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MILITARY HANDBOOK

AIRCRAFT STRUCTURAL INTEGRITY PROGRAM GENERAL GUIDELINES FOR

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 DO NOT CITE THIS DOCUMENT AS A REQUIREMENT

FORWARD

1. This Military Handbook is approved for use by all Departments and Agencies of the Department of Defense. This handbook is for guidance only. This handbook cannot be cited as a requirement. If it is, the contractor does not have to comply.

2. Recommended corrections, additions, or deletions should be addressed to Aeronautical Systems Center, ASC/ENFS, 2530 Loop Road West, Wright-Patterson AFB OH 45433-7101.

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 the structural integrity while maintaining affordability of these Air Force systems 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 managing cost and schedule risks. 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 concerning 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 ensuring the safe operation of the 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.

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1. SCOPE

1.1 Scope. This handbook contains general guidelines for the Air Force Aircraft Structural Integrity Program (ASIP). These guidelines describe the processes proven successful in achieving structural integrity of USAF aircraft while minimizing the cost of ownership and managing cost and schedule risks through a series of disciplined time phased tasks.

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

a. Type of aircraft. This handbook is directly applicable to manned aircraft having fixed or adjustable fixed wings and to those portions of manned helicopter and Vertical/Short Takeoff and Landing (V/STOL) aircraft which have similar structural characteristics. Helicopter-type power transmission systems, including lifting and control rotors, and other dynamic machinery, and 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 aircraft systems, to aircraft systems procured by the Air Force but developed under the auspices of other government agencies or departments(such as Federal Aviation Administration or United States Navy), and aircraft modified or directed to new missions. Procurement of off-the-shelf new or used aircraft for military use presents somewhat different problems than procurement of aircraft developed under the auspices of the military services. Although the ASIP process still applies, additional tailoring is needed to optimize these programs. Appendix A herein provides additional guidance for procurement of off-the-shelf aircraft. Appendix B provides additional guidance for aging aircraft 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. Documents listed below~~in Appendix A~~ are needed to fully understand the information provided by this handbook.

FEDERAL SPECIFICATIONS

MILITARY SPECIFICATIONS

JSGS-87221 Joint Service Guide Specification, Aircraft Structures, General Specification For and Handbook.

MIL-I-6870 Inspection Program Requirements, Nondestructive, for Aircraft and Missile Materials and Parts.

FEDERAL STANDARDS

MILITARY STANDARDS

MIL-STD-882 System Safety Program for Systems and Associated Subsystems and Equipment, Requirements for.

MIL-STD-1568 Materials and Processes for Corrosion and Prevention Control in Aerospace Weapons Systems

MIL-STD-1587 Materials and Processes Requirements for Air Force Weapons Systems

MILITARY HANDBOOKS

MIL-HDBK-5 Metallic Materials and Elements for Aerospace Vehicle Structures.

MIL-HDBK-17 Plastics for Flight Vehicles.

MIL-HDBK-23 Structural Sandwich Composites.

OTHER GOVERNMENT DOCUMENTS

Air Force Policy Directive 21-1 Managing Aerospace Equipment Maintenance

Air Force Instruction 21-105 Aerospace Equipment Structural Maintenance

Air Force Policy Directive 63-10 Aircraft Structural Integrity

Air Force Instruction 63-1001 Aircraft Structural Integrity Program

Air Force Material Command Instruction 21-102 Analytical Condition Inspections

T.O. 1-1B-40 Weight and Balance Data.

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

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

NON-GOVERNMENT DOCUMENTS

EIA Interim Standard 632 Systems Engineering

IEEE P1220 (Draft) Standard for Systems Engineering

Society of Allied Weight Engineers Recommend Practice Number 7.

2.2 Applicable issues. Unless otherwise described, the applicable issues of documents listed above ~~in Appendix A~~ are those listed in the Department of Defense Index of Specifications and Standards (DODISS) described in the solicitation. The applicable issue of nongovernment documents not listed in the DODISS should be the issue described in solicitation.

2.3 Copies. Copies of specifications, standards, handbooks, drawings and publications required by contractors in connection with specific acquisition functions can be obtained from the acquisition activity or as directed by the contracting officer.

3. DEFINITIONS

3.1 Durability. 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 described period of time.

3.2 Economic life. 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 aircraft, 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 Joint Service Guide Specification Aircraft Structures General Specification for and Handbook, ~~JSGS-87221~~JSGS-87221. The economic life should be evaluated with the incorporation of 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 affecting 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

3.3 Initial quality. 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.

3.4 Structural operating mechanisms. Those operating, articulating, and control mechanisms which transmit structural forces during actuation and movement of structural surfaces and elements.

3.5 Damage tolerance. Damage tolerance is the attribute of a structure that permits it to retain it required residual strength for a period of unrepaired usage after the structure has sustained described levels of fatigue, corrosion, 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.

3.6 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 in maintaining the overall structural integrity of the airplane.

3.7 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 reasonable free from significant structural degradation.

3.8 Fail-safe. ~~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.

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

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 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).

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 aircraft system affecting 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. To maintain operational readiness, the capabilities, condition, and operational limitations of the airframe of each aircraft weapon and support system must be established. 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 aircraft with the required airframe structural characteristics is referred to as the 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 aircraft structures.

b. Acquire, evaluate, and apply operational usage data to provide a continual update of the structural integrity of operational aircraft.

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

d. Provide a basis for improving structural criteria and methods of design, evaluation, and substantiation for future aircraft systems and modifications.

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

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

b. Task II (design analysis and development tests). 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). Flight and laboratory tests of the airframe to assist in determining the structural adequacy of the analysis and design.

d. Task IV (force management data package). Generation of data required to manage force operations in terms of inspections, maintenance, modifications, and damage assessments when aircraft is flown differently than design.

e. Task V (force management). Those operations that must be conducted by the Air Force during force operations to ensure damage tolerance and durability throughout the useful life of individual airplanes.

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 aircraft. The objective is to ensure that the appropriate criteria and planned usage are applied to an aircraft 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 aircraft life cycle.

5.1.1 ASIP Master Plan. The ASIP manager will translate the requirements of AFI 63-1001 into a program for each aircraft and document these in the ASIP master plan. This plan will be integrated into the Integrated Master Plan and Integrated Master Schedule.~~described~~ The purpose of the ASIP Master Plan is to define and document the specific approach for accomplishment of 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, 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. Detail structural design criteria for the specific aircraft 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 JSGS-87221.

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 aircraft due to propagation of undetected cracks, flaws, or other damage.

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 insure structural safety since undetected flaws or damage can exist in critical structural components despite the design, fabrication, and inspection efforts expended to eliminate their occurrence. Durability structural design approaches should be used to achieve Air Force 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 JSGS-87221 and should be applied to the principle 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.

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 described 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 JSGS-87221. 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 Air Force in the contract specifications for each new aircraft. 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 JSGS-87221, 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 design. Materials and processes, finishes, coatings, and films that have been proven in either 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 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 JSGS-87221~~JSGS-87221~~.

5.1.2.3 Repairability. Repairability must be designed into the aircraft 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 ~~JSGS-87221~~JSGS-87221.

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 JSGS-87221. These processes should identify and define all of the tasks necessary to ensure compliance with the damage tolerance requirements as described in 5.1.2.1.1 and JSGS-87221, and the durability requirements as described in 5.1.2.1.2 and JSGS-87221. 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 JSGS-87221. 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, cost effective designs which comply with the requirements of 3.11, 3.12 and 3.13 of JSGS-87221.

5.1.4 Selection of materials, processes, and joining methods. Materials, processes, and joining methods should be selected to result in a light-weight, 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~~supporability~~. 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, 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. Rationale should include all pertinent data upon which the selections were based including the data base, previous experience, and trade study results. Paragraph 3.2.19 and 4.2.19 of JSGS-87221 should be used for material requirements and processes respectively.

5.1.5 Design service goal and design usage. The 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., HQ USAF, HQ AFMC, and using commands). Design mission profiles and mission mixes which are realistic estimates of expected service usage will be established using guidelines of paragraphs 3.2.14 and 4.2.14 of JSGS-87221. It is recognized that special force management actions will probably be required (i.e., early retirement, early modification, or rotation of selected aircraft) 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 JSGS-87221 and MIL-I-6870. NDT/I 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, vibratory and acoustic environment), (2) to perform preliminary and final analyses and tests based on these environments, and (3) to 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, and MCIC-HDBK-01 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, generate analysis test data should be formulated and performed using the guidelines~~guidlaines~~ of paragraphs 3.2.19.1 and 4.2.19.1 of JSGS-87221.

5.2.2 Loads analysis. Loads analysis should consist of determining the magnitude and distribution of significant static and dynamic loads which the airframe may encounter when operating within the envelope established by the structural design criteria. This analysis consists of determining 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 JSGS-87221 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 are in JSGS-87221 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 resulting 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 aircraft and in determining the adequacy of the structure for new loading conditions that 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 paragraphs 3.12 and 4.12 of JSGS-87221. 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 paragraphs 3.11 and 4.11 of JSGS-87221. 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 affecting 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 guidance of paragraphs 4.4.3, 4.5, 4.5.1, and 4.5.1.1 of JSGS-87221 to comply with the requirements for sonic durability of the contract. The objective of the sonic durability analysis is to ensure that 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 guidance of paragraphs 4.3.3, 4.6 and 4.6.1 of JSGS-87221 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 aircraft 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 aircraft.

5.2.10 Flutter analysis. Utilize the guidance contained in paragraph 4.7 of JSGS-87221 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 aircraft for flutter, divergence, and other related aeroelastic or aeroservoelastic instabilities. The primary objective of the analyses is to substantiate the ability of the aircraft 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 Air Force. Unimpeachable vehicle mass properties estimates should be established based on the Initial Operational Capability (IOC) aircraft. Analysis should continue throughout this task and be provided to the Air Force. Detailed guidance may be found in JSGS-87221 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 paragraph 3.8 and 4.8 of JSGS-87221. The objectives of the nuclear weapons effects analyses are to:

a. Verify that the design of the airframe will successfully resist the described environmental conditions with no more than the described residual damage.

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. Nuclear weapons effects capability envelope, including crew radiation protection, for a specified range of variations of weapon delivery trajectories, weapon size, aircraft 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 paragraphs 3.9 and 4.9 of JSGS-87221.

5.2.14 Design development tests. Detail guidance for design development tests are contained in JSGS-87221. 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 determining the structural adequacy of the basic design through a series of ground and flight tests.

5.3.1 Static tests. Detail guidance is contained in paragraph 4.10.5 of JSGS-87221. Prior to initiation of testing, the test plans, procedures, and schedules should be reviewed by the SPO and the contractor. The static test program should consist of a series of laboratory tests conducted on an instrumented airframe that simulates the loads resulting 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 aircraft where the airframe has been verified by full scale tests.

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 JSGS-87221.

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 aircraft and allow unrestricted flight within the design envelope on schedule. The guidance of JSGS-87221 is recommended.

5.3.2 Durability tests. The detail guidance of paragraph 4.11.1.2.2 of JSGS-87221 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.

c. Provide a basis for establishing special inspection and modification requirements for force aircraft.

5.3.2.1 Selection of test articles. The test article should be an early Engineering and Manufacturing Development (EMD) 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 aircraft, 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 guidance of paragraph 4.11.1.2.2.6 of JSGS-87221JSGS-8721B. One lifetime of durability testing plus an inspection of critical structural areas should be completed prior to full production go ahead decision. Two lifetimes of durability testing plus an inspection of critical structural areas in accordance should be scheduled to be completed prior to delivery of the first production aircraft. 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 and b and data evaluation should be completed prior to delivery of the first production aircraft 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. Monitoring the progress of the durability test and verifying or redefining the analytically defined critical areas.

b. Design inspections in accordance with paragraph 4.11.1.2.2.e of JSGS-87221.

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 guidance of paragraph 4.11.1.2.2 of JSGS-87221. It may be advantageous to the Air Force to continue testing beyond the minimum requirement (1) to determine life extension capabilities, (2) to validate design life capability for usage that is more severe than design usage, (3) to validate repairs, modifications, and changes, and (4) to support damage tolerance requirements.

5.3.3 Damage tolerance tests. Guidance for damage tolerance tests is contained in paragraph 4.12.2.3 of JSGS-87221. 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. Guidance for detail planning for flight and ground operations tests are found in paragraph 4.4 of JSGS-87221. An early Engineering and Manufacturing Development (EMD) aircraft 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 aircraft, sufficiently late in the production program to ensure obtaining the final configuration, should be the backup aircraft for these flight tests and should be instrumented similar to the primary test aircraft. 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 operating an instrumented and calibrated aircraft 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 aircraft structure. The objectives of the loads survey should be as follows:

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

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

c. Determination and definition of 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 operating an instrumented and calibrated aircraft to measure the structural loads and inputs while flying 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 for use in substantiating or correcting the loads analysis, fatigue analysis, and for interpreting the operational loads data.

5.3.5 Aeroacoustic durability tests. Utilize the guidance for sonic durability tests of 4.4.3, 4.5, 4.5.1, 4.5.1.2 and subparagraphs of JSGS-87221. 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 aircraft to verify or modify the initial design aeroacoustic loads/environment. The sonic durability test should be conducted on a representative aircraft (or its major components) to demonstrate structural adequacy for the design service goal. Sonic durability tests normally are accomplished by ground testing of the complete aircraft with the power plants operating at full power for a time sufficient to assure design service goal. However, testing of major portions of the aircraft in special non-reverberate ground test stands using the aircraft propulsion system as the noise source, or in high intensity noise facilities, may be acceptable.

5.3.6 Flight vibration tests. Utilize the guidance for flight vibration tests in 4.4.3, 4.6, 4.6.2 and subparagraphs of JSGS-87221. 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. Guidance for flutter related tests is in paragraph 4.7 of JSGS-87221. 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 that the airframe is free from aeroelastic instabilities and has satisfactory damping throughout the operational flight envelope.

5.3.8 Mass properties testing. The aircraft should be weighed to verify the aircraft 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 Air Force. Guidance may be found in JSGS-87221~~-B~~ 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 in 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 resulting from correction of deficiencies will be used to make major program decisions such as major redesign, program cancellation, awards or penalties, and production aircraft 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). Maintaining the strength, rigidity, damage tolerance, and durability is dependent on the capability of the appropriate 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). To properly perform these tasks, the Air Force must have detailed knowledge of the required actions. Additionally, experience has shown that the actual usage of military aircraft may differ significantly from the assumed original design usage. It is necessary that the Air Force have the technical methods and actual usage data to assess the effect of these changes in usage on aircraft damage tolerance and durability. Task IV describes the minimum required elements of a data package so the 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 between analysis and test that are revealed 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 detail 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 diagrammatic form showing the aircraft 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, indicating 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 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 data base.

c. Materials data base.

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 aircraft will be instrumented to measure such parameters as velocity, accelerations, altitude, fuel usage, temperature, strains, etc. Ten to 20 percent of the data will be captured by the 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 aircraft. 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 aircraft 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 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 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 aircraft. Plans for transfer of data processing provisions to Air Force facilities including training of 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 aircraft tracking program. The objective of the individual aircraft tracking program is to predict potential flaw growth in critical areas of each airframe that are key to damage growth limits of paragraph 4.14 of JSGS-87221, 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 aircraft. The program should include serialization of major components (e.g., wings, horizontal and vertical stabilizers, landing gears, etc.) so that component tracking can be implemented by the Air Force.

5.4.5.1 Tracking analysis method. An individual aircraft tracking analysis method to establish and adjust inspection and repair intervals for each critical area of each airframe based on the individual aircraft usage data should be developed. 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 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 aircraft usage and to recognize changes in operational mission usage

5.5 Force management (Task V). Task V includes those actions that must be conducted by the Air Force during force operations to ensure the damage tolerance and durability of each aircraft. Task V will be primarily the responsibility of the Air Force and will be performed by the appropriate commands utilizing 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 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.

d. Ensure that 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 for ensuring that 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 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 aircraft to support additional updates of the baseline spectra and inspection and maintenance information to update the -6 and -36 Technical Orders.

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

a. Establish data collection procedures and data transmission channels within the 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.

d. Ensure that the data are obtained and processed in a timely manner to provide adjusted maintenance times for each critical area of each aircraft.

5.5.3 Individual aircraft maintenance times. The ASIP manager will be responsible for deriving individual maintenance (inspection and repair) times for each critical area of each aircraft by use of the tracking analysis methods as specified in 5.4.5.1 and the individual aircraft 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 aircraft and each critical area thereof. With the force structural maintenance data and the individual aircraft maintenance time requirements available, the 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 for maintaining structural maintenance records (inspection, repair, modification, and replacement) for individual aircraft. These records should contain complete listings of structural maintenance actions that are performed with all pertinent data included (Time Compliance Technical Order (TCTO) action, component flight time, component and aircraft serial number, etc.). The Maintenance Requirements Review Board (MRRB) is one forum used by AFMC 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 aircraft user during operations to ensure the aircraft remains within its design restrains should be established and provided by the contractor. Guidance may be found in Society of Allied Weight Engineers (SAWE) Recommended Practice Number 7 (RP #7), T.O. 1-1B-40 and T.O. 1-1B-50.

6. NOTES

(This section contains information of a general or explanatory nature which may be helpful.)

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

6.2 Data requirements. The long term operation and maintenance of Air Force aircraft and equipment is directly dependent on the availability of certain structural data developed during an ASIP. These data bases 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 assure that these data are available to the 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 JSGS-87221. 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. ASIP 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 ~~and divergence~~ analysis (see 5.2.10).
p. Nuclear weapons effects analyses (see 5.2.11).
q. Nonnuclear weapons effects analysis (see 5.2.12).
r. Static tests (see 5.3.1).
t. Durability tests (see 5.3.2).
u. Damage tolerance tests (see 5.3.3).
v. Flight and ground operations tests (see 5.3.4).
w. Aeroacoustic durability tests (see 5.3.5).
x. Flight vibration tests (see 5.3.6).
y. Flutter tests (see 5.3.7).
z. Strength summary (see 5.4.2).
aa. Force structural maintenance plan (see 5.4.3).
bb. Loads/environment spectra survey (see 5.4.4).
cc. Individual aircraft tracking program (see 5.4.5).
dd. Loads/environment spectra survey (see 5.5.1).
ee. Individual aircraft tracking data (see 5.5.2).
ff. Individual aircraft maintenance times (see 5.5.3).
gg. Structural maintenance records (see 5.5.4).
hh. Mass Properties Control and Management Process (MPCMP) data (see 5.2.11).
ii. Weight and Balance data for Aircraft (see 5.2.11 and 5.3.8).
JJ. Sample Charts A and E data (see 5.5.5).
kk. Analytical Condition Inspection (ACI) results (see AFMCI 21-102).

TABLE I. USAF Aircraft structural integrity program tasks.

TASK I	TASK II	TASK II	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 AIRCRAFT TRACKING DATA
SELECTION OF MATERIALS, PROCESSES, & JOINING METHODS	DESIGN CHEMICAL/THERMAL ENVIRONMENT SPECTRA	FLIGHT & GROUND OPERATIONS TESTS	LOADS/ENVIRONMENT SPECTRA SURVEY	INDIVIDUAL AIRPLANE MAINTENANCE TIMES
DESIGN SERVICE GOAL AND DESIGN USAGE	STRESS ANALYSIS	AEROACOUSTIC TESTS	INDIVIDUAL AIRCRAFT 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			

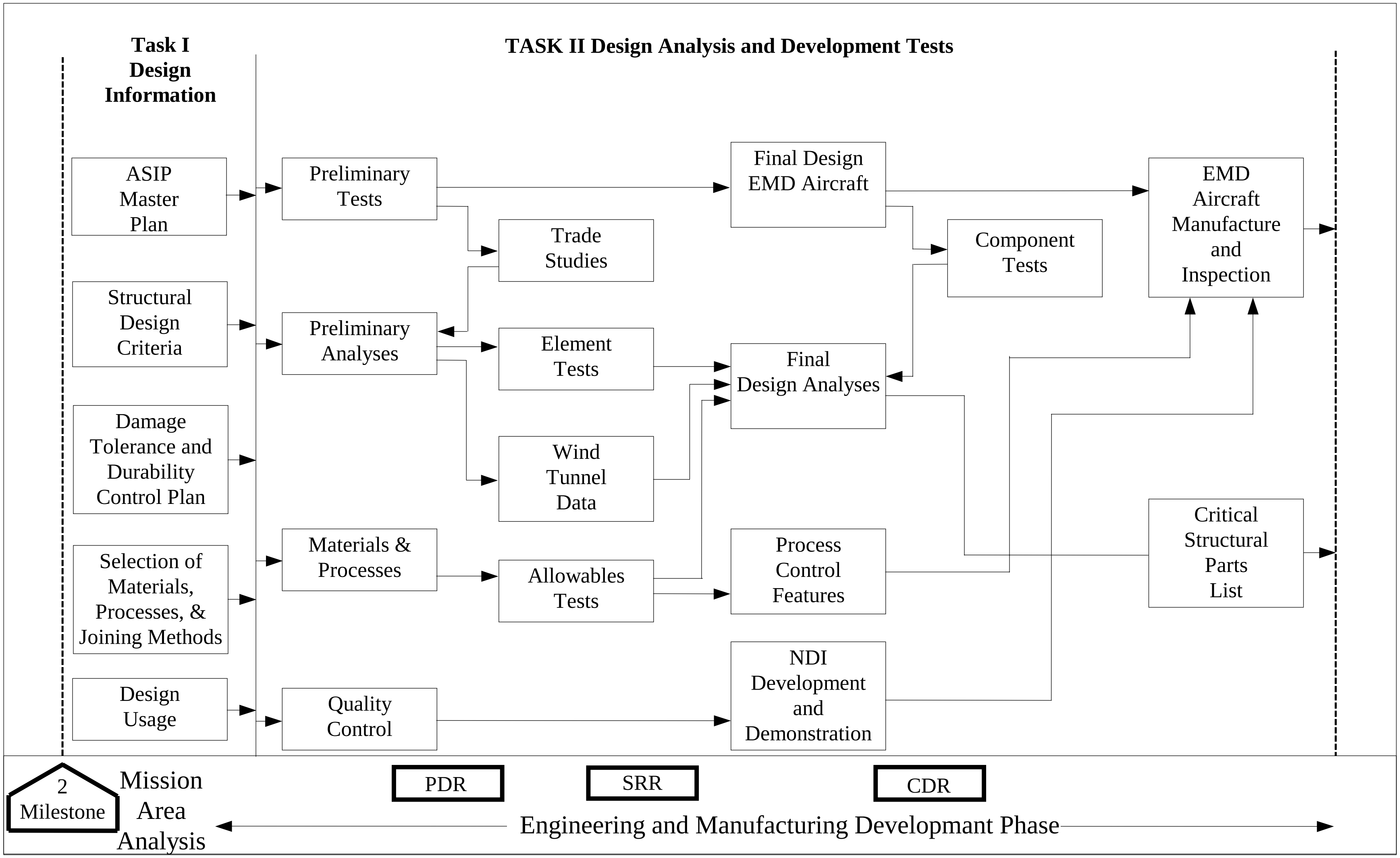

FIGURE 1 Aircraft structural integrity program - Part 1

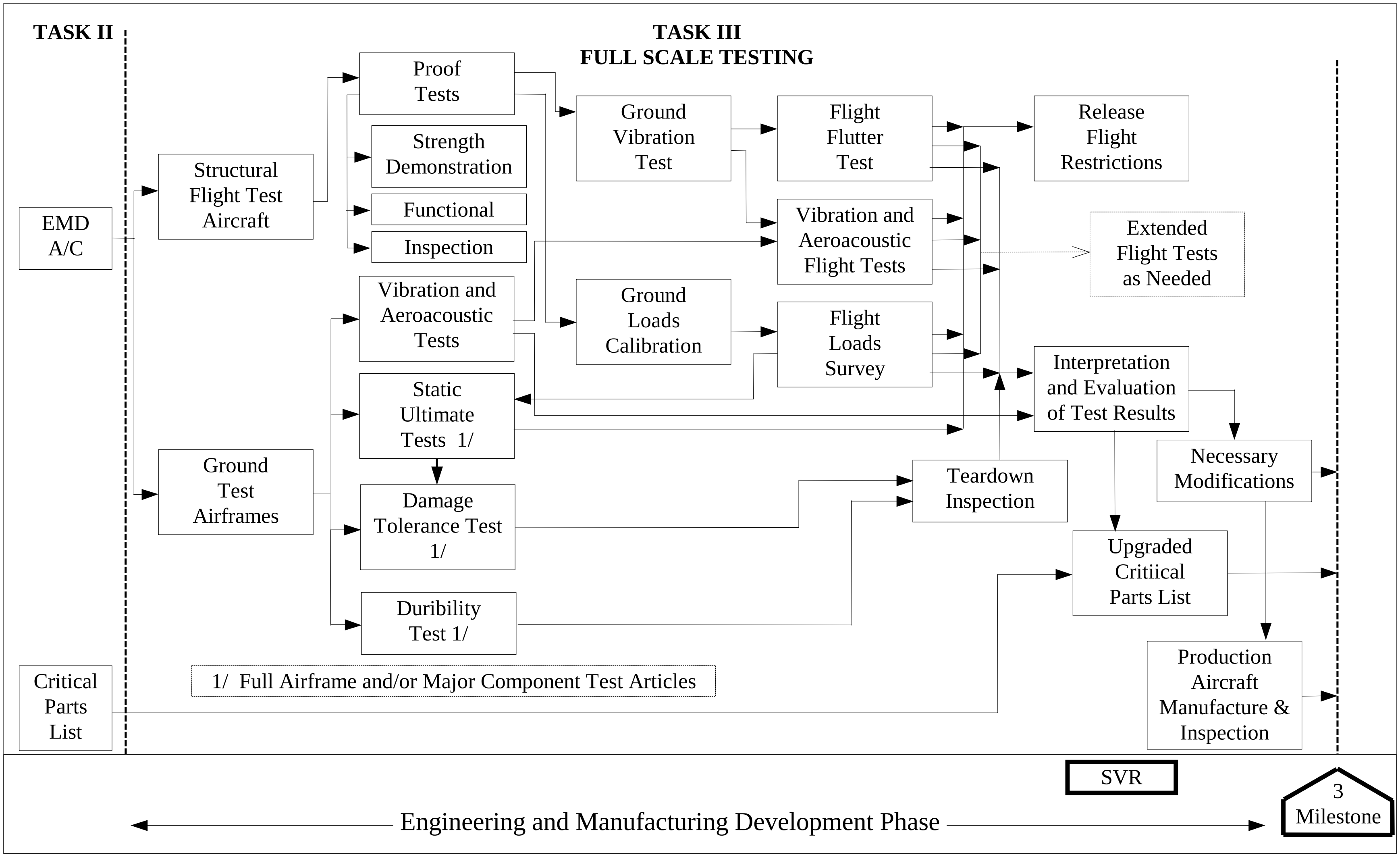

FIGURE 2 Aircraft structural integrity program - Part 2.

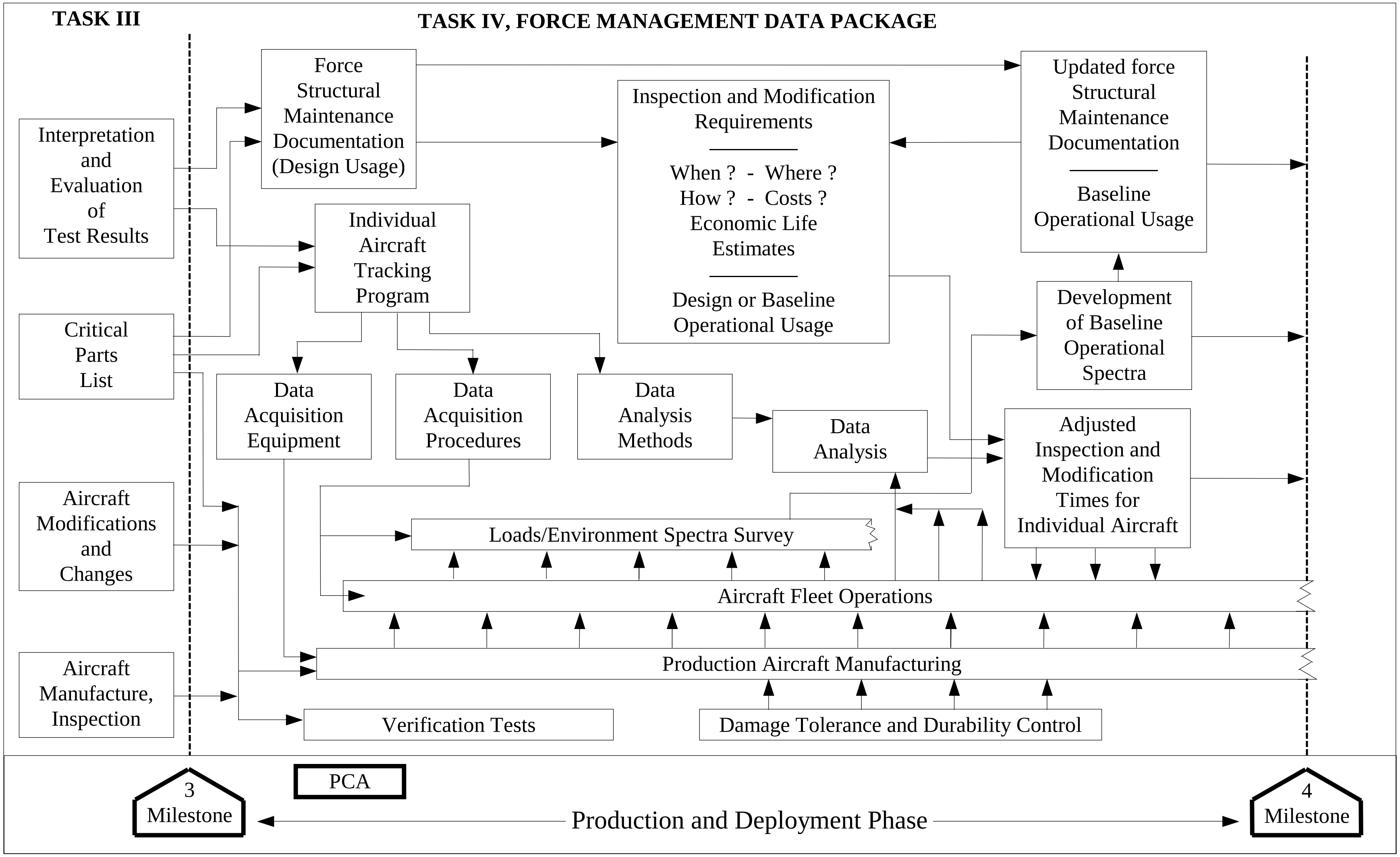

FIGURE 3. Aircraft structural integrity program - Part 3.

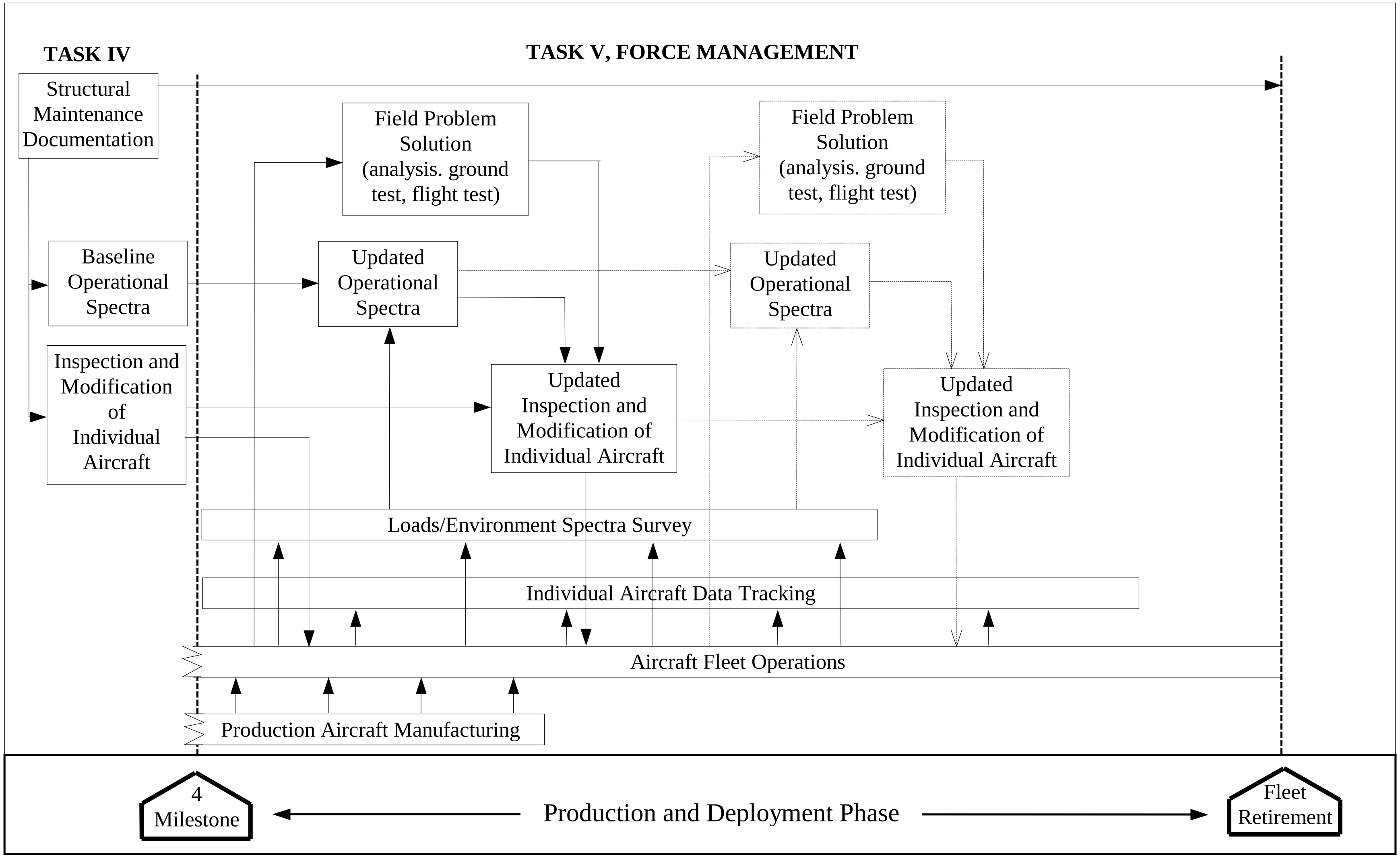

FIGURE 4. Aircraft structural integrity program - Part 4.

APPENDIX A

ADDITIONAL GUIDANCE FOR NEW OFF-THE- SHELF AIRCRAFT

10. Structural qualification. The following general guidance should be used in tailoring 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 aircraft could be a major structural development if major mission variations adversely affected the structural life.

10.1 Performance requirements. The structural performance requirements should be established by the program manager. The structural performance requirements will identify the structural criteria that should be used to establish the strength, durability and damage tolerance of the aircraft. This should include weights, speeds, altitudes and runway surface preparation from which the aircraft is to be operated.

10.2 Service goal concept. The program manager should also establish the desired service goal concept for the aircraft, the missions to be flown and the usage of these missions during the service goal.

10.3 Preliminary structural evaluation. The candidate aircraft should be examined through a preliminary structural evaluation. This effort should be directed towards the characterization of the structural integrity of the proposed system and should be based on the data base that currently exist for the aircraft. This should be a critical evaluation of the certification basis for the aircraft 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 aircraft 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 associated testing that are described in the first three tasks of the ASIP. The guidance for acceptable compliance with these tasks can be found in JSGS-87221. 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 cost to the program if not previously executed or executed improperly. The lack of adequate testing may also mean that there could be high risk that there is a structural deficiency. The individual aircraft 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 aircraft. For FAR Part 25 aircraft, 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 aircraft, the requirement for the evaluation is normally greater since the structural requirements for these aircraft are less stringent than for the Part 25 aircraft. 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. For aircraft certified by foreign authorities, the certification basis should be examined on a case-by-case basis. If the certification basis is not considered adequate, then the aircraft should be subjected to an in-depth technical assessment. This technical assessment be based on the data provided by the contractor. This assessment would, in general, include effort in the vibration, acoustic, flutter, load, stress, fatigue and damage tolerance analysis disciplines. Durability and damage tolerance would typically be the areas where the certification basis would be lacking. For the in-house durability and damage tolerance assessment, the available data base would be used to locate critical areas of the structure. This would be a limited effort and would concentrate on a few generic areas and areas that could result in major modification costs if found deficient. The next task would be to generate a flight-by-flight spectra of stresses at these critical locations. These spectra would represent the lifetime operation of the aircraft which would include loads from taxi, maneuvering , turbulence and landing impact. Fracture analyses using these spectra of stresses would be used to estimate the durability and damage tolerance capability of the aircraft. In some cases, the use of coupon testing may be required to provide validation of these analyses. These studies would be used as a basis to assess the economic impact of bringing the aircraft into the Air Force inventory. If the certification basis is considered adequate then the compliance with the Air Force structural performance requirements for the candidate aircraft is evaluated. This effort would examine the differences between the structural design criteria of the candidate aircraft and the Air Force structural design criteria. Each aspect of the criteria that affected the vibration, acoustic, flutter, load, strength, fatigue and damage tolerance capability of the aircraft should be examined. For example, the candidate aircraft may have been designed to a limit load factor of 3.5 and the Air Force operations dictate the need for a limit load factor of 4.5. This would indicate 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 aircraft are not compatible with the design of the candidate aircraft, then the aircraft is subjected to a technical assessment. If it is compatible then the candidate aircraft is assessed against the service life goals, missions and usage that are desired. If the candidate aircraft is not compatible with the desired service goal, missions and usage then it goes to the technical assessment. If it is compatible then the candidate aircraft service history is examined. For this task the maintenance program for the candidate aircraft 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 aircraft has been revealed and that any potential safety issue will be revealed before it occurs on a USAF aircraft. If there is adequate service history, then the aircraft would be expected to meet the structural requirements, and the evaluation would be complete. If it is judged that there is not adequate service history then it would be subjected to a technical assessment.

10.4 Additional analyses. If the aircraft can not meet the requirements from 30.2., 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 aircraft 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.

10.5 Risk assessment. In the event that the in-house assessment reveals that the candidate aircraft has significant deficiencies or an inadequate data base exists then the results are referred back to the program manager with an assessment of the associated risks so that a decision can be made to either reject the candidate aircraft or define further efforts. If the in-house assessment of the candidate aircraft shows that it can meet the desired objectives then that information is given to the program manager.

10.6 New or modified structure. For new or extensively modified structure, the engineering and manufacturing structural development and qualification guidance in this document are appropriate for this 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 further clarify the required level of design effort, analyses and testing.

10.7 Airframe condition. Particularly difficult structural integrity problems often accompany the procurement of aging, off-the-shelf aircraft. In the marketplace there are many used aircraft that may be purchased far below the price of a new off-the-shelf aircraft. 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. 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 AIRCRAFT

20 Aging Aircraft. For a new aircraft the development of the Force Structural Maintenance Plan (FSMP) in Task IV provides the basis for the maintenance costs that are expected to be incurred for the aircraft during its design service goal. When the FSMP needs to be changed because the aircraft 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 aircraft is said to be aging.

20.1 Operations beyond the design service goal of the aircraft. If the aircraft 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 assure structural integrity. This is accomplished through a damage tolerance assessment to search for new structural areas that may need to be inspected or modified. This would include a review of inspection results from operational aircraft, and a review of findings from previous durability testing. If an aircraft can be removed from operational service, then a teardown inspection should be performed to determine if there are any fatigue cracking or corrosion problems that were not predicted earlier through design and test.

20.2 Corrosion. Inspections of individual aircraft should be accomplished to ascertain 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. In some rare cases this may not be feasible 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.

20.3 Widespread fatigue damage. An initial prediction of the time of onset of WFD should be made based on the results from the durability test, aircraft inspections, and usage tracking. Before the predicted time of ~~of~~ the onset of WFD a teardown inspection of a high time aircraft 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 aircraft reach this time a detailed nondestructive inspection program is needed to validate the prediction. When the aircraft has reached the time of onset of WFD then is should be modified to remove the problem since routine inspections are inadequate to protect flight safety.

20.4 Repairs. Both metallic and composite repairs 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. Further, the data base for the aircraft needs to be established such that there is configuration control of the repairs. Any interaction of repairs should be taken into consideration in the damage tolerance assessment of them.