BY ORDER OF THE COMMANDER

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New issue

Air Force Space Command

SPACE AND MISSILE SYSTEMS CENTER STANDARD

SURVIVABILITY PROGRAM FOR SPACE SYSTEMS

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FOREWORD

1. This standard defines the Government's requirements and expectations for contractor performance in defense system acquisitions and technology developments.

2. This new-issue SMC standard comprises the text of The Aerospace Corporation report number TOR-92(2904)-5.

3. Beneficial comments (recommendations, changes, additions, deletions, etc.) and any pertinent data that may be of use in improving this standard should be forwarded to the following addressee using the Standardization Document Improvement Proposal appearing at the end of this document or by letter:

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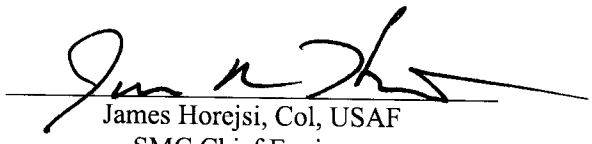
4. This standard has been approved for use on all Space and Missile Systems Center/Air Force Program Executive Office - Space development, acquisition, and sustainment contracts.



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1. SCOPE

1.1 Purpose. This standard defines fundamental survivability program management requirements for each of the system acquisition life-cycle phases, namely: concept exploration and definition (Phase 0), demonstration and validation (Phase I), engineering and manufacturing development (Phase II), production and deployment (Phase III) and operations and support (Phase IV).

It is important to understand that the generalized programmatic requirements of this standard will be defined for a particular program/system in the Survivability Program Plan (SPP). This standard should be interpreted as the top-level document that facilitates the establishment of an efficient and effective survivability engineering program that is an integral part of the systems engineering organization.

When applicable, this standard is consistent with the general guidelines, policies, and procedures established by the latest revisions of Air Force Regulation (AFR) 80-38 (The Air Force Systems Survivability Program), Department of Defense Instruction (DoDI) 5000.2 (specifically, Part 6, Section F, "Survivability") and AFR 57-1 (Air Force Mission Needs and Operational Requirements Process). For a space system, this standard guides the specification of essential survivability engineering management tasks and requirements that are implicitly refered to in AFR 80-38 and DoDI 5000.2.

1.2 Application. This standard is applicable to space systems (i.e., space and ground segments) that are required to operate without degradation of performance, if exposed to natural environments and/or hostile threats. Space environments are characterized in reference MIL-STD-1809 (USAF), however, specification of space environments for a particular system will be provided by the government and will take into consideration top-level mission and operational requirements (MNS and ORD).

1.2.1 Tailoring. The contractor shall work in unison with the government to optimally tailor this standard, taking into consideration the government's Mission Need Statement (MNS) and Operational Requirements Document (ORD). The MNS and ORD are described in reference AFR 57-1. Interpretation and tailoring of this standard should be initiated early in the concept exploration and definition phase. Tailoring shall take into consideration policies and procedures of Appendix A.

2. REFERENCED DOCUMENTS

2.1 Government and Non-Government Documents

DoD-STD-1766A(USAF)	Nuclear Hardness And Survivability Survivability Program Requirements for ICBM Requirements For ICBM Systems
DoD Directive 5000.1	Defense Acquisition Policies And Responsibilities
DoD Instruction 5000.2	Defense Acquisition ManagementPolicies And Procedures
AFR 80-38	The Air Force Systems Survivability Program
AFR 57-1	Air Force Mission Needs And Operational Requirements Process
MIL-STD-490A	Specification Practices
MIL-STD-499B	Systems Engineering
MIL-STD-1521B	Technical Reviews And Audits For Systems, Equipments, And Computer Software
MIL-STD-1546A(USAF)	Parts, Materials, and Processes Standardization, Control And Management Program For Spacecraft And Launch Vehicles
MIL-STD-1547B(USAF)	Parts, Materials, And Processes For Space And Launch Vehicles, Technical Requirements For
MIL-STD-1809(USAF)	Space Environment For USAF Space Vehicles
DNA Document	System Development HardnessAssurance Guide-line Document:Nuclear And Space Radiation Effects Aspects (DRAFT)

2.2 Order of Precedence. If there is a conflict between the text of this standard and the references cited herein, the text of this standard shall take precedence.

3. DEFINITIONS

3.1 Acquisition Life-Cycle. A subset of the system life-cycle that consists of the program phases through which a system passes from the time it is initially conceived and developed until the time it is deployed and enters operational use. The acquisition life-cycle is usually considered to consist of the following five phases, although the precise terminology used tends to vary. The terminologies used for the phases in this standard are: (1) Phase 0 - concept exploration and definition phase (CE/D); (2) Phase I - demonstration and validation phase (DEM/VAL); (3) Phase II - engineering and manufacturing development (EMD); (4) Phase III - production and deployment; and (5) Phase IV - operations and support.

3.2 Commercial-Off-The-Shelf (COTS) Equipment. A category of commercial product that is produced and placed in stock by a manufacturer or stocked by a distributor, before receiving orders or contracts for its sale. The design and possible future changes to the design and configuration are controlled solely by the manufacturer. It must be bought, used, and supported exactly as found in the civilian market.

3.3 Concept Exploration and Definition Phase (CE/D). The first phase of the system acquisition life-cycle that extends from the determination of a needed operational capability to the program decision that authorizes the implementation of the demonstration and validation phase. During this phase, the system concepts that warrant further development in response to the identified operational need are defined and selected.

3.4 Configuration Item (CI). An aggregation or grouping of hardware, firmware, and software that satisfies an end use function and is designated for configuration management. During development and manufacturing of the prototype production configurations, CIs are those items whose performance parameters and physical characteristics must be separately specified and controlled.

3.5 Contractor. As used in this standard, contractor refers to one of the organizations contracted by either the implementing or supporting Systems Program Office (SPO) or government. Government and SPO are interchangeable terms in this standard.

3.6 Critical Design Review (CDR). One series of three design reviews mandated by MIL-STD-1521B during the EMD phase of the program. It is conducted for each CI when the detail design has been essentially completed. From the perspective of this standard, its primary purpose is to determine prior to a production decision that the detail design of the CI under review satisfies all specified survivability/hardness requirements.

3.7 Demonstration and Validation Phase. The second phase of the system acquisition life-cycle. During this phase, selected candidate solutions to the identified operational need derived from the conceptual phase are validated and refined through extensive evaluations, including trade studies and analyses, hardware development, and prototype testing. The objective is to validate one or more of the selected solutions, and thereby provide a basis for deciding whether to proceed into the engineering and manufacturing development (EMD) phase of the program.

3.8 Engineering and Manufacturing Development Phase. The third phase of the system acquisition life-cycle. During this phase, the system, including all support items, is designed, fabricated, tested, and evaluated. The intended output is, as a minimum, a) a

preproduction system that closely approximates the final product; b) the documentation needed to enter the production and deployment phase; and c) the test results that show the product will meet its requirements.

3.9 **Hardening.** The use of design techniques that increase the ability of a system or any of its constituent elements to withstand exposure to one or more effects of natural or hostile environments.

3.10 **Hardness.** A measure of the ability of a system or any of its constituent elements to withstand exposure to one or more effects of natural or hostile environments.

3.11 **Hardness Assessment.** A program of iterative and interactive hardness analyses and tests performed to evaluate the hardness of a design in support of establishing that the design satisfies (or is compliant with) all survivability hardness requirements either specified or allocated to it. The concept of hardness assessment applies both to developmental and nondevelopmental hardware.

3.12 **Hardness Assurance.** A program element of life-cycle survivability. It refers to those activities performed to preserve system hardness during the production and deployment phase of the program so that hardware produced and initially deployed will continue to satisfy the survivability hardness requirements originally allocated on the system design.

3.13 **Hardness Assurance Lot Acceptance Testing.** Acceptance testing for environment effects (natural and/or nuclear effects) of statistically based samples of hardware items selected from production, delivery or other types of lots of such items procured in support of system production. The intent of this testing is to demonstrate statistically that the hardware items in the lot under evaluation are at least as "hard", with respect to environmental effects of concern, as the sample qualified prior to production, and that the item manufacturing process has not changed to the detriment of the end product.

3.14 **Hardness Design.** The process and end result of creating a design which satisfies specified or allocated hardness requirements. Hardness designs must be accomplished without violating any other specified design requirements or constraints.

3.15 **Hardness Design Margin.** A numerical measure of the extent to which the hardness element exceeds the requirements imposed on it.

3.16 **Hardness Maintenance.** A program element of life-cycle survivability. It refers to those activities conducted by the supporting command to maintain and preserve the hardness of a deployed system throughout operational life. The SPO's role in hardness maintenance is to prepare a hardness capability for transfer to the supporting command.

3.17 **Hardness Surveillance.** A program element of life-cycle survivability. It consists of a program of periodic hardness tests and inspections of a deployed system with the purpose of identifying, in a timely manner, any hardness related degradations that reduce the hardness of the fielded system.

3.18 **Hardness Verification.** The activity by which the contractor establishes to the satisfaction of the implementing command that the final system (or any system components)

design(s), as presented at the CDR, satisfies the applicable survivability hardness requirements. Hardness verification is accomplished by a review of existing hardness analysis and test data, and, as appropriate, the engineering drawing for the hardware element under evaluation.

3.19 **Operations and Support Phase.** The final phase of the system acquisition life-cycle. During this phase, the system that was designed and produced, in response to an identified operational need, is maintained on full operational status until it is determined that the need no longer exists, and the system is deactivated and removed from the field. The key survivability hardness tasks during this phase are implementation of hardness maintenance and hardness surveillance.

3.20 **Preliminary Design Review (PDR).** One of the three design reviews for CIs mandated by MIL-STD-1521B. It is a formal technical EMD phase review of the design approaches for CIs that are held prior to the start of detailed design. Among its purposes are a) to evaluate the progress, technical adequacy, and associated risks of the selected design approach, and b) to determine the compatibility of the design approach with performance and specialty engineering, such as the specified survivability hardness requirements. Among items presented for review are trade study results.

3.21 **Prime Item Development Specification (PIDS).** One of the MIL-STD-490A categories of specification documents. It establishes the performance, design, development, and test requirements for those complex elements of a system that the responsible implementing command decides will be procured as separated CIs.

3.22 **Production and Deployment Phase.** The fourth phase of the system acquisition life-cycle. During this phase, the system, as well as support equipment, is produced for operational use. It extends from production approval until the last system is delivered and accepted.

3.23 **Survivability.** The capability of a system to operate without degraded performance if exposed to natural and/or hostile environments.

3.24 **Survivability Program.** The systematic plan or system and associated sequence of operations by which a survivability engineering organization intends to ensure that a system design is survivable.

3.25 **Survivability Program Plan (SPP).** The documented survivability engineering management and technical approaches essential for the cost-effective development of a survivable system. The SPP is the quantifier, via specific management and technical tasks (defined in the Work Breakdown Structure), of the programmatic requirements delineated in this standard. SPP tasks are developed consistent with the system acquisition life-cycle activities and milestones.

3.26 **Systems Engineering.** A comprehensive, system life-cycle iterative technical management process to: 1) translate operational need into a configured system by a systematic, concurrent approach to integrated design of the system and its related manufacturing, test, and support processes; 2) integrate the technical inputs of the entire development community and all technical disciplines into a coordinated effort that meets established program cost, schedule, and performance objectives; 3) ensure the compatibility of all functional and physical interfaces, and ensure that system definition and design reflect the requirements for all system elements; and 4)

characterize technical risks, develop risk abatement approaches, and reduce technical risk through early test and demonstration of system elements.

3.27 **System Engineering Management Plan (SEMP).** The SEMP documents the management of the systems engineering process, integration of the required specialties, performance measures development and reporting (including intermediate performance criteria), and key engineering milestones and schedules.

3.28 **System Requirements Analysis (SRA).** A structured approach for developing, integrating, optimizing, and verifying system requirements.

3.29 **System Design Review (SDR).** One of the three design reviews for CIs mandated by MIL-STD-1521B. It is conducted when the system definition effort has proceeded to the point where system characteristics are defined and the CIs are identified. Its purpose is to evaluate the optimization, correlation, completeness, and risks associated with the allocated technical requirements.

3.30 **System Life-Cycle.** The total set of program phases a system passes through from the time it is initially conceived and developed until the time it is deactivated and removed from operation use. The first five phases of the system life-cycle are referred to as the "acquisition life-cycle".

3.31 **System Program Office (SPO).** The organization consisting of technical, administrative, and management personnel assigned full time to a system program manager. In this standard, SPO and government are used interchangeability.

3.32 **Survivability Working Group (SWG).** A relatively small group of key SPO, contractor and subcontractor/supplier personnel, whose primary function is to identify and resolve system survivability engineering issues and problems. The SWG is a forum for Total Quality Management.

3.33 **Test and Evaluation Master Plan (TEMP).** A top-level document that is used to generate detailed test and evaluation plans and to ascertain schedule and resource implications associated with the test and evaluation program.

3.34 **Total Quality Management (TQM).** Developing and applying a "common sense" approach to obtain continuous improvement. In developing an effective TQM approach, managers must be able to accomplish organizational (or program) goals and objectives by developing trust, teamwork, and open communications. These qualities are as important as technical skills.

3.35 **Work Breakdown Structure (WBS).** The framework relating statement of work tasks, contract line items, configuration items, technical and management reports, and the hardware, software, and data elements of the system. A survivability engineering WBS is a required element of the Survivability Program Plan.

4. GENERAL REQUIREMENTS

Described in this section are general survivability engineering program management requirements, functions and controls. Specific program phase survivability management requirements are delineated in Section 5.

Contractor systems engineering and/or survivability organizations should comprehensively understand the policies and procedures of AFR 80-38 and DoDI 5000.2, Part 6, Section F. DoDI 5000.2, Part 6, Section F "Survivability" is reproduced in Appendix A. It is imperative that survivability engineering managers understand how the general policies and procedures of Appendix A apply to the survivability program.

4.1 Survivability Program Considerations. The prime contractor shall establish a Survivability Organization and Program. Typically, the Survivability Organization is an element of the systems engineering organization.

Contractor survivability engineering organization responsibilities and functions include: customer interfacing, establishment of subcontractor liaison activities, development of design guidelines, development of survivability system specification requirements, point-of-contact for survivability activities, review and assistance in survivability/hardening designs, performing trade studies, participating in formal design reviews, and conducting tests, analyses and inspections.

4.1.1 Survivability Program Plan. The contractor shall, during Phase 0, initiate the development of a Survivability Program Plan (SPP). The SPP shall address both space and ground segment elements of the system. The text (content, format, etc.) of the SPP shall be developed per tailored data item description, DI-ENVR-80262 (see Appendix B). The first formal submittal of the SPP shall be prior to the System Design Review (SDR) during the DEM/VAL phase, with updates before EMD phase Preliminary and Critical Design Reviews (PDR and CDR, respectively). Explicit application of this standard will be accomplished by the implementation of the SPP. The SPP shall describe in detail the survivability program management and technical approaches. As a minimum, the Plan shall address organizational structure, formal management/programmatic tasks, schedules and key milestones, functions and controls, lines of authority, contractor interfacing activities, the survivability engineering work breakdown structure (WBS), budgets and cost-analysis, technical tasks and approaches, and trade studies.

The SPP shall be consistent with, and part of, the contractor's System Engineering Management Plan (SEMP), which defines an integrated approach to engineering management of each system, subsystem, configuration item (CI), and component for which the contractor has responsibility for design, development, production, and, generally, ensuring compliance with specification requirements.

A comprehensive approach to systems engineering, and structure for a SEMP, are described in reference MIL-STD-499B.

4.1.2 Survivability Working Group. Early in the DEM/VAL phase, the contractor shall establish a survivability working group (SWG) with representation from the government (SPO), contractor's organization and other subcontractor/supplier organizations.

A primary purpose of the SWG is to provide a Total Quality Management (TQM) forum for survivability engineering. Programs can establish a survivability control board (SCB) and/or a SWG, but realistic consideration of program costs does not justify the establishment of both organizations. Therefore, in the context of this standard, the term SWG will be used.

The charter and functions of the SWG shall be described in the Survivability Program Plan. Generally, the members of the SWG will work towards resolution of survivability technical and management issues and concerns. The SWG will address issues such as: optimal hardening designs/approaches, developmental and verification testing (procedures/plans, facilities, scheduling, etc.), requirement tailoring, system specification development, and numerous other systems engineering and management concerns.

The SWG interfaces with nearly all in-house prime contractor organizations, e.g., Parts, Materials, and Processes Control Board (PMPCB), configuration management (configuration control board), quality assurance, reliability and maintainability, and the EMC/TEMPEST organization. Additionally, designated personnel from subcontractor/supplier organizations will be members of the SWG. System/program technical and management resolutions resulting from the SWG activity will support technical interchange meetings (TIMs) and program/system design reviews. Survivability engineering will support each of the aforementioned disciplines as well as be supported by them. Minutes and attendance shall be maintained.

4.1.3 Technical Interchange Meetings and Design Reviews. The contractor's survivability organization shall prepare material and participate in regularly scheduled formal TIMs, as well as impromptu TIMs, focusing on specific issues/problems. Additionally, the contractor's survivability organization shall prepare material and support all program design reviews in accordance with MIL-STD-1521B.

4.1.4 Subcontractor Management. The prime contractor shall establish management controls with all subcontractors, associate contractors and suppliers/venders. Various subcontractor survivability engineering interface functions and controls shall be defined in the SPP via tasking statements. Additionally, key subcontractors/suppliers (determined by the prime contractor) shall be required to participate in the Survivability Working Group function.

The prime contractor shall require the major subcontractors and/or associate contractors to establish survivability organizations and develop Survivability Program Plans. Subcontractor SPPs shall be consistent with, and based upon, the prime contractor's SPP. These Plans will be subcontractor data requirements (SDRLs) that are submitted to the prime contractor for review and approval.

5. DETAILED REQUIREMENTS

5.1 System Life-Cycle Survivability Requirements. The contractor shall implement the SPP tasks that are applicable to: 1) the program role performed by the contractor, 2) the particular system life-cycle phase(s) under contract (see Appendix A), and 3) the particular categories of equipments utilized, as applicable. Fundamental life-cycle survivability (LCS) program requirements, which are defined in this standard, shall be quantified and expanded by tasks delineated in the SPP.

5.1.1 Phase 0 - Concept Exploration and Definition

5.1.1.1 Contractor Responsibilities. During the concept exploration and definition phase, the contractor supports the SPO's activity of defining and selecting the system concept that warrants further development in response to the government's Mission Need Statement (MNS) and Operational Requirements Document (ORD).

During Phase 0 the contractor shall establish a survivability program and develop a draft Survivability Program Plan (SPP). The SPP shall comprehensively describe the survivability engineering management and technical approaches and be consistent with the Systems Engineering Management Plan (SEMP) described in MIL-STD-499B.

The SPP ground segment section (or part) shall include, in addition to Phases 0, I, II, and III requirements of this standard, an approach to survivability engineering hardness maintenance (HM) and hardness surveillance (HS) which shall be implemented in Phase IV.

5.1.1.1.1 DoD Instruction 5000.2. Policies and procedures of DoDI 5000.2, Part 6, Section F: Survivability and Attachment 1 (reproduced in Appendix A) applicable to this program phase shall be incorporated into the SPP. Milestone 0 of Attachment 1 specifically applies to Phase 0. System and acquisition unique top-level requirements and considerations (ORD, MNS, etc.), along with SPO coordination, are fundamental to this requirement.

5.1.1.1.2 Government-Contractor Interactions. The contractor shall establish a survivability engineering interface with the appropriate government (SPO) representatives. Interfacing/liaison activities shall include the tailoring and/or interpretation of this standard for all phases of the acquisition process, resolution of early survivability program management issues/concerns, subcontractor management and capabilities/resources, and determination of early survivability engineering trade studies.

5.1.1.1.2.1 Specification of Threat Environments. It is the SPO's responsibility to specify natural and/or hostile threat environments for the system based upon the MNS, ORD, System Threat Assessment Report (STAR) and any other top-level requirements, taking into consideration policies and procedures delineated in Appendix A, Attachment 1, items 1 and 2.

5.1.1.1.3 Survivability Program Plan Tasks. The subtasks under this section shall be initiated by the contractor in Phase 0 and coordinated with the government. Most of the tasks initiated in Phase 0 will continue into the DEM/VAL phase (Phase I) and, optimally, should be completed early in Phase II (EMD).

5.1.1.1.3.1 Threat Assessment/Environmental Effects Analysis. The contractor, working with the government, shall initiate (in Phase 0) a system threat assessment that specifically addresses the threat categories. This assessment should result in specific statements for or against the expected likelihood of threats (see Appendix A, Attachment 1, item 2a). Some results of the threat assessment will be documented in the STAR.

Once the top-level threat criteria are specified (SPO and contractor interfacing) for the space system, system threat interaction analyses for each of the natural and/or hostile threat environments and associated effects shall be performed. Results of these analyses will be used in the System Requirements Analysis (SRA) to derive survivability design, performance and verification requirements for all system components (pieceparts, boxes, surfaces, etc.).

5.1.1.1.3.2 Survivability Trade Studies. The contractor, in conjunction with the SPO, shall perform trade studies to evaluate the efficacy of various survivability enhancement options in order to select the types and complement that provides the best performance in prescribed threat environments and scenarios. An overview of these trades can be found in Appendix C.

The trade studies shall take into consideration the government's MNS, operational concepts and the ORD, top-level mission requirements, and Appendix A policies and procedures. Results of the trade studies will be used in the survivability engineering SRA (see Appendix D, Figure D1).

5.1.1.1.3.3 System Requirements Analysis and Allocations. The contractor shall perform system requirements analysis (see MIL-STD-499B) and develop a methodology for allocating system survivability specification requirements. A discussion of the general aspects of the survivability requirements allocation process indicating the role of SRA can be found in Appendix D.

Formal, survivability requirements for system specifications are derived by performing an SRA. Various types of SPP analyses and tests will be performed in support of the SRA. Fundamental to the SRA are the results of trade studies and threat-system interaction analyses.

Allocated survivability requirements are formally documented in the system/segment specifications (Type A spec), development specifications (Type B specs), product specifications (Type C specs), process specifications (Type D specs), and material specifications (Type E specs). Development of specifications shall be in accordance with MIL-STD-490A.

5.1.1.1.3.4 Hardness Assurance. Ideally, planning for production and deployment phase (Phase III) Hardness Assurance (HA) shall be initiated in Phase 0. However, this SPP task may be out-of-scope for Phase 0, depending upon top-level SPO acquisition priorities.

Identifying HA under Phase 0 management tasks, emphasizes that an efficient and effective Phase III HA activity should optimally be planned from the outset of the program acquisition cycle.

5.1.2 Phase I - Demonstration and Validation

5.1.2.1 Contractor Responsibilities. Generally, during the DEM/VAL phase, the contractor will strive to complete survivability engineering SPP tasks initiated in Phase 0.

It is essential that survivability specification requirements (design, performance and verification) be maturely developed and documented (specifications) upon completion of the DEM/VAL phase. Finalization of survivability specification requirements will be complete prior to the system critical design review (CDR), an EMD phase milestone. Additionally, during DEM/VAL, hardness assurance (HA) shall be systematically addressed by all contractors.

5.1.2.1.1 DoD Instruction 5000.2. Policies and procedures of DoDI 5000.2, Part 6, Section F: Survivability and Attachment 1 (reproduced in Appendix A) applicable to this program phase shall be incorporated into the SPP. Milestone I of Attachment 1 specifically applies to Phase I. System and acquisition unique top-level requirements and considerations (ORD, MNS, etc.), along with SPO coordination, are fundamental to this requirement.

5.1.2.1.2 Survivability Program Plan Tasks. Identified in the following subparagraphs are primary SPP tasks that the contractor shall perform. Additional supporting and/or secondary SPP tasks will also have to be performed and described in the Work Breakdown Structure (WBS), which is an element of the SPP.

5.1.2.1.2.1 Survivability Working Group. The contractor shall establish a Survivability Working Group (SWG). The charter and functions of the working shall be described in the SPP (see Section 4.1.2).

5.1.2.1.2.2 Survivability Trade Studies. During the DEM/VAL phase, the contractor shall complete all survivability trade studies initiated in Phase 0 and perform additional trade studies, if necessary. Specific methodologies and objectives of the trade studies will be described in the SPP. (See Appendix C.)

Additionally, for the ground segment, special trade studies for commercial-off-the-shelf (COTS) equipment shall be conducted and coordinated with the SPO. Survivability/hardening engineering approaches resulting from these trade studies shall be documented in the SPP, and quantified in the HM/HS Plan.

5.1.2.1.2.3 System Requirements Analysis and Allocations. The SRA task (see Appendix D and Figure D1) initiated in Phase 0 shall be refined and completed by the end of the DEM/VAL phase. Once a comprehensive survivability SRA has been completed, survivability specification requirements can be allocated. Finalization of survivability specification requirements should be completed prior to the system critical design review (CDR) which is an EMD phase milestone.

5.1.2.1.2.4 Survivability Design Guidelines. The contractor shall develop and document system specific survivability design guidelines. Development of survivability design guidelines will facilitate the implementation of hardening techniques and/or designs. Implementation and interpretation of survivability design guidelines techniques shall be the responsibility of the contractor's survivability organization.

5.1.2.1.2.5 Survivability Test Planning. The contractor shall prepare and maintain a comprehensive survivability engineering test plan. Development of the survivability test plan shall be consistent with the system Test and Evaluation Master Plan (TEMP).

The plan is a tool for evaluation of overall test program completeness, evaluation of individual test objectives and methodologies, elimination of unnecessary redundancy, efficient scheduling of test

facilities and other resources, and integration with other program activities. Additionally, the plan provides traceability from test requirements in system specifications to individual tests, test plans/procedures, and test reports.

5.1.2.1.2.5.1 Development Tests. In addition to test planning, during this phase it will be necessary to perform developmental and characterization tests. The purpose of these tests is to resolve uncertainties in survivability analyses in order to assist design choices.

The contractor shall conduct development or characterization tests. This task includes conducting simulated environmental effects (nuclear, non-nuclear, etc.) tests on circuits, subassemblies, and components, as necessary, to resolve analytical uncertainties. Types of tests, techniques, procedures and scheduling should be determined by the SWG.

5.1.2.1.2.5.2 Pieceparts/Materials Characterization Tests. The contractor shall conduct pieceparts/materials characterization test that expose pieceparts/materials to simulated environmental effects (transient ionizing radiation, neutrons, total ionizing dose, etc.). The responses of pieceparts/materials exposed to threat environments must be known in order to properly select parts and materials for the design and to perform the analyses necessary to qualify designs for survivability. Results of these tests will be integrated into the program-approved Parts and Materials Lists and used by design engineers for parts/materials selections (see Appendix A and references, MIL-STD-1546A and 1547B).

The SWG, working together with other systems engineering organizations (especially, the Parts, Materials, and Processes Control Board), should determine the test techniques, procedures and scheduling. These results shall be documented in the HAP. In order to reduce costs, contractors and subcontractors/suppliers shall optimally use SWG and/or PMPCP approved parts/materials data banks.

5.1.2.1.2.6 Hardness Assurance. The contractor shall develop a hardness assurance plan (HAP) that addresses HA for all program contractors and suppliers/venders. The HAP is a subtask and subplan described in the SPP.

HA as used in the context of this standard relates to the survivability management and technical tasks described in the HAP that must be performed to ensure survivability hardening designs are cost-effectively implemented during Phase III. During DEM/VAL, hardness design margin (HDM) requirements for pieceparts shall be established which minimize expensive lot sample tests and severe production line screens/controls.

5.1.2.1.2.7 Hardness Maintenance/Hardness Surveillance If the government requires ground segment elements to survive in natural and/or hostile threat environments, the SPP shall address ground segment life-cycle survivability. This will require the development of a HM/HS Plan, which will be implemented in Phase IV. Therefore, the contractor shall develop an HM/HS Plan that is based upon the HAP.

5.1.2.1.3 Deliverable Survivability Data

5.1.2.1.3.1 Survivability Program Plan. The contractor shall develop a deliverable Survivability Program Plan (consistent with the SEMP) in accordance with DI-ENVR-80262 (Nuclear Hardness and Survivability Program Plan). This DID shall be tailored based upon unique

program and system considerations and requirements. Since development of the SPP is fundamental and critical to the application of this standard, a typical SPP outline with narratives, applicable to a space system, can be found in Appendix B. The initial delivery of the SPP shall be prior to the system design review (SDR), with updates during Phase II, prior to PDR and CDR (final version due).

5.1.3 Phase II - Engineering and Manufacturing Development

5.1.3.1 Contractor Responsibilities. During this phase of the program, between the preliminary design review (PDR) and CDR (EMD phase milestones), survivability trade studies, SRA, HA planning, and specification requirements shall be completed.

5.1.3.1.1 DoD Instruction 5000.2. Policies and procedures of DoDI 5000.2, Part 6, Section F: Survivability and Attachment 1 (reproduced in Appendix A) applicable to this program phase shall be incorporated into the SPP. Milestone II of Attachment 1 specifically applies to Phase II. System and acquisition unique top-level requirements and considerations (ORD, MNS, etc.), along with SPO coordination, are fundamental to this requirement.

5.1.3.1.2 Survivability Program Plan Tasks. Generally, depending upon the nature of the task, survivability program tasks initiated in earlier program phases shall be completed prior to Phase II PDR and CDR milestones.

5.1.3.1.2.1 Survivability Trade Studies. All survivability trade studies shall be completed prior to PDR (or CDR in some cases) and results formally presented at PDR.

5.1.3.1.2.2 Survivability Specification Requirements. The contractor shall finalize all survivability specification requirements (developed in accordance with MIL-STD-490A) before the end of the EMD phase. Optimally, these survivability specification requirements should be completed prior to CDR, but, practically, that goal may not be realized.

5.1.3.1.2.3 Hardness Assurance. During this phase, HA planning related to inspections, procedures, tests, and other controls (documented in the HAP), shall be finalized prior to CDR. Implementation of the HAP will take place in Phase III (Production and Deployment phase).

Additionally, for the ground segment, special trade studies for commercial-off-the-shelf (COTS) equipment shall be conducted and coordinated with the SPO. Survivability/hardening approaches resulting from these trade studies shall be documented in the SPP, and quantified in the HAP.

5.1.3.1.2.4 Hardness Maintenance/Hardness Surveillance During this phase, HA planning related to inspections, procedures, tests, and other controls (documented in the HAP) shall be used to develop an HM/HS Plan. The HM/HS Plan shall be finalized prior to CDR and implemented in Phase IV. (Operations and Support phase).

5.1.3.1.3 Survivability Specifications. The contractor shall complete specification of all system survivability design, performance and verification requirements. Documentation of survivability requirements shall be in accordance with MIL-STD-490A.

5.1.3.1.4 Deliverable Survivability Data. During the EMD phase, survivability engineering contractor deliverable documentation, formally listed on the contract data requirements list (CDRL) and formatted per data item descriptions (DIDs), will be required by the government.

These DIDs will be a tailored subset of those specified in reference document, DOD-STD-1766A (Nuclear Hardness and Survivability Program Requirements For ICBM Weapon Systems).

It will be necessary to tailor these DIDs for a space system but requirements delineated in these DIDs generally apply to any system required to comply with survivability specification requirements. Delivery dates for survivability documentation will be prior to PDR and CDR program milestones depending upon the nature of the documentation. Specific dates will be determined by negotiations between the contractor and the government (SPO).

5.1.3.1.4.1 Survivability Program Plan. The contractor shall develop a deliverable Survivability Program Plan in accordance with data item description DI-ENVR-80262 (Nuclear Hardness and Survivability Program Plan). This DID shall be tailored based upon unique program and system considerations and requirements. Since development of the SPP is fundamental and critical to the application of this standard, a typical SPP outline with narrative, applicable to a space vehicle, can be found in Appendix B. Delivery of the SPP shall be prior to PDR.

5.1.3.1.4.2 Survivability Trade Study Report. The contractor shall develop a deliverable Survivability Trade Study Report in accordance with data item description DI-ENVR-80267 (Nuclear Hardness and Survivability Trade Study Report). This DID shall be tailored based upon unique program and system considerations and requirements. This report will formally document all trade studies initiated in previous program phases. Delivery of the Trade Study report shall be prior to PDR.

5.1.3.1.4.3 Survivability Test Reports. The contractor shall develop a deliverable Survivability Test Report in accordance with data item description DI-T-3718 (Test Reports - General).

This DID shall be tailored based upon unique program and system considerations and requirements. This report will formally document all survivability tests initiated in previous program phases and EMD phase survivability qualification tests. Delivery of the Test Report shall be prior to PDR.

5.1.3.1.4.4 Hardness Assurance Plan. The contractor shall develop a deliverable Hardness Assurance Plan (HAP) in accordance with data item description DI-ENVR-80263 (Hardness Assurance Plan). This DID shall be tailored based upon unique program and system considerations and requirements. Delivery of the HAP shall be prior to CDR. Implementation of the HAP shall take place in Phase III.

5.1.3.1.4.5 Hardness Maintenance/Hardness Surveillance Plan. The contractor shall develop a deliverable HM/HS Plan in accordance with data item descriptions DI-ENVR-80264 (Hardness Maintenance Plan) and DI-ENVR-80265 (Hardness Surveillance Plan). These DIDs shall be tailored to produce a combined HM/HS plan for the ground segment. Delivery of the HM/HS Plan shall be prior to CDR. Implementation of the HM/HS Plan for the ground segment shall take place in Phase IV.

5.1.4 Phase III - Production and Deployment

5.1.4.1 Contractor Responsibilities

5.1.4.1.1 DoD Instruction 5000.2. Policies and procedures of DoDI 5000.2, Part 6, Section F: Survivability and Attachment 1 (reproduced in Appendix A), applicable to this program phase, shall be incorporated into the SPP. Milestone III of Attachment 1 specifically applies to Phase III. System and acquisition unique top-level requirements and considerations (ORD, MNS, etc.), along with SPO coordination, are fundamental to this requirement.

5.1.4.1.2 Hardness Assurance Program. During this phase, the contractor shall implement a survivability hardness assurance program in accordance with the HAP. The objective of the hardness assurance program is to maintain all hardening design parameters within acceptable limits throughout hardware production and ensure that fabrication techniques are consistent with survivability hardening designs and/or mitigation techniques.

Major hardness assurance areas that should be addressed are management and organization, technical aspects of production, and special emphasis given to development of piecepart specifications, piecepart lot-acceptance testing, and procurement. The HAP shall require specific quality assurance procedures to ensure that characteristics of critical design features are not degraded during the manufacturing process.

5.1.5 Phase IV - Operations and Support

5.1.5.1 Contractor Responsibilities

5.1.5.1.1 DoD Instruction 5000.2. Policies and procedures of DoDI 5000.2, Part 6, Section F: Survivability and Attachment 1 (reproduced in Appendix A), applicable to this program phase, shall be incorporated into the SPP. Milestone IV of Attachment 1 specifically applies to Phase IV. System and acquisition unique top-level requirements and considerations (ORD, MNS, etc.), along with SPO coordination, are fundamental to this requirement.

5.1.5.1.2 Hardness Maintenance/Hardness Surveillance Program.
HM/HS procedures, inspections and tests, delineated in the HM/HS Plan, shall be initiated and implemented in Phase IV to ensure system survivability and/or hardening designs are not degraded through operational use, maintenance actions, or logistic support.

6. NOTES

The contents of this section are generally intended for guidance and information only. However, if the government requires deliverable survivability documentation, the contractor shall comply with the data requirements described in Section 6.2.

6.1 Intended Use. This standard is intended to facilitate the establishment of an effective and efficient systems engineering survivability program. That goal will be realized if a systematic approach for survivability specification requirements is developed, documented, and implemented. Development of that approach results in the Survivability Program Plan, which balances the management and technical aspects of survivability engineering. Since this standard only addresses the management aspects of the contractor's survivability program, specific survivability specification requirements are only generally referred to.

Application of this standard is primarily the responsibility of the prime contractor. However, other system contractors are encouraged to use this standard as a survivability engineering management guidelines document. Additionally, representative Survivability Program Plan section and subsection narratives, delineated in Appendix B, are informative supplements to this standard.

Contractor as used in this standard implies either the prime contractor, associate contractor(s), subcontractors or suppliers/venders. This standard should be implemented in a manner that is consistent with AFR 80-38, AFR 57-1, and DoDI 5000.2, Section 6, Part F - Survivability (including Attachment 1).

6.2 Data Requirements. The data required by this standard shall be prepared in accordance with the following data item descriptions (DIDs):

- DI-ENVR-80262 (Nuclear Hardness and Survivability Program Plan),
- DI-ENVR-80267 (Nuclear Hardness and Survivability Trade Study Report),
- DI-T-3718 (Test Reports - General), and
- DI-ENVR-80263 (Hardness Assurance Plan).
- DI-ENVR-80264 (Hardness Maintenance Plan)
- DI-ENVR-80265 (Hardness Surveillance Plan)

These DIDs shall be tailored based upon unique program and system considerations.

6.3 Guidance Documents. All the reference documents should be considered as a source of supporting and guidance information. The prime contractor and subcontractors or suppliers are encouraged to obtain these documents.

6.4 Acronyms

AFR	Air Force Regulation
BMO	Ballistic Missile Office
CDR	Critical Design Review
CDRL	Contractor Data Requirements List
CE/D	Concept Exploration and Definition
CI	Configuration Item
COTS	Commercial-Off-The-Shelf
DEM/VAL	Demonstration and Validation
DI	Data Item
DID	Data Item Description
DoD	Department of Defense
DoDD	Department of Defense Directive
DoDI	Department of Defense Instruction
ECCM	Electronic Counter-Countermeasures
ECM	Electronic Countermeasures
EMD	Engineering and Manufacturing Development
EMP	Electromagnetic Pulse
HA	Hardness Assurance
HAMS	Hardness Assurance, Maintenance and Surveillance
HAP	Hardness Assurance Plan
HDM	Hardness Design Margin
HEMP	High-Altitude EMP
HM	Hardness Maintenance
HS	Hardness Surveillance
ICBM	Intercontinental Ballistic Missile
ILSP	Integrated Logistics Support Plan
LCS	Life-Cycle Survivability
MIL	Military
MNS	Mission Need Statement
NBC	Nuclear, Biological and Chemical
ORD	Operational Requirements Document
PDR	Preliminary Design Review
PMPCB	Parts, Materials, and Processes Control Board
SCB	Survivability Control Board
SDRL	Subcontractor Data Requirements List
SE	Systems Engineering
SEMP	System Engineering Management Plan
SPO	Systems Program Office
SPP	Survivability Program Plan
SRA	System Requirements Analysis
SRR	System Requirements Review
SSD	Space Systems Division
STAR	System Threat Assessment Report
STD	Standard
SWG	Survivability Working Group

TEMP	Test and Evaluation Master Plan
TQM	Total Quality Management
WBS	Work Breakdown Structure

APPENDIX A

DOD INSTRUCTION 5000.2
PART 6
SECTION F - SURVIVABILITY

PART 6

SECTION F

SURVIVABILITY

References:
(a) DoD Directive 4245.4, "Acquisition of Nuclear Survivable Systems," July 25, 1988 (canceled)
(b) DoD Instruction 4245.13, "Design and Acquisition of Nuclear, Biological, and Chemical (NBC) Contamination-Survivable Systems," June 15, 1987 (canceled)
(c) DoD Directive 4600.3, "Electronic Counter-Countermeasures (ECCM) Policy," March 12, 1990 (canceled)
(d) QSTAG-244, "Nuclear Survivability Criteria for Military Equipment (U)"
(e) QSTAG-620, "Consistent Set of Nuclear Survivability Criteria for Communications-Electronics Equipment (U) "
(f) STANAG-4145, "Nuclear Survivability Criteria for Armed Forces Materials and Installations (AEP-4), "March 1984
(g) Title 10, United States Code, Section 2366, "Major Systems and Munitions Programs: Survivability Testing and Lethality Testing Required Before Full-Scale Production"
(h) DoD Directive 3150.3, "Survivability of Non-Strategic Nuclear Forces (NSNF)," February 27, 1986
(i) DoD Directive 5160.5, "Responsibilities for Research, Development, and Acquisition of Chemical Weapons and Chemical and Biological Defense,"May 1, 1985
(j) MIL-STD-1799, "Survivability, Aeronautical Systems (for Combat Effectiveness)"
(k) MIL-STD-2069, "Requirements for Aircraft Non-Nuclear Survivability"
(l) DoD-STD-2169, "Military Standard High-Altitude Electromagnetic Pulse (HEMP) Environment"
(m) MIL-HDBK-336, "Survivability, Aircraft, Non-Nuclear"

1. PURPOSE

a. This section replaces DoD Directive 4245.4, "Acquisition of Nuclear Survivable Systems"; DoD Instruction 4245.13, "Design and Acquisition of Nuclear, Biological, and Chemical (NBC) Contamination-Survivable Systems"; and DoD Directive 4600.3, "Electronic Counter-Countermeasures (ECCM) Policy" (references (a),(b), and (c)), which have been canceled.

b. These policies and procedures establish the basis for sustaining operational effectiveness and warfighting capability in peacetime and at all levels of conflict (from low-intensity to strategic nuclear) through acquisition of survivable systems, equipment, and support.

2. POLICIES

a. The survivability of all systems that must perform critical functions in a man-made hostile environment shall be an essential consideration during the acquisition life-cycle of all programs, to include developmental and nondevelopmental programs.

b. Survivability from all threats found in the various levels of conflict shall be considered. This includes conventional; electronic; initial nuclear weapon effects; nuclear, biological, and chemical contamination (NBCC); advanced threats such as high power microwave, kinetic energy weapons, and directed energy weapons; and terrorism or sabotage.

3. PROCEDURES

a. Critical Survivability Characteristics. The Operational Requirements Document (see Section 4-B) will identify objectives for survivability characteristics critical to the mission (see Section 4-C).

(1) These objectives will be:

(a) Expressed in terms of measurable, quantitative parameters,

(b) Relatively insensitive to minor changes in system operations and specific threats,

(c) Evaluated in terms of their significance to overall system or force survivability, and

(d) Amenable to validation by test and evaluation.

(2) The assumption made on system performance, operations, and architecture will form an explicit part of the survivability characteristics.

(3) Survivability criteria will be balanced among the different weapon effects, mission critical elements, and personnel capabilities and limitations.

(4) Critical survivability characteristics will be used to evolve survivability design criteria which will be included in appropriate configuration baselines (see Section 9-A).

b. Survivability Methods. Survivability will be achieved through a mix of threat effect tolerance, hardness, active defense, avoidance, proliferation, reconstitution, deception, and redundancy. All methods will be considered and fully assessed to determine the most cost-effective means prior to Milestone II, Development Approval.

(1) Hardware design for nuclear, biological, and chemical contamination will include hardness, decontaminability, and compatibility characteristics.

Hardness designs will permit effective use by people in full protective ensemble.

(2) Systems developed jointly with the NATO or Quadripartite nations will use QSTAG-244, "Nuclear Survivability Criteria for Military Equipment"; QSTAG-620, "Consistent Set of Nuclear Survivability Criteria for Communications-Electronics Equipment"; and STANAG-4145, "Nuclear Survivability Criteria for Armed Forces and Installations (AEP-4)" (references (d), (e), and (f)) to establish nuclear survivability criteria.

(3) Mission-critical electronic equipment in a conventional threat will, as a minimum, be survivable to high-altitude electromagnetic pulse.

(4) Mission-critical electronic equipment in a conventional threat environment will, as minimum, be survivable in an electronic countermeasures environment.

c. Test and Evaluation. As early as practicable, developers and test agencies will assess survivability and validate critical survivability characteristics at as high a system level as possible. During test and evaluation, the assumption on system performance used to derive the survivability characteristics will also be validated. The Test and Evaluation Master Plan (TEMP) will identify the means by which the survivability objectives are validated (see Part 8).

(1) Conventional weapons effects survivability and electronic counter-countermeasures will be validated and verified by analysis and test. All survivability design criteria affecting operational effectiveness in a conventional threat environment will be included.

NOTE: For covered major systems (see Part 8), realistic survivability testing must be completed and reported to Congress before proceeding beyond low-rate initial production. [10 U.S.C. 2366 (reference (g))]

(2) Initial nuclear weapons effects and advanced technology survivability will be validated in realistic system configurations with a cost-effective combination of underground nuclear testing and above ground simulation supported by analysis.

(3) Nuclear, biological, and chemical contamination survivability will be validated through a combination of realistic testing, modeling, simulation, and analysis.

d. Life-Cycle Survivability. Using, maintaining, and testing agencies will periodically reassess system survivability characteristics.

(1) These reassessments should occur at selected points in the system life-cycle, particularly:

(a) After changes in operational use or procedures;

(a) After changes in operational use or procedures;

(b) After retrofits, modifications, or system architecture changes; and

(c) In the event of changes in the mission or threats.

(2) If hardening is a survivability characteristic, the hardening design will consider the need to maintain the integrity of the design throughout the operational life of the system.

e. Hardened Systems. For systems hardened in order to meet a survivability requirement, hardness assurance, maintenance, and surveillance (HAMS) programs will be developed to identify and correct changes in manufacture, repair, or spare parts procurement, and maintenance or repair activities that may degrade system hardness during the system's life.

(1) Hardness assurance, maintenance, and surveillance programs will include:

(a) Hardness assurance plans for maintaining the integrity of the hardened design during production,

(b) Hardness maintenance plans for maintaining the hardened system, and

(c) Hardness surveillance plans for detecting degradations due to use, environmental exposure, or aging and for monitoring the effectiveness of maintenance.

(2) Nuclear, biological, and chemical contamination survivable systems must include maintenance and surveillance plans for compatibility and decontaminability as well as hardness.

f. Logistics Support. The Integrated Logistics Support Plan (ILSP) for systems with critical survivability characteristics will define a program to ensure those characteristics are not compromised during the system life-cycle through loss of configuration control; use of improper spare or repair parts; or hardness degradations due to normal operations, maintenance, and environments.

(1) The program will identify and document activities (including training), inspections, parts procedures, and configurations that are critical to maintaining survivability and hardening throughout the system's life.

(2) For nuclear, biological, and chemical contamination, the additional characteristics of decontaminability and compatibility must also be defined.

(3) When these provisions have been addressed in specific hardness maintenance or hardness surveillance plans, the Integrated Logistics Support Plan will reference these plans.

(4) Survivability characteristics requiring unique facility support (e.g., electromagnetic pulse test facilities, electronic warfare environment, climate controlled hangers) will also be addressed.

(5) The Integrated Logistics Support Plan will address the acquisition of battle damage repair procedures, supplies, tools, manuals, and training to ensure rapid return to battle of damaged systems. Battle damage repair plans will address hardness maintenance and surveillance.

g. Additional Guidance.

(1) Survivability of the system and the plans for the following phase will be addressed at each milestone decision point. A representative list of considerations to be addressed is at Attachment 1.

4. RESPONSIBILITIES AND POINTS OF CONTACT

NOTE: THIS PART OF DoDI 5000.2 WAS NOT REPRODUCED.

PART 6

SECTION F

ATTACHMENT 1:

SURVIVABILITY CONSIDERATIONS AT MILESTONE DECISION POINTS

This attachment contains a representative listing of typical issues to be considered and addressed at milesone decision points and during the acquisition phases leading up to these points.

1. Milestone 0: Concept Studies Approval

   The expected operational environment for each threat (i.e., conventional; electronic; initial nuclear weapons effects; advanced technology; nuclear, biological, and chemical contamination; and terrorism, or sabotage) should be highlighted and discussed in the Mission Need Statement.

2. Milestone I: Concept Demonstration Approval

   a. The system threat assessment should specifically address the threat categories, making specific statements for or against their expected likelihood.

   b. Initial survivability objectives should have been defined and validation criteria established. These objectives should be identified in the Operational Requirements Document. Key objectives should be included in the Concept Baseline.

   c. Critical survivability characteristics and issues that require test and evaluation should have been identified and included in the Test and Evaluation Master Plan.

   d. Critical survivability technology shortfalls should be identified and research requirements established.

   e. Preliminary facilities characteristics required to support unique survivability characteristics should have been identified-to be tracked through the Integrated Logistics Support Plan (ILSP).

3. Milestone II: Development Approval

   a. Critical survivability characteristics and issues that require test and evaluation should have been identified and included in the Test and Evaluation Master Plan.

   b. Key survivability objectives are included in the Development Baseline.

   c. The system specification and Integrated Logistics Support Plan should incorporate the survivability objectives.

d. If hardening is used as a method for achieving survivability, development of hardness assurance, maintenance, and surveillance programs should be included in the Integrated Logistics Support Plan.

e. Survivability issues are addressed in the Integrated Program Summary.

4. Milestone III: Production Approval

a. An assessment of how well the survivability objectives have been met has been completed and the results are included in the beyond low-rate initial production report.

b. All survivability issues should have been resolved.

c. Key survivability objectives are included in the Production Baseline.

d. If hardening is used as a method for achieving survivability, the hardness assurance program should have been developed and should be ready for implementation. For nuclear, biological, and chemical contamination, the assurance program also includes decontaminability and compatibility. Hardness maintenance and surveillance plans should have been completed with the exception of data from the hardness assurance program.

5. Milestone IV: Major Modification Approval

a. Survivability considerations have been included in major modification or upgrade packages. They should address the possibility of retrofitting survivability into the system.

b. If hardening is used to achieve survivability, the hardness assurance, maintenance, and surveillance programs have been developed or modified and are ready for implementation.

APPENDIX B

REPRESENTATIVE SURVIVABILITY PROGRAM PLAN OUTLINE AND NARRATIVES

SPACE SYSTEM
SURVIVABILITY PROGRAM PLAN
OUTLINE

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NARRATIVES OF KEY OUTLINE SECTIONS AND SUBSECTIONS

1. INTRODUCTION

Under 1.2 (Purpose), key elements of the Survivability Program Plan should be identified. These elements are: 1) survivability tasks, schedules, and key milestones; 2) the survivability engineering organizational structure, responsibilities, key personnel and program/system interfaces and relationships; and 3) survivability program deliverables (CDRLs). The other subsections (1.1 and 1.3) are self-explanatory.

2. SURVIVABILITY PROGRAM TASK SUMMARIES

Provided in this section/subsections are descriptions of tasks required to implement the survivability program plan. Descriptions should be organized into the major activity areas of the survivability program: planning; systems engineering; design; survivability analysis; survivability testing; and production support.

3.0 SURVIVABILITY PROGRAM SCHEDULES

Presented in this section is the overall survivability program schedule, which relates survivability activities to major system/program milestones. More detailed schedules based upon survivability program plan tasks will be required. These schedules should be correlated with the systems engineering master schedule (SEMS).

4. SURVIVABILITY PROGRAM ORGANIZATION & MANAGEMENT

A general discussion of the survivability program management organi- zation should be presented in this "introductory" section. The discussion should include: relationship and responsibilities with respect to program management (and/or systems engineering management), lines of authority and identification of key contractor management personnel.

4.1 Program Organization and Responsibilities. Described in this subsection are organizations and responsibilities of interest to the system survivability program. Typically, there are two organizational structures of interest.

The first is the formal program organization which defines lines of authority, assigns specific responsibilities, and through which instructions are sent regarding scope of work, requirements, schedules, budgets, and other programmatic matters.

The second is the informal network of individuals directly involved in implementing the system survivability program throughout all government and contractor organizations. The myriad tasks of planning, analyzing, testing, evaluating, and reporting are channelled through this informal network.

Responsibilities for the various elements of the system survivability program are discussed in the subsection and can described by three general categories:

1. The responsibilities of the prime contractor survivability engineering management and those of the subcontractors that directly support the prime at the system-level.

2. The responsibilities of the subcontractors/suppliers which provide system elements devoted exclusively to survivability engineering functions.

3. The responsibilities of other prime contractor organizational elements, which either perform specific system survivability tasks or have important interfaces between their primary functions and system survivability.

4.2 Program Control. Described in this subsection are the system survivability program management and technical controls. A typical prime contractor approach has the following key features:

- Involve the survivability organizations in all trade studies in which survivability requirements or concepts are variables.

- Establish ongoing working relationships between the survivability organizations and the design organizations, so that survivability organizations are aware of the current state of the design and are in a position to identify potential problems, and respond quickly and intelligently to requests for assistance from the design organizations. This control or function is facilitated by the Survivability Working Group forum.

- Put the survivability organization on distribution for all engineering specifications, drawings, and changes.

- Educate key managers in regards to the kinds of engineering information which should be reviewed by the survivability organizations prior to approval.

- Require survivability organization participation in all design reviews and audits.

- After the Critical Design Review (CDR), require survivability sign-off on all engineering changes.

- Empower the survivability organization with veto authority on the Parts, Materials, and Processes Control Board.

- Require design organizations to comply with design guidelines and standardized methodologies/procedures for parts derating and design analysis.

- Require design organizations to comply with design guidelines and standardized methodologies/procedures for parts and materials characterization tests and design verification or qualification tests with survivability requirements.

One way the prime contractor can assure effective control over sub-contractors is by implementing a single-point-of-contact system. Each subcontractor has a cognizant project engineer within the prime's program organization who is responsible for all technical direction to that subcontractor.

This approach avoids conflicting direction to a subcontractor from different program elements within the prime's organization, and assures that technical direction to a subcontractor is fully coordinated within prime's organization prior to authorization or release.

It is essential that the precepts necessary for implementation of the survivability program be included in each subcontractor's Statement of Work (SOW) at the outset, and it is the responsibility of the prime contractor's survivability organization to assure that happens. Once the requirements are embedded in the SOW and the necessary resources negotiated to do the work, the prime's survivability organization's role is to assure that the requirements are complied with (satisfied).

4.3 Program Interfaces. Described in this subsection are the coordination and cooperation roles required among many of the functional groups participating in the program. The specific organizational interfaces associated with survivability engineering will vary from one contractor to another, depending upon each contractor's organizational structure, and whether a separate survivability organization exists. However, the nature of the interfaces required among personnel doing specific tasks are, generally, the same for any program. Discussed in this subsection are the important relationships among the various functions.

5. REQUIREMENTS AND METHODOLOGIES

Described in this section are the system survivability requirements and the methodologies and processes which will be utilized for deriving and allocating these requirements. Generally, the process by which system requirements are derived is referred to as system requirements analysis (SRA). For a particular engineering discipline, the analysis techniques, trade studies, etc., may be unique, but the SRA process is essentially the same. Explained in this section are the analyses, tests and methodologies used in for survivability engineering SRA.

5.1 Threats and Environments. Subsection 5.1 should provide an informative summary of the rationale and trades that led to the specification of the threats and environments the system is required to survive in.

Since threat and environment criteria are usually classified, it is not explicitly documented in the Survivability Program Plan. However, general characteristics of the environments/threats and the associated system interactions and/or effects should be discussed for each threat/environment. This is important, since threat and/or environmental criteria is the starting point for survivability engineering SRA.

Typically, the process for specifying the threats and environments for a system is initiated in the Concept Exploration and Definition phase (Phase 0) of the program and may extend in to the DEM/VAL phase (Phase I). Specification of the system threat and environment criteria is a joint SPO-contractor effort, since it is strongly dependent upon the government's top-level system requirements (MNS and ORD) and other high-level governmental considerations.

5.2 System Trades and Survivability and Allocations. Summarized in this subsection are key system trade studies and requirements allocation methodologies for the space and ground segments. These trade studies, in conjunction with, survivability or hardness analyses and developmental tests are elements of the survivability SRA. The primary product of the SRA is

survivability system specification requirements, which will be allocated to all tiers of the system, such as configuration items (CIs).

5.3 Design Engineering

Described in this subsection is the process by which survivability design features are incorporated into the system design. Typically, incorporation is accomplished through five major vehicles:

- Development Specifications: These are written for configuration items (CIs) and define performance requirements for CIs which have a specific survivability function.

- Process Specifications: These are written for survivability fabrication processes to assure that parameters which affect survivability characteristics are properly controlled.

- Candidate Parts and Materials List: This list will be screened to eliminate parts and materials which are especially susceptible to the hostile environments and associated effects, and to identify and recommend parts and materials which have superior tolerances to environments/effects. Each item on the list requires characterization data which are obtained from available databases and, when data are not available, defines the need for characterization tests.

- Semiconductor Parts Derating Factors: These factors are derived from characterization data using a consistent set of rules employed throughout the program.

- Design Guidelines: These are developed to provide the designer with a set of rules and information so the designer can select the appropriate hardening methodology in order to achieve a balance and minimize the design impacts involved (cost, weight, size, etc.).

Note: Survivability design guidelines for designers have to be interpreted by survivability engineers.

5.4 Survivability Assessment. Discussed in this subsection is the systematic evaluation of the entire system design, utilizing all survivability-related testing and analysis performed during the conduct of the program. The essential feature of the survivability assessment is that every possible performance requirement and response mode of the threat-stressed system must be identified, quantified and shown to be acceptable within the context of requirements established by controlling documents.

5.5 Survivability Analysis. Described in this subsection are the analyses to be performed during the system development. The analyses (e.g., shielding analysis) will either bound a stress produced by a natural or hostile environment, quantify a response produced by an environment (e.g., worst-case circuit analysis), or evaluate a performance requirement (e.g., a requirement of the active countermeasures). The analyses divide naturally into those related to active countermeasures and those related to passive hardening.

5.6 Survivability Testing. Described in this subsection are the tests required to implement the survivability program. The test program, generally, divides into major groups, as follows:

- Parts and Materials Characterization Tests: These tests are performed on candidate pieceparts and materials to quantify their radiation responses and performance parameters.

- Engineering Development Tests: These tests are performed on engineering models of system hardware to reduce uncertainties and provide engineering data for the survivability design process.

- Design Verification/Qualification Tests: These tests are performed on qualification hardware to demonstrate that survivability has been achieved.

- Acceptance and Hardness Assurance Tests: There are two levels of testing to consider for this category of tests. The first is performed at the piecepart level and is designed to screen production lot purchases to determine suitability for fabrication of survivable hardware. The acceptance criteria are that the characteristics of the purchased lots be as good as or better than the characteristics used for design. The second level focuses on fabricated component production units to verify a particular hardness-related attribute (e.g., cable shielding effectiveness).

- Hardness Surveillance Tests (Ground Segment Only): These tests are performed on the ground segment operational hardware to detect degradation of equipment survivability over time.

5.7 Production and Deployment Phase. Described in this subsection are the survivability engineering hardness assurance plan (HAP) and hardness assurance program that must be developed prior to CDR and implemented during the production and deployment phase (Phase III) of the program. The hardness assurance program ensures that survivability hardening designs and/or mitigation techniques will not be degraded during production.

Major areas to be addressed by the HAP are management and organization , and the technical aspects of production, with major emphasis given to development of piecepart specifications, piecepart lot-acceptance tenting and procurement.

5.8 Operations and Support Phase (Ground Segment Only)

Described in this subsection are the hardness maintenance (HM) and hardness surveillance (HS) program which must be conducted on the survivable ground segment to ensure that elements of the ground segment remain survivable throughout the system life-cycle. The plan for the HM/HS program should be prepared during the EMD phase (Phase II) of the program. The HM/HS program should be implemented as the survivable ground segment is fielded and transitioned to operational status.

The HM/HS plan applies to all ground segment equipment, including equipment on operational status and equipment in depot for maintenance and repair. The plan is to identify:

1) Controls, procedures, facilities, and resources necessary for retention of equipment hardness during operational deployment;

2) Inspections, tests, and procedures required during the operational phase to ensure that the equipment is capable of meeting mission requirements.

Specific elements of the plan include:

- Manning and Resources Requirements
- Operation and Maintenance Personnel Training
- Technical Orders and Manuals
- HM/HS Procedures
- Logistics
- Configuration Control

6. REFERENCE MATERIAL

(To be supplied.)

APPENDIX C

SURVIVABILITY TRADE STUDIES

SURVIVABILITY TRADE STUDIES

1. SCOPE

Described herein are general aspects of fundamental survivability engineering trade studies which should be performed during the system acquisition life-cycle. These trades should be described in detail in the Survivability Program Plan and must be properly time-phased with the master program schedule and the systems engineering master schedule (SEMS).

2. SURVIVABILITY TRADE STUDIES OVERVIEW

The primary purpose of survivability trades is to determine the most cost-effective methods for achieving system survivability. Through the process of system trades, a multi-dimensional approach to system survivability can evolve, consisting of system architecture, active and passive design features, and operations protocols.

Design trades are an essential part of system design. Balances must be achieved among competing design objectives and constraints - highest possible mission performance (best available technology), lowest possible vulnerability to hostile threats, lowest possible cost, low electric power consumption, and satellite weight limited to launch capability. Threat scenarios become a part of this "balancing act" because they forecast enemy capabilities over the entire life-cycle of the system.

2.1 Space Segment Trade Studies. The top-level requirements considered in these trades are the Mission Need Statement (MNS), Operation Requirements Document (ORD) and threat/environmental criteria (based upon orbits, postulated hostile threat scenarios, etc.). There are two general approaches to achieving system survivability: 1) active countermeasures and 2) passive countermeasures.

Active countermeasures are used to achieve survivability against hostile enemy threats, such as, anti-satellite (ASAT) nuclear threats, high power lasers, and kinetic energy weapons, which are postulated in the pre-Concept phase of the program by mission planners.

Examples of active countermeasures are maneuvering, decoys, and shootback. This general approach can apply to a single satellite but generally applies to an entire constellation of space vehicles.

Active countermeasures are a feasible trade option versus passive countermeasures, if there is a reasonable possibility of a multi-dimensional threat. However, active countermeasures severely impact system performance and architecture requirements (constellation size, orbit configuration, etc.), and therefore, can drive system costs.

Passive countermeasures refers to hardening or mitigation methods that apply to system components (surfaces, electronic box enclosures, cables, circuits, and pieceparts). Passive countermeasures apply to both natural space environments/effects [Van Allen belt radiation, solar flares, single event upsets (SEUs), etc.] as well as hostile threats (nuclear weapon detonations and lasers). Passive hardening techniques include shielding against environments/effects, hardened

circuit designs and implementing hardened circuit pieceparts. For severe orbits (e.g., polar orbits), the total accumulated radiation dose (total dose) and other system effects (spacecraft charging, electron caused electromagnetic pulses, etc.), resulting from Van Allen belt radiation, are significant. Independent of the feasibly of hostile threat scenarios, passive hardening techniques must be implemented for all space vehicles.

Trades are made by weighing the advantages and disadvantages of shielding, circuit design and selection of customized hardened parts. With the increasing use of miniature electronic components/circuits (VLSI circuits, etc.), passive hardening against natural space environments is an essential survivability engineering activity, that must have significant management visibility to ensure the survivability of a space vehicle over its life-cycle.

For future space systems, survivability/hardening trade studies will probably involve trades related to passive countermeasures techniques. Active countermeasures SEOs can only be justified, if there is a likelihood of hostile threats, e.g., ASAT attacks (primary hostile threat that justified active countermeasures).

2.1.1 Space Segment Trade Study Example. A typical system trade would be to examine altitude versus constellation size versus electronic sensitivity to determine the most effective approach to achieving the desired coverage. From a survivability perspective, altitude would be examined in the context of what hostile threats can reach that altitude, what is the magnitude of the threat(s) and how long the system has to respond to the threats. Constellation size drives the requirements for the probability of survival (POS) requirements for each of the satellites. Sensitivity of the electronics would determine the type of noise processing algorithms which must be used and recovery time after attack.

The primary result of these trades will be an optimized application of both active and passive countermeasures. Not only will specific counter-measures be identified, but the characteristics associated with these countermeasures will be developed.

2.2 Survivable Ground Segment Trade Studies. The most important trade study for the survivable ground segment (SGS) will address the survivability/hardening approaches for commericial-off-the-shelf (COTS) equipments. New space system ground segment acquisition and modernizing programs are predominantly procuring COTS equipments for military applications. Generally, COTS equipments do not have any survivability/hardening unique design characteristics, therefore, trade studies have to be performed to ensure that these equipments are not susceptible to ground system threat environments. For most military acquisitions, the nuclear weapon generated high-altitude electromagnetic pulse (HEMP) environment will still apply to the SGS. However, total dose (resulting from nuclear fallout radiation) and prompt nuclear radiation requirements will probably not apply to upgraded and new systems. By properly designing facilities and mobile units of the SGS, COTS equipments can be totally shielded from HEMP induced effects.

Contractors and the government need to address the COTS issue in the DEM/VAL phase and EMD in the Production and Deployment phase. The approach for COTS equipment should be, part of, and documented in SGS HM/HS plan.

APPENDIX D

SURVIVABILITY REQUIREMENTS ALLOCATION PROCESS

SURVIVABILITY REQUIREMENTS ALLOCATION PROCESS

1. INTRODUCTION

System requirements analysis (SRA) is a fundamental systems engineering (SE) process and the survivability SRA is one element of the general SE SRA process. The primary products of the survivability SRA process arethe development and allocation of system survivability specification requirements (hardware and software). These requirements are delineated in the following types of specifications: system/segment (Type A), development (Type B), product (Type C), process (Type D), and material (Type E). General descriptions of these specification types are defined in MIL-STD-490A (Specification Practices).

The survivability SRA process(es) should be described in the survivability program plan (SPP), which is an integral part of the contractor's systems engineering management plan (SEMP). All survivability engineering SRA processes should be completed (optimally) prior to CDR in the EMD phase of the program.

2. SURVIVABILITY REQUIREMENTS ALLOCATION PROCESS

Depicted in Figure D1 is a representative prime contractor survivability requirements allocation process. Indicated on the figure are the SRA processes (SRA-1, SRA-2, SRA-3 and SRA-4) and resulting allocations of requirements delineated in Type A and B specifications.

Other specification requirements (C, D and E specifications) will result from additional SRA processes. These lower tier SRA processes and specifications are not indicated in the figure.

Inputs to the SRA processes include: trade study results, developmental test results, various analyses (e.g., threat analysis (STAR), threat-system interaction analyses, operational/mission analyses, hardening design analyses, etc.), and survivability working group (SWG) resolutions. It is important to understand that the SRA processes are inherently related to, and correlated with, the program phases of the acquisition life-cycle. Typically, SRA-1 takes place in the Concept Exploration and Definition (CE/D) phase, SRA-2 is a DEM/VAL process, and SRA-3&4 can be both DEM/VAL and EMD processes.

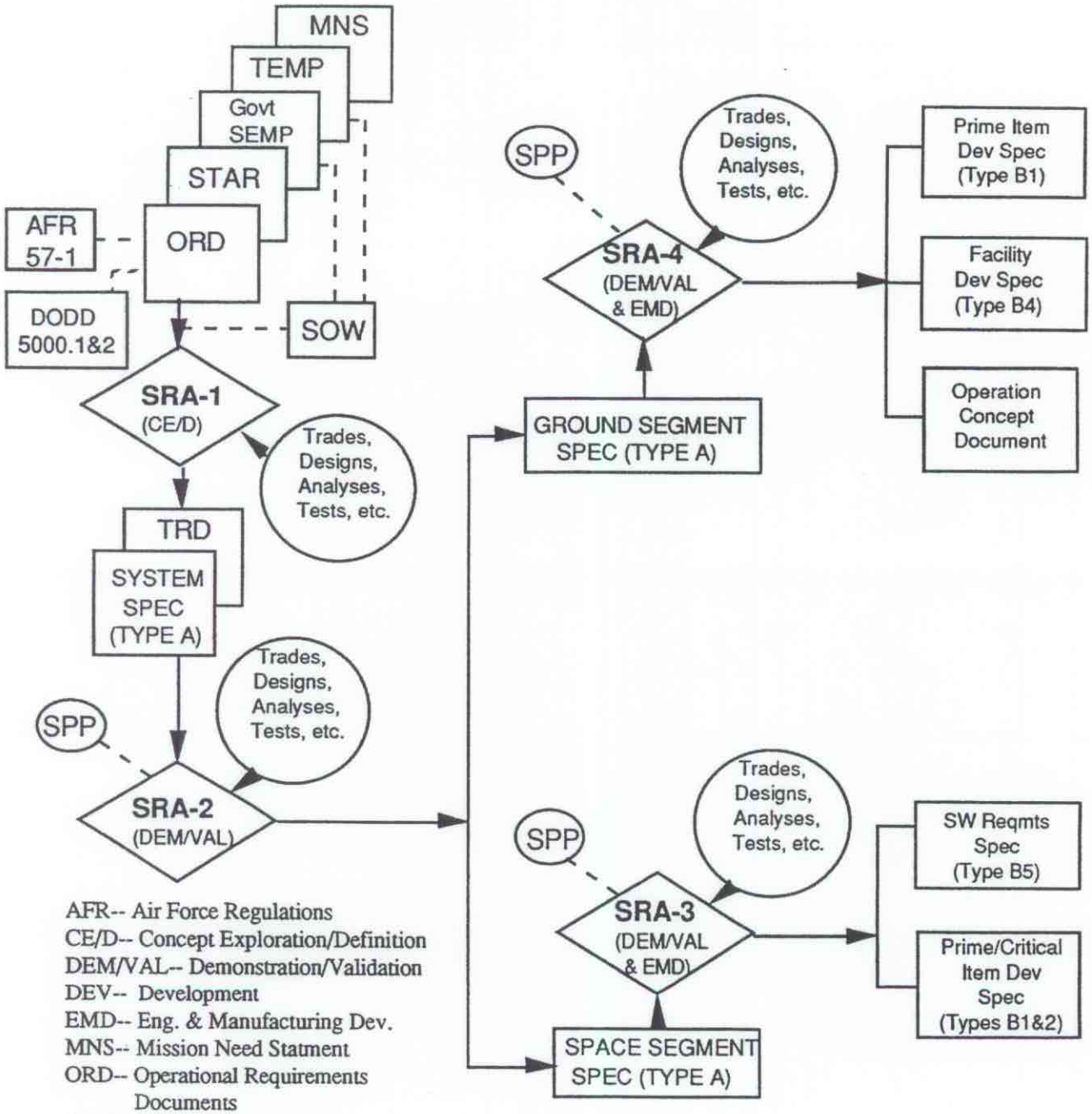
Each of the SRA processes indicated in Figure D1 are comprised of many subprocesses and supporting systems engineering activities. The SRAs are evolving processes (1 through 3&4), with SRA-3 and SRA-4 taking place at the same time during DEM/VAL and EMD (completion before CDR).

SRA-1 (general program process) is a CE/D phase activity, which may involve the government and contractors or just the government. This high-level program process includes: operational and/or mission analysis, top-level trade studies, refining of top-level customer requirements (MNS, ORD), SOW development, government SEMP and TEMP development, and (depending upon the nature of the acquisition) the development of a system-level (space and ground segments) A-specification or technical requirements document (TRD). The A-Spec/TRD specifies the functional baseline requirements at the system-level.

For survivability engineering, specification of system hostile and natural threat environments and development of the system threat assessment report (STAR) are the primary products of the SRA-1 process. These tasks could be initiated in a pre-CD/E phase.

Survivability tasks and/or activities that support the DEM/VAL SRA-2 include: trade studies, development tests, survivability program planning (i.e., the development of the SPP) and the establishment of a SWG.
During this phase the SE process for developing and allocating system survivability requirements should be developed and documented in the SPP. Primary products of the survivability SRA-2 process are survivability requirements specified in space and ground segment Type-A specifications (functional baselines for these segments).

SRA-3 and SRA-4 are comprised of the same types of engineering tasks as SRA-2 (trades, tests, designs, etc.). However, these processes and the SPP should be significantly "mature" by the end of DEM/VAL and they extend into EMD. The products are allocated hardware and software baseline requirements specified in Type B1-4 and B-5 specifications, respectively.



AFR-- Air Force Regulations
CE/D-- Concept Exploration/Definition
DEM/VAL-- Demonstration/Validation
DEV-- Development
EMD-- Eng. & Manufacturing Dev.
MNS-- Mission Need Statment
ORD-- Operational Requirements Documents
SEMP-- Systems Engineering Management Plan
SOW-- Statement of Work
SPEC-- Specification
SPP-- Survivability Program Plan
SRA-- System Requirements Analysis
STAR-- System Threat Assessment Report
TEMP-- Test & Evaluation Master Plan
TRD--Technical Requirements Document

FIGURE D1 - REPRESENTATIVE SURVIVABILITY REQUIREMENTS ALLOCATION PROCESS

SMC Standard Improvement Proposal

INSTRUCTIONS

1. Complete blocks 1 through 7. All blocks must be completed.
2. Send to the Preparing Activity specified in block 8.

NOTE: Do not be used to request copies of documents, or to request waivers, or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements. Comments submitted on this form do not constitute a commitment by the Preparing Activity to implement the suggestion; the Preparing Authority will coordinate a review of the comment and provide disposition to the comment submitter specified in Block 6.

SMC STANDARD CHANGE RECOMMENDATION:	**1. Document Number**	**2. Document Date**
3. Document Title		

4. Nature of Change
(Identify paragraph number; include proposed revision language and supporting data. Attach extra sheets as needed.)

5. Reason for Recommendation

6. Submitter Information

a. Name	**b. Organization**
c. Address	**d. Telephone**
e. E-mail address	**7. Date Submitted**

8. Preparing Activity

Space and Missile Systems Center
AIR FORCE SPACE COMMAND
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El Segundo, CA 91245
Attention: SMC/EAE