

MIL-STD-2069
24 AUGUST 1961

MILITARY STANDARD

REQUIREMENTS FOR AIRCRAFT NONNUCLEAR SURVIVABILITY PROGRAM



FSC-15GP

MIL-STD-2069

DEPARTMENT OF DEFENSE

Washington, D.C. 20301

Aircraft Nonnuclear Survivability Program, Requirements for

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1. This Military Standard is approved for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Engineering Specifications and Standards Department (Code 9311), Naval Air Engineering Center, Lakehurst, New Jersey 08733, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this specification or by letter.

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FOREWORD

The survivability of an aircraft operating in an enemy threat environment depends on its design and on the emphasis placed on its survivability throughout its life cycle. The cost of modern aircraft weapon systems, the aircraft and personnel attrition experienced in recent combat, and the resulting loss of operational capability make survivability enhancement imperative.

Significant advances in technology have been, and are being made which provide the potential to increase substantially the survivability of existing and future military aircraft in the nonnuclear threat environment. To obtain the maximum payoff from these technology advances, it is essential that the survivability design discipline be effectively implemented throughout the life cycle of the aircraft weapon system.

This standard was prepared in recognition of the need for a standardized systems approach to improving the survivability of military aircraft. The standard provides the requirements and guidelines necessary for the establishment and conduct of aircraft survivability programs while maintaining the flexibility required by system acquisition program managers in the development of a survivability program compatible with the needs of the procuring service and the scope of the system acquisition program.

The Department of Defense views this standard as a tool requiring continuing modification and improvement to increase its effectiveness and to meet changing needs. The comments and recommendations of all users are solicited to achieve this goal.

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1. SCOPE

1.1 General. This standard provides:

- a. Uniform requirements and criteria for establishing and conducting aircraft survivability programs and guidelines for preparing survivability program plans.
- b. Directions and requirements for management organization, plans, procedures, and reviews for the defined survivability program tasks.
- c. Guidelines for program tasks (analyses, assessments and studies).
- d. Guidelines for survivability enhancement.
- e. Guidelines for verification and demonstration.

1.2 Application. This standard is applicable to major system acquisitions of all Department of Defense Combat and Combat support aircraft, including Remotely Piloted Vehicles and excluding aircraft designated solely for research and training.

1.2.1 New aircraft programs. This standard shall be applied to aeronautical systems programs from program initiation through demonstration, validation, full scale engineering development, production and operational phases described in Figure 1.

1.2.2 Existing aircraft programs. This standard shall be applied to aircraft which have already begun full-scale engineering development or production, or are in service use, where it appears likely that significant survivability enhancement can be achieved at acceptable costs and weight or performance penalties.

1.3 Implementation.

1.3.1 Prior to full scale engineering development. In the early phases of a major system acquisition, prior to full-scale development, this standard will be invoked in system definition studies, requests for information, requests for proposal, contract statements of work, and other contractual documents. Its purpose here is to require studies, threat definitions, and conceptual trade-offs to allow contractors to propose conceptual or notional designs which will meet combat survivability demands and to generate data upon which firm design requirements will be based for full scale engineering development detail specifications.

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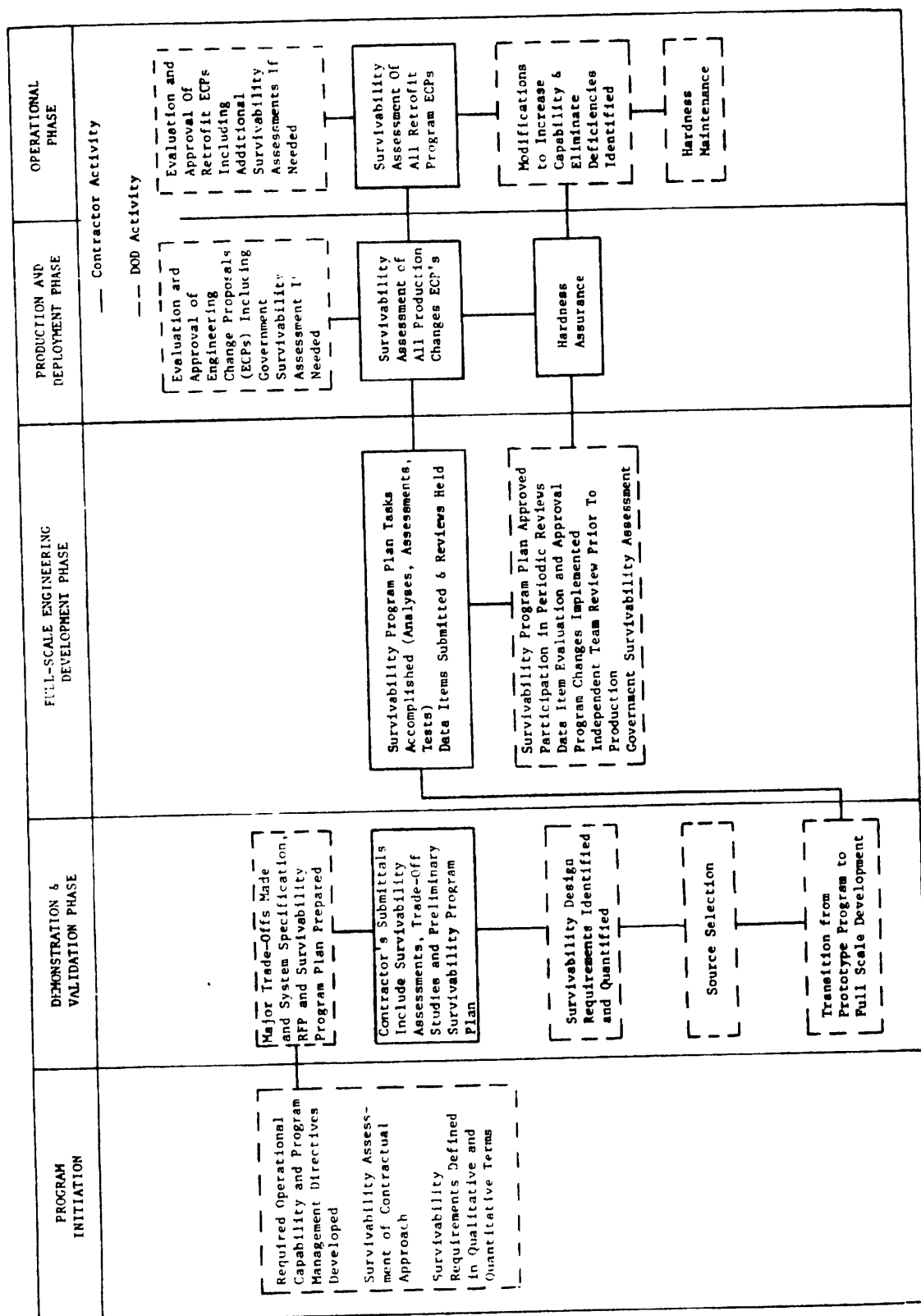


FIGURE 1. Life cycle survivability

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1.3.2 Full-scale engineering development. In full-scale development, this standard will be invoked by and used in conjunction with the aircraft detail specification and other implementing documentation. It is intended that this standard be applied in whole or in part as specified in implementing documentation. This standard should be used as a general specification. It is applied by a detailed specification which indicates the paragraphs of this standard which are applicable and also tailors the requirements to the specific aircraft. This standard is implemented by inclusion as an attachment, appendix, or reference to the aircraft detailed specification.

2. REFERENCED DOCUMENTS

2.1 Publications. The following documents, in effect on the date of invitations for bids or request for proposal, form a part of this standard to the extent specified herein.

SPECIFICATIONS

MIL-H-8501	Helicopter Flying and Ground Handling Qualities; General Requirements for
MIL-I-8675	Installation; Aircraft Armor
MIL-F-8785	Flying Qualities of Piloted Airplanes
MIL-F-83300	Flying Qualities of Piloted V/STOL Aircraft

STANDARDS

MIL-STD-470	Maintainability Program Requirements (For Systems and Equipment)
MIL-STD-471	Maintainability/Verification/Demonstration/Evaluation
MIL-STD-1288	Aircrew Protection Requirements Nonnuclear Weapons Threat
MIL-STD-1629	Procedures for Performing a Failure Mode, Effects and Criticality Analysis
MIL-STD-2089	Aircraft Nonnuclear Survivability Terms

HANDBOOKS

MIL-HDBK-221	Fire Protection Design Handbook for U.S. Navy Aircraft Powered by Turbine Engines.
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PUBLICATIONSJoint Chiefs of Staff

JCS Pub. 1, Department of Defense Dictionary of Military and Associated Terms

Air Force

Criteria for High Altitude EMP Environment AFWL-SAB-TN-75-5

"EMP Handbook for Missiles and Aircraft in Flight," AFWL-TR-73-68 of September 1972.

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Joint Technical Coordinating Group/Munitions Effectiveness

JTCG/ME TN 4565-16-73, "Air Force Armament Test Laboratory, Eglin Air Force Base, Florida, Anti Aircraft Artillery Simulation Computer Program", AFATL P001 Volume II, Analyst Manual.

61JTCG/ME-71-5-1, Shot Generator Computer Program, Volume I, User Manual, JUL 70.

61JTCG/ME-71-5-2, Shot Generator Computer Program, Volume II, Analysts Manual, JUL 70.

61JTCG/ME-71-7-1, MAGIC Computer Simulation, Volume I, Users Manual, Part I, MAY 71.

61JTCG/ME-71-7-2-1, MAGIC Computer Simulation, Volume II, Analysts Manual, Part I, MAY 71.

61JTCG/ME-71-7-2-2, MAGIC Computer Simulation, Volume II, Analysts Manual, Part II, MAY 71.

Joint Technical Coordinating Group/Aircraft Survivability

JTCG/AS-78-V-002, FASTGEN II Target Description Computer Program

2.2 Availability of documents. Copies of specifications, standards, handbooks and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.

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3. DEFINITIONS

3.1 Terms. The definitions included in the reference documents listed in Section 2 and the Appendix shall apply. Additional definitions are listed in MIL-STD-2089.

4. GENERAL REQUIREMENTS

4.1 Survivability program. Within the framework of the contractor's engineering organization or contractually specified systems engineering discipline, the contractor shall develop, propose, implement and maintain an effective survivability program that is planned for and integrated into all phases of aircraft design, development, and production. Survivability program management shall be integrated into the contractor engineering management organization and the engineering management plan required by the implementing documentation.

4.2 Organization. The contractor shall provide adequate staff for managing and accomplishing the survivability program. The responsibilities and functions of those personnel directly involved with implementation of the program shall be clearly defined. The responsibility and authority of the survivability organization shall be involved with all relevant design, support, and program management activities so that the survivability design requirements are effectively incorporated into the aircraft. The relationships to each relevant activity shall be defined.

4.3 Procedures. The contractor shall establish the procedures that are necessary to conduct the survivability program. They shall require.

- a. Inclusion of contractually specified survivability requirements in the system design.
- b. Imposition and allocation of survivability requirements on subcontractors.
- c. Provision of system design, analysis and management activities with survivability information and guidance.
- d. Control and monitoring of survivability program funds and expenditures.
- e. Implementation and control of developmental, evaluation, and verification tests and/or analyses.
- f. Means by which design and support activities will provide the survivability engineering organization with the information needed for each of the survivability program tasks.
- g. Methods of apprising the responsible procuring activity of the program and funding status.

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4.4 Program plan. The contractor shall develop, propose, obtain government approval of, and implement a survivability program plan. It shall outline the procedures (4.3) by which the contractor proposes to conduct the program tasks, incorporate the design requirement-s, and conduct the demonstration and tests for which he is responsible. The functional relationship with other program tasks and events shall be clearly shown and described. Each task in the plan shall be identified with the work breakdown structure so that traceability and monitoring of funding may be accomplished. The required survivability program tasks are contained in paragraph 5.2, the design requirements in 5.3, and the demonstrations and tests in 5.4. Program task time phasing is shown in Figure 1. The survivability program plan shall conform to the basic format shown in Figure 2. The contractor shall conduct the survivability program in accordance with this standard and the approved program plan. The plan shall describe:

- a. The tasks, schedules, manpower requirements, special facilities, and significant milestones of the program. Planned use of subcontractors, to supplement in-house capabilities, must be indicated and the subcontractors identified when possible.
- b. An organizational structure with survivability personnel at a level such that survivability design techniques are effectively implemented.
- c. A procedure for conveying to subsystem and component designers the latest survivability design techniques applicable to their particular design areas. This procedure might be in the form of periodic briefings, internal information bulletins, personal contact between survivability and design engineers on a regular basis, and shall include active participation by survivability personnel in making design decisions.
- d. A procedure for designers to provide current design information to survivability analysis personnel so that survivability assessments and trade studies reflect the status of weapon system design as it actually exists.
- e. The plan and schedule for survivability program reviews.
- f. A description of the anticipated design support tests in all areas of survivability (vulnerability reduction, detectables, etc.).
- g. Proposal of methodologies for specific requirements of this standard where procuring agency approval is required.

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FOREWORD

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2. ORGANIZATION

- 2.1 Organizational Structure
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3. PROCEDURES

4. REVIEWS

5. TASKS

(Separate subparagraphs shall cover each program task and the verification and demonstration efforts described under 5.2 and 5.4 of MIL-STD-2069.)

6. SCHEDULES

6.1 Master Schedule

(shall include effort versus time chart with supporting narrative to describe the total aircraft survivability program phasing and major milestones.)

6.2 Detailed Schedules

(Shall include effort versus time charts and supporting narratives for required analysis tasks, hardware developments, and verification and demonstration efforts.)

FIGURE 2. Aircraft survivability program plan outline

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h. Technical support for Government or other contractors' effort to be carried out concurrently or in conjunction with or in support of the contractor survivability effort.

i. Submission of data in accordance with the Contract Data Requirements List (CDRL), DD Form 1423.

4.5 Program reviews. Program reviews shall be planned and scheduled to permit the contractor and Government representatives to periodically examine the status of the survivability program. These reviews shall be coordinated with the aircraft system design reviews and be identified in the survivability program plan. The contractor shall document all survivability actions which have taken place on the aircraft systems during the period covered by the program review. These reviews shall include:

a. Review of survivability enhancement features proposed for incorporation in the aircraft design and comparison with system specification requirements and current threat estimates. The reviews shall be supported by survivability analysis, or other approved quantitative means of assessing the survivability enhancement tradeoffs resulting from such proposals.

b. Review of current system survivability estimates and achievements for each specified design requirement.

c. Review of potential engineering, development, or testing problem areas, and possible solutions.

d. Identification of the principal items inhibiting planned achievement and proposed solutions.

e. Status of survivability program funds, expenditures, and allocations for future tasks.

f. Status and results of tradeoff studies conducted for survivability engineering. and the effects of engineering decisions and tradeoffs upon survivability achievements and potential.

g. Review of incorporated survivability design features. This shall be conducted during design reviews as specified in the procurement contract.

h. Review of vulnerability and survivability assessments conducted as scheduled in the survivability program plan.

i. Review of all development and verification testing and results.

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- necessary. j. Participation by subsystem designers to the extent
- k. The documentation of the results of design reviews.
- m. Review of life cycle survivability program for
hardness assurance and maintenance provisions during production and
operational phases.

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5. DETAILED REQUIREMENTS

5.1 Aircraft survivability, general. The survivability of an aircraft system is expressed in terms of susceptibility and vulnerability and where:

a. Susceptibility is concerned with detection, acquisition, and tracking, which are a function of energy generated or emitted by and/or reflected by the aircraft and its components. Contributing to the aircraft detectable signatures are radar reflectivity (radar cross section), infrared, ultraviolet, visual/optical, smoke, noise, and either intentional or inadvertent electromagnetic emissions. Threat avoidance is related to countermeasures, the aircraft speed and altitude capability, maneuverability, and vehicle size.

b. Aircraft vulnerability is a measure of the probability that an aircraft will be degraded to one of the defined kill levels after responding to threat mechanisms.

5.1.1 Survivability requirements. The requirements are designed to analyze and assess all of the various survivability factors involved in order to influence aircraft design and ensure optimum survivability in the delivered aircraft.

5.2 Program tasks. The survivability program shall consist of the tasks specified herein unless otherwise stated in the implementing documents. The contractor shall provide full documentation and obtain government approval for any methodology proposed to satisfy requirements contained herein by including them in the survivability program procedures portion of the survivability program plan. The analysis requirements specified herein as contractor tasks may be met by the contractor, the government, another contractor to either the government or the prime contractor, or any combination of the above as specified in the implementing documentation. Unless otherwise specified the responsibility remains with the Prime Contractor.

5.2.1 Mission-threat analysis. The missions and threat systems considered in this mission-threat analysis shall be those specified in the aircraft detail specification, operational requirements, and implementing documentation. Detailed survivability specifications based on this standard (1.3.2) will include or reference the specific threats, mission profiles and scenarios, and anti aircraft defense situations to be used throughout. The contractor shall:

a. Define each operational mode required by the specified missions. Aircraft configuration factors (weights, C.G. locations, fuel status, armament loading, etc.) and proposed operational concepts and tactics shall contain the maximum possible detail.

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b. List the threats and threat characteristics applicable to the defined operational modes.

c. Analyze aircraft operational modes and threats and determine encounter conditions.

The derived encounter conditions shall be used as a basis for the required survivability assessments and tradeoff studies. These studies, in turn,

which will ensure that the aircraft will be able to operate effectively in its expected threat environment.

5.2.2 Flight and mission essential functions. The contractor shall determine the flight essential and mission essential functions for each mission phase. The contractor shall identify the components required to perform these functions. Redundancies shall also be identified. This shall include degraded modes of operation where such conditions are related to specific kill levels in survivability assessments and for system effectiveness analyses. A simple example of a tabulation of critical functions is shown in Figure 3.

5.2.3 Failure mode, effects, and criticality analysis (FMECA). The Failure Mode, Effects, and Criticality Analysis (FMECA) is a key part of the vulnerability assessment process and defines the response of the aircraft and its subsystems and components to the damage caused by the threat weapons. The FMECA and its results have applications in the assessments of vulnerability to all types of weapons.

a. The FMECA process and requirements are defined in MIL-STD-785 and MIL-STD-1629A. The FMECA is a multi-discipline (reliability, maintainability, safety, survivability, etc.) design evaluation procedure that documents all possible potential failures for a component or subsystem, determines by analysis the effect of each of these potential failures on system operation, identifies failures critical to operational success or personnel safety, and ranks each potential failure according to failure effect severity. The FMECA procedure required to support a survivability assessment is further defined in MIL-STD-1629A and is performed in two basic steps: a Failure Mode and Effects Analysis (FMEA) and a Criticality Analysis (CA).

b. The role of the FMECA in the overall vulnerability assessment and the interfaces between the FMECA and other phases in the assessment are shown in Figure 4. The tasks and outputs of the FMECA are those within the dashed enclosure. Tasks or steps in the assessment are identified with rectangles. Task input and output are shown in the circles or ellipses.

MISSION SEGMENT	SUBSYSTEM	REQUIRED FUNCTIONS
COMBAT	PROPULSION	FULL MIL POWER
	FLIGHT CONTROLS	FULL AUTHORITY ABOUT ALL THREE AXES
LANDING	FIRE CONTROL	TARGET ACQUISITION RADAR COMPUTER WEAPON SELECTION/RELEASE
	PROPULSION	____ % NORMAL POWER
	FLIGHT CONTROL	____ % RESPONSE ABOUT PITCH AND ROLL AXES
	FIRE CONTROL	NONE REQUIRED
	ALIGHTING/ARRESTING	FULL GEAR EXTENSION AND LOCK TAIL HOOK

FIGURE 3. Sample critical functions analysis

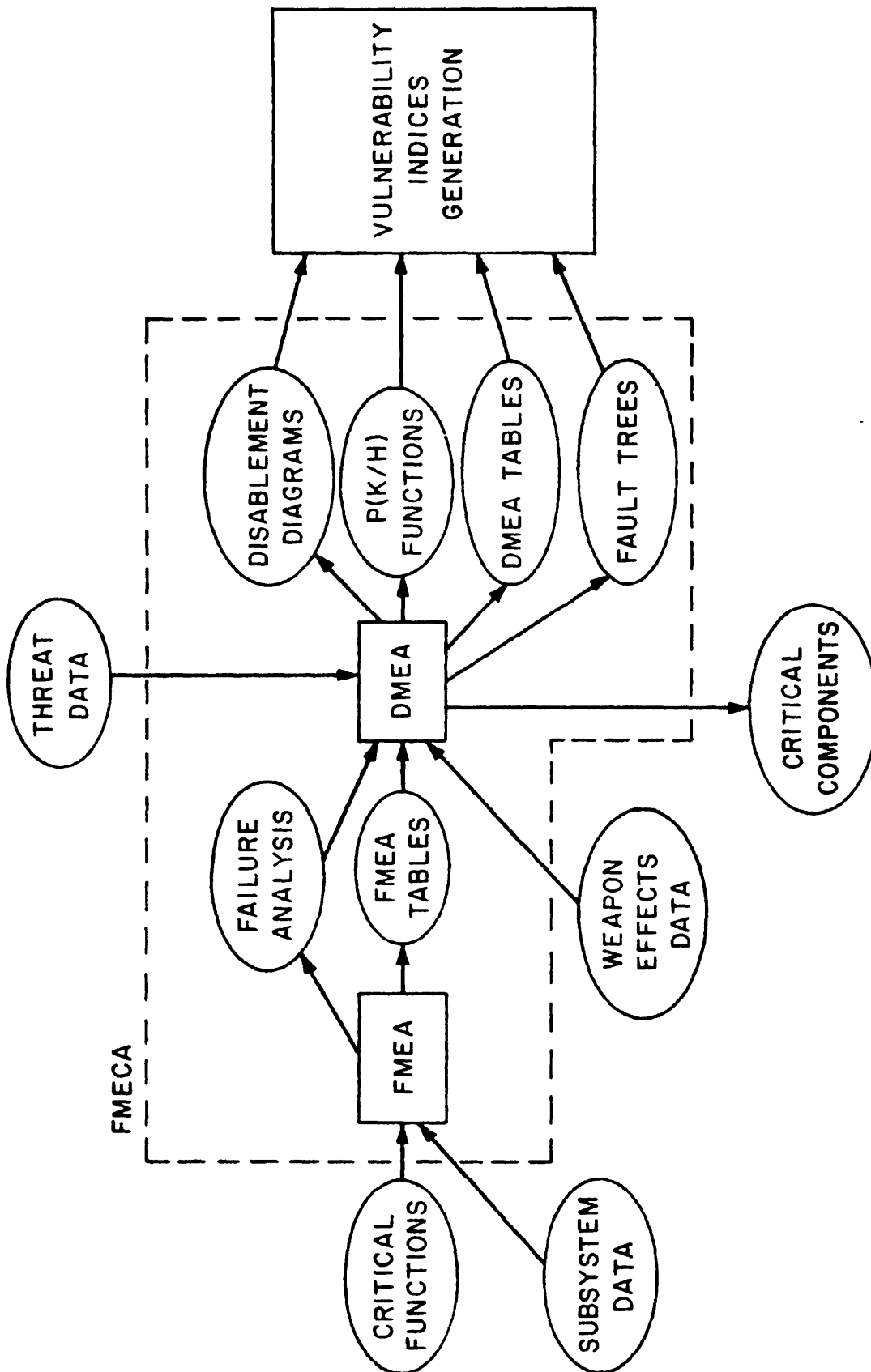


FIGURE 4. Interfaces of the FMECA process

5.2.3.1 Failure mode and effects analysis (FMEA). The FMEA identifies, at least theoretically, all possible failures and their effects on the aircraft flight and mission capabilities. Each critical component (for both flight and mission requirements) is identified and its functions are defined. The component and its environment within the aircraft are then reviewed to determine all of the ways in which the component can fail. The results of these failures are then determined with respect to the functional capability of the component itself, the capabilities and requirements of the subsystem of which the component is an element, the effect on any higher level subsystem, and on the total aircraft.

5.2.3.1.1 FMEA Input requirements. The input required for the FMEA is provided by the Critical Functions Analysis and by the aircraft's physical and functional description. This latter data base includes engineering drawings, functional block diagrams, schematics, performance measurements or predictions, narrative descriptions of components and subsystems, weights, and other applicable data.

5.2.3.1.2 FMEA Output format. The output of the FMEA is normally the conventional FMEA table or matrix. This format is described in MIL-STD-1629A. The contents of the FMEA table include all of the FMEA data described above.

5.2.3.2 Damage mode and effects analysis (DMEA). The DMEA is dependent upon the kill criteria and the threat. In a truly multi-discipline FMECA, the failures and their effects are independent of the cause of the failure. Therefore, there would be no threat dependence. The criticality in such an FMECA is related to a set of four hazard levels that vary from no significant loss of capability to failures that result in imminent loss of the aircraft and/or the crew. In a combat-damage-related FMECA, the DMEA associates the potential failures with threat weapons and their damage mechanisms, relates the effects of the failures to kill criteria, redundancy and flight conditions, and quantifies the response of the component to the damage mechanisms. There are four sets of data which comprise the results of the DMEA. The required DMEA data will be specified by the procuring agency.

5.2.3.2.1 The DMEA matrix. The first set of DMEA data is the DMEA matrix. This matrix is illustrated in Figure 5 and relates components and their failure modes to the probability of kill given a hit ($P(K/H)$) functions, kill criteria, and redundancy levels through a tabular format.

5.2.3.2.2 Disablement diagrams. The second set of data developed in the DMEA are the disablement diagrams which graphically combine and display parts of both the FMEA and DMEA. The disablement diagrams contain the following information:

AIRCRAFT _____
SYSTEM FLIGHT CONTROLS (MECHANICAL)

FMEA REF		COMPONENT NAME	COMPONENT NUMBER	DISABLE- MENT DIAG. NO	DAMAGE MODE	"KILL" CATEGORY						REMARKS	PKH FUNC. NO
						NON REDUNDANT		REDUNDANT					
						ATTENTION	MISSION ABORT	VERTICAL	ATTENTION	MISSION ABORT	VERTICAL		
	STICK				BREAK OR DISABLE								
	ASSEMBLY											DEGRADED	
	(GRIP)	3001				X						FLIGHT CONTROL	32
				(1)									
					LOSS OF ELECTRICAL							LOSS OF CAS PITCH &	
	CAS SENSOR	3002			CONNECTIONS	X		X				ROLL CONTROL	32
				(2)	(LOSS OF CAS)							CONTROL THROUGH D2L.	
					LOSS OF ELECTRICAL							REVERSION TO MECH.	
					AND MECHANICAL	X	X					(IF DEL IS LOST).	
					LINKAGES								
	RUDDER PEDALS	3006			BREAK OR DISABLE								
	ARMS	3007			ONE ARM								32
	SUPPORT	3008		(3)									32
	FEEL SPRING SUPPORT	3301			BREAK OR DISABLE								32
	SPRING	3302			SUPPORT, FEEL							NO ELECTRICAL	32
	TRANSDUCER	3303			SPRING ASSY, OR	X	X					INPUTS TO	24
					TRANSDUCER							RUDDERS	

FIGURE 5. DMEA matrix

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- a. Component and/or subsystem relative physical locations within the system.
- b. The ways these components can fail.
- c. The effect of these failures on the subsystem and total aircraft.
- d. The result of these failures in terms of aircraft kill criteria.

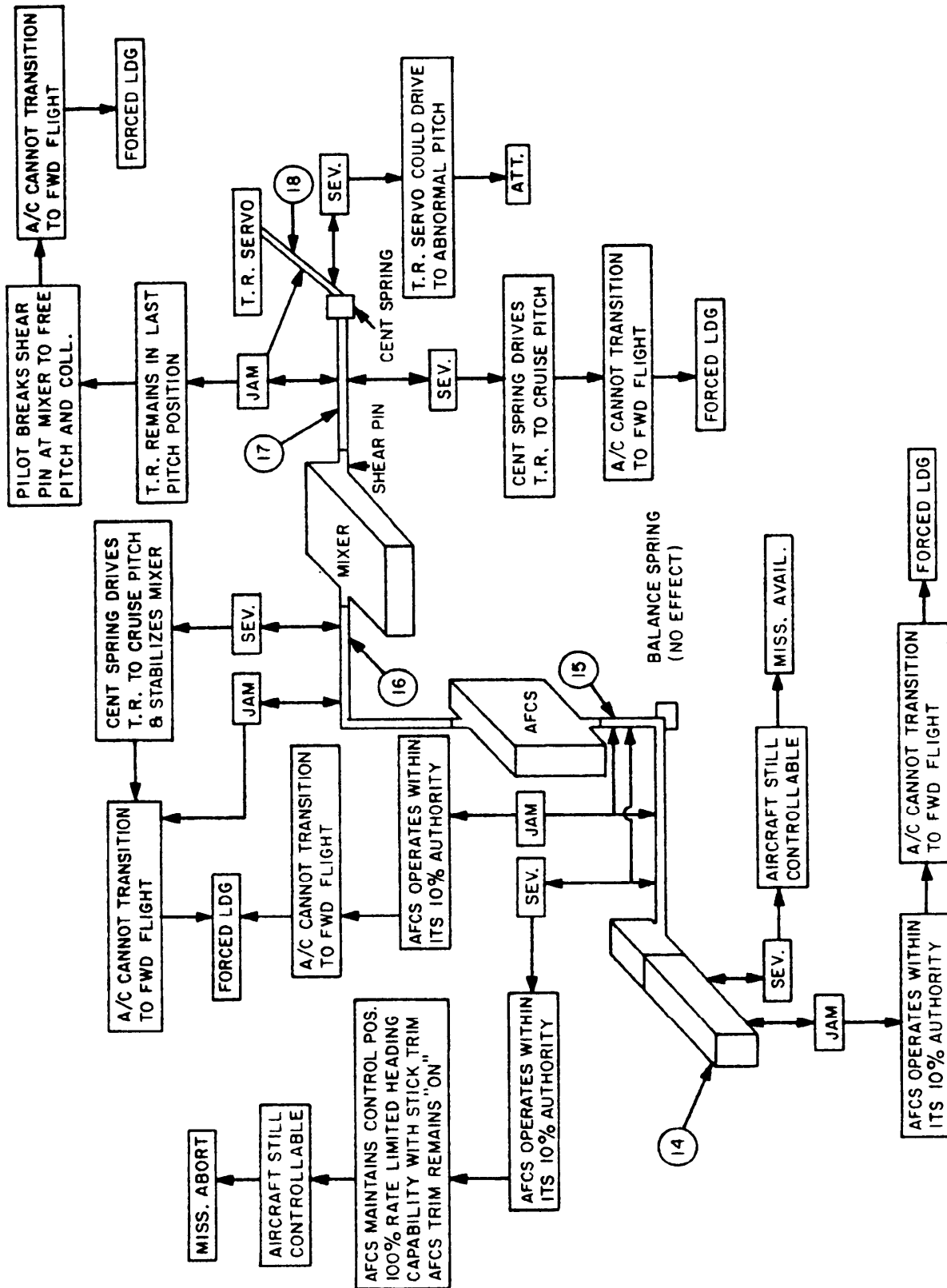
The disablement diagrams are a presentation device and provide rapid traceability of component failures to the kill levels. The disablement diagram is illustrated in Figure 6.

5.2. 3.2.3 Fault trees. The third set of DMEA results are the fault trees. Fault trees, or kill diagrams, illustrate the critical components of the aircraft and their logical redundancy relationships. These fault trees are a function of kill level (attrition, mission, etc.) and graphically depict which components (or systems) or combinations of components and systems must be sufficiently degraded to effect the particular type of kill on the aircraft. Non-redundant (also referred to as "singly vulnerable") components are shown in series; redundant (multiply vulnerable) components are shown in parallel with the components with which they share a physical or functional redundancy. Development of these fault trees involves combining of data from the mission-threat assessment, flight and mission-essential components determination, FMEA, DMEA, disablement diagrams, and should include input from members of the operational community and engineers responsible for the design and production of the aircraft. A generic example of fault tree structure is shown in Figure 7.

5.2.3.2.4 P(K/H) functions. The final data element of the DMEA is the set of P(K/H) functions. These P(K/H) functions define the response of the components when impacted by a fragment or projectile, and are presented graphically as a function of the mass and velocity of the penetrator. When components contribute to multiple kill criteria through different failure modes, separate P(K/H) functions are required for each failure mode. The P(K/H) functions for ballistic threats are developed using available ballistic test and analysis data to the maximum extent possible.

5.2.3.2.5 Scope of the DMEA. The analyses of the DMEA shall include the following:

- a. The contractor shall identify primary and secondary weapon damage mechanisms to which each component can be exposed. The type of damage mode that each component can experience (i.e., shattering, jamming, loss of fluid, etc.) shall be identified. The possibility of secondary hazards that may be created by the primary weapon damage modes (i.e., fire, explosion, engine fuel ingestion, toxic fumes, smoke-corrosive materials, etc.) shall be identified.



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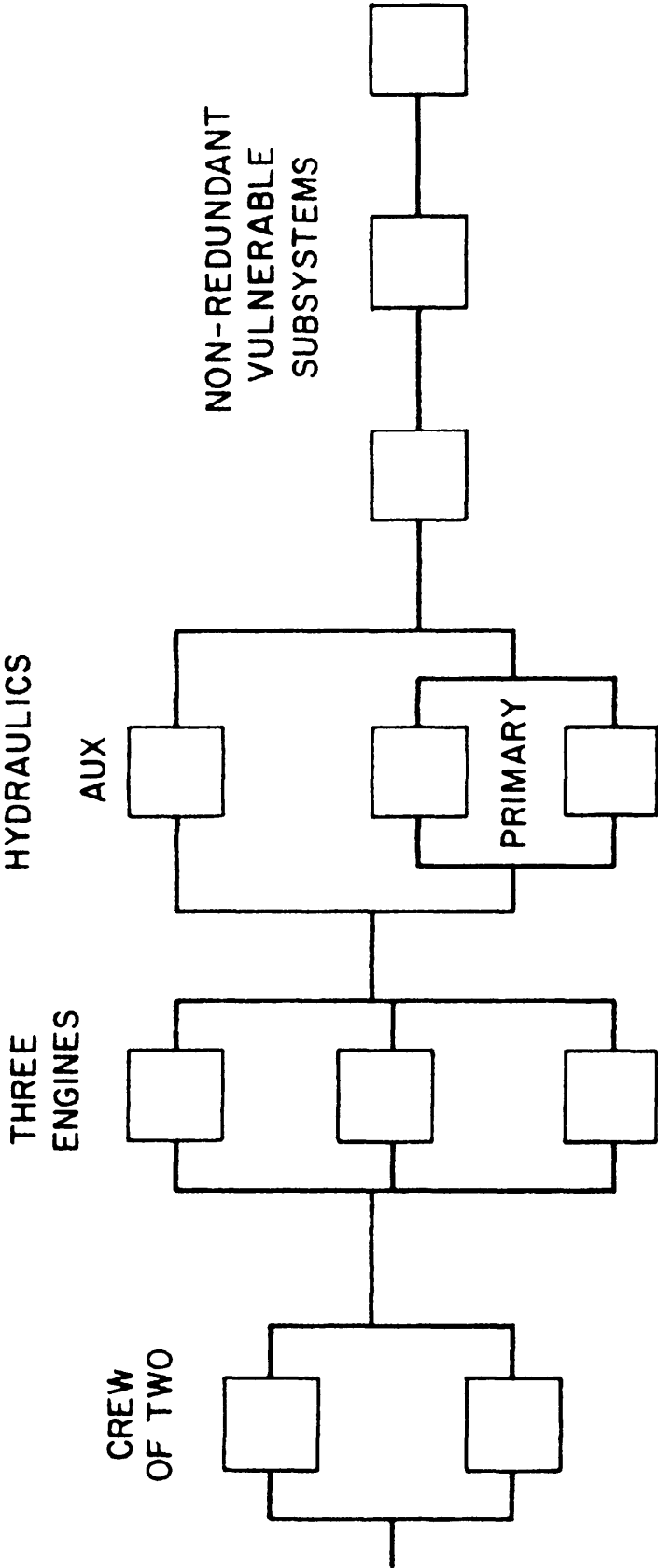


FIGURE 7. Typical fault tree

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b. Each nonessential component also shall be examined to determine if a hazardous environment may be created by its suffering the type/level of damage identified. This will also include any cascading effect on other subsystems from an initial systems or component response. The essential components that might be exposed to these hazardous environments shall be identified.

5.2.4 Aircraft geometric description. An aircraft geometric description shall be developed and documented for use in the calculation of vulnerability Indices. The description technique shall be either that compatible with SHOTGEN/FASTGEN or MAGIC or a contractor proposed, procurement agency approved technique.

5.2.5 Aircraft vulnerability assessments. Aircraft vulnerability assessments shall be made using the results of the analyses produced in paragraphs 5.2. 1 through 5.2.4 above. This shall be a continuous or iterative process during design and development. The objectives of the vulnerability assessments are to:

- a. Identify deficiencies and evaluate methods and design changes to reduce vulnerability.
- b. Provide quantified measures of vulnerability for specified threats and kill levels for use in design analyses and tradeoff studies.
- c. Provide inputs for the survivability assessment of the aircraft.

The methodology to be used in vulnerability assessments in programs conducted under the provisions of this standard shall be either government provided (when available and specified) or contractor proposed and approved by the procuring agency. Complete documentation shall be supplied on any methodology proposed for approval. Documentation of vulnerability assessment methodologies, presently available, are included in the Appendix, Section 10, Pertinent Other Publications. The selected methodology shall provide a means for effective, iterative vulnerability assessments during aircraft design, development, and production. The methodology chosen must be such that vulnerability assessments required by changes in missions, tactics, threats, and aircraft configurations can be conducted throughout the operational life of the aircraft.

5.2.5.1 P(K/H) Inputs for vulnerability assessments. The contractor shall use (where available and specified) government provided P(K/H) functions in the determination of vulnerable areas. Where P(K/H) functions are not provided by the government, the contractor shall use those developed in the DMEA. The contractor may also submit, for approval, P(K/H) functions developed during the DMEA that differ from those specified and provided by the government. Regardless of source, the contractor shall be responsible for the completeness of the P(K/H) functions used

in the assessment and shall document the development or verify the derivation of all functions used. The vulnerability assessment shall include all singly vulnerable and non-singly vulnerable components which exhibit a vulnerable system response as defined in paragraphs 3.4 and 3.23.

5.2.5.1.1 Assessments during the conceptual phase. During the conceptual phase the contractor shall use a methodology that is compatible with the aircraft design data and program resources and that is responsive to the needs of both the contractor and the government with respect to the applicability, validity, and timeliness. The contractor shall use the government specified methodology or a contractor proposed methodology that has been approved by the procuring agency.

5.2.5.1.2 Assessments in full-scale development. During full-scale development the contractor shall assess vulnerability using the methodologies listed below (unless otherwise specified in the implementing documentation).

a. For single fragments and kinetic energy projectiles at specified velocities, a shot line generator computer program with associated target description and computer model for determining vulnerable areas, as approved by the procuring activity, shall be used.

b. For contact- and delay-fuzed high explosive (HE or HEI) projectiles a government provided program or a contractor proposed government approved program shall be used.

5.2.5.2 Laser vulnerability assessment methodology. Laser vulnerability assessments shall employ methodology provided by the Government or a contractor proposed model approved by the procuring agency.

5.2.5.3 Documentation of vulnerability assessments. Complete documentation shall be submitted for all vulnerability assessments. For vulnerable area assessments, this documentation shall include the presented areas, P(K/H) functions, and vulnerable areas along with all pertinent assumptions upon which the analysis is based. Shielding items shall also be quantitatively described. For the laser assessments, the documentation shall include thermal calculations, material/coating properties including absorptivities, and analysis assumptions, as well as the presented areas and vulnerable areas. For blast and energy deposition assessments, the documentation shall include the techniques used to predict failure loadings and a summary of the calculations. Results shall be presented in the form of three-dimensional lethality contours. The documentation shall also include a drawing no smaller than 1/20 scale, that accurately identifies and locates all critical components together with all significant masking and shielding.

5.2.6 Susceptibility assessment. The contractor shall perform a susceptibility assessment to determine the effect of threat weapon characteristics, aircraft characteristics, performance, and tactics on the net probability that the aircraft is hit by the damaging mechanisms of the threat weapon. The threat parameters that shall be considered

include those that affect detection, acquisition, lock-on, track, missile guidance, gun fire control, fuzing, and the necessary interfacing command and control functions. The aircraft parameters shall include those that affect detectable signatures, countermeasures, tactics, and the flight path of the aircraft (performance and maneuverability). The susceptibility assessment shall also include the physical environment in which the aircraft-threat interaction occurs. Unless a methodology is called out in the procurement requirements, the contractor shall document the analytical process used in the assessment, all input data describing the threat, and the input data describing the aircraft. The documentation will include the detectable signatures, countermeasures characteristics and performance, and the flight paths.

5.2.7 Survivability assessments. The contractor shall perform a survivability assessment using the results of the vulnerability assessment of 5.2-5 and the susceptibility assessment of 5.2.6.

a. Survivability assessments provide data that permit determination of the effectiveness in terms of attrition deltas and cost factors of proposed survival enhancement techniques under a variety of threat and encounter conditions and also provide quantified levels of system survivability. The survivability assessments shall be accomplished using:

(1) The results of the mission-threat analysis of 5.2.1 including the derived encounter conditions.

(2) The results of the vulnerability analysis of 5.2.5; and descriptions of enemy anti-aircraft defense systems provided in the implementing documentation.

b. The contractor shall use the methodology specified herein or may propose an alternate methodology for approval by the procuring agency (see Appendix for additional methodologies). The methodology must provide effective, iterative survivability assessments during design, development, and production. The methodology chosen must be suitable for use by the applicable service during the operational life of the aircraft so that survivability assessments required due to changes in missions tactics, threats, and aircraft configuration may be conducted.

5.2.7.1 Survivability assessment methodologies. The contractor shall conduct survivability assessments using the methodologies specified below or contractor proposed methodologies that have been approved by the procuring agency. See Appendix for full identification of these models.

a. For kinetic energy, contact or delay fuze threat, use the P001 computer program. JTCG/ME TN 4565-16-73, "AFATL Program P001 Anti-Aircraft Artillery Simulation Computer Program."

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b. For proximity-fuzed projectiles and missiles use the JTTCG/ME Computer Program Standard End Game Model (ATTACK/REFMOD Computer program or superseding model), or an equivalent methodology approved by the procuring activity.

c. For air-to-air close in encounters use the PACAM computer program.

d. For SAM encounter use the MICE models, the TAC ZINGER models or an equivalent methodology approved by the procuring activity.

5.2.7.2 Laser survivability assessment. Laser survivability assessments shall be conducted with a government provided or government approved methodology.

5.2.8 System cost effectiveness analysis. The contractor shall conduct a cost effectiveness analysis to support tradeoff studies of candidate survivability enhancement techniques. The methodology may be government provided or government approved (as specified in the procurement document). The method must provide a measure of effectiveness (MOE) with which to compare the relative effectiveness of proposed survivability techniques along with their associated costs. This shall include reduction of detection and survivability aids as well as vulnerability reduction. Cost analysis activity in support of tradeoff studies shall be documented to include the data rationale and procedures used in developing cost estimates.

5.2.9 Survivability enhancement tradeoff studies. The contractor shall conduct survivability enhancement tradeoff studies. These studies shall identify the effects of variations in each significant survivability analysis parameter (e.g., threat, mission, operational utilization, performance, and incorporation of survivability enhancement techniques) on overall combat effectiveness, cost, and schedule. The contractor shall continuously evaluate tradeoffs affecting survivability enhancement and shall take appropriate design or design change action to ensure optimum aircraft survivability in terms of overall combat effectiveness, cost, and schedule. The tradeoff study shall contain:

a. A description of survivability enhancement techniques considered.

b. Vulnerability reduction realized with respect to specified threats and kill criteria.

c. Susceptibility reduction with respect to specified threats.

d. Impacts on Weight, performance, cost, reliability, maintainability, safety, ease of repairability, producibility schedule, etc.

e. Verification test requirements, if needed to verify improvement in survivability.

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f. Recommendations and alternatives regarding optimum design and configuration.

g. Details concerning installation and removal, if "kit form" techniques are recommended for use.

5.2.10 Combat damage repair assessment. The contractor shall determine manhours, downtime, logistic support, and levels of repair for aircraft under combat operational conditions. This effort shall be accomplished in conjunction with any maintainability program requirements contained in MIL-STD-470 and MIL-STD-471 when these documents are specified in the implementing documentation. The operational conditions and types and quantities of damage considered shall be as specified in 5.2.1 through 5.2.6. Assumptions shall be documented. The assessment shall include the activities shown in Table I. In addition, the assessment shall provide the following:

a. Identification and description of quick turnaround fixes.

b. Identification and description of complete repairs and proposed level of repairs.

c. Identification of long lead time items and spare parts storage requirements related to combat operations. This listing is to include identification of those items that are long lead time items. Stockage level of spare parts will be determined in relation to expected threat and length of engagement (30 days, 60 days, etc.).

5.3 Survivability enhancement requirements. This section contains basic survivability enhancement requirements which are applicable unless otherwise specified.

a. During the concept phase, in studies, prototype programs, RFPs, RFIs, or other pre-Full Scale Development effort, the requirements of this section are intended to generate proposed solutions to survivability performance requirements; provide realistic signature level requirements; and quantify performance cost and schedule allowances which must be made. Design studies are required.

b. During full scale engineering development, insofar as possible, this section will specify hard performance requirements and specific signature levels which must be met within contractual limits for cost, performance, and schedule. If it should become necessary to enter full scale engineering development without sufficient information to specify hard requirements, the CDRL will specify Design Studies to allow developing solutions to survivability performance requirements and developing the associated performance cost and schedule penalties (may be applicable for aircraft programs begun before publication of this standard or for major rework, conversion or service life extension programs).

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Table I. Combat damage repair activities

Activities	Sequential		Concurrent manhours
	Manhours	Elapsed time	
Damage assessment			
Removal of parts for access			
Damaged part removal			
Repair in aircraft			
Repair out of aircraft			
item delivery delay			
Damaged part replacement			
Repaired part reinstallation			
Reinstallation parts removed for access			
Component functional check			
Subsystem functional check			
Inspection of repairs			
Aircraft functional check			
Manhours subtotal			
Elapsed time total			
Manhours total			

5.3.1 Reduction of detection. Levels of radar reflection, infrared, visual and electromagnetic emission and reflection, and aural noise level shall be in accordance with the aircraft detail specification. If no levels are specified, the contractor shall conduct survivability enhancement tradeoff studies and cost effectiveness analyses for each applicable threat-detectable signature combination defined in the mission threat analysis. The contractor shall recommend appropriate signature levels, based on effectiveness achievable versus associated cost and penalties, in the survivability plan or supplement thereto. These recommended levels must be supported by test and analysis. Once approved, the recommended levels shall become binding system specification requirements.

5.3.1.1 Radar cross section reduction. The radar cross section (RCS) of the aircraft weapon system, including the mission stores, shall be reduced to the levels required to achieve the jamming-to-signal (J/S) ratio specified for each aspect angle-threat frequency combination called out in the aircraft detail specification and the approved survivability plan. Areas which shall be given special consideration include engine inlet ducts and engine front faces, engine exhausts, inherent structural corner reflectors, cavities (crew compartment, radomes, antenna and antenna apertures, radar-visible internal bulkheads, etc.), and external or semi-submerged stores.

5.3.1.2 Infrared signature reduction. The contractor shall design to the IR emission requirements specified in the aircraft detail specification or the survivability plan. Aircraft areas to be given special attention are exposed engine hot sections, heated surfaces, engine exhaust, exhaust plume, aircraft IR reflections from transparencies and metallic or IR reflective surfaces, and internal and external illumination devices.

5.3.1.3 Visual signature reduction. The contractor shall design to the aircraft visibility requirements specified in the aircraft detail specification and the survivability plan, by reducing the contrast of the aircraft with its background (both sky and surface), reducing the reflection of light, and reducing smoke or contrail emissions.

5.3.1.4 Aural signature reduction. The contractor shall reduce or eliminate noise signature from propulsion and aerodynamic surfaces to the extent practicable and as specified in the survivability plan.

5.3.1.5 Electromagnetic emission reduction. Inadvertent electromagnetic emissions that can be detected by surveillance devices to locate the aircraft system shall be eliminated or reduced, so that no emitter in the standby mode of operation and no other equipment in full operation will emit radiation which exceeds the level specified in the aircraft detail specification and the survivability plan.

5.3.2 Survivability aids. The survivability of the aircraft system shall be enhanced through the use of electronic warfare countermeasures and electronic warfare counter-countermeasures as required by the aircraft detail specification and the avionics system performance specification. Selection of, and specification for, survivability aids shall be based on the survivability enhancement tradeoff studies of 5.2.8. The tradeoff studies shall consider all aspects of susceptibility reduction for specified threat weapons. The contractor shall determine the J/S Levels required to permit effective operation in the threat environment.

5.3.3 Vulnerability reduction. For aircraft systems whose missions involve exposure to nonnuclear threats, protection of the system shall be provided to the extent required by the aircraft detail specification (see 5.2.1). Where no specific levels of protection are levied, the contractor shall, upon approval by the government, provide the most effective combination of protective features that were determined by the aircraft survivability assessment and system cost effectiveness analyses of 5.2.6 and 5.2.7.

5.3.3.1 Design configuration. The general design configuration of the aircraft system shall be arranged to obtain the highest level of protection practical for the least penalties. Techniques such as: redundancy and separation of system components, lines, and structures; natural masking of essential components; location of fuel cells in relation to engine inlets so as to minimize ingestion of fuel leakage; elimination of fire paths that jeopardize controls; integral armor; and isolation of hazardous elements such as armament, oxygen containers, flammable fluids, etc., from sensitive or susceptible areas. Provisions shall be incorporated to prevent or suppress hazardous fires in the location where they start (i.e., engine nacelle, fuel tank, dry bay, etc.) to decrease the possibility of aircraft kill due to fire. The flying qualities for safe flight after sustaining the specified hostile weapon effects shall meet MIL-H-8501 for helicopters or shall be no less than level 3, MIL-F-8785 for fixed-wing aircraft and MIL-F-83300 for V/STOL aircraft.

5.3.3.2 Structures. The aircraft structure shall be of 3 fail-safe design achieved through the use of multiple load paths and crack stoppers to reduce the probability of catastrophic structural failure due to battle damage with the aircraft in full "g" maneuvering flight. There shall be no flight critical structural components or load paths vulnerable to a single detonation, impact or other damage mechanism of threats specified in the implementing documentation that would preclude a safe return and landing (arrested landing in the case of aircraft equipped with an arresting hook) . Additional requirements may be listed under Damage Tolerance or Crashworthiness in the detail specification.

5.3.3.3 Crew station. Protection shall be provided for the aircrew as required by the aircraft detail specification or as determined by the government approved, contractor conducted Aircraft vulnerability Assessment, 5.2.5. When ballistic protection is required, it shall be

for the V₀₅ ballistic limit as defined in 3.23.2d and 3.23.2e. The crew station design shall minimize the generation of hazardous spallation within the crew area and minimize the probability of simultaneous incapacitation of more than one pilot (in multipilot aircraft) due to a fragmenting round. The guidance provided in MIL-STD-1288 and MIL-I-8675 shall be used.

5.3.3.4 Fuel system. The fuel system shall be designed to withstand the specific threats identified in the aircraft detail specification and in the implementing documentation while providing a specified quantity of protected "get home" fuel. Fire and explosion suppression techniques shall be employed throughout the fuel system, (see MIL-HDBK-221). Such suppression techniques shall include location of fuel tankage and lines away from ignition sources and employment of predictable nonhazardous fuel leakage paths following impact by the specified threats. For carrier-based aircraft, the fuel systems shall be designed to contain the fuel with the aircraft engulfed in a fire for the time specified in the aircraft detail specification and in the implementing documentation of this standard. Hydraulic ram protection shall be provided to meet the requirements of 5.3.3.1, 5.3.3.2 and the requirements of this paragraph. Hydraulic ram protection shall be designed to prevent the creation of hazardous secondary damage mechanisms such as fuel ingestion by the engine.

5.3.3.5 Propulsion system. The engine installation shall be designed to be protected from the weapon effects required by the aircraft detail specification and the implementing documentation of this standard. Where multiple engines are employed, design techniques shall be used to prevent the combat damage response of one engine from propagating to another engine, causing its failure or degradation. Fire detection and extinguishing shall be provided in multiple engine propulsion systems and shall be considered in single engine systems. Responsibility for engine vulnerability reduction and survivability enhancement of the installed engine is vested in the airframe contractor.

5.3.3.6 Power train system. Power train systems, such as those employed by V/STOL or turboprop aircraft, shall be designed to be damage tolerant against the level of threats required by the mission specified in the aircraft detail specification, the operational requirements, and implementing documentation. Redundancy, reserve capacity, damage tolerance, and ballistically protected elements shall be evaluated as methods to obtain the specified or established protection levels. Design techniques to delay failure upon loss of lubrication shall be utilized for essential power train elements. Rotating shafts and blade assemblies shall be ballistically tolerant to the threats specified in the implementing documentation of this standard, and shall not be the source of secondary damage mechanisms for other critical components.

5.3.3.7 Flight control system. The primary flight control system shall be designed to minimize failure or malfunction from the nonnuclear weapon effects specified in the implementing documentation of this standard. No single hit by the specified threat, on the flight

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control subsystem shall kill the aircraft. The design of the flight control subsystem shall be such that, if the actuating elements of the control surfaces fail, they return the control surfaces to a position to maintain level flight. The design of the flight control subsystem shall be such that:

a. Failure of the primary system shall not result in a jammed system. For snip-based aircraft, control functions necessary for safe recovery of the aircraft aboard the ship shall be as specified in the aircraft detail specification.

b. Secondary controls, such as slats, flaps, speed brakes, etc., shall be designed so that their response to weapon effects will not result in hazardous flight and recovery operations.

c. Applicable techniques such as redundancy, separation, miniaturization, exploitation of inherent shielding, damage tolerant and damage resistant components, ballistic armor, fly-by-wire, emergency backup subsystems, and integrated power packages shall be evaluated as methods to achieve the desired protection levels. Routing and separation shall be such that:

(1) Maximum protection against hostile threats is afforded by the aircraft engines, structure, or other subsystems.

(2) Points where a single hit from a specified threat will result in loss of more than one control axis, or result in an uncontrollable aircraft, are eliminated.

(3) Damage resulting from multiple fragment hits is minimized.

5.3.3.8 Fluid power system. Protection for the fluid power systems (hydraulic and/or pneumatic) shall be provided to the extent required by the aircraft detail specification, The following survivability design techniques shall be evaluated to achieve the required protection levels:

- a. Less flammable hydraulic fluids.
- b. Hydraulic circuit monitoring and control.
- c. Redundant systems.
- d. Shatterproof components.
- e. Miniaturization.
- f. Separation.

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g. High-heat tolerant component or lines.

h. Component manifolding (the combination of several hydraulic functions in a single damage resistant package with concurrent reductions in presented area).

5.3.3.9 Electrical power system. The electrical power generation and distribution system, including emergency backup systems, shall be designed to survive the specified nonnuclear weapon effects. Circuits for essential functions, including active countermeasure devices, shall be given priority for protection and shall not fail as a result of a single hit by the specified threat. Hazardous circuits shall be isolated from potential sources of short circuit actuation or failure from primary or secondary weapon effects. Multiple/cascading failures in electrical bus systems shall be avoided.

5.3.3.10 Armament system. Armament systems shall be designed to minimize or prevent hazardous effects upon the aircraft from hostile weapon effects specified in the aircraft detail specification and in the implementing documentation of this standard. Provisions shall be incorporated to delay the hazardous response of the aircraft internal and external armament loadings when subjected to fuel fire, e.g., JP-4, JP-5, JP-8 and NATO fuels.

5.3.3.11 Environmental control system. The environmental control system shall be designed to minimize creation of hazardous conditions for the aircrew and essential components from the specified weapon effects. This includes conditions such as explosive decompression, shattering of liquid oxygen containers, hot gas line rupture, etc. Protection shall be provided when high temperature bleed gases or engine exhaust are routed through or adjacent to compartments containing combustibles or temperature sensitive structure.

5.3.3.12 Launch/recovery system. The takeoff and landing system of the aircraft shall be designed to allow recovery of the aircraft when exposed to the weapon effects specified in the aircraft detail specification and in the implementing documentation of this standard.

5.3.3.13 Avionics system. The installation of government furnished equipment (GFE) and the design and installation of contractor furnished equipment (CFE) electronic and weapon delivery systems shall include methods to minimize their failure or malfunction from the weapon effects specified in the aircraft detail specification and in the implementing documentation of this standard. This shall be a primary design factor in the installation of any such equipment for aircraft application. Provisions to delay failure from loss of normal environmental conditions shall be included so that operations can be performed in degraded modes.

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a. The avionics system (including interconnecting wiring) shall incorporate design features that minimize, within the limits of practicality, the loss of mission essential functions due to a single hit from a specified threat. Avionic components supporting nonessential functions may be used to provide shielding for components supporting essential functions.

b. Special attention shall be given to the reduction of the vulnerability of avionics components that are employed in flight or mission essential functions. These include electronic flight control system components, engine and inlet controls, and any other components in which electronic or fiber optic technology has been substituted for mechanical, electromechanical, or hydraulic power and control. The assessment and design shall also consider the degradation in survivability which can result from the loss of countermeasures, navigation, fire control, target acquisition, or communications capabilities.

c. The aircraft shall not be vulnerable to mission kill from nonnuclear EMP.

5.3.4 Laser vulnerability reduction. When laser weapons are included among the specified threats (see 5.2.1), the contractor shall design the aircraft to withstand the specified levels of laser radiation. Techniques for laser vulnerability reduction often follow the same guidelines as for ballistic vulnerability reduction, such as providing redundancy, separation, and burnthrough tolerance. These must be supplemented with techniques to reflect or block the laser energy, where required, for crew and airframe survivability. Structural tolerance to low level heating of large areas must be incorporated as specified in the implementing documentation.

5.4 Verification and demonstration. Tests and analyses are required to determine aircraft vulnerable areas and show that the various aircraft systems will meet the required invulnerability. The purpose of this program is to determine system/subsystem and component combat sensitivity and verification of the design and materials. The program shall include ballistic firing, controlled damage tests and a vulnerability reduction demonstration. These tests shall be conducted on actual or simulated components (same material and design as the actual components), and on complete subsystems or portions thereof. The vulnerability reduction substantiation, verification, and demonstration tests should be integrated and "piggy backed" on other existing endurance, fatigue, and failure type test programs to the fullest extent possible. Below is a brief description of the three general types of test and their procedure. The contractor shall specify the proposed testing in the Survivability Program Plan. For gunfire tests the following brief information will be provided for each components:

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- a. Component identification.
- b. Number of specimens.
- c. Threat caliber(s) and type(s).
- d. Type of structural loading during impact, if any.
- e. Type of structural post damage test, if any.

5.4.1 Ballistic firing tests. Ballistic tests shall be conducted to determine the extent of damage to a critical component by an impact whether or not armor or other integral shielding is present, and the resultant component or specimen failure mode, reaction, and secondary effects. The "worse" case conditions shall be used for gunfire tests; considering projectile type, projectile orientation (straight-in versus degree of tumble), angle of attack, obliquity, projectile striking velocity, load and speed characteristics, and the most vulnerable location. Components shall be under load to simulate operation during ballistic impacts. In general, the post damage structural tests shall be of the same type used to qualify that component (static, fatigue (S/N) or operational run). Qualification and acceptance tests of armor materials shall be of the V50 type. Armor installation adequacy shall also be determined.

5.4.2 Controlled damage tests. Controlled damage tests simulate the secondary effects of projectile damage. Where primary damage can be accurately predicted and is not solely responsible for component or subsystem failure, tests shall be conducted without using gunfire to initiate the failure sequence. Typical of these tests are oil leakage rate, oil starvation, fuel leakage and drainage, fire detection and prevention, adequacy or redundant designs, and hydraulic subsystem leakage/redundancy adequacy. These tests shall be conducted under the direction of cognizant contractor personnel of the particular functional area. Whenever possible they shall be "piggy-backed" on other endurance, fatigue, or failure type test programs.

5.4.3 Vulnerability reduction demonstration. A vulnerability reduction demonstration shall be conducted with an aircraft to assure that the design concept, configuration, integration, and subsystem designs meet the System Specification requirements. The Ground Test Vehicle, Static Test Article, or any other aircraft may be used provided it is suitably fitted with critical components and subsystems capable of functioning to the extent required for the test. The program shall include ballistic firing tests as specified in 5.4.3.1.

5.4.3.1 Ballistic firing tests. Ballistic firing tests or destructive type secondary damage tests shall be conducted as follows:

5.4.3.1.1 Fire/explosion prevention plus hydraulic ram effects. Firing threat projectiles at fuel plumbing and tank/structure above and below fuel level under typical environmental conditions.

5.4.3. 1.2 Crew compartment. Firing threat projectiles to determine level of ballistic, span, and debris protection for the pilot and co-pilot with all shielding (including armor) and hazardous items in their proper place. See paragraph 6 of MIL-STD-1288.

5.4.3. 1.2 Support systems control system and engines. Firing threat projectiles at various mechanical, hydraulic, and electrical system areas to qualify adequate separation of redundant components and prevention of one failed component from destroying a second one.

5.4.3. 1.4 Structural response to internal blast. Firing threat projectiles against critical structural areas.

5.4.4 Component selection. Critical components for testing shall be selected based on the vulnerability analysis and verification tests. Additional components and subsystems which can best be tested by being installed shall be included to determine the secondary effects such as jamming, spall, redundancy, separation, shielding and fire/explosion. Other conditions to be tested as multiple subsystems "kills" by a single projectile and by one subsystem killing another due to close proximity. In general, there are items and subsystems whose reaction to ballistic testing might produce effects not otherwise readily determinable. Aircraft components may be previously tested or reject items, but which are representative.

5.4.4.1 Typical critical components. The following is a list of subsystems with some examples of typical critical components which should be subjected, where applicable to verification tests:

- a. Fuel subsystem. Fuel cells, fittings, pumps, sumps and ullage inerting or void area protection systems.
- b. Control subsystem. Rods, bellcranks, mixing units, combining units, actuators, pitch change links, cables, swashplate.
- c. Drive subsystem. Driveshafts, hangar bearing assemblies, main transmission, gearboxes. lubricant sumps and reservoirs.
- d. Support subsystems. Hydraulic actuators, wire bundles, fluid lines.
- e. Rotor. Blades and hub assemblies.
- f. Crew station. Pilot/co-pilot seat armor, instrument panel material, canopy, windshield, crew separation barrier.

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g. Structural. Fuselage, tailboom, structural attachment fittings for transmissions, gearboxes, vertical stabilizer.

h. Engine installations. Mounts, separation structure, controls.

i. Ammunition feed and storage. Ammo magazine, ammo conveyors, missile pods.

5.4.5 Testing documentation. In each of the test/verification efforts above, the contractor shall document:

a. The methods of testing, facilities used, and test instrumentation.

b. The criteria for establishing failure modes.

c. The procedures for comparing test data with analytical data.

5.4.6 Test results. Test results shall be reported in periodic progress reports, if required by the Contract Data Requirements List (CDRL), or quarterly if no other progress report is specified.

Custodians:

Army-AV
Air Force- 11
Navy-AS

Preparing Activity

Navy-AS

(Project No. 15GP-0024)

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APPENDIX A

10. DATA ITEMS FOR SURVIVABILITY PROGRAMS

10.1 When this standard is used in an acquisition which incorporates a DD Form 1423 and invokes the provisions of 7-104.9(n) of the Defense Acquisition Regulations, the data requirements identified in this appendix will be developed as specified by an approved Data Item Description (DD Form 1664) and delivered in accordance with the approved Contract Data Requirements List (DD Form 1423) incorporated into the contract. When the provisions of DAR-7-104.9 (n) are not invoked, the data specified below will be delivered by the contractor in accordance with the contract requirements.

<u>Paragraph</u>	<u>Data Requirement</u>	<u>Applicable DID</u>
4.4	Survivability Program Plan	DI-R-30515
5.2.1	Mission-Threat Analysis	DI-R-21482
5.2.2	Flight and Mission Essential Functions	DI-R-21482
5.2.3	Failure Modes and Effects Analysis	DI-R-21482
5.2.4	Aircraft Geometric Description	DI-R-30514
5.2.5	Aircraft Vulnerability Assessments	DI-R-21482
5.2.5. 1.2	Target Description	DI-R-30514
5.2.5.3	Vulnerability Assessment	DI-R-21482
5.2.6	Susceptibility Assessment	DI-R-21498
5.2.7	Survivability Assessment	DI-R-21498
5.2.8	Survivability Cost Effectiveness	DI-R-21498
5.2.9	Survivability Enhancement Tradeoff Study	DI-R-21498
5.2.10	Combat Damage Repair Assessment	DI-R-21481

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APPENDIX B

20. PERTINENT OTHER PUBLICATIONS

20.1 General. The documents listed under 10.2 and 10.4 are applicable to the accomplishment of vulnerability and survivability assessments as required by paragraphs 5.2.5 and 5.2.6 of this Standard. Those listed under 10.5 are basic requirement and design guides. It is not intended that this appendix be a comprehensive list of references in the survivability area. Such listings are contained in survivability handbooks and other sources.

20.2 Conventional munitions vulnerability assessments.

a. Joint Technical Coordinating Group/Aircraft Survivability Publications.

(1) JTCG/AS-78-V-002, FASTGEN II Target Description Computer Program, February 1980.

(2) JTCG/AS-75-V-008, Minimum Elements of a JTCG/AS Vulnerability Assessment, October 1976.

(3) JTCG/AS-79-V-009, Vulnerability Predictors for US Aircraft and two Large Threat Weapons, November 1978.

(4) JTCG/AS-77-S-002, Generic Missile Warheads for Use in Aircraft Preliminary Design Hardening Trade Studies, December 1977.

(5) JTCG/AS-78-V-003, Preliminary Design External Blast Vulnerability Assessment Procedure, March 1978.

be Joint Technical Coordinating Group/Munitions Effectiveness Publications.

(1) 61JTCG/ME-71-5-1, Shot Generator Computer Program, Volume I, User Manual, JUL 70.

(2) 61JTCG/ME-71-5-2, Shot Generator Computer Program, Volume II, Analysts Manual, JUL 70.

(3) 61JTCG/ME-71-6-1, VAREA Computer Program, Volume I, User Manual, FEB 71.

(4) 61JTCG/ME-71-6-2, VAREA Computer Program, Volume II, Analysts Manual, FEB 71.

(5) 61JTCG/ME-71-7-1, MAGIC Computer Simulation, Volume I, Users Manual, Part I, MAY 71.

(6) 61JTCG/ME-71-7-2-1, MAGIC Computer Simulation, Volume II, Analysts Manual, Part I, MAY 71.

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(7) 61JTCC/ME-71-7-2-2, MAGIC Computer Simulation, Volume II, Analysts Manual, Part II, MAY 71.

(8) JTCG/ME, Simulation Program for Computation of Vulnerable Areas and Repair Times (COVART), Volume I, Users Manual, AUG 75.

(9) JTCG/ME, simulation Program for Computation of Vulnerable Areas and Repair Times (COVART), Volume II, Analysts Manual, Aug 75.

20.3 Laser vulnerability assessment .

a. J. Terrence Klopccic et al., LV Methodology and Code Users Manual, APR 75, BRL Report 1779.

b. L.L. Doran et al., Target Vulnerability Analysis (U), Volumes I through V, FEB 75, AFWL-TR-73-197 (SECRET REPORT).

20.4 Survivability assessments.

a. JTCG/ME TN 4565-16-73, "Air Force Armament Test Laboratory, Eglin Air Force Base, Florida, Program P001 Anti-Aircraft Artillery Simulation Computer program," Volume I, Users Manual.

b. JTCG/ME TN 4565-3-73, "EVADE II - A Simulation Program for Evaluation of Air Defense Effectiveness," Volume I, Users Manual, FEB 73.

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20.5 General publications.

a. MIL-F-18372, Flight Control Systems: Design, Installation and Test of Aircraft (Gen. Spec. for).

b. SAE Aerospace Information Report (AIR) 1083, "Hydraulic System Survivability".

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