC); however, the period may be longer for systems with a wide variety of usage types or a slow ramp-up of operations. If it is determined by the U.S. Air Force that the force usage survey data collection should be continued, the ASIP manager will, with Program Director and Lead/Operating Command participation and coordination, establish and document minimum baselined loads/environment spectra survey data requirements and revalidate them on an annual basis. This minimum data requirement will become a part of the baseline to maintain airworthiness certification for the system. The USAF does not have a simple formula to determine the amount of data to be collected on a given system at any point in time after the initial survey. The minimum amount of survey data required depends heavily on the type of air vehicle, mission flexibility, fleet size, possible basing scenarios, communication with the operators, statistical sample size considerations, and the capability of the individual air vehicle tracking system to detect mission changes. As an initial planning number, it is recommended the force usage spectra data requirement be established as an average of ten-percent of the anticipated usage over a five-year period. The initially-established requirement and any subsequent revisions of the requirement will be approved by SAF/AQ upon the recommendation of the Technical Advisor for Aircraft Structural Integrity from ASC/EN, Wright-Patterson AFB OH.

5.5.2 Individual air vehicle tracking data. The ASIP manager will be responsible for the overall planning and management of the individual air vehicle tracking data gathering effort and will:

a. establish data collection procedures and data transmission channels within the U.S. Air Force;

b. train squadron-, base-, and depot-level personnel as necessary to ensure the acquisition of acceptable quality data;

c. maintain and repair the instrumentation and recording equipment; and

d. ensure the data are obtained and processed in a timely manner to provide adjusted maintenance times for each critical area of each air vehicle.

5.5.3 Individual air vehicle maintenance times. The ASIP manager will be responsible to derive individual maintenance (inspection and repair) times for each critical area of each air vehicle by use of the tracking analysis methods as specified in 5.4.5.1 and the individual air vehicle tracking data as specified in 5.5.2. The objective is to determine adjusted times at which the force structural maintenance actions as specified in 5.4.3 have to be performed on individual air vehicles and each critical area thereof. With the force structural maintenance data and the individual air vehicle maintenance time requirements available, the U.S. Air Force can schedule force structural maintenance actions on a selective basis that accounts for the effect of usage variations on structural maintenance intervals.

5.5.4 Structural maintenance records. The SPO and the Using Command will be responsible to maintain structural maintenance records (inspection, repair, modification, and replacement) for individual air vehicles. These records should contain complete listings of structural maintenance actions which are performed, and should include all pertinent data (Time Compliant Technical Order [TCTO] action, component flight time, component and air vehicle serial number, etc.). The Maintenance Requirements Review Board (MRRB) is one forum used by
Air Force Materiel Command and Using Commands to review selected or summary records on an annual basis.

5.5.5 Weight and balance records. Weight and balance actions that must be conducted by the air vehicle user during operations to ensure the air vehicle remains within its design restrains should be established and provided by the contractor. Guidance may be found in Society of Allied Weight Engineers Recommended Practice Number 7 (SAWE RP #7), T.O. 1-1B-40, and T.O. 1-1B-50.

6. NOTES

6.1 Intended use. This handbook is intended as a general guide to establish and conduct an ASIP. Contractual documents should contain tailored requirements for each program, based on the guidance contained herein.

6.2 Supersession data. This document supersedes MIL-HDBK-1530, dated 31 October 1996.

6.3 Data requirements. The long-term operation and maintenance of U.S. Air Force air vehicles and equipment is directly dependent on the availability of certain structural data developed during an ASIP. These databases are used to establish, assess, and support inspections; maintenance activities; repairs; modification tasks; and replacement actions for the life of the airframe. The contract should contain provisions which ensure these data are available to the U.S. Air Force and to relevant contractors and subcontractors throughout the operational life of the system. The following list is provided as a general guide to the necessary data. This list should be tailored based on system operational requirements, the support concept/strategy, the guidance contained in this document, and the guidance contained in the handbook section of JSSG-2006. To the maximum extent feasible, this data should remain with the prime contractor, with access as required by government agencies. Data delivery should be kept to the minimum required to accomplish specific organic responsibilities during post-production phases.

a. SIP portions of the IMP and IMS (See 5.1.1.)
b. Structural design criteria (See 5.1.2.)
c. Damage tolerance and durability control process (See 5.1.3.)
d. Selection of materials, processes, and joining methods (See 5.1.4.)
e. Design service goal and design usage (See 5.1.5.)
f. Material and joint allowables (See 5.2.1.)
g. Loads analysis (See 5.2.2.)
h. Design service loads spectra (See 5.2.3.)
i. Design chemical/thermal environment spectra (See 5.2.4.)
j. Stress analysis (See 5.2.5.)
k Damage tolerance analysis (See 5.2.6.)
l. Durability analysis (See 5.2.7.)
m. Aeroacoustic durability analysis (See 5.2.8.)
n Vibration analysis (See 5.2.9.)
o. Flutter analysis (See 5.2.10.)
p. Nuclear weapons effects analyses (See 5.2.12.)
q. Nonnuclear weapons effects analysis (See 5.2.13.)
r. Static tests (See 5.3.1.)
s. Durability tests (See 5.3.2.)
t. Damage tolerance tests (See 5.3.3.)

u. Flight and ground operations tests (See 5.3.4.)
v. Aeroacoustic durability tests (See 5.3.5.)
w. Flight vibration tests (See 5.3.6.)
x. Flutter tests (see 5.3.7.)
y. Strength summary (See 5.4.2.)
z. Force structural maintenance plan (See 5.4.3.)
aa. Loads/environment spectra survey (See 5.4.4.)
bb. Individual air vehicle tracking program (See 5.4.5.)
cc. Loads/environment spectra survey (See 5.5.1.)
dd. Individual air vehicle tracking data (See 5.5.2.)
ee. Individual air vehicle maintenance times (See 5.5.3.)
ff. Structural maintenance records (See 5.5.4.)
gg. Mass Properties Control and Management Process (MPCMP) data (See 5.2.11.)
hh. Weight and Balance data for Air Vehicles (See 5.2.11 and 5.3.8.)
ii. Sample Charts A and E data (See 5.5.5.)
jj. Analytical Condition Inspection (ACI) results (See AFMCI 21-102.)

6.4 Subject term (key word) listing.

Aeroacoustics
Aging Aircraft
Airframe
ASIP
Battle Damage
Corrosion
Cracking
Damage Tolerance
Durability
Fatigue
Flutter
Loads
Maintenance
Mass
NDT/I
Off-the-Shelf Aircraft
Repairability
Strength
Stress
Vibration
Weight and Balance

6.5 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue, due to the extent of the changes.

TABLE I. USAF Aircraft Structural Integrity Program tasks.

TASK I	TASK II	TASK III	TASK IV	TASK V
DESIGN INFORMATION	**DESIGN ANALYSIS AND DEVELOPMENT TESTS**	**FULL-SCALE TESTING**	**FORCE MANAGEMENT DATA PACKAGE**	**FORCE MANAGEMENT**
ASIP MASTER PLAN	MATERIALS AND JOINT ALLOWABLES	STATIC TESTS	FINAL ANALYSES	LOADS/ ENVIRONMENT
STRUCTURAL DESIGN CRITERIA	LOAD ANALYSES	DURABILITY TESTS	STRENGTH SUMMARY	SPECTRA SURVEY
DAMAGE TOLERANCE & DURABILITY CONTROL PROCESS	DESIGN SERVICE LOADS SPECTRA	DAMAGE TOLERANCE TESTS	FORCE STRUCTURAL MAINTENANCE PLAN	INDIVIDUAL AIR VEHICLE TRACKING DATA
SELECTION OF MATERIALS, PROCESSES, & JOINING METHODS	DESIGN CHEMICAL/ THERMAL ENVIRONMENT SPECTRA	FLIGHT & GROUND OPERATIONS TESTS	LOADS/ ENVIRONMENT SPECTRA SURVEY	INDIVIDUAL AIR VEHICLE MAINTENANCE TIMES
DESIGN SERVICE GOAL AND DESIGN USAGE	STRESS ANALYSIS	AEROACOUSTIC TESTS	INDIVIDUAL AIR VEHICLE TRACKING PROGRAM	STRUCTURAL MAINTENANCE RECORDS
MASS PROPERTIES	DAMAGE TOLERANCE ANALYSIS	FLIGHT VIBRATION TESTS		WEIGHT AND BALANCE RECORDS
	DURABILITY ANALYSIS	FLUTTER TESTS		
	AEROACOUSTICS ANALYSIS	INTERPRETATION & EVALUATION OF TEST RESULTS		
	VIBRATION ANALYSIS	WEIGHT AND BALANCE TESTING		
	FLUTTER ANALYSIS			
	EFFECTS ANALYSIS NUCLEAR WEAPONS			
	EFFECTS ANALYSIS NON-NUCLEAR			
	WEAPONS EFFECTS ANALYSIS			
	DESIGN DEVELOPMENT TESTS			
	MASS PROPERTIES ANALYSIS			

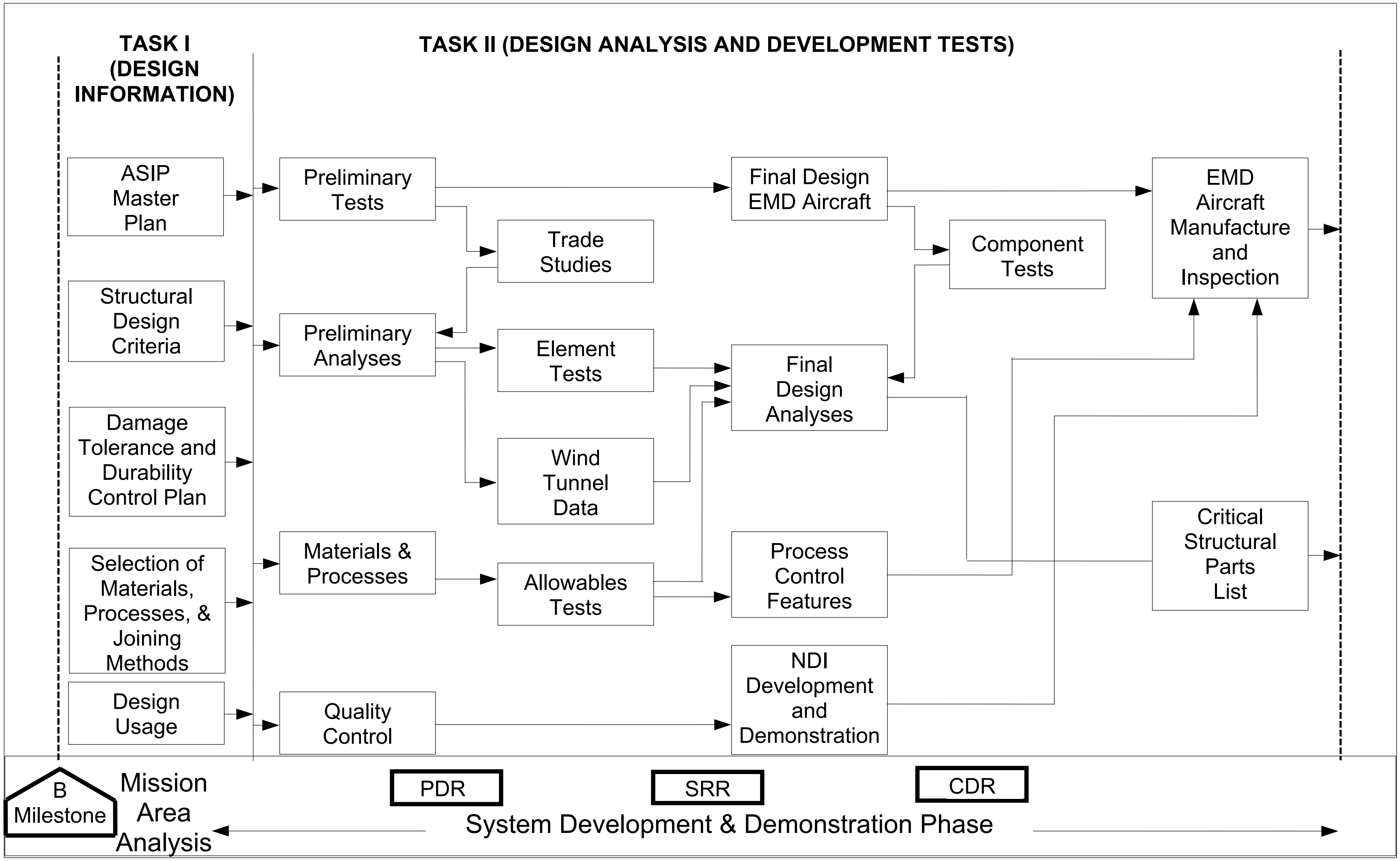

FIGURE 1. Aircraft Structural Integrity Program - Part 1.

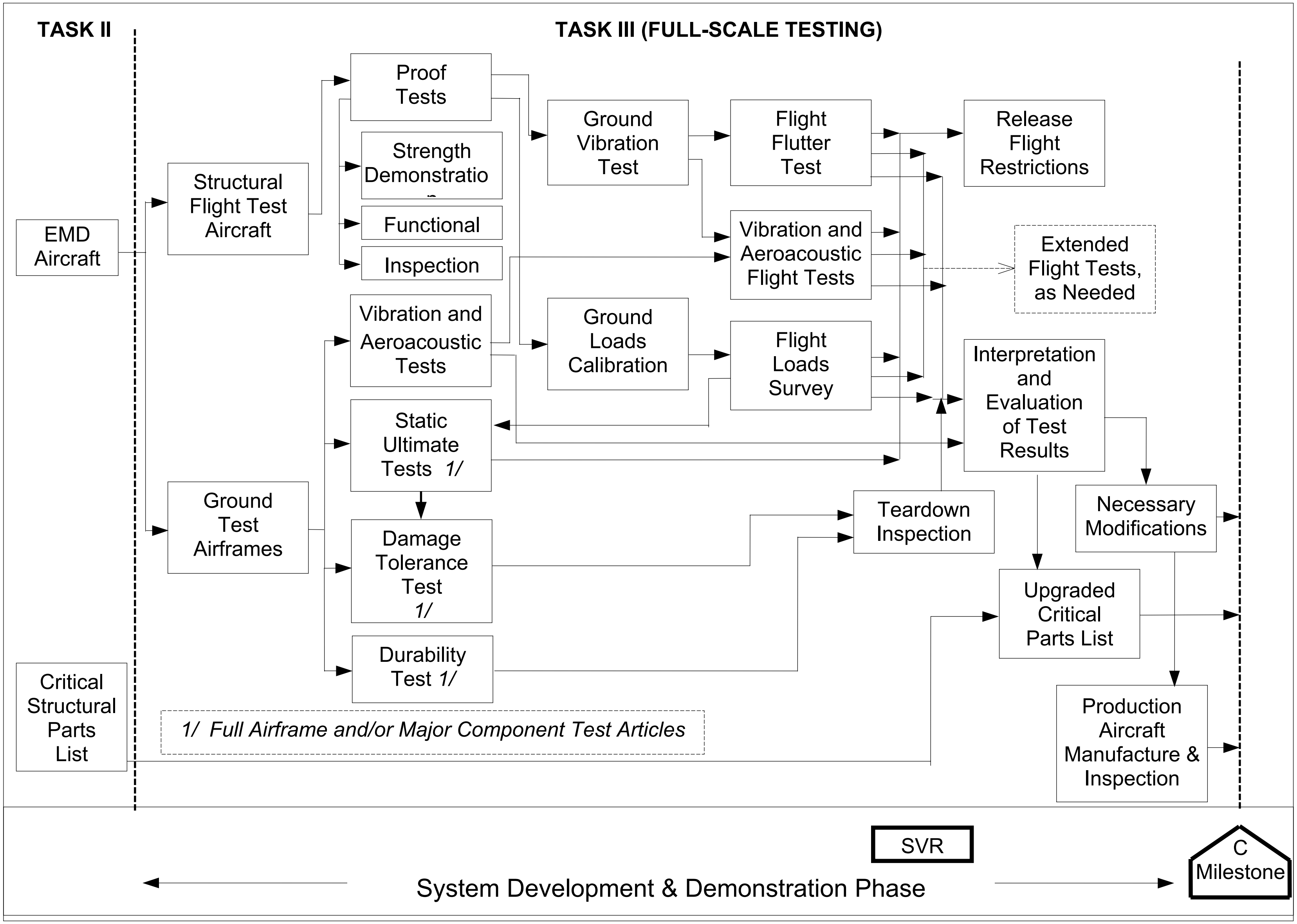

FIGURE 2. Aircraft Structural Integrity Program - Part 2.

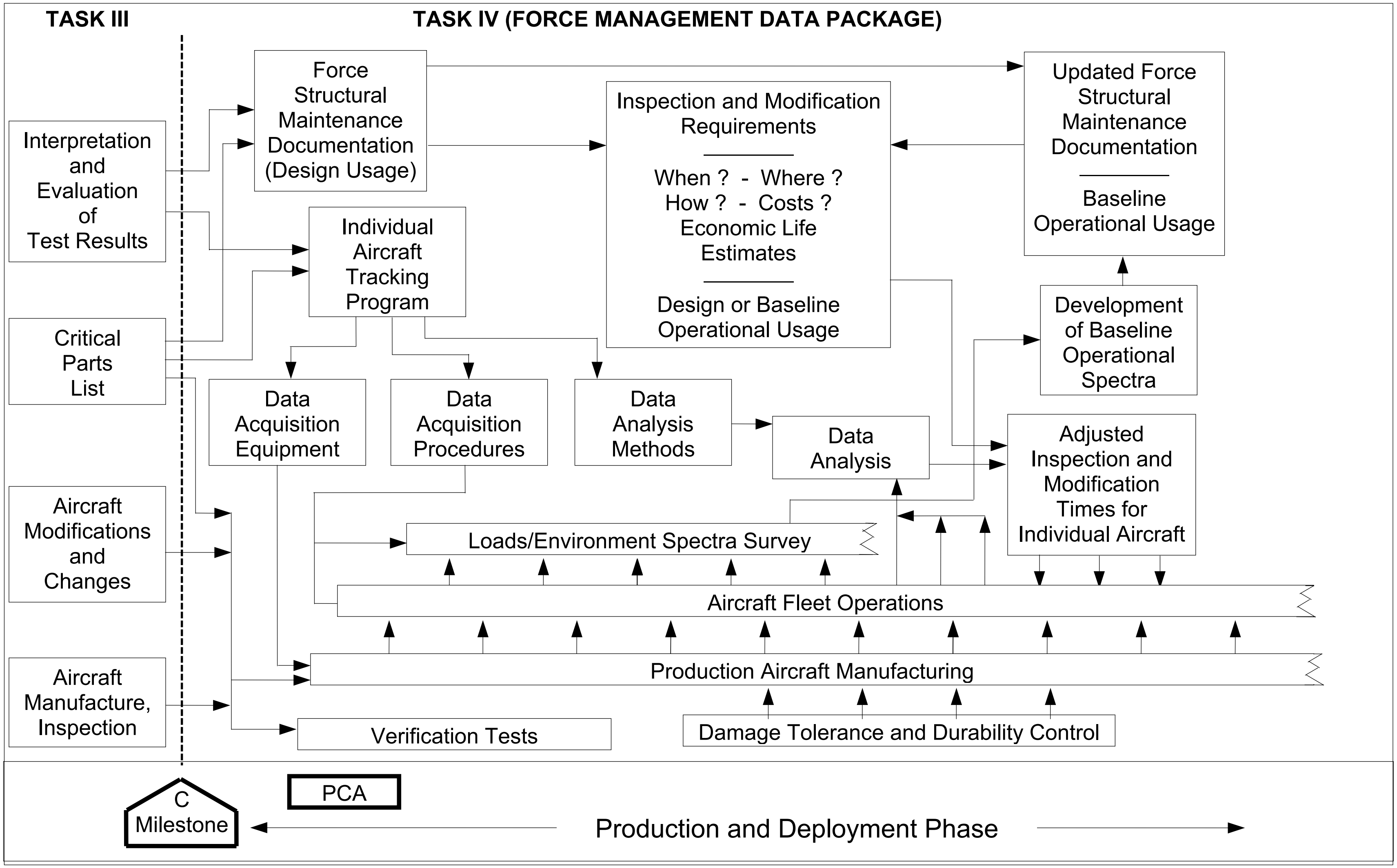

FIGURE 3. Aircraft Structural Integrity Program - Part 3.

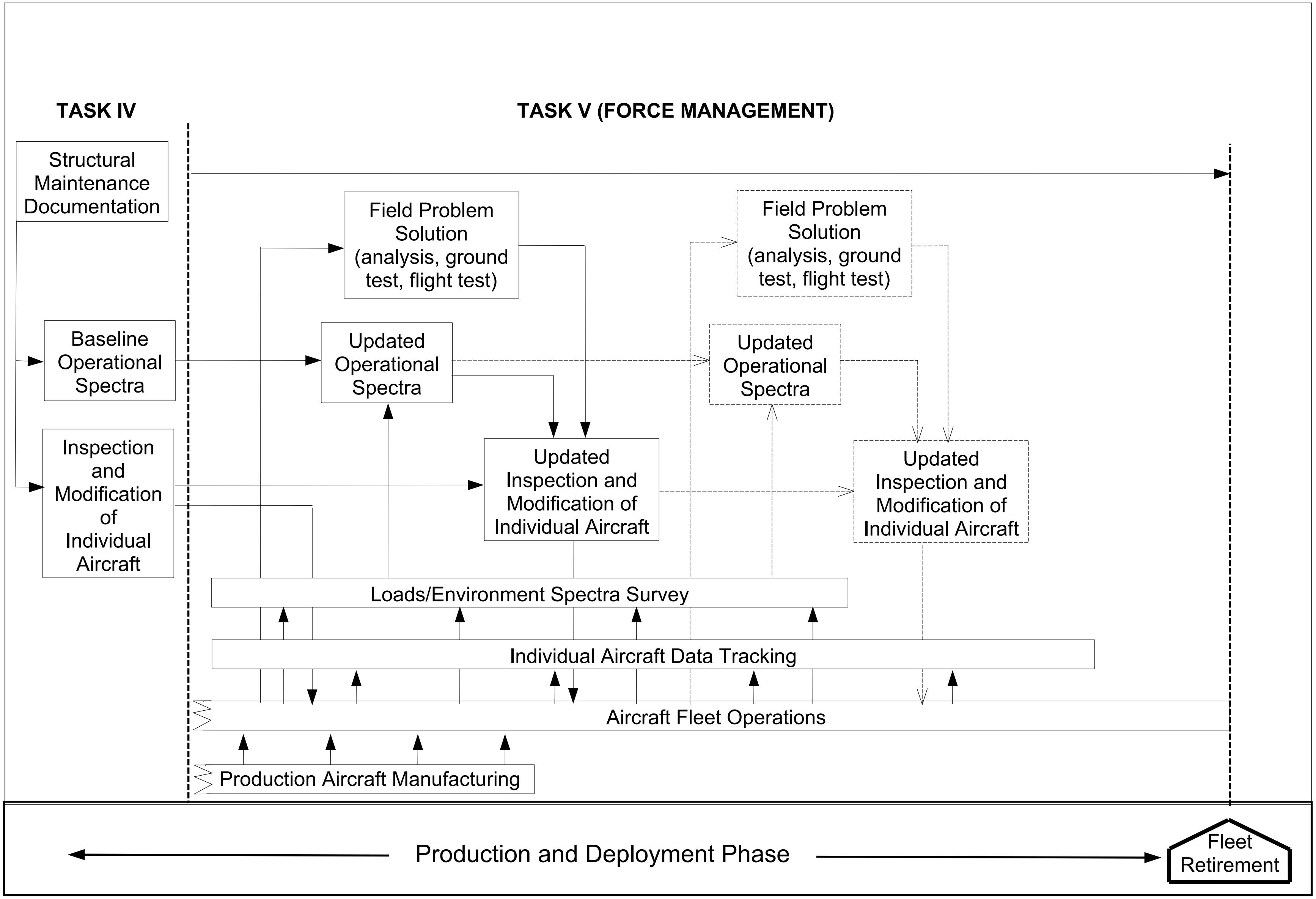

FIGURE 4. Aircraft Structural Integrity Program - Part 4.

APPENDIX A

ADDITIONAL GUIDANCE FOR NEW, OFF-THE- SHELF AIR VEHICLES

A.1 Structural qualification. The following general guidance should be used to tailor the guidance contained in the main body of this document to conform to a specific program. The degree of structural development necessary should be determined as part of an in-house technical assessment. It should be noted that even a FAR-25-certified air vehicle could be a major structural development if major mission variations adversely affected the structural life.

A.1.1 Performance requirements. The structural performance requirements should be established by the Program Manager. The structural performance requirements will identify the structural criteria which should be used to establish the strength, durability, and damage-tolerance of the air vehicle. This should include weights, speeds, altitudes, and runway surface preparation from which the air vehicle is to be operated.

A.1.2 Service goal concept. The Program Manager should also establish the desired service goal concept for the air vehicle, the missions to be flown, and the usage of those missions during the service goal.

A.1.3 Preliminary structural evaluation. The candidate air vehicle should be examined through a preliminary structural evaluation. This effort should characterize the structural integrity of the proposed system and should be based on the database that currently exists for the air vehicle. This should be a critical evaluation of the certification basis for the air vehicle as compared to the requirements of the ASIP. The design criteria used in the certification process should be the basis for this evaluation. The ASIP should be tailored to be consistent with the intended use of the air vehicle and the scope of this evaluation. The primary effort should be an examination of vibration, acoustic, flutter, loads, static strength, fatigue and damage tolerance analyses, and the associated testing described in the first three tasks of the ASIP. The guidance for acceptable compliance with these tasks can be found in JSSG-2006. Particular attention should be given to the third task of ASIP, which includes the full-scale testing. The elements of this task—which include the laboratory static and durability tests and the flight and ground operations test—represent significant costs to the program if not previously executed or executed improperly. The lack of adequate testing may also mean there could be high risk that there is a structural deficiency. The individual air vehicle tracking program and the loads/environment spectra survey found in fourth task of the ASIP will, in general, not be included in the original certification basis for the air vehicle. For FAR Part 25 air vehicles, many of the ASIP required analyses and tests are routinely accomplished during the certification process However, they should be critically examined for compliance with the ASIP. For FAR Part 23 air vehicles, the requirement for the evaluation is normally greater, since the structural requirements for these air vehicles are less stringent than for the FAR Part 25 air vehicles. In addition, consideration should be given to rules that were current at the time the certification took place, since the requirements have been significantly modified over the years.

The certification basis for air vehicles certified by foreign authorities should be examined on a case-by-case basis. If the certification basis is not considered adequate, then the air vehicle should be subjected to an in-depth technical assessment. This technical assessment should be based on the data provided by the contractor. This assessment should, in general, include effort in the vibration, acoustic, flutter, load, stress, fatigue, and damage tolerance analysis disciplines. Durability and damage tolerance are typically the areas where the certification basis is lacking.

The available database should be used for the in-house durability and damage tolerance assessment to locate critical areas of the structure. This should be a limited effort and should concentrate on a few generic areas and areas which, if found deficient, could result in major modification costs. The next task should be to generate a flight-by-flight spectra of stresses at these critical locations. These spectra should represent the lifetime operation of the air vehicle, which should include loads from taxi, maneuvering, turbulence, and landing impact. Fracture analyses using these spectra of stresses should be used to estimate the durability and damage tolerance capability of the air vehicle. In some cases, the use of coupon testing may be required to provide validation of these analyses. These studies should be used as a basis to assess the economic impact of bringing the air vehicle into the U.S. Air Force inventory. If the certification basis is considered adequate, then the compliance with the U.S. Air Force structural performance requirements for the candidate air vehicle is evaluated. This effort should examine the differences between the structural design criteria of the candidate air vehicle and the U.S. Air Force structural design criteria. Each aspect of the criteria that affects the vibration, acoustic, flutter, load, strength, fatigue, and damage tolerance capability of the air vehicle should be examined. For example, the candidate air vehicle may have been designed to a limit load factor of 3.5, while the U.S. Air Force operations dictate the need for a limit load factor of 4.5. This indicates a deficiency in strength and possibly in durability and damage tolerance capability. An incompatibility in the velocity/altitude boundary requirements may indicate a deficiency in the flutter margins. If the structural performance requirements for the air vehicle are not compatible with the design of the candidate air vehicle, then the air vehicle is subjected to a technical assessment. If it is compatible, then the candidate air vehicle is assessed against the service life goals, missions, and usage desired. If the candidate air vehicle is not compatible with the desired service goals, missions, and usage, then it goes to the technical assessment. If it is compatible, then the candidate air vehicle service history is examined. For this task, the maintenance program for the candidate air vehicle and its operational history would be assessed. Also, it should be determined if it has adequate past and continuing operational experience to ensure that any potential economic issue with the air vehicle has been revealed and that any potential safety issue will be revealed before it occurs on a USAF air vehicle. If there is adequate service history, then the air vehicle should be expected to meet the structural requirements, and the evaluation would be complete. If it is judged that there is not an adequate service history, then it should be subjected to a technical assessment.

A.1.4 Additional analyses. If the air vehicle cannot meet the requirements from A.1.2, then suitable additional analyses should be performed in an in-house technical assessment to ensure that any potential economic or safety problem is revealed. In many cases, FAR Part 25 air vehicles have been subjected to a damage tolerance assessment as part of the FAA requirements for a Supplementary Structural Inspection Document (SSID). In these cases, this damage tolerance assessment can be modified by the contractor to evaluate the impact of usage changes. The in-house assessment should be based on information from the contractor. Typically, this information is more easily obtained during on-site visits to the contractor facility. This information should include information on design configuration and design usage, loads, stresses, tests, corrosion protection systems, and service experience.

A.1.5 Risk assessment. If the in-house assessment of the candidate air vehicle shows it can meet the desired objectives, then that information is given to the Program Manager. In the event the in-house assessment reveals the candidate air vehicle has significant deficiencies or an inadequate database exists, then the results are submitted to the Program Manager with an assessment of the associated risks so that a decision can be made to either reject the candidate air vehicle or define further efforts.

A.1.6 New or modified structure. The engineering and manufacturing structural development and qualification guidance in this document are appropriate for new or extensively-modified structure. This describes the level of effort, design analyses, and testing required regardless of who certifies the new or modified structure. An in-house structural assessment of the magnitude of the structural modification can be conducted to clarify further the required level of design effort, analyses, and testing.

A.1.7 Airframe condition. Particularly difficult structural integrity problems often accompany the procurement of aging, off-the-shelf aircraft. There are many used aircraft in the marketplace which may be purchased far below the price of a new, off-the-shelf air vehicle. The reasons for the low price on these aircraft may be that they have flown beyond their design service goal, they have corrosion problems, they have widespread fatigue problems, they have numerous repairs (many of which are not damage tolerant), or any combination of these reasons. That is, they generally possess all of the ingredients to be classified as aging aircraft. Unfortunately, many of these problems can be hidden from view and the aircraft may appear to be airworthy. Experience has shown that significant problems do exist and the cost of refurbishing these aircraft is considerably above original expectations.

APPENDIX B

ADDITIONAL GUIDANCE FOR AGING AIR VEHICLES

B.1 Aging air vehicles. For a new air vehicle, the development of the Force Structural Maintenance Plan (FSMP) in Task IV provides the basis for the maintenance costs expected to be incurred for the air vehicle during its design service goal. When the FSMP needs to be changed because the air vehicle: 1.) has overflown its design service goal, 2.) is corroded, 3.) has reached the time of onset of widespread fatigue damage (WFD), or 4.) has been repaired; then the air vehicle is said to be aging.

B.1.1 Operations beyond the design service goal of the air vehicle. If the air vehicle has flown or is expected to be flown beyond its design service lifetime, the service inspection program should be updated to include necessary additional structural locations and/or inspection intervals to ensure structural integrity. This is accomplished through a damage tolerance assessment to search for new structural areas which may need to be inspected or modified. This would include a review of inspection results from operational air vehicles and a review of findings from previous durability testing. If an air vehicle can be removed from operational service, then a teardown inspection should be performed to determine if there are any fatigue cracking or corrosion problems not predicted earlier through design and test.

B.1.2 Corrosion. Inspections of individual air vehicles should be accomplished to ascertain the condition of the airframes with respect to corrosion. Emphasis should be placed on corrosion detection through nondestructive inspections and prevention. For those areas found to be corroded, the preferred approach is to eliminate the corrosion by removing it or replacing the structural elements in question. This may not be feasible in rare cases because of near-term operational requirements. In these cases, an assessment should be accomplished to determine the change in the inspection program that will account for the influence of corrosion on structural integrity.

B.1.3 Widespread fatigue damage. An initial prediction of the time of onset of WFD should be made based on the results from the durability test, air vehicle inspections, and usage tracking. Before the predicted time of the onset of WFD, a teardown inspection of a high-time air vehicle needs to be accomplished to validate the crack distribution function. This refined distribution should be used to recalculate the time of onset of WFD. Before operational air vehicles reach this time, a detailed nondestructive inspection program is needed to validate the prediction. When the air vehicle has reached the time of onset of WFD, then it should be modified to remove the problem since routine inspections are inadequate to protect flight safety.

B.1.4 Repairs. Both metallic and composite repairs should be designed to be damage-tolerant in addition to satisfying the strength and aeroelastic requirements. Further, they should be added to the FSMP so that they can be properly tracked to determine the inspection times. Additionally, a database needs to be established to maintain configuration control of air vehicle repairs. Any interaction of repairs should be taken into consideration in the damage tolerance assessment of them.

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AIRCRAFT STRUCTURAL INTEGRITY PROGRAM, GENERAL GUIDELINES FOR

4. NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets, as needed.)*

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