INCH-POUND
AFGS-87242A
AMENDMENT 1
25 October 1996

AIR FORCE GUIDE SPECIFICATION

FLIGHT CONTROL SYSTEM GENERAL SPECIFICATION FOR

This amendment forms a part of AFGS-87242A, dated 30 August 1991, and 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.

COVER PAGE

Delete entire Distribution Statement D and substitute: “Distribution Statement A. Approved for public release; distribution is unlimited.”

PAGE ii

Delete entire Export Control Warning and Destruction Notice.

Beneficial Comments block. Delete address and substitute: “ASC/ENSI, 2530 Loop Rd W, Wright-Patterson AFB OH 45433-7101”.

PAGES 39 to 194

Change document identifier from “Appendix” to “Appendix A“.

Add new pages:

Following page 194, insert Appendix B (attached).

PAGE 195 to 201

Renumber Contents from ”195 to 201” to “223 to 229”.

Insert Contents for Appendix B (attached), pages 230 to 232.

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Appendix B

FLIGHT CONTROL SYSTEM DEVELOPMENT PROCESS (FLCDP)

B.1 SCOPE

B.1.1 Purpose. The purpose of this tailorable document is to define the Air Force Integrated Flight Control System Development Process (FLCDP). The FLCDP provides a framework for defining and managing the process by which integrated flight control system hardware, software, and support elements are to be designed, evaluated, analyzed, verified, validated, qualified, and tested to assure the integrity of the system and its support and to specify acceptable methods of contractor compliance. As such, it is part of the overall Air Force engineering activities to ensure that the total system has built-in quality, affordable life cycle characteristics, will function as required for its specified life and in its specified environments, and has been successfully integrated to satisfy overall system and safety requirements. Criteria, similar to B.6.3, shall be used to enter and exit the phased approach used here. The suggested criteria to enter and exit programmatic events are included in B.6.4. This appendix is a mandatory part of the specification. The information contained herein is intended for guidance only.

B.1.2 Applicability. This document shall be used by contractors involved in the development or modification of flight controls to satisfy Air Force mission requirements and by government personnel in managing the development, production, and operational support of air vehicle systems throughout their life cycles.

B.1.3 System life cycle phases. The FLCDP consists of the following five interrelated phases that parallel the development, production, and operational life cycle of any aerospace system as illustrated in table B-I.

a. Phase I (Design Information and Concept Definition): Development of those criteria (normal and risk) which must be applied during design so that the requirements specified by the procuring activity will be met by the proposed concept.

b. Phase II (Analyses, Design, and Development Tests): Development of the component and system design for the environment in which the system must operate; analysis of the response of the vehicle to operation of the total system in that environment; and testing of components and subsystems.

c. Phase III (Formal Testing and Synthesis): Engineering, qualification, flight, and ground tests of the air vehicle to verify the adequacy of the design to allow satisfactory completion of its intended missions, specification compliance and its support for the entire life cycle.

d. Phase IV (Force Management Data Package): Generation of final data required to manage force operations in terms of system operating and support characteristics, complete system definition, required inspections, diagnostic equipment, and support procedures.

e. Phase V (Force Management and Product Enhancements): Those operations that must be conducted by the Air Force during force operations to ensure continued soundness of the flight control system throughout the useful life of each air vehicle and those development activities necessary to eliminate identified deficiencies or enhance the system by procedural methods or design modification.

B.2 APPLICABLE DOCUMENTS

B.2.1 Government documents. Unless otherwise indicated, the documents specified herein are referenced solely to provide supplemental technical data.

B.2.1.1 Specifications, standards, and handbooks

SPECIFICATIONS

Military

AFGS-87221	Aircraft Structures, General Specification For
AFGS-87249	Mechanical Equipment & Subsystems, Requirements for Integrity of
AFGS-87253	System Specification
AFGS-87256	Integrated Diagnostics

STANDARDS

Military

MIL-STD-210	Climatic Extremes For Military Equipment
MIL-STD-1530	Aircraft Structural Integrity Program, Airplane Requirements (ASIP)
MIL-STD-1783	Engine Structural Integrity Program (ENSIP)
MIL-STD-1796	Avionics Integrity Program (AVIP)
MIL-STD-1797	Flying Qualities of Piloted Aircraft
MIL-STD-1803	Software Development Integrity (SDIP)
DOD-STD-2167	Defense System Software Development
DOD-STD-2168	Defense System Software Quality Program

HANDBOOKS

Military

MIL-HDBK-87244	Avionic Integrity Requirements For Avionics/Electronics

B.3 GENERAL REQUIREMENTS

B.3.1 Requirements. Detailed flight control system (FLCS) integrity requirements will be contained in the integrated flight control system requirements section of the applicable contractual specifications and the statement of work (SOW) as tailored from AFGS-87253, the specification portion of this document, and other AFGS specifications and standards. They provide detailed integrity and performance requirements, while this document specifies the process through which this work will be done by the contractor and the Air Force to develop a safe, reliable, and maintainable system.

B.3.2 Additional requirements. The following process requirements shall apply to integrated flight control system to the extent that they are consistent with the requirements of the developed integrated FLCS specification as tailored from the specification portion of this document.

B.3.2.1 Structural integrity. The structural integrity of the mechanical elements of integrated flight control systems shall be designed, analyzed, tested, and qualified by the contractor according to the applicable contractual specifications as tailored from MIL-STD-1530 and AFGS-87221.

B.3.2.2 Electronic component integrity. Electronic elements of integrated flight control systems shall be designed, tested and qualified by the contractor according to applicable contractual specifications as tailored from MIL-STD-1796 and MIL-HDBK-87244.

B.3.2.3 Software integrity. Integrated flight control system software shall be developed, tested, and qualified by the contractor according to applicable contractual specifications as tailored from MIL-STD-1803, DOD-STD-2167, DOD-STD-2168, and other appropriate DoD and Air Force specifications and standards.

B.3.2.4 Mechanical component integrity. Integrated flight control system mechanical components shall be developed to the requirements of the applicable contractual specifications as tailored from AFGS-87249 and MIL-STD-1783.

B.3.2.5 Subsystem integration integrity. Subsystems or functions with which the flight control system integrates such as, hydraulic power, electrical power, pneumatic power, landing gear nose wheel steering, engine inlet/fuel/nozzle control, avionics, and mission modes shall be analyzed, developed, tested, and qualified to the requirements of the applicable contractual specifications. Integration is a technique to ensure interdependent and independent functions, using flight critical information, are able to determine whether or not the other function(s) are working properly and take appropriate corrective actions to maintain the safety of the vehicle. The contractor and procuring activity shall ensure that flight critical integrating functions meet this requirement as well as accommodating any single failure in such defined functions while maintaining Level I handling qualities.

B.3.2.6 Environmental spectra. Unless otherwise specified in the applicable contractual specifications, all integrated flight control system and subsystem hardware, software, and firmware elements shall be designed and tested by the contractor to the actual environment the equipment is actually exposed to during its intended use and failure free operating period. MIL-STD-210 should be consulted for temperature extremes.

B.3.2.7 Metrics. Metrics shall be used during the development to gauge the status, predict areas which need attention and result in improvements to the method of work, quality, the design, and test of the product. Metrics shall have value to the preceding characteristics in the areas of performance, cost, and schedule. If the metric does not result in some type of measurement taken over time to communicate vital information which results in actions that are linked to events in the flight control or master development plan, the metric should not be used. Each metric developed should define a description, purpose, desired outcome, linkage to the plans, a process owner, a customer, an affected population or product, frequency of measurement, source of the data, description of the equations used, key terms

related to the subject of measurement and the metric, some form of graphic representation ability, and an improvement strategy. Metrics shall be applied to the requirements in sections B.3 and B.4 as appropriate for the particular acquisition. The entry and exit criteria cited in section B.6 may be used as a starting place for the development of metrics and in some cases, e.g., completion of integration requirements, used directly.

B.3.3 Process management. To ensure the successful implementation of FLCDP, the contractor shall perform the following process management tasks in close coordination with the procuring activity. These tasks shall be addressed early in the development cycle and revised throughout the system life cycle as the system evolves and matures. These tasks include:

Management

a. Determining the organizational management level at which FLCDP will be implemented.

b. Determining what human resource specialties will be required to administer the program.

c. Determining what background and training will be needed for these specialists.

d. Analyzing the organizational structure, personnel manning, manufacturing processes, and quality control provisions, and generating detailed requirements for each appropriate level.

System Engineering

a. Analyzing the statement of need for each air vehicle application for characteristics that may dominate system integrity considerations.

b. Analyzing and iterating the proposed FLCS mechanization, support equipment, and environment and generating a top down requirement structure for each level of requirements.

c. Monitoring and analyzing the design and development process to insure that the detailed requirements are met at each level and in each discipline.

d. Establishing a risk management process for high risk technology which allows implementation of a fallback position without impacting cost or schedule.

e. Establishing a test process which verifies that the requirements have been met and determines the level of integrity that has been achieved.

f. Establishing the method and detail requirements for force management and product improvement during field usage.

B.3.4 Reports. All the contractor efforts required by the program shall be documented in technical and management reports that shall be submitted by the contractor to the procuring activity for approval according to the FLCDP master plan schedule. These reports shall also be updated by the contractor periodically throughout the program/project life cycle according to the integrated master plan schedule. These reports shall be included in the air vehicle program Contractor Data Requirements List (CDRL) as appropriate data items, as modified by the procuring activity. Typical reports are subsystem design and analysis report, trade study reports, and a final design report. There are Data Item Descriptions that cover these reports, but they may be eliminated soon.

B.3.5 Tailored flight control system development process. Integrated flight control systems shall be developed in accordance with this guide to the extent specified in the contract clauses, SOW, and CDRL. The procuring activity shall tailor this guide to each particular vehicle procurement and incorporate it into

the RFP (Request for Proposal)(ITO (Instructions to Offeror)/SOW/Requirements) documents at the time the RFP is released.

B.3.5.1 Proposal preparation and evaluation. Proposal preparation for any acquisition phase shall define the contractual performance requirements for the integrated flight control system. The response by the contractor often adds or deletes some requirements and has some TBDs (To Be Determined) for requirements. While this is acceptable up to some threshold, a commitment by the contractor to have the TBDs resolved by PDR should be made in the master plan. A rule of thumb to judge the amount of TBDs included in a contractor's response is no more than 20% of the requirements should be TBDs prior to awarding the contract.

B.3.5.2 Statement of Work content. The specific requirements in sections 30 and 40 of this document are worded such that they may be lifted in their entirety and used as SOW tasks in the SOW section of the RFP. Any of the task requirements may be modified or tailored as desired. The task requirements are not all inclusive and may have additional SOW tasks for a particular development. The examples in these sections should provide ideas of how to formulate any additional tasks desired. As a rule, the tasks outlined in section 40 and the additional requirements in section 30 are a minimum set of task requirements. Section 30 requirements will require the most modification by the procuring activity to arrive at acceptable SOW task formats.

B.4 DETAILED REQUIREMENTS. Table B-I represents a summary of the following paragraphs. Figures B-1 and B-2 show the flow of the development process.

B.4.1 Design Information and Concept Definition (Phase I). This phase encompasses those efforts required by the contractor to apply the existing theoretical, experimental, applied research, and operational experience to specific criteria for the design of an integrated flight control system for an air vehicle. The objective is to ensure that appropriate system, subsystem, and component requirements and planned usage are applied to the air vehicle design so that specific operational requirements will be met for its specified operational life.

B.4.1.1 FLCDP plan. A Flight Control System Development Process shall be included in the Master Plan required by the procuring activity and shall be prepared by the contractor at the start of any program. This plan shall be provided to the procuring activity as part of the proposal. This plan should become part of the program contractual documents and should be revised and updated by the contractor only as agreed to by the procuring activity. The FLCDP plan shall include, but not be limited to, the items described in the following paragraphs.

a. A high level event schedule shall be developed that addresses the overall flight control system development task from a top level perspective showing the interrelationships between all phases of the development work to be accomplished, specific milestones at which revisions to the FLCDP will be made and the technical and management reviews that will take place, such as the Preliminary Design Review (PDR) and Critical Design Review (CDR). Starting and completion events for all work items and reports shall be shown. A second level schedule shall be available for each major development sub-task, and additional lower level schedules shall be developed as appropriate to the complexity of the system, to provide visibility of the technical and management processes required for successful development of the system down to the hardware and software component level.

b. Synthesis, analysis, and trade study tasks to be accomplished shall be included in the plan, describing the technical approach, analytical procedures, and flight control performance parameters to be used during the development process. Analyses and criteria to be used to generate requirements for the FLCS specification shall be defined and described.

c. Verification and validation tasks to be accomplished to verify that the integrated hardware and software design meets all the requirements of the weapon system contract and the FLCS specification in particular shall be included in the plan. Software error reduction methods, resources, and limitations shall be specifically addressed and correlated with each applicable requirement and metric.

d. A risk management process for high risk technology which allows implementation of fallback positions without significantly impacting cost or schedule shall be addressed where applicable. Factors such as decision points, entry/exit criteria, metrics and impacts to cost, technical performance, or schedule shall be addressed.

TABLE B-I: FLCDP phase table.

Phase I Design Information & Concept Definition	Phase II Analyses, Design, and Development Tests	Phase III Formal Testing and Synthesis	Phase IV Force Management Data Package	Phase V Force Management & Product Enhancement
* Develop FLCDP Master Plan * Preliminary architecture and control law analysis * Develop Tailored FLCS Specification * Establish Design Performance * Establish Integration Performance * Track FLCS Development * Conduct Trade Studies on Key Issues * Preliminary Layouts * Identify Integrated Diagnostic Requirements * Establish Preliminary Support Equipment Requirements * Preliminary Software Sizing/Partitioning * Selection of Hardware	* Conduct Control Law Analyses/ Synthesis * Conduct Integration, -ility, and Safety Analyses & Synthesis * Establish Software Requirements * Perform Developmental Tests * Establish Software Verification & Validation Plans & Procedures * Establish Hardware/ Firmware Test Plans/Procedures * Finalize HW & SW Product & Support Specifications * Finalize FLCS Support Configuration Baseline * Finalize FLCS Configuration Baseline	* Control Law Analyses/Synthesis/ Simulation * Integration, -ility & Safety Analyses/Synthesis/ Simulation * Software Coding/Test * Perform Simulations * Integrated Hardware/ Software Testing * Full Integration Testing * Safety of Flight Tests * Qualification Testing * Support Equipment Testing * Flight Testing * Complete Design Refinements & Improvements * Complete Supporting Documentation * Verify Design Meets Requirements * Establish Production Configuration Baseline	* Finalize Analyses, Test Results, Specs, SW Documentation, Drawings, Procedures * Finalize FLCS Maintenance Plan * Finalize Tech Manuals/Support Equipment Documentation/ Drawings * Establish Field Usage Data & Criteria & Collection Approach * Finalize Production & Field Configuration Control Methods for Hardware & Software	* Maintain Quality of All Production Items * Collect, Reduce, and Analyze Field Usage/Environment/ Repair Data * Maintain & Update All Documentation * Implement Preplanned Product Enhancements * Implement Engineering Hardware & Software Changes

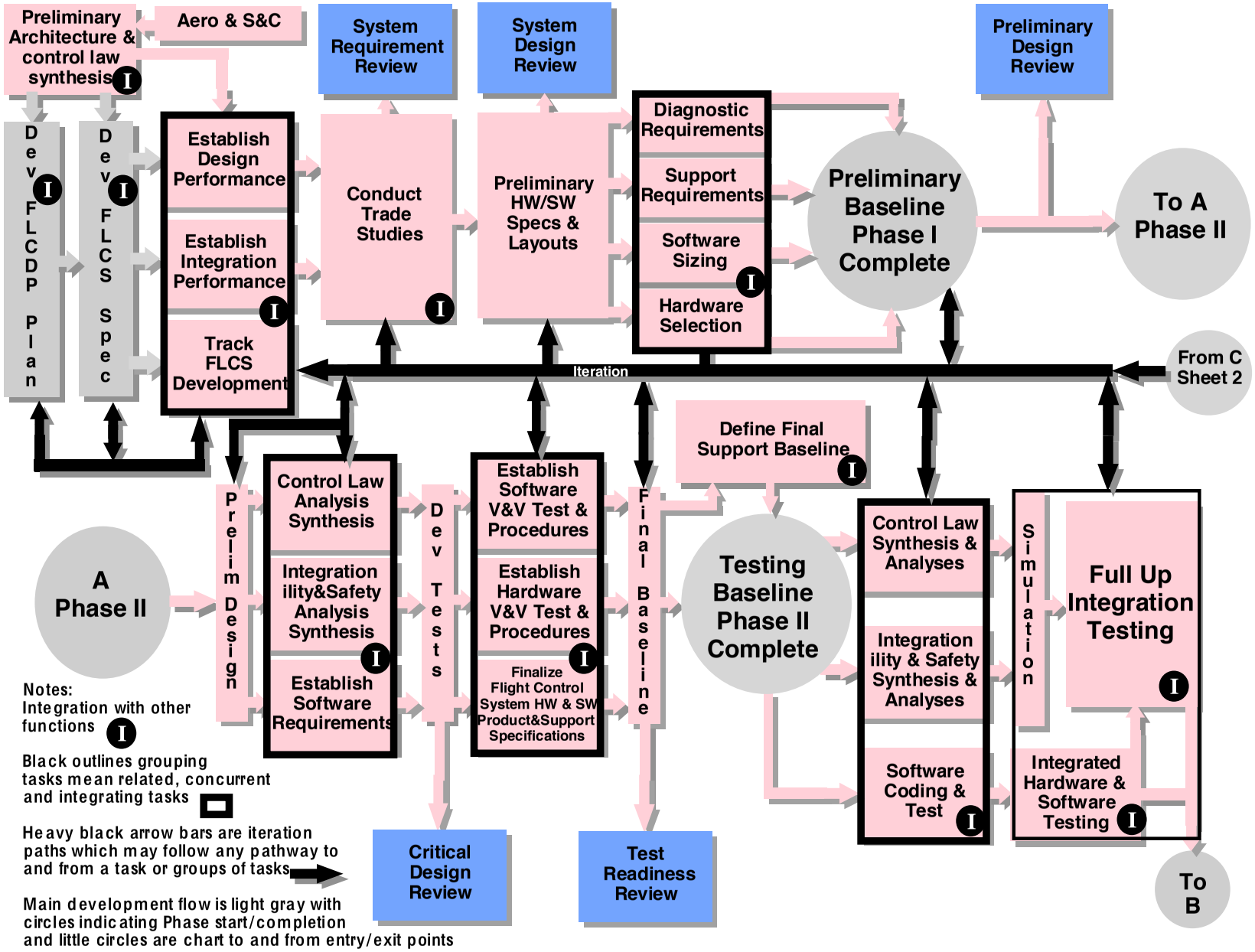

Figure B-1: FLCDP Development Process Flowchart (sheet 1)

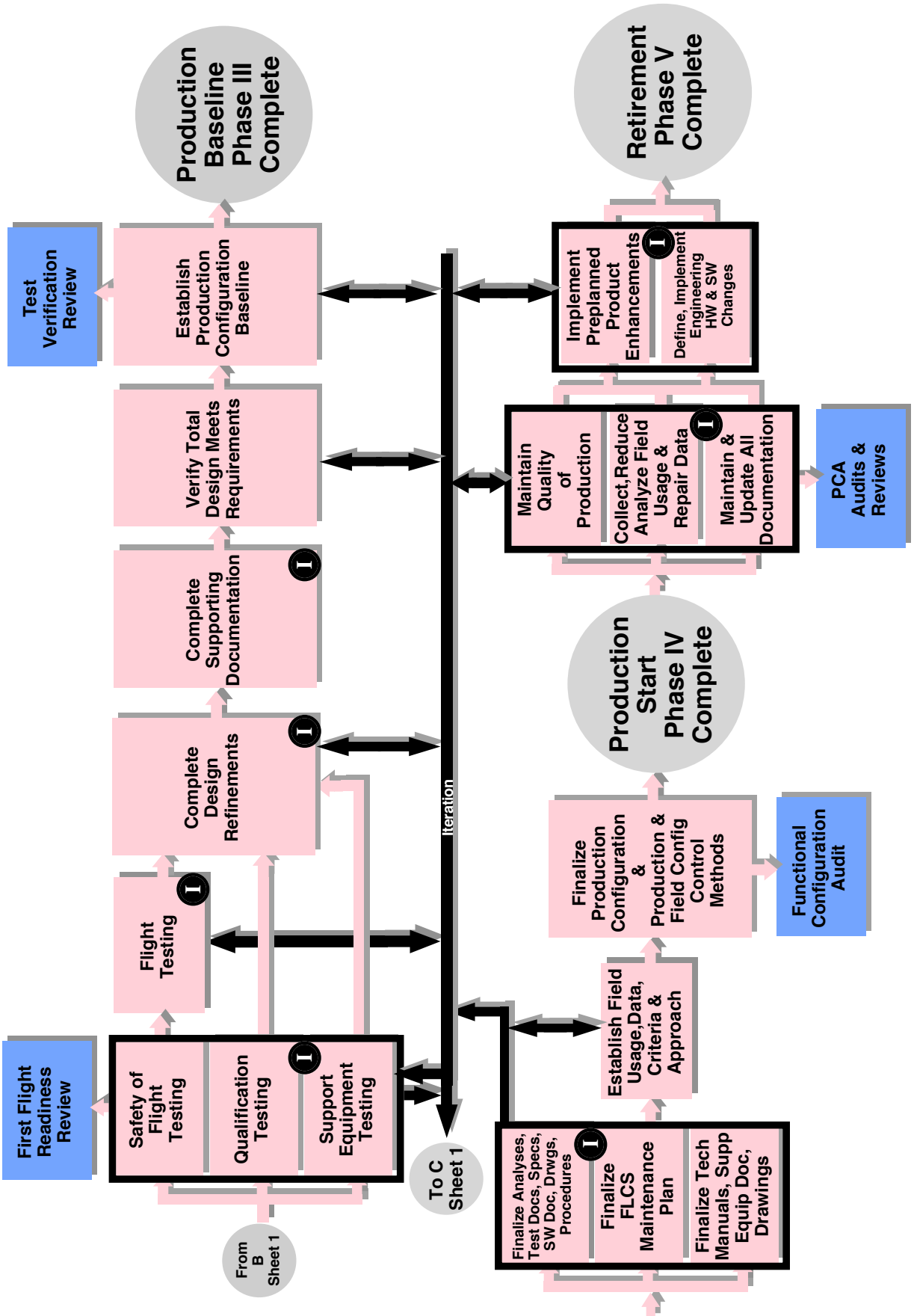

Figure 2: FLCDP Development Process Flowchart (sheet 2)

e. Analyses to be accomplished to verify integrated system integrity such as flight safety, failure modes and effects, reliability, maintainability, component life, and vulnerability shall be identified together with the analytical, testing, or other means selected for design verification in those areas.

f. Functional mockups and simulators to be used shall be described by the contractor, including the test approach with specific verification requirements to be satisfied by each test.

g. Ground tests to be conducted prior to first flight to verify system integrity in the required natural and man made environments to verify the design failure-free operating life shall be identified. Ground tests to verify the maintenance and support requirements shall be discussed. Necessary procedures and contractor and/or government test facilities shall be identified.

h. Flight tests to verify system integrity, including procedures, maneuvers, special instrumentation, available maintenance and support features, and the flight control performance shall be identified.

i. Force management tasks shall be identified by the contractor to obtain, reduce, document, and analyze data from field (operational and maintenance) usage with respect to predicted maintenance actions, failures, wear history, abort rates, built-in-test experience, diagnostics results, servicing frequencies and life against the flight control function design. Tasks to correct, modify, change, and enhance the force management production configuration design baseline shall be addressed.

j. Tasks to be conducted with respect to integrated diagnostics, integration analyses and tests, subsystem integration, laboratory tests, and flight safety tests shall be identified by the contractor.

k. Aspects of flight control performance shall be identified.

l. Any other tasks to be accomplished by the contractor to design, test, and qualify the mechanical, electronic, and software elements of the integrated FLCS shall be identified and included in the plan.

The FLCS is equally made up of integration as well as control aspects. The following planning documents need to be incorporated into FLCDP giving careful attention to detail and full consideration of the following paragraphs.

B.4.1.1.1 FLCS structural development plan. The contractor shall indicate the approach as part of the FLCDP plan to design, develop, test, qualify, and force manage the structural/mechanical elements of the integrated FLCS as tailored from MIL-STD-1530.

B.4.1.1.2 FLCS electronic development plan. The contractor shall indicate the approach as part of the FLCDP plan to design, develop, test, qualify and force manage the electronic elements of the integrated FLCS as tailored from MIL-STD-1796.

B.4.1.1.3 FLCS software development plan. The contractor shall indicate the approach as part of the FLCDP plan to design, develop, test, qualify, and force manage the software elements of the integrated FLCS as tailored from MIL-STD-1803, DOD-STD-2168, and other appropriate and valid DOD and Air Force software standards and specifications.

B.4.1.1.4 FLCS subsystem development plan. The contractor shall indicate the approach as part of the FLCDP plan that addresses the design, development, testing, qualification, and force management of subsystems that are part of the integrated flight control system as tailored from AFGS-87249.

B.4.1.2 Preliminary architecture and control law analysis. The planform and external physical and response characteristics (simulations) should already be in work by the aero and stability and control engineers. Their inputs should provide the basis for preliminary architecture and control law analysis which aids in establishing the FLCS plan, specification, and overall design and integration performance.

The contractor should have enough work accomplished to justify the overall FLCS and control law architectures. This effort continues in subsequent phases.

B.4.1.3 Develop tailored FLCS specification. The contractor and procuring activity shall prepare a preliminary version of the integrated flight control system specification by tailoring the requirements of this document to each specific procurement. If appropriate, this preliminary specification may be provided to the contractor by the procuring activity as part of the RFP package. Items that may be configuration dependent may be left blank at this time, to be filled in by the contractor. The contractor shall submit an initial contractual version of the integrated flight control system specification to the procuring activity for approval as part of his proposal. Additionally, all TBDs shall be filled in by the contractor and approved by the procuring activity by a mutually agreed to event as shown in the master plan, but not later than production contract award.

B.4.1.4 Establish design performance. The contractor shall, in concert with the specification development, define the design performance parameters to be included in the functional specification between the procuring activity and the contractor. Design performance consists of safety margins, level of operational states for various failures of the basic control function as derived from subsystem hazard assessments, level of integration with other functions, specific tolerances allowed for phase and gain margins, level of support equipment, level of maintenance, levels of diagnostics, basic control modes, and methods for verification balanced against the total mission. The requirements should be written in terms of functional performance and not design; e.g. fail-operate/fail-operate or 10^{-7} loss of control event per flight hour versus triplex redundancy. The contractor shall develop the environmental spectra within which the integrated flight control system, subsystems, and components must operate and meet their performance requirements during their failure-free operating lives. These spectra shall include, but not be limited to, the repeated acceleration, loads, thermal, pressure, vibration, acoustic, humidity, aerodynamic, and chemical environments experienced by the system, subsystems, and components during ground and flight operation, storage, ground handling and transportation. To the extent possible, the spectrum should reflect the actual usage.

B.4.1.5 Establish integration performance. The contractor shall, in concert with the specification development, define the integration performance of the flight control function within the function and between other functions. Integration performance consists of safety margins for each function, level of operational states for each integrated function, control phase and gain margins for each function and combination of functions which produce operating modes in the part of the operational flight envelope in which they are used, criticality of each function and combinations of functions, support functions on and off the vehicle, single failure performance for each function and combination of functions and verification methods.

B.4.1.6 Track FLCS development. The contractor shall define the metrics to measure the progress of the development as well as the adequacy of the design. The key parameter is safety, balanced but not sacrificed, against cost and schedule. The contractor shall (within the FLCDP plan) report the status of the development at technical meetings and present the status in an unbiased, objective way. The areas of design, integration, and tracking are concurrent and integrated. They require a large effort in functional coordination as well as many iterations between these tasks to arrive at an adequate solution.

B.4.1.7 Trade studies. The contractor shall perform trade studies for the overall architecture and all individual system components and evaluate the trade-offs between failure-free operating life and scheduled/unscheduled maintenance actions with respect to life cycle cost, weight, performance, history, accessibility, and maintenance manpower requirements. The results of these trade studies shall be used by the contractor to substantiate his integrated FLCS design and maintenance concept to the procuring activity. The results of the trade studies and successful definition of the specification are the basic criteria to support the program's System Requirement Review.

B.4.1.8 Preliminary layouts. The contractor, upon completion of the specification and trades, shall define the entire integrated flight control function by preliminary layouts of the functions, preferably in block diagram form. Accompanying analyses shall support the preferred layouts in enough detail to be able to understand the selections versus the alternatives considered against the pertinent performance and design parameters such as weight, power, memory, bus communication, sensor information, actuation, power type, hydraulic power, integration of special modes like terrain following, autopilot, autohome, autoland, navigation, weapon delivery, stealth, c.g. control, thrust vectoring, direct force controllers, cockpit controls, displays, maintenance modes, landing modes, thrust reversing, collision avoidance, plus whatever other modes may be appropriate for the particular vehicle or update. Any additional analysis beyond the trade studies such as safety, reliability, survivability, redundancy, backups, phase and gain margins, control margins, and error tolerances shall be documented, updated as needed, and available to the procuring activity. This and the following tasks are usually performed concurrently with integration/iteration taking place between these, other tasks, and other integrating functions to FLCS. These layouts with the FLCS specification, hardware, and software specifications and the identification of long lead items which have a major impact on the schedule (e.g., actuators, computers, low observable air data) are the basic criteria to typically support the program's System Design Review.

B.4.1.8.1 Failure modes evaluation/critical function analysis. As part of the integration and preliminary design, the contractor shall conduct subsystem hazard and failure modes and effects analysis of the integrated flight control system. As part of this analysis, all components shall be evaluated with respect to criticality of function and classified as flight/safety, mission, durability, economic, or non-critical. All flight critical functions, components, elements, and other integrating functions to FLCS shall be identified and given a high priority to be tracked and evaluated by technical and program managers during the development, test, and force management phases of the life cycle to ensure a safe design. This part of the integration effort in concert with the trade studies is iterative and this analysis should be repeated with each design iteration. The Phase II task of Integration Analyses is where this is addressed for the remaining phases.

B.4.1.9 Identify diagnostic requirements. The contractor shall define the requirements necessary to recognize, isolate, and repair faults unambiguously for the integrated flight control system and tailor AFGS- 87256, as appropriate. These are not limited to support functions but are usually part of the safety aspects of control design where faults are passively detected and actively isolated and corrected while in flight. Once the design is known, partitioned, and the support and diagnostic requirements are available, the functional design may be refined.

B.4.1.10 Establish preliminary support requirements. Support functions lag the development due to the need to define and select the basic system components. The contractor shall define the support requirements necessary to support the function(s) for the entire life cycle. Although the requirements are preliminary, they should be defined in enough detail to quantitatively set a 90% complete criteria. This effort is done concurrently with software and hardware sizing and selection and requires a determined effort in communication and coordination to arrive at an adequate set of support and other integrating functional requirements for FLCS.

B.4.1.11 Preliminary software sizing/partitioning. The contractor shall establish the hardware and software functions to be performed. Based on the previous considerations and studies, the software functions should be estimated regarding memory, timing, and throughput. From this estimate, the reserves needed should be established for the preliminary functional design.

B.4.1.12 Selection of hardware. After completing the studies, layouts, partitioning, and subvendor specifications, the hardware components shall be defined by the contractor as to subvendors, type of components, the number of components, the tests required for the components, the design features of the components and units, and reporting on them at technical meetings. Following successful conclusion of preliminary selection of hardware and establishment of performance and detail design requirements by

the contractor, the program's Preliminary Design Review may be supported and Phase I considered completed.

B.4.2 Design analysis and development tests (Phase II). This phase encompasses the analysis and design iterations and design of experiments that are necessary to finalize the design of the integrated flight control function within the applicable environments. The design of the function, its architecture and usage to meet system performance, support, and life cycle requirements shall be demonstrated to the extent that the configuration of hardware and software at the end of this phase are ready to enter formal test of the next phase. Adequate technical reviews shall be planned to encompass the full design down to the piece-part/module level including the manufacturing processes.

B.4.2.1 Conduct control law analyses & synthesis. The contractor shall conduct those analyses required to support flight control function development with respect to the vehicle and its handling qualities (MIL-STD-1797). This is a continuation from Phase I and requires integration with separate design efforts in the hardware/software areas as well as coordination with the using community. These analyses and the associated documentation shall, as a minimum, address:

a. Design requirements and criteria used during Phase I to establish the type of vehicle response needed.

b. Flight control laws and block diagrams of the integrated FLCS. They shall include transfer and describing functions and indicate normal control paths, redundancy, manual overrides, emergency provisions, and analytical models for all components of the integrated FLCS.

c. Establishing the stability and performance characteristics of the FLCS and a correlation of system characteristics with requirements of the integrated FLCS specification. Where analytical predictions are used to satisfy specification requirements, the assumptions, approximations, and tolerances placed on these predictions shall be documented and substantiated. Simulations shall include the effects of nonlinearities such as limiters, actuator rates and position limits, amplifier saturation, mechanical deadbands and hysteresis, digital sampling rates, and computational delays. Analytical techniques may include linear, small perturbation analyses, nonlinear off-line simulations, modern control theory techniques such as pole placement and singular value analyses and manned simulations. The contractor shall substantiate the appropriateness of the techniques used for the vehicle design to meet the response requirements.

d. Mathematical models of the integrated FLCS, the unaugmented air vehicle, and other data required to allow the procuring activity to independently simulate the total system accurately during and after the development process. Mathematical models, block diagrams, stability and performance data, and layouts shall be updated in accordance with the approved FLCDP plan.

B.4.2.2 Conduct integration, -ility, and safety analyses/synthesis. The contractor shall continue to iterate, from Phase I, analyses which effect the performance, integration, and safety of the integrated FLCS. This is a continuation of work started in Phase I (B.4.1.4 and B.4.1.5) and integrates with control law analysis and software requirements. As a minimum the analyses shall address the following:

a. The integrated FLCS, including the various modes of operation, both manual and automatic, and the theory of operation.

b. Unusual, difficult or technically risky design features or problems, descriptions of efforts to solve, reduce, and evaluate the risks associated with these problems, and features that will be used to evaluate the risk items and process.

c. The integrated FLCS safety, reliability, maintainability, and vulnerability analyses with a detailed identification of possible failure modes, the sources of data used, and the analytical methods used shall

be addressed. These shall include safety margins, level of operational states for various failures of the basic control function including integration with other functions, specific tolerances allowed for phase and gain margins, level of support equipment, level of maintenance, levels of diagnostics, basic control modes, redundancy and integration management, and methods for verification.

d. The integrated FLCS analysis and synthesis process should show an integrated flight control system layout or series of layouts showing control surfaces, actuation systems, feel systems, pilot's controls, location, and type of sensors and other devices. Means of providing redundancy and emergency provisions shall be illustrated. Layouts shall include wiring schematics for all electrical and electronic portions of the integrated FLCS, interfaces and attendant electrical, hydraulic, and pneumatic power inputs to the FLCS. The architecture of the integrated flight control system shall include other appropriate functions such as propulsion, fire control, and flutter suppression to name a few.

B.4.2.3 Establish software requirements. The previous analyses combined with the results from Phase I shall establish and substantiate the software requirements in terms of the functions the software will perform. These requirements shall address the use of processors, whether synchronous or asynchronous operation, the kinds of data buses, redundancy management techniques, programming language, protocol, bus control, redundancy and fault management including integrating functions, executive control, program control and flow, memory usage, and execution times/frames for the control laws and all integrating functions. Diagrams shall be provided showing all program subelements/modules and their interrelationships and other integrating functions to FLCS.

B.4.2.4 Perform developmental tests. The contractor shall perform the developmental tests necessary to prove the functional design. These tests should include (but are not limited to) bench, hot bench, real & non-real-time simulations, iron bird, hardware and software in the loop, HW and SW latent failures, man in the loop, structural integrity, and failure mode and effects tests. The test results should demonstrate that the proposed design is sound, risk is minimized, and functional performance is valid. The end result shall provide proof that the integrated FLCS will most likely meet its functional requirements. The successful conclusion of this effort shall be the criteria for supporting the program's Critical Design Review.

B.4.2.5 Establish software verification and validation plan/procedures. The contractor shall verify and validate all integrated FLCS software. Computer software configuration items (CSCIs), computer software components (CSCs), coding modules, coding error identification methods, functional execution tests, higher order language usage, and other appropriate technical items shall be addressed. Flight critical software error reduction methods, facilities and schedules shall get special emphasis. The error reduction methods shall address requirements verification, analysis of test cases, analysis of redundancy, fault management and integration functions, component, module and total program functional tests, simulations and logic error analysis. Pass/fail criteria and testing procedures shall be described and may be subject to approval.

B.4.2.6 Establish hardware/firmware test plans/procedures. The contractor shall define the test plan and procedures, instrumentation, and manufacturing accessibility by which safety of flight, environmental, full integration testing, simulations, support equipment, and flight testing shall formally prove the integrated FLCS function is ready for production. The testing required integrates with establishing the final FLCS, support configurations and other integrating functions to FLCS. The plan and procedures should be made available for review and approval of these critical tests.

B.4.2.7 Finalize HW (Hardware) and SW (Software) product and support specifications. The contractor shall finalize the FLCS and subtier specifications to his vendors with the changes incorporated during development. These specifications and resulting configuration will form part of the configuration baseline for formal test and is part of the criteria to support the program's Test Readiness Review. This task is integrated with the above two tasks to prepare for formal test and other integrating functions to FLCS.

B.4.2.8 Finalize FLCS support configuration baseline. The contractor shall finalize the support configuration baseline. This configuration is part of the criteria to support the program's Test Readiness Review.

B.4.2.9 Finalize FLCS configuration baseline. The contractor shall finalize the integrated FLCS configuration baseline in preparation for formal test. This configuration is part of the criteria to support the program's Test Readiness Review.

B.4.3 Formal testing and synthesis (Phase III). This phase encompasses the full scale verification and validation that the integrated flight control system meets all air vehicle performance and integrity requirements through all types of ground and flight tests. The purpose is to discover problems and iterate the design to correct them to establish a production configuration baseline.

B.4.3.1 Control law analyses/synthesis/simulation. This is a continuation of the task identified in B.4.2.1 with more emphasis on refinement and finalization using real-time and pilot in the loop simulations.

B.4.3.2 Integration, -ility and safety analyses/synthesis/simulation. This is a continuation of the task identified in B.4.2.2 with more emphasis on finalization through the use of real-time simulations and full integration testing.

B.4.3.3 Software coding and test. The contractor shall code the software functions and test the software units, modules, and CSCs. This area is integrated with the above two tasks and iterative. Final verification and validation of the software will take place in full integration testing with use of simulations as needed.

B.4.3.4 Perform simulations. The contractor shall perform the non-real-time and real-time simulations to establish the final control law, redundancy management, integration management, and software requirement/functions. This is a preparatory and iterative/integrated task to support full integration testing and other integrating functions to FLCS.

B.4.3.5 Integrated hardware and software testing. The contractor shall test the hardware and software as an integrated package to verify a limited functional set or combinations of sets. This testing is limited and preparatory to full integration testing and integrated/iterated with the above tasks. Of primary interest is that the hardware and software work together, the diagnostics (passive and active) work correctly, and the failure protection and correction is adequate.

B.4.3.6 Full integration testing. The contractor shall perform full up integration tests of the entire integrated FLCS. It is preferred that the actual hardware and software be used. Emulation and simulation of any of the flight critical parts is not recommended. If functions must be modeled, the models should be verified against the actual hardware/software performance. Traditionally this is the "iron bird" testing which incorporates an integrated FLCS with simulated surfaces. An important part of this testing is pilot in the loop with the actual equipment and failure mode(s) and effects testing (FMET). FMET (derived from the FMECA (Failure Modes Effects Criticality Analysis) and FMEA (Failure Modes Effects Analysis) analyses) should cover all aspects of verifying correct fault detection, isolation, redundancy, and integration management, and the maintenance portions of diagnostics. Support testing may also be integrated with this effort and other integrating functions to FLCS. This is the major test to verify the integrated FLCS functional requirements.

B.4.3.7 Safety of flight tests. The contractor shall identify tests required to substantiate that the air vehicle is ready for flight testing. Safety of flight analyses and tests shall be completed satisfactorily prior to the First Flight Readiness Review (FFRR). In addition, those safety of flight, verification and validation, system integration, hardware, failure modes and effects, and other ground tests and analyses specifically

required to demonstrate acceptable system integrity in the structural, electronic, and software elements prior to flight test shall also be satisfactorily completed prior to the FFRR. The contractor shall substantiate the choice of tests, test conditions, document the results, and submit them for approval. Typical tests for this area are satisfactory completion of full integration testing, limited environmental (vibration, humidity, temperature, altitude, shock, explosion, life, and acceleration), EMI/EMC (Electro-Magnetic Interference/Compatibility), structural vibration, and flutter. Typical analyses are the FMECA and System Safety Hazard Analysis. Successful completion of this and the above task are the criteria to support the program's First Flight Readiness Review.

B.4.3.8 Qualification tests. Flight critical functions, components, and elements shall receive particular attention. The contractor shall identify all the component and system ground and qualification tests, conditions, procedures, and pass-fail criteria to be used to verify that the integrated FLCS hardware and software requirements are met at both the component and system levels and to verify component, subsystem, and system failure free operating lives in their applicable environmental (natural and man-made such as EMI/EMC) conditions and climatic extremes. Rationale for choosing particular techniques and facilities shall be provided and all test results shall be reported. The contractor shall also provide justification for the choice of test conditions and substantiate that they adequately emulate the required operational, environmental, and climatic conditions. The contractor shall not initiate formal testing without that approval. This task integrates with the above and following task and other integrating functions to FLCS.

B.4.3.9 Support equipment testing. The contractor shall conduct tests of the support equipment to verify the requirements for the full integrated FLCS. This task may be done in conjunction with any of the tasks involving testing, but must be complete prior to the program's establishment of a production configuration baseline. The recommended combinations are during full integration and flight testing. This task integrates with the above and other integrating functions to FLCS.

B.4.3.10 Flight testing. The contractor shall submit all flight test plans and procedures for approval prior to the start of testing. These plans shall address all test conditions, configurations, and maneuvers to be flown, normal pilot procedures to operate the various modes of the integrated flight control system, "what if" emergency procedures in the event of in-flight failures and malfunctions, and how the performance of flight critical subsystems, components, and elements will be monitored. Additionally, the plans shall contain go/no-go criteria for each test with respect to instrumentation, system/subsystem functional, and weather requirements. The contractor shall conduct the flight testing and verify that the integrated FLCS meets the normal mode of operation (Operational State I) functional requirements.

B.4.3.10.1 Flight test results. The contractor shall document the flight tests performed, the data generated to verify that the requirements of the FLCS specification have been met, and correlation with design predictions. This documentation shall include:

a. A detailed description of the integrated flight control system configuration as flown.

b. A chronological diary documenting all modifications made to the flight control system, as well as to interfaced and integrated subsystems during the course of the flight test program and the reasons for and effects of the modifications.

c. Results of the flight test experience with the flight control system hardware and software including preflight built-in-test (BIT) failures, in-flight failures, scheduled and unscheduled maintenance actions, diagnostics methods and support equipment, inspections, software anomalies, etc.

d. Deficiencies and corrective actions identified during the flight test program that resulted in production modifications.

e. Technical discussions of all modifications that occurred during flight test showing affected portions of the integrated flight control system hardware and software.

B.4.3.11 Complete design refinements and improvements. Each test conducted will either verify the design or require some modification/improvement to achieve the functional performance desired. The contractor shall refine the design as required by each of the tests and maintain configuration control as the configuration baseline changes. Any change of the function(s) form, fit, or function shall require approval of the procuring activity. This task integrates with the above and following task and other integrating functions to FLCS.

B.4.3.12 Complete supporting documentation. The contractor shall complete and/or update the documentation which supports the integrated FLCS design including the refinements and improvements. This documentation shall also include the complete support structure, hazard, and failure mode analyses for the FLCS. This task integrates with the above and following task and other integrating functions to FLCS.

B.4.3.13 Verify design meets requirements. The contractor shall demonstrate through the testing and supporting documentation that the design of the integrated FLCS and any refinements/improvements meet the functional requirements. This task is the culmination of any design refinement or improvement.

B.4.3.14 Establish production configuration baseline. The contractor shall establish the production configuration baseline subject to the approval of the procuring activity. The successful completion of this and the above tasks provide the criteria to support the program's Test Verification Review.

B.4.4 Force management data package (Phase IV). Maintaining the integrity of the integrated flight control system throughout its useful life depends upon the capability of the Air Force to perform specific scheduled inspection, maintenance, modification, and replacement tasks at specific intervals throughout the service life of the air vehicle in addition to unscheduled maintenance actions or system changes to correct deficiencies. It also depends on the continuing production and delivery of quality components by the prime contractor and his vendors that meet Air Force requirements throughout the life cycle of the air vehicle. Additionally, past experience has shown that the actual usage and operational environmental conditions of military air vehicles may differ significantly from those assumed during the design, development, and qualification testing process. To perform its life cycle integrity tasks successfully, the Air Force must know in detail what actions are required, when they are required to be performed, and what technical methods, skills, and facilities are required to satisfactorily accomplish them. This phase of the FLCDP describes the minimum elements of a data package which the contractor shall provide so that the Air Force can successfully perform its force management tasks.

B.4.4.1 Finalize analyses, test results, specifications, software documentation, drawings, and procedures. The contractor is given this task to provide the time necessary to complete all the integrated FLCS documentation necessary to produce, and substantiate the existing design. This task integrates with the above and following tasks and other integrating functions to FLCS.

B.4.4.2 Finalize FLCS maintenance plan. The contractor shall prepare an integrated flight control system integrity maintenance plan to identify the flight and mission critical hardware and software documentation, inspection, replacement, and modification requirements for the air vehicle in the operational environment. This plan shall be approved by the procuring activity and will be used in budgetary, force structure, and maintenance planning by the Air Force. This plan shall be revised and updated by the contractor throughout the service life of the vehicle as analysis of actual field usage data indicates trends, either good or bad, relative to design usage and the predicted maintenance burden, such as those identified during the operational usage sensitivity analysis, and also to account for the effects of product enhancement efforts. This task integrates with the above and following tasks and other integrating functions to FLCS.

B.4.4.2.1 Development of inspection and repair criteria. The contractor shall use the production configuration baseline data and the results of qualification, safety of flight, laboratory, and flight tests to develop a quantitative approach to establishing scheduled periodic inspection, repair, replacement, modification, and other preventative maintenance procedures and criteria. As part of this effort, the contractor shall perform a sensitivity analysis of the effects of variations in operational usage on the integrated flight control system relative to the specified design usage and shall describe the resulting impacts on documentation, inspections, maintenance actions, support requirements, spares provisioning, and projected costs to maintain system integrity. Allowable wear, component failure rate, rigging tolerance, and other limits shall be defined. Criteria shall be developed related to failure-free operating period, MTBF (Mean Time Between Failure), MTTR (Mean Time To Repair), NMC (Not-Mission Capable) rate, and other appropriate maintenance action parameters that will trigger preventive and corrective action by the Air Force and the contractor. These limits, criteria, metrics, and actions, especially for flight critical items, shall be incorporated into the integrated flight control system integrity maintenance plan.

B.4.4.3 Finalize technical manuals, support equipment documentation, drawings, and procedures. The contractor is given this task to provide the time necessary to complete all the integrated FLCS support documentation necessary to produce and justify the existing support design. This task integrates with the above and following tasks and other integrating functions to FLCS.

B.4.4.4 Establish field usage data, criteria, and collection approach. The contractor shall propose a management and technical approach to collect, reduce, and analyze field usage and environmental data on the integrated flight control system, its subsystems, components, and impacts due to vendor changes for use in refining and revising the provisions of the integrated flight control system integrity maintenance plan. Means of monitoring wear, leakage, usage cycles, environmental conditions, component failure rate, etc., as necessary to perform this function, shall be provided in the system hardware/software design and shall be addressed early in the design information and concept development phase (Phase I) of the FLCDP. These data shall be used both to improve FLCS design and verification processes used during development (lessons learned and guidance) and provide the basis for future redesign or maintenance improvements that may be considered by the procuring activity to improve flight safety, reliability, and maintainability or reduce life cycle costs.

B.4.4.5 Finalize production and field configuration control methods for hardware and software. The contractor shall provide a configuration baseline definition for the production configuration of the integrated flight control system and its support including any updates of integrated flight control system hardware and software documentation, analyses, ground test results, and component specifications. This data package shall be revised by the contractor throughout the vehicle production program to address whatever modifications occur to the vehicle configuration. This task integrates with the above tasks and other integrating functions to FLCS. This task with the other tasks forms the basis to support the program's Functional Configuration Audit.

B.4.5 Force management and product enhancements (Phase V). This phase describes those actions that must be conducted by the Air Force and by the contractor during force operations to insure the continuing integrity of the integrated flight control system, its subsystems, components, and support system, and to minimize the maintenance burden on the Air Force using command. This phase also covers changing operational needs, mission changes, design changes and implementation, and documentation maintenance for the weapon system service life.

B.4.5.1 Maintain quality of all production items. The contractor shall ensure that integrated flight control system/component product integrity is maintained during manufacturing in accordance with manufacturing producibility requirements, quality assurance practices, and product screening strategies. The contractor shall keep his manufacturing process and those of his vendors under control through various methods such as environmental stress screening, process control techniques, inspections, and acceptance tests. The contractor shall include specific methods for controlling product quality characteristics that may be dominated by process, machine, workmanship, or purchased material

property considerations. This task integrates with the above tasks and other integrating functions to FLCS.

B.4.5.2 Collect, reduce, and analyze field usage/environmental/repair data. The Air Force will be responsible for the overall planning and management of the field data gathering effort and will be assisted by the contractor as defined in the air vehicle contract. The contractor, as part of the FLCDP plan, shall propose an overall approach to the Air Force and provide technical assistance as required. Tracking approaches should provide the data needed to identify component and system level problems in the flight control and integrated subsystems that were not anticipated during design and development, determine if cost effective redesign, product improvements, or work-arounds are justified, and define required modifications to the integrated flight control system integrity maintenance plan to minimize the maintenance burden on the Air Force using command. This task integrates with the above and following tasks and other integrating functions to FLCS

B.4.5.2.1 Maintenance records. The procuring agency and the using command will be responsible for maintaining integrated flight control system maintenance records (inspection, repair, replacement, modification, etc.) for individual vehicles and integrated FLCS software control documentation. These records shall contain complete descriptions of maintenance actions performed including Time Compliance Technical Order (TCTO) action, component flight time, component serial number, air vehicle serial number, Operational Flight Program (OFP) version and change numbers, etc.

B.4.5.3 Maintain and update all documentation. The contractor shall complete, update, and maintain the documentation of the integrated FLCS design including the enhancements and engineering changes. This documentation also includes the complete support structure for the FLCS. This task integrates with the above tasks and other integrating functions to FLCS. Successful completion of this and the preceding task form the criteria to support the program's Physical Configuration Audit after the first few systems are produced.

B.4.5.4 Implement preplanned product enhancements. The contractor shall schedule into production and retrofit product enhancements according to previous agreements with the procuring activity. The contractor shall also be responsible for submitting and implementing product enhancements based on technology, mission, industrial base, and usage changes. This is a continuing effort that endures throughout the life of the system.

B.4.5.5 Implement engineering hardware and software changes. The contractor shall implement the necessary hardware and software changes resulting from design or environmental deficiencies. The contractor and procuring activity shall decide what is the appropriate place in the development process to start and finish these activities. This is a continuing effort that endures throughout the life of the system.

B.5 PACKAGING. This section is not applicable to this document.

B.6 NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

B.6.1 Intended use. This section is intended to provide explanations, event criteria, suggested data requests, definitions, and any errata of interest to this document.

B.6.2 Acquisition requirements. The data requirements will be reflected in the contractor data requirements list (DD Form 1423) attached to the request for proposal, invitation for bids, or the contract, as appropriate.

B.6.3 Phase entry/exit criteria. The following entry/exit criteria for each of the phases is not meant to be all inclusive, but to stimulate ideas to arrive at criteria for each entry and exit point of the phases:

	Entry	Exit

Phase I	Valid Mission Need Statement
	Preliminary Operational Requirements
	Basic Mission Profile(s)
		Concept defined
		Proof of concept established
		Draft event schedule
		Cost estimate (unit/LCC)
		Flight Control Requirements
		  Fail Capability
		  Processor Architecture
		  Support Requirements
		System Layout
		Risk Assessment Complete

Phase II	Exit criteria of Phase I met
	Risk management approach established
		Complete architecture designed
		Weight limits established
		Cost established
		Schedule established
		Risk Items less than high
		Risk management process verified
		Data Processing requirements done
		Complete integration requirements
		  Electrical power
		  Hydraulics
		  Air data
		  Inertials
		  Cooling
		  Cockpit controllers & layout
		  Landing gear
		  Special controls, e.g. thrust vector
		  Flight modes, e.g. TF, stealth
		  Actuation
		  Redundancy management
		Autopilot design complete
		System integration complete

management

		Complete support concept defined Draft service life needs identified
Phase III	Exit criteria of Phase II met Risk assessment low	Testing Complete Ground test Flight test Qual tests Integrity/life tests Support tests Configuration baselined All requirements verified Schedule accomplished okay Actual cost satisfactory Service lives established Life cycle cost defined Ops limits established Manufacturing processes verified Plans for second sourcing estab'd Force management plan complete
Phase IV	Exit criteria of Phase III met Config control in place	Changes Identified by force mgmt Design deficiencies Ops needs changing Expanded mission role Upgrades for obsolete items Change plan in place Force management working Changes designed Service life re-verified Production cost & schedule done Force management in place
Phase V	Exit criteria of Phase IV met	Implement Changes Test changes as required Initial Ops testing complete Fielded changes Introduce into production Force manage changes Cost & schedule verified

B.6.4 Programmatic event entry/exit criteria. The following is suggested criteria to enter and exit programmatic events.

	Entry	Exit
System Req Review	FLCDP plan FLCS specification Interface control document Contractor config plan	FLCS functional architecture Trade study results Risk management approach Technical strategy Detailed event schedules
System Design Review	Updated SRR exit criteria	Hardware/software partitioning Integrated FLCS functional architecture baseline Support requirement and architecture baseline
Preliminary Design Review	Updated SDR exit criteria	Preliminary layouts complete Hardware selection complete
Critical Design Review	Updated PDR exit criteria	Configuration baseline firm Software requirements established Development tests complete
Test Readiness Review	Updated CDR exit criteria	Final FLCS test configuration done Software test plans/procedures done Hardware test plans/procedures done Final support test configuration
First Flight Review	Updated TRR exit criteria	Software code and testing done Control laws, integration, and simulations done Integrated HW/SW tests complete Full integration tests complete Safety of flight tests complete
Test Verification Review	Updated FFRR exit criteria	Flight testing 80% complete Qualification tests complete Support functional tests complete Design refinements/changes done Supporting documentation done Production configuration baseline established Manufacturing process verified
Functional Config Audit	Updated TVR exit criteria	Analyses, tests, SW documentation drawings, procedures complete Maintenance plan complete Tech manuals, support equipment documentation, drawings, procedures complete

		Usage criteria, approach and utilization complete Production and field configuration control complete
Physical Config Audit	Updated FCA exit criteria	Production and field configuration control re-established As-built matches drawings Production processes adequate Production quality maintained Usage data approach working Documentation for maintenance working Improvements/changes to date completed according to plans and processes

B.6.5 Definitions. Definitions used in this document are defined as follows:

B.6.5.1 Acquisition events: The acquisition events (preliminary design review (PDR), critical design review (CDR),.....etc.) used in this document may be related to the major acquisition phases or to any type of acquisition. The events should be viewed as events within the process phases and applied to particular acquisition phases as applicable. The following defines the acquisition events and discusses two terms which are peculiar to this process: (Section six covers entry/exit criteria of these events and ENS 94-01 has typical review questions and processes).

Systems Requirements Review (SRR): This review usually establishes the major functional performance requirements from which lower level requirements will be derived. System mission reliability, safety, and probability of loss of control should be defined. At the systems (first or second specification) level, the flight control requirements should cover major performance (control laws), integration, support, and failure management. A few of these requirements may be derived rather than supplied by the customer or the procuring agency.

System Design Review (SDR): This review usually establishes the functional performance requirements at the flight control (third or fourth specification) level. They include the same areas as above, but will probably be derived requirements. At this review, results of the trade studies have defined the architecture, technology, and hardware which will be pursued. As a rule of thumb, 80% of the requirements should be known (for software this is partitioning of the software requirements).

Preliminary Design Review: This review provides the hardware and software detail of the architecture and design to the box level (for software this is how big it is and the breakdown of the modules). The subcontractors should be known and on contract. The subsystem hardware and software requirements documents should be complete. The requirements on contract between the contractor and the government should be 100% filled in.

Critical Design Review: This review should be very detailed with regards to hardware and software. The design should be finished inside the box (for software all the modules and units should be designed to the software functional requirements). As a rule of thumb, at least 50% of the drawings for hardware and 100% of the drawings for software should be complete. Test plan and procedure work should begin at this time.

Test Readiness Review (TRR): This review derives from DOD-STD-2167 and marks the completion of Phase II and the beginning of Phase III. The software design and hardware design should

be 100% complete with all informal and developmental tests demonstrating this design baseline to be ready for formal test. Test plans, procedures, and expected results should be 100% complete. An informal TRR may be done with concurrence of the contracted parties.

First Flight Readiness Review (FFRR): This event encompasses verification that on the ground and in the laboratories the system works as intended and is safe to fly. This is basically a safety-of-flight review where 100% of the verification testing for system performance is complete. Life and support testing may be in various stages of completion, but should be around 50% complete. The maximum changes to the system due to flight testing should be no more than 10% and must go through significant regression testing for safety validation. Documentation relating to functional descriptions and verifications of the system should be complete.

Test Verification Review (TVR): This is a new acronym peculiar to this document but is also derived from DOD-STD-2167's Software verification review. The TVR takes place after formal qualification testing and considers all pertinent test results and design changes implemented or needed. The hardware and software design, their iteration due to problems found during all the tests, and any requirement changes due to design limitations or customer needs should be very close to 100% complete and demonstrate compliance with the performance, support, and life requirements. What may not be complete is the completion of the documentation for test, design, and the production configuration. This is why this event marks the end of Phase III and the beginning of Phase IV; the documentation phase.

Functional Configuration Audit (FCA): Given that the TVR has occurred, this event should be anti-climactic and consists of auditing the documentation plus a check of the functional (acceptance) tests performed on production units at each of the vendors. The manufacturing processes and procedures should be 100% ready. This event marks the end of Phase IV and the beginning of Phase V. The documentation should be 100% accurate and the production baseline should be established.

Physical Configuration Audit (PCA): This event occurs soon after the start of Phase V in early production. At each vendor, this audit pulls the hardware and software drawings (for software this is the detailed design, version, and compiled source code documents) and compares them to the as-built units being produced on the floor. The audit also looks at the assembly procedures and processes and verifies the item is being built and controlled per the processes established.

B.6.5.2 Development process. An organized and disciplined engineering approach to the analysis, design, development, qualification, production, and life cycle management of air vehicles, engines, electronics, subsystems, and associated major support and training equipment.

B.6.5.3 Failure free operating life. The minimum period of time, in operational usage, that a function, subsystem, or component can perform its intended functions successfully without failure and/or results in a maintenance action.

B.6.5.4 Flight control function. The function, including all its mechanical, electrical, electronic, hydraulic, optical, pneumatic, hardware and software elements, that provides flight path, attitude, and airframe response control by transmitting pilot control commands, generating and transmitting commands that augment pilot control commands, and providing pilot assistance and relief through automatic or semi-automatic control modes.

B.6.5.5 Flight critical. Flight critical refers to those functions and features of the flight control and related subsystems, such as electrical and hydraulic power, required for an air vehicle to be flown safely, even though pilot workload may be high and performance degraded. Safe flight operation is not possible without these functions and features. Partial failure/loss of these functions is related to Operational State III or better in the flight control system requirements (tailored from the specification portion of this document) and Level 2 or better in the flying qualities requirements (tailored from MIL-STD-1797). Further degradation of these functions result in Operational State V and Level 3 flying qualities which is

not necessarily a safe condition. This is closely related to, if not identical to, safety of flight and any requirements mentioned for safety of flight will be applicable to this category of functions.

B.6.5.6 Integrated flight control system. That integrated combination of functions that permits an air vehicle to be controlled in a manner that allows its specified missions to be accomplished satisfactorily, and which is critical to safety of flight. An integrated flight control system is a combination of the flight controls and any other air vehicle functions or subsystems that cause, augment, or replace pilot initiated commands or provide basic, necessary data/information for the flight control subsystem to function and insure safety of flight.

B.6.5.7 Integration. A method of communication, data transfer, power distribution, and physical/structural contact between two functions such that at least one cannot function successfully by itself and independent of the other for its primary intended use. At least one function depends upon normal operation of the other function for it and the total system to perform normally. In this context, a fly-by wire flight control function is integrated with the electrical power, hydraulic power, and structural subsystems since it cannot perform successfully without them.

B.6.5.8 Integrity. As applied to integrated flight control systems, integrity embodies quality and soundness of all components, elements, support and subsystems that make up the system, as well as the integrated system as a whole, to provide the capabilities necessary for successful mission accomplishment throughout its intended service life.

B.6.5.9 Interfacing. A method of communication, data transfer, power-distribution, and physical/structural contact between two functions such that, as opposed to integration, either function can perform successfully by itself and independent of the other for its primary intended use and flight critical information is not passed between the functions. In this context, flight controls are usually interfaced with the standard avionics. Flight controls are required to control the air vehicle safely without avionics operating and the avionics (radar, radios, etc.) can perform without flight controls.

B.6.5.10 Mission critical. Mission critical refers to those functions and features necessary for the flight crew to perform its mission successfully in accordance with the air vehicle system requirements. Safe and satisfactory flight operation shall be possible without these functions and features and during failure transient conditions while using these functions. They usually include outer loop functions such as autopilot, automatic navigation, automatic attack, and similar modes.

B.6.5.11 Safety critical elements. Those elements of the integrated flight control system whose failure will result in loss of the air vehicle and/or crew. This normally applies to elements which are subject to a single failure (such as actuator rod ends) which will cause the loss of aircraft or crew.

B.6.5.12 Safety of flight. A condition that exists when flight activities and operations in pursuit of mission objectives could result in loss of air vehicle control, loss of flight critical functions, loss of air vehicle, loss of crew, or controlled flight into the terrain.

B.6.6 Abbreviations and acronyms. Abbreviations and acronyms used in this document are defined as follows:

ASIP	Aircraft structural integrity program
AVIP	Avionic integrity program
BIT	Built-In-Test
CDR	Critical design review
CDRL	Contractor data requirements list
CSC	Computer software component

CSCI	Computer software configuration item
EMI/EMC	Electro-Magnetic Interference/Electro-Magnetic Compatability
FCA	Functional configuration audit
FFRR	First Flight Readiness Review
FLCDP	Flight Control System Development Process
FLCS	Flight control system
FMEA	Failure Mode Effects Analysis
FMECA	Failure Mode Effects Criticality Analysis
FMET	Failure Modes and Effects Testing
HW	Hardware
ITO	Instructions to offeror
LCC	Life Cycle Cost
MTBF	Mean time between failures
MTTR	Mean time to repair
NMC	Not mission capable
OFP	Operational flight program
PCA	Physical configuration audit
PDR	Preliminary design review
RFP	Request for proposal
SDR	System design review
SOW	Statement of work
SRR	System requirements review
SW	Software
TBD	To be determined
TCTO	Time compliance technical order
TF	Terrain Following
TRR	Test readiness review
TVR	Test verification review

B.6.7 Subject term (key word) listing.

Cost
Development process
Diagnostics
Failure mode and effects testing
Failure modes
Flight control
Flight control system
Handbooks
Integration
Life cycle
Maintenance
Processes
Redundancy
Schedule
Simulations
Specifications
Stability and control
Standards
Test
Vehicle management

B.6.8 Responsible engineering office. The office responsible for development and technical maintenance of this document is ASC/ENFT, 2530 Loop Rd W, Wright-Patterson AFB, OH 45433-7101; DSN 785-5503, Commercial (937) 255-5503. Any information obtained relating to government contracts must be obtained through contracting officers.

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