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MILITARY STANDARD

SURVIVABILITY, AIRCRAFT; ESTABLISHMENT AND
CONDUCT OF PROGRAMS FOR

DEPARTMENT OF THE NAVY
AIR SYSTEMS COMMAND

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DEPARTMENT OF THE NAVY
NAVAL AIR SYSTEMS COMMAND
WASHINGTON, D. C. 20361

Survivability, Aircraft; establishment and conduct of programs for

MIL-STD-2072

1. This military standard is approved for use by the Naval Air Systems Command, Department of the Navy.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Air Systems Command by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document, or by letter.

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 acquisition program managers in the development of a survivability program compatible with the needs of the procuring service and the scope of the acquisition program.

The Naval Air Systems Command 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. Purpose this standard provides:

a. Uniform requirements and criteria for establishing and conducting aircraft survivability programs and provides guidelines for preparing survivability program plans.

b. Directions and requirements for management organization, plans, procedures, and reviews for the defined survivability program tasks.

c. Requirements for program tasks (analyses, assessments and studies).

d. Requirements for survivability enhancement.

e. Requirements for verification and demonstration.

1.2 Application. This standard is applicable to procurement of all Navy/Marine service aircraft, including Remotely Piloted Vehicles and excluding aircraft designated solely for research and training.

1.2.1 New Aircraft Programs. It is intended that this standard be applied to aircraft as they enter the conceptual, validation and full-scale engineering development, production, and operational phases described in Figure 1.

1.2.2 Existing Aircraft Programs. It is intended that this standard 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. This standard will be invoked by and used in conjunction with the aircraft detail specification and other implementing documentation, in preparing aircraft survivability requirements. It may be included in requests for proposals, contract statements-of-work, survivability program plans, and other contractual documents. It is intended that this standard be applied in whole or in part as specified in implementing documentation.

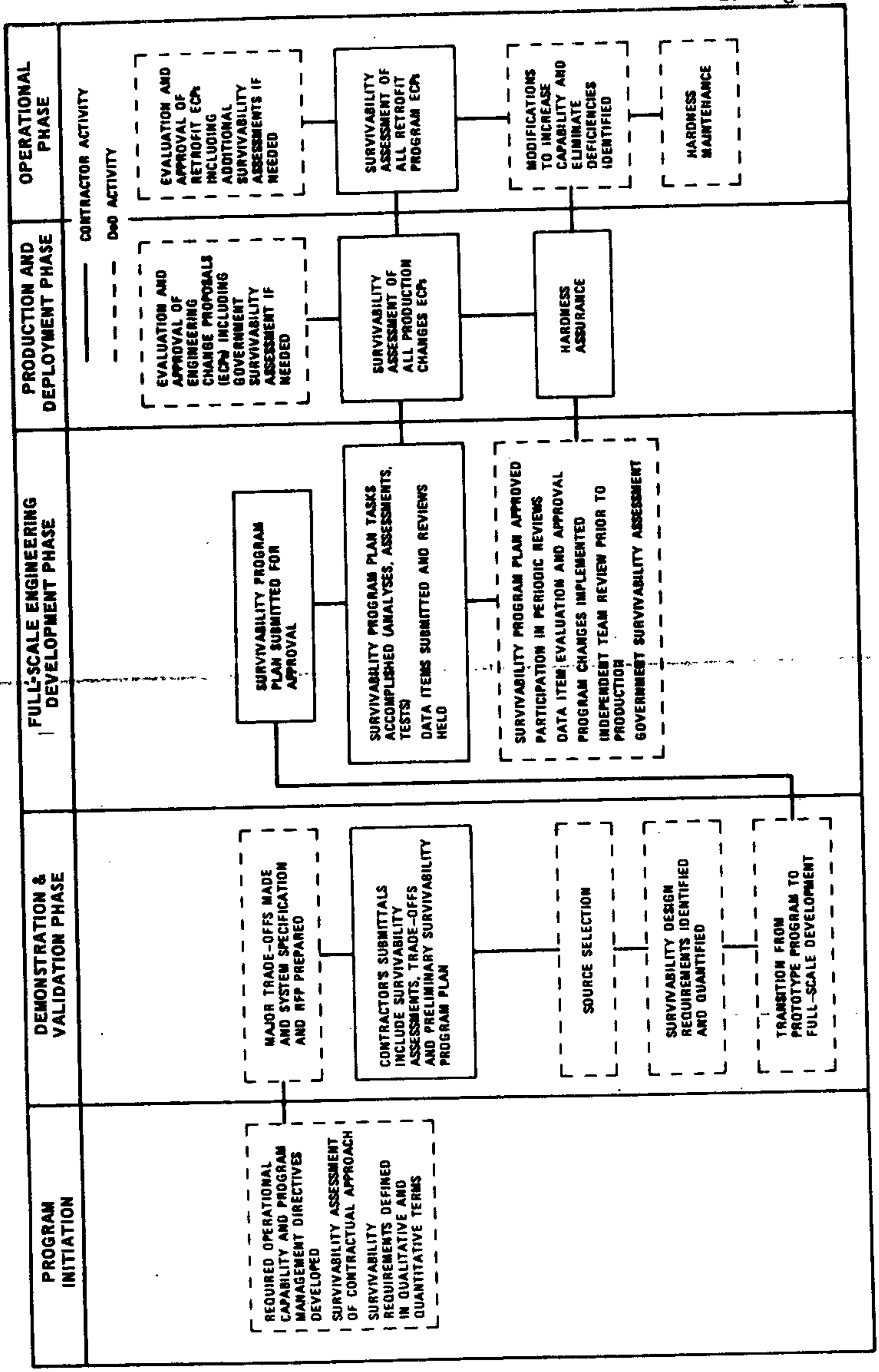

FIGURE 1. Life cycle survivability

2. REFERENCED DOCUMENTS

2.1 Publications. The following documents, of the issue 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-D-8706	Data and Tests, Engineering: Contract Requirements for Aircraft Weapon Systems
MIL-D-8708	Demonstration Requirements for Airplanes
MIL-F-8785	Flying Qualities of Piloted Airplanes

STANDARDS

MIL-STD-470	Maintainability Program Requirements (for Systems and Equipment)
MIL-STD-471	Maintainability/Verification/Demonstration/Evaluation
MIL-STD-480	Configuration Control - Engineering Changes, Deviations, and Waivers
MIL-STD-785	Reliability Program for Systems and Equipment Development and Production
MIL-STD-881	Work Breakdown Structures for Defense Material Items
MIL-STD-1288	Aircrew Protection Requirements Nonnuclear Weapons Threat

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MIL-STD-2070(AS)	Procedure for Performing Failure Mode, Effects and Criticality Analysis for Aeronautical Equipment
NAVAIR SD 24	General Specification for Design and Construction of Aircraft Weapon Systems

PUBLICATIONS

Joint Chiefs of Staff

JCS Publ, Department of Defense Dictionary of Military and Associated Terms

Defense Nuclear Agency

Handbook for Analysis of Nuclear Weapon Effects on Aircraft, Volumes I and II, DNA 2048H-1 and -2, Mar 76.

DNA EMP (Electromagnetic Pulse) Handbook, Volume 3, "Environment and Applications," DNA 2114H-3.

AFWL EMP Phenomenology 1-1, "Electromagnetic Pulse Environment Handbook," January 1972.

"EMP Handbook for Missiles and Aircraft in Flight," AFWL 63-68 of September 1972.

Joint Technical Coordinating Group/Munitions Effectiveness

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 II, Analyst Manual.

2.2 Availability of Documents. Copies of specifications, standards, drawings, 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.

3. DEFINITIONS

3.1 Terms. The definitions included in the referenced documents listed in section 2 and the Appendix shall apply. Additional definitions are listed in the subsequent paragraphs.

3.2 Survivability. The capability of an aircraft to avoid and/or withstand a man-made hostile environment without sustaining an impairment of its ability to accomplish its designated mission.

3.3 Survivability Enhancement. The use of any tactic, technique, or survivability equipment, or combination of techniques that increases the probability of survival of an aircraft when operating in a man-made hostile environment.

3.4 Vulnerability. The characteristics of a system that cause it to suffer a finite level of degradation in performing its mission as a result of having been subjected to a certain level of threat mechanisms in a man-made hostile environment.

3.5 Vulnerability Reduction. Any technique that enhances the aircraft design in a manner that reduces the aircraft's vulnerability to damage when subjected to threat mechanisms.

3.6 Threats. Those elements of a man-made environment designed to reduce the ability of an aircraft to perform mission-related functions by inflicting damaging effects, forcing undesirable maneuvers or degrading systems effectiveness.

3.6.1 Threat Characteristics. The classification of threats according to generic characteristics - type, warhead, and associated threat mechanisms.

3.6.1.1 Threat Types. A general characterization of the threat unit in terms of firing platform and site type, the entity containing the threat mechanism, and similar descriptors.

a. Conventional Weapon - Any weapon whose damage mechanisms do not include nuclear effects, biological agents, or chemical agents other than incendiary and tracer materials. "Conventional weapon" is used to represent all classes and types of nonnuclear threats such as small arms, anti-aircraft artillery, surface-to-air and air-to-air missiles with blast or fragmenting warheads, and high-energy lasers. Threat mechanisms included consist of blast, penetrators, fragments, incendiaries, and power (laser or directed energy effects).

b. Projectile - An object propelled by an applied exterior force and continuing in motion by virtue of its own inertia, as a bullet, bomb, shell, or grenade. "Projectile" is generally used to represent the device containing the warhead and threat mechanism associated with small arms and anti-aircraft artillery.

c. Small Arms - Weapons that fire projectiles up to and including 14.5mm. "Small arms" is generally used to represent enemy weapons with calibers of 7.62mm, 12.7mm, and 14.5mm. These weapons employ visual or optical tracking, and they are fabricated in differing configurations (i.e., single barrel, two barrel, four barrel, etc.). The projectiles fired by these weapons are either of the ball, armor-piercing, or armor-piercing-incendiary type.

d. Anti-aircraft Artillery (AAA) - Gun-fired projectiles greater than 20mm in size that are designed to operate against airborne targets. They are generally of calibers 23mm, 30mm, 37mm, 57mm, 85mm, and 100mm, although there are some older types with calibers greater than 100mm. The projectiles are usually high-explosive, but may be armor-piercing. Either may contain an incendiary and/or tracer type material. The weapons that fire these projectiles may be ground- or sea-based, employ either optical or radar tracking, or both, and be fabricated in differing configurations (i.e., single barrel, two barrel, four barrel, etc.).

e. Missile - An aerospace vehicle, with varying guidance capabilities, which is self-propelled through space for the purpose of inflicting damage on a designated target. These vehicles are fabricated for air-to-air, surface-to-air, air-to-surface, or surface-to-surface roles. They contain a propulsion system, warhead section, guidance system and sensor (or antennae for receiving remote guidance signals), and control surfaces. The guidance capabilities of the different missiles vary from self-guided to complete dependence on the launch equipment for guidance signals.

f. Air-to-Air Missile (AAM) - Missiles launched from interceptor aircraft for the purpose of inflicting damage on an airborne target. These missiles have varying guidance and propulsion capabilities which dictate the launch envelopes relative to the airborne target and their susceptibility to countermeasures or any other means of threat negation.

g. Surface-to-Air Missile (SAM) - Missiles launched from ground-based (or sea-based) equipment for the purpose of inflicting damage on an airborne target. These missiles have varying guidance and propulsion capabilities which dictate their launch envelopes relative to the target and their susceptibility to countermeasures or any other means of threat negation.

h. SAM Launch and Guidance Equipment - Equipment which is used to launch and guide SAMs to an intercept point. "SAM launch and guidance equipment" generally represents systems capable of launching the different SAMs, and varying in size from a single hand-held launch tube to a semi-permanent complex containing numerous trailers/vans and launch units. The systems employ both optical tracking (for the launch tube) and radar tracking in conjunction with a special missile tracking and guidance mode for the equipment complexes. The missiles launched by these systems contain warheads that are of the high-explosive, shaped-charge, or continuous-rod type.

i. Airborne Interceptor (AI) - High-performance and normally highly maneuverable aircraft designed to engage and destroy aircraft targets. Weapon systems consist of air-to-air cannon, air-to-air missiles, and associated equipments for the purpose of identifying and tracking aircraft and firing weapons. These interceptors may be limited to visual flight conditions (i.e., a day fighter) or may be configured to operate under all weather conditions (i.e., an all-weather interceptor).

j. Warhead - The part of a projectile or missile which constitutes the explosive, chemical, or other charge intended to inflict damage. These constituents in combination with the fuze and case produce the threat mechanisms.

k. Non-terminal Electromagnetic Threats - Electronic systems used by enemy forces to support and aid the active (or terminal) threat units. These systems normally consist of acquisition, detection, tracking, and communication systems. They can be land-, sea-, or air-based, and are normally an integrated part of the enemy's offensive and defensive forces. Their purpose is to supply appropriate position, velocity, heading, etc., information to the terminal or active threat units.

l. High-Energy Laser (HEL) - A weapons system which produces a collimated beam of electromagnetic radiation with an intensity sufficient to melt or thermally degrade a portion of the target. It may also be used to damage electromagnetic subsystems of the target by overloading (in-band kill).

3.6.1.2 Warhead (or Laser) Descriptors. Descriptors characterizing the basic configuration and ingredients of the warhead and the activation methods/devices which collectively generate the threat mechanisms.

a. Warhead Fuze - That element of a warhead which initiates the detonation of the explosive charge. Proximity fuzing (i.e., initiation within a predetermined distance to a target) is normally used for missile warheads and some large AAA projectiles. Contact fuzing (i.e., initiation on impact) is normally used for AAA projectiles and may be delayed or instantaneous.

b. High-Explosive Charge - Any powerful, nonatomic explosive material characterized by high-order detonation and a powerful disruptive or shattering effect. The high-explosive charge is used to generate high-speed fragments as well as to develop potentially damaging blast effects on the target. In practical application (e.g., reports, articles), the full term should be used initially. In subsequent references to the term, "high explosive" or "charge" may be used. "High-explosive charge" is normally used to modify (and describe) specific warhead types such as high-explosive incendiary, high-explosive incendiary tracer, etc.

c. Shaped Charge - A high-explosive charge that is shaped in conjunction with the casing so that energy created by detonation is focused in a desired direction. The focused energy creates high fragment velocities. In general, there are two types of shaped charges - spherical, which focuses energy to a selected point in the warhead, and linear, which focuses the energy in a desired array around the warhead.

d. Ball-Type Projectile - A passive projectile with a relatively soft metal interior or core which is typically associated with small arms. These warheads are primarily intended for use against personnel and unarmored targets. In practical application (e.g., reports, articles), the full term should be used initially. In subsequent references to the term, "ball" may be used.

e. Armor-Piercing Projectile (AP) - A projectile composed of a hardened steel core encased in a metal jacket; the shape of the core is designed to maximize its penetrability. These projectiles are utilized to penetrate hard or armored targets and are normally associated with small arms and anti-aircraft artillery.

f. Armor-Piercing Incendiary Projectile (AP-I) - A projectile utilizing a hardened steel core with an incendiary mix in the nose, all of which is encased in a metal jacket. These projectiles are utilized to penetrate hard or armored targets and to ignite fires or explosions with the incendiary materials. These projectiles are normally associated with small arms and anti-aircraft artillery.

g. High-Explosive Projectile (HE) - A projectile composed of a hollow steel body containing a high-explosive filler. Such projectiles normally consist of a steel outer shell with an internal explosive charge detonated by a fuze in the nose. Fuzing may be contact, fixed time (FT), variable time (VT), or proximity (PROX). There are two types of contact fuzes for HE projectiles: delay and super quick. Delay-fuzed HE projectiles are designed to penetrate a target and explode internally to cause the maximum damage from the blast effects. Super quick fuzes will cause external detonation. Externally detonated HE projectiles rely on penetration of the target from fragments of the exploding projectile body. Fragment size and population depend on the specific projectile. HE projectiles are normally associated with anti-aircraft artillery (AAA).

h. High-Explosive Incendiary Projectile (HE-I) - A projectile composed of a hollow steel body containing a high-explosive filler and an incendiary mixture. Such projectiles normally consist of a steel outer shell with an internal explosive charge and incendiary mixture detonated by a contact fuze, either delay or super quick, on the nose. Delay-fuzed HE-I projectiles penetrate a target and explode internally to cause damage from blast effects as well as with fragments and burning incendiary. Fragment size and population depend on the specific projectile. HE-I projectiles are normally associated with anti-aircraft artillery (AAA).

i. High-Explosive Incendiary Tracer Projectile (HE-I-T) - A projectile composed of a hollow steel body containing high-explosive, incendiary, and tracer materials. The incendiary material is included to provide an ignition source on impact, and the tracer material is added to provide a visual image of the projectile's flight path.

j. Fragmenting Case - A casing designed to break into fragments upon detonation. The fragments may be of a uniform size calculated to optimize the effectiveness of the weapon against a particular type of target. The desired fragment dimensions can be obtained by scoring the case or by wrapping it with wire.

k. Continuous Rod Warhead - A warhead which contains a bundle of rods welded together at alternate ends. Upon detonation of the explosive load the rod bundle expands at right angles to the missile to a maximum radius and then breaks apart. This steel ring can knife through skin and skeletal members of aircraft structure.

l. Delivered Energy Distribution (DED) - The distribution of energy/area delivered to a target (i.e., through a plane normal to the incident laser beam at the target location). The DED includes both a description of the energy pile (time integral of the intensity that has passed through each point of the incident plane) and a probability distribution of energy piles about the desired aimpoint.

3.6.1.3 Threat Mechanisms. Mechanisms, embodied in or employed as a threat, which are designed to damage (i.e., to degrade the functioning of or to destroy) a target component or the target itself.

a. Blast - The brief and rapid movement of air or other fluid away from a center of outward pressure, as in an explosion; the pressure accompanying this movement. Blast is a threat mechanism associated with high-explosive warheads such as contained on anti-aircraft artillery (20mm and larger) or surface-to-air and air-to-air missiles. Depending on the warhead and fuzing, the blast may be external or internal to the target.

b. Penetrator - The core or that part of an armor-piercing projectile designed to penetrate to the interior of a target. Penetrators are threat mechanisms associated with small arms and anti-aircraft artillery.

c. Fragment - Metal particles of varying weight, size, and velocity that are produced by ballistic impact and the detonation of projectiles and missile warheads. Fragments are threat mechanisms associated with anti-aircraft artillery and surface-to-air and air-to-air missile warheads. Depending on the warhead fuzing, initial fragment impact may be external (proximity-fuzed) or internal (contact-fuzed) to the aircraft. In addition to being directly produced by the detonation of a warhead, fragments can be the result of a ballistic impact on a target. In this case, fragments are a by-product of material response such as spall.

d. Tracer - An active bright-burning material typically used with a projectile to make the flight of the projectile visible both by day and by night. Tracers are primarily used as an aiming aid with small arms, AAA, and airborne gun systems. However, tracers do have the capability to initiate combustion and, hence, are categorized as a threat mechanism.

e. Incendiary - Any chemical agent designed to cause combustion; used especially as a filling for certain bombs, shells, projectiles, or the like. A typical application of an incendiary material is in a small arms or contact-fuzed anti-aircraft artillery (AAA) projectile. For the small-arms projectile, for example, a thermally active incendiary filler is used with a passive core, either ball or armor-piercing material. The incendiary is located in front of the passive core and is initiated upon contact with the target.

f. Electromagnetic Flux - Electromagnetic energy per unit time or power passing through a surface. (See also JCS Publ, Electromagnetic Pulse.)

g. Power - The energy per unit time which a High-Energy Laser Weapon System (HELWS) is capable of delivering.

3.6.2 Threat Levels. A term used primarily in vulnerability assessment calculations and relating to the energy at impact of a given threat, e.g., 14.5mm API Soviet Type B32 M1932 anti-aircraft projectile impacting at velocities from 500 feet per second to 3500 feet per second in 500 feet per second intervals.

3.7 Aircraft Vulnerability Assessment. Systematic description, delineation, and quantification of the vulnerability of an aircraft when subjected to threat mechanisms.

3.8 Aircraft Survivability Assessment. Systematic description, delineation, quantification, and statistical characterization of the survivability of an aircraft in encounters with hostile defenses.

3.9 Aircraft Probability of Survival. The probability that an aircraft will survive a defined damage level in specified threat encounters.

3.10 Aircraft Probability of Kill. The probability that an aircraft will not survive a defined damage level in specified threat encounters.

3.11 Hardening. That type of vulnerability reduction effected by interposing less essential components between critical components and the damage mechanisms, by eliminating critical components, or by the use of materials having improved characteristics.

3.12 Survivability Enhancement Tradeoffs. The process of examining and quantifying both the survival benefits and the penalties associated with alternative survivability enhancement techniques of aircraft and subsystems; the objective of this tradeoff process is to derive the insights necessary to select the optimal configuration or utilization for defined mission roles.

3.13 Reduction of Detection. The use of techniques that reduce the target aircraft signatures (i.e., infrared, radar, visual, and aural) that are used for guidance by a man-made threat mechanism.

3.14 Passive Countermeasures. Those techniques related to reduction of detection which differ from active countermeasures in the sense that they do not directly influence enemy radiation, but exploit it for survivability enhancement. No electromagnetic spectrum is generated for defense. (See also Electronic Warfare, JCS Publ.)

3.15 Susceptibility. The combined characteristics of all the factors that determine the probability of hit of an aircraft component, subsystem, or system by a given threat mechanism. (This is a special case subset of susceptibility as defined in JCS Publ.)

3.16 Encounter Conditions. Significant conditions of the aircraft and its surroundings which may be derived from mission profiles. They may usually include aircraft configuration, altitude, attitude, velocity, course, fuel load, rate of climb or dive, relationship with horizon, meteorological conditions, type of threat, open fire range, target offset, and angles off. Encounter conditions are determined in the mission threat analysis and used in survivability assessments, tradeoff studies, and in the aircraft design process.

3.17 Singly Vulnerable. The property attributed to a component if the killing of that component is sufficient to result in an aircraft kill in a specified kill category.

3.18 Non-Singly Vulnerable (also called Multiply Vulnerable). The property attributed to components of a set when the killing of less than $\underline{n}$ members of the set does not result in an aircraft kill (in a specified kill category), but the killing of $\underline{n}$ or more members does result in a kill (for $n > 1$).

3.19 Standard Aspects. Calculations which call for viewing the aircraft from particular angles will be specified as either:

a. The Six Cardinal Views - These are front, rear, right side, left side, bottom, and top.

b. The 26 Standard Aspects - These include 8 views in the horizontal plane at 45° intervals about the vertical axis starting at the front, 8 views looking downward at a 45° angle, at 45° intervals about the vertical axis from viewpoints over the viewpoints used in the horizontal plane; 8 views looking upward at 45° from points under the horizontal viewpoints; and a top view and bottom view.

3.20 Critical Components. Those aircraft components which, if damaged or destroyed, would yield a defined or definable aircraft kill level.

3.21 Flight Essential Functions. Those subsystem functions required to enable an aircraft to sustain controlled flight with qualities of no less than level 3 as defined by MIL-F-8785 or MIL-F-83300 for the given classifications of aircraft or by MIL-H-8501.

3.22 Mission Essential Functions. Those subsystem functions required to enable an aircraft to perform its designated mission(s).

3.23 System Response. The actions and reactions of an aircraft system, including crew, when a threat is detected, or when the system is subjected to a threat mechanism.

3.23.1 Damage Processes. Descriptors of the nature, type, form, or state of the interaction between the threat mechanism and the target or target element.

a. Penetration - A damage process relating to the ability of a threat mechanism to force a way into or through a target or target element.

b. Blast Effects - A damage process relating to the ability of a threat mechanism to produce sufficient pressure forces to impose structural degradation, geometrical deformation, or other types of damage on a target or target element.

c. Ignition - A damage process relating to the ability of a threat mechanism to create a condition suitable for the combustion of flammable materials.

d. Thermal Effects - A damage process, exclusive of ignition, relating to the ability of a threat mechanism to deposit sufficient quantities of heat to impose structural degradation, geometrical deformation, or other types of damage on the target or target element.

3.23.2 Target Lethality Criteria. Quantitative and qualitative data that collectively define (1) the susceptibility of the target to damage processes and (2) the resultant responses of the target, given that threat-induced damage occurs.

a. Damage/Kill Criteria - Quantitative and qualitative data that relate target response to damage processes (penetration, blast effects, etc.) in terms of mission performance factors. (See also Damage Criterion, JCS Publ.)

b. Primary Damage Effects - Damage directly resulting from damage processes. Examples of "primary damage effects" are incendiary caused fire, control linkage severance, etc.

c. Secondary Damage Effects - Damage indirectly caused by the interaction of a damage process with a component, subsystem, or system. Examples of "secondary damage effects" are fire which results from a penetrator-caused fuel leakage contacting a hot surface, control linkage jamming due to blast-induced buckled skin panels, etc.

d. Ballistic Limit - The average of two striking velocities, one of which is the highest velocity giving a partial penetration and the other of which is the lowest velocity giving a complete penetration. It is the striking velocity of a fragment or projectile below which partial (rather than complete) penetrations of the target will predominate. The Navy ballistic limit requires the projectile or fragment to exit from the ballistic protection material for it to be considered a complete penetration.

e. "X" Ballistic Limit - Any expression of ballistic limit wherein the "x" subscript denotes the probability of complete penetration for a projectile or fragment striking at a velocity "V". For example, the V_{05} ballistic limit specifies that the projectile or fragment will pass completely through the protection no more than 5 times out of 100.

3.23.3 Response Measures. Qualitative and quantitative measures of the reaction, in terms of mission performance factors, of a target or target element from exposure to damage processes.

3.23.3.1 Kill Processes. The reaction and interaction between damage processes and the target or target element which result in mission performance degradation.

3.23.3.2 Kill Levels (Nonnuclear). Measures of the degree to which a target or target element suffers performance degradation due to damage processes.

a. Attrition Kill - A measure of the degree of aircraft damage which renders it incapable of being repaired, or not economical to repair, so that it is lost from the inventory. Examples of attrition kill levels that have been used are:

(1) KK-kill - damage that will cause an aircraft to disintegrate immediately upon being hit.

(2) K-kill - damage that will cause an aircraft to fall out of manned control within 30 seconds after being hit.

(3) A-kill - damage that causes an aircraft to fall out of manned control within 5 minutes after being hit.

(4) B-kill - damage that causes an aircraft to fall out of manned control within 30 minutes after being hit.

(5) C-kill - damage that causes an aircraft to fall out of manned control before completing its designated mission. (This type of attrition kill is also commonly referred to as a "Mission Kill.")

b. Catastrophic Kill - A measure of the degree of aircraft damage which causes it to disintegrate immediately after the damage is inflicted. This type of kill is generally referred to as a KK-kill. See explanatory notes under "Attrition Kill."

c. Mission Available Kill - A measure of a degree of aircraft damage which does not prevent the aircraft from completing its designated mission, but necessitates repairs before the next scheduled mission.

d. Mission Abort Kill - A measure of the degree of aircraft damage which prevents the aircraft from completing its designated mission, but is not sufficient to cause a loss of the aircraft to the inventory.

e. Forced Landing Kill - A helicopter kill category in which damage to the helicopter or a warning indication causes the pilot to land, powered or unpowered. The extent of damage may be such that very little repair is required to fly the helicopter back to base; however, if the pilot continues to fly the aircraft will be destroyed. The forced landing kill category includes a forced landing at any time after damage occurs, but before the expenditure of the aircraft fuel load.

f. Repair Time Kill - A measure of the degree of aircraft damage which will be sufficient to cause the aircraft to miss its next scheduled mission.

g. Mission-Limiting Condition - A measure of a degree of aircraft damage which prevents an aircraft from completing a portion of its assigned mission. An example would be the loss of one engine on a supersonic fighter, which would inhibit its ability to engage supersonic targets.

h. E-Kill - A measure of the degree of damage that will cause an aircraft to be structurally damaged upon landing, given it survives to the point of landing (e.g., a tire blown).

i. V-Kill - A measure of the degree of damage that will cause a vertical takeoff or landing (VTOL) aircraft to be incapable of vertical flight, vertical takeoff, or vertical landing.

3.23.3.3 Kill Levels (Nuclear).

a. Sure Safe - That level of response to nuclear weapons effects where no appreciable damage is sustained, and the aircraft is capable of being refueled and reloaded within the normal turnaround period for operational flight.

b. Mission Kill - That level of damage to the aircraft that results in conditions that prevent the mission objectives from being attained, but allows continued controlled flight.

c. Sure Kill - That level of damage to the aircraft that causes it to fall immediately out of control.

4. GENERAL REQUIREMENTS

4.1 Survivability Program. 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. The program shall be conducted in accordance with the requirements of this standard together with MIL-STD-480, MIL-D-8706, MIL-D-8708, and MIL-STD-881, unless otherwise specified in the aircraft detail specification (SD 24 or equivalent specification) or implementing documentation.

4.2 Program Management. The contractor shall define the required elements for management of the survivability program, including fund allocations and cost controls, to be conducted during design, development, test, and production of aircraft. Survivability program management shall be integrated into the contractor engineering management organization or engineering management plan required by the implementing documentation (i.e., systems engineering plan required by AR59).

4.2.1 Organization. The contractor shall be responsible for staffing, managing, and accomplishing the survivability program. The responsibilities and functions of those personnel directly involved with survivability policies and implementation of the program shall be clearly defined. The responsibility and authority delegated to the survivability organization and its relationships with all levels of management shall be identified. The survivability organization shall be involved with all relevant design, support, and program management activities so that the survivability requirements are effectively incorporated into the aircraft. The relationships to each relevant activity shall be defined.

4.2.2 Program Plan. The contractor shall develop, propose, obtain government approval of, and implement a survivability program plan. It shall outline the procedures by which the contractor proposes to conduct the program tasks 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 paragraphs 5.2 and 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.

FOREWORD

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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-2072.)

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

4.2.3 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 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.

h. Proposals of methodologies for specific requirements of this standard where procuring agency approval is required.

4.2.4 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 systems survivability requirements. The reviews shall be supported by survivability analysis, or other approved quantitative means of assessing the survivability enhancement tradeoffs resulting from such proposals.

b. Identification of problem areas, or noncompliance with requirements, and proposed plans for correction.

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

d. Status and results of tradeoff studies conducted for survivability engineering.

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

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

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

5. DETAILED REQUIREMENTS

5.1 General. The survivability of an aircraft system is expressed in terms of susceptibility (detection, acquisition, tracking, and threat avoidance), and vulnerability (to the threat mechanism). Detection, acquisition, and tracking 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. 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. The requirements below 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.

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. The contractor shall:

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

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, shall be the basis for selecting survivability enhancement features 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.

5.2.3 Failure Modes, Effects and Criticality Analysis (FMECA). The contractor shall describe the function of each flight essential and mission essential aircraft component. The effects of each combat damage induced failure mode of that component on the total aircraft system shall be included. The contractor shall conduct this Failure Modes, Effects and Criticality Analysis in accordance with MIL-STD-785 and MIL-STD-2070(AS).

5.2.4 Damage Mode and Effects Analysis (DMEA). A DMEA shall be performed for the specified threats. The failure (response) mode(s) for each flight/mission essential component as caused by the threat mechanism(s) shall be identified. The effect of each failure mode upon the essential function(s) of the aircraft system shall be determined, along with the effect upon flight capability and/or mission completion. The analysis shall include all identified flight and mission essential subsystems and components. 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. 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 the hazardous environments shall be identified. The results of the DMEA shall include the probability of a kill given a hit ($P_{K/H}$) functions for each component damage mechanism combination. These $P_{K/H}$ functions shall include the specified spectrum of threat energy levels.

5.2.5 Aircraft Vulnerability Assessments. Continual aircraft vulnerability assessments shall be made using the results of the analyses produced in 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 vulnerable areas 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 paragraph 2.1 under 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 Nonnuclear Vulnerability Assessment Methodology. The contractor shall use (where available and specified) government provided $P_{K/H}$ functions in the determination of vulnerable areas. When $P_{K/H}$ 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 multiply 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. In the absence of a specified methodology, the methodology chosen by the contractor shall be subject to government approval.

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, the SHOTGEN/FASTGEN shot line generator computer programs with their associated target descriptions and the COVART computer program for determining vulnerable areas shall be used. (See Appendix.)

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

5.2.5.2 Nuclear Vulnerability Assessment Methodology. The contractor shall conduct nuclear weapon vulnerability assessments. They shall be conducted for the weapon yields specified in the implementing documentation using the encounter conditions derived in 5.2.1. The results shall be plots of the sure safe (SS), the mission completion (MC) and the sure kill (SK) condition envelopes for each of the weapon effects. (See 3.23.3.3.) "Except for the electromagnetic pulse (EMP), weapon effects shall be calculated in accordance with methods contained in Handbook for Analysis of Nuclear Weapon Effects on Aircraft, DNA 2048H (see 2.1). EMP effects on aircraft shall be calculated with methods contained in DNA 2114H-3, AFWL EMP Phenomenology and AFWL 73-68."

5.2.5.3 Laser Vulnerability Assessment Methodology. Laser vulnerability assessments shall employ methodology provided by the Government or a contractor proposed model approved by the procuring agency.

5.2.5.4 Documentation of Vulnerability Assessments. Complete documentation shall be submitted for all vulnerability assessments. For nonnuclear 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 nuclear assessments, the documentation shall include the envelopes for each kill category and nuclear weapon effect. 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. 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 Survivability Assessments.

a. Survivability assessments provide data that permit determination of the effectiveness 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.

5.2.6.1 Nonnuclear Survivability Assessments. The contractor shall conduct nonnuclear survivability assessments using the methodologies specified below. 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."

b. For proximity-fuzed projectiles and missiles use the JTCG/ME Computer Program Standard End Game Model (ATTACK Computer program or superseding model).

5.2.6.2 Nuclear Survivability Assessment. Nuclear survivability assessments shall be conducted with a government provided or government approved methodology.

5.2.6.3 Laser Survivability Assessment. Laser survivability assessments shall be conducted with a government provided or government approved methodology.

5.2.7 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.

5.2.8 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 tradoff study shall contain:

a. A description of survivability enhancement techniques considered.

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

c. Reduction in IR, RF, and visual signatures (Reduction of Detectables).

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

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

f. Recommendations and alternatives regarding optimum design and configuration.

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

5.2.9 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 471a 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.

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.).

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 Survivability Enhancement Requirements. The following are basic survivability enhancement requirements which are applicable unless otherwise specified.

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 or 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 or 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 or 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 in the standby mode of operation no equipment will emit radiation which exceeds the level specified in the aircraft detail specification or 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 reduction of detection and electronic warfare capabilities, decoys, for specified threat weapons. The contractor shall determine the J/S levels required to permit effective operation in the threat environment.

5.3.3 Nonnuclear 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. 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 nonnuclear 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 shall be considered in the design. Provisions shall be incorporated to contain hazardous fires in the location where they start (i.e., engine nacelle, fuel bay, etc.) to decrease the possibility of secondary fire kill modes. 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.

5.3.3.2 Structures. The aircraft structure shall be of a 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 an arrested landing. Additional requirements may be listed under Damage Tolerance in the aircraft detail specification.

5.3.3.3 Crew Station. Nonnuclear 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 V_{05} 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. The guidance provided in MIL-STD-1288 and MIL-I-8675 shall be used.

5.3.3.4 Fuel Subsystems. The fuel subsystem shall be designed to withstand the specific nonnuclear threats identified in the aircraft detail specification and in the implementing documentation of this standard, while providing a specified quantity of protected "get home" fuel. Fire and explosion suppression techniques shall be employed throughout the fuel subsystem. 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 subsystems 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 Subsystem. The engine installation shall be designed to be protected from the nonnuclear 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 Subsystem. Power train subsystems, 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 armor 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.

5.3.3.7 Flight Control Subsystem. The primary flight control subsystem 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 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 carrier-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 nonnuclear weapon effects will not result in hazardous flight and recovery operations.

c. 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 <u>Fluid Power Subsystem</u>. Protection for the fluid power subsystems (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.

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 Subsystem. The electrical power generation and distribution subsystem, including emergency backup subsystems, 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 Subsystems. Armament subsystems 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., JP4, JP5, JP8, and NATO fuels.

5.3.3.11 Environmental Control Systems. The environmental control system shall be designed to minimize creation of hazardous conditions for the aircrew and essential components from nonnuclear 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. The takeoff and landing subsystem of the aircraft shall be designed to maximize the possibility of safe recovery of the aircraft when exposed to the hostile nonnuclear effects specified in the aircraft detail specification and in the implementing documentation of this standard.

5.3.3.13 Avionic Systems. 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 nonnuclear 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.

a. The avionics system (including interconnecting wiring) shall incorporate design features that minimize as much as practical 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.

5.3.4 Nuclear Vulnerability Reduction. The aircraft shall be designed to survive (to the specified nuclear kill level), the intensity of nuclear weapon effects required by the aircraft detail specification and the implementing documentation of this standard.

5.3.4.1 Nuclear Blast. The aircraft shall be designed to withstand the overpressure and resultant gust effects from the nuclear weapon type and yield contained in the implementing documentation of this standard. The aircraft weights, fuel loadings, and weapon loading are the encounter conditions derived in the mission-threat analysis for the missions in which the aircraft is exposed to the nuclear threat.

5.3.4.2 Thermal Radiation. The contractor shall design the aircraft structure, crew stations, and external essential components to withstand the nuclear kill level of thermal radiation cited by the survivability specification and Statement-of-Work.

5.3.4.3 Gamma/Neutron Radiation. The contractor shall design the flight and mission essential electronic components of the aircraft systems and weapon delivery subsystem to withstand the levels of gamma and neutron radiation cited by the implementing documentation of this standard. These components must be hardened so that the functions required for weapon delivery will be intact. The contractor shall provide a means of protecting the crew from radioactive fallout particles by filtering or other techniques. The aircraft must be designed to prevent radioactive particles from collecting where they can be hazardous to the crew or sensitive equipment.

5.3.4.4 Electromagnetic Pulse. The contractor shall design the aircraft system to preclude the failure or malfunction of flight or mission essential electronic equipment from the levels of electromagnetic pulse (EMP) cited in the implementing documentation of this standard. The contractor shall select the hardening techniques most effective for the specific system application.

5.3.4.5 Transient Radiation Effects on Electronics (TREE). TREE effects are the transient malfunctions and the performance degradations of subsystems resulting from both the delayed and prompt ionizing dose rate levels. The contractor shall protect the subsystems from these effects through component selection and controlled application of the components within the circuits.

5.3.5 Laser Vulnerability Reduction. When laser weapons are included among the specified threats, 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. The contractor shall provide for verifying and demonstrating that contract survivability requirements have been met. The survivability program plan shall include tasks and schedules for accomplishing verification and demonstration.

5.4.1 Analysis and Testing. It is intended that analysis, supported by data from testing already accomplished, be used wherever it can be rigorously shown that the application of such data and analysis to the particular case is valid. Beginning during the concept phase the contractor shall identify data which is required for design and evaluation of survivability features and include plans for acquisition of that data in the survivability program plan. The contractor shall make maximum use of hardware which has been acquired for other verification and evaluation efforts.

5.4.2 Verification and Demonstration Plan. In addition to scheduling the verification and demonstration tasks in the survivability program plan, the contractor shall prepare a detailed test plan. The plan shall clearly indicate the number of tests to be conducted, schedule, type of threat mechanism(s) being examined, threat mechanism intensity, objective of test (e.g., material response), number of applications of threat mechanism to show statistical validity, etc. The plan shall be approved by the procuring agency, and changes to the schedule shall be made known to the procuring agency sufficiently in advance as to permit the attendance at the test of procuring agency personnel.

5.4.3 Component Testing. In support of the vulnerability analysis the contractor will prepare, conduct, and report the test efforts necessary to obtain survivability data on parts, components, and subsystems response which cannot be obtained analytically, or which are not contained in survivability data banks maintained by industry and government activities.

5.4.4 Pre First Flight Testing. Prior to aircraft first flight, at times specified in the Verification and Demonstration Plan, tests shall be scheduled and conducted on the final configurations of mission essential components to verify that the system and subsystem designs meet the survivability specification requirements.

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.

Preparing Activity:

NAVY - AS
(Project 15GP-0024)

10. APPENDIX

PERTINENT OTHER PUBLICATIONS

10.1 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.

10.2 Conventional Munitions Vulnerability Assessments.

a. Joint Technical Coordinating Group/Aircraft Survivability Publications.

(1) None.

b. 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-71-2-1, Magic Computer Simulation, Volume I, Users Manual, Part I, MAY 71.

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

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

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

10.3 Laser Vulnerability Assessment.

a. J. Terrence Klopcic 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).

10.4 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.

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

d. AFATL-TR-74-93, "Air Force Armament Test Laboratory, Eglin Air Force Base, Florida, Computer Program for NORSAM Model," MAY 74.

10.5 General Publications.

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

b. MIL-F-83300, Flying Qualities of Piloted V/STOL Aircraft.

c. NAVAIR AR 59, Project Reporting Organization and Management Planning Techniques.

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