BY ORDER OF THE COMMANDER

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19 July 2010

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SMC-S-014 (2008)

Air Force Space Command

SPACE AND MISSILE SYSTEMS CENTER STANDARD

SURVIVABILITY PROGRAM MANAGEMENT FOR SPACE

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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 revised SMC standard comprises the text of The Aerospace Corporation report number TOR-2008(8583)-8164 Rev A, entitled *Survivability Program Management for Space* and contains the following major changes:

- covers all man-made threats (directed energy, RF, ASAT, NBC, etc.) and countermeasure options for the individual and combined threats in addition to the natural environments
- can be applied to space vehicles powered by nuclear reactors
- applies to ground fixed and mobile and/or transportable environments, including NBC
- includes the links between the ground segment and satellites and/or constellations within the environments

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:

Division Chief, SMC/EAE
SPACE AND MISSILE SYSTEMS CENTER
Air Force Space Command
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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 document defines fundamental survivability program management requirements for the system acquisition life-cycle. As a management standard, this document requires that the contractor shall:

a. Identify the hardness allocations to the building blocks that make up a survivability program for each design concept.

b. Describe how these basic elements are integrated into concurrent activities and disciplines within a contractor's overall hardware program.

c. Draft and establish a survivability program and set up the necessary infrastructure to sustain it and to effectively carry out the prescribed survivability tasks.

d. Identify the necessary order and sequence for timely execution of all tasks in a survivability program plan (SPP) including review of the vulnerability assessment.

The technical aspects of survivability, as well as methodology for implementation, shall be detailed in the contractor's survivability and vulnerability program plan (SVPP). Therefore, this document should facilitate the establishment of an efficient and effective survivability engineering program that is an integral part of a contractor's systems engineering organization.

1.2 Application

This document is applicable to space systems (i.e., composed of space, link, and ground support segments) that are required to operate within specified performance boundaries when exposed to natural environments and/or hostile threats. All probable hostile threats shall be investigated, including combinations of directed energy, laser, biological, and chemical attacks as a minimum.

1.3 Tailoring

The acquisition authority and the contractor shall work together to tailor this standard, to meet the system threat requirements for each particular program unique mission.

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2. Referenced Documents

2.1 Applicable Documents

The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issue in effect on the date of invitation for bids or requests for proposal shall apply.

AFR 80-38	The Air Force Systems Survivability Program
AFR 57-1	Air Force Mission Needs And Operational Requirements Process
SMC-S-009	Parts, Materials and Processes Control Program for Space and Launch Vehicles
MIL-STD-188-125	HEMP Ground Based C4I
MIL-STD-1546	Parts, Materials and Processes Engineering, Management and Control Program for Space and Launch Vehicles
MIL-HDBK 1766	Nuclear Hardware and Accountability Program guidelines Vol II Space Systems.
	Program Management Handbook on Nuclear Survivability DNA-H-93-52 Jul 1999
MIL-STD-1809	Natural Space Environment
NASA SP-8042	Micrometeoroid Environment
MIL-HDBK-814	Ionizing Radiation and Neutron Hardness Assurance
MIL-HDBK-815	Dose Rate Hardness Assurance
MIL-HDBK-816	Guidelines for Developing Specifications for Radiation Hardness Assured Devices
MIL-HDBK-817	System Development Radiation Hardness Assurance
	Henderson, L., Simpkins, L. Nameson, A., Campbell, A. Ritter, J., and E. Wolicki, “A Practical System Hardness Assurance Program.” *IEEE Transaction on Nuclear Science*, 40:6, Dec. 1993. p. 1725-34.

2.2 Order of Precedence

In the event of conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. Definitions

3.1 Definitions

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.

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

Electrical, Electronic, Electromechanical and Electro-optical (EEEE) Parts. The term "EEEE Parts" is used in a broad sense in this standard and includes electrical, electronic, electromechanical, and electro-optical parts. These parts are associated with electronic assemblies such as computers, communications equipment, control systems, electrical power, guidance, instruments, payloads, and sensors.

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.

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.

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 non-developmental hardware.

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.

Hardness Assurance Lot Acceptance Testing (HALAT). Acceptance testing for environment effects (natural and/or nuclear effects) of statistically-based samples of EEEE parts 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 EEEE parts in the lot under evaluation is 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.

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.

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

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.

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.

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.

Key Decision Point (KDP). The period preceding entrance to the next acquisition phase and where a determination is made by the DoD Milestone Decision Authority (MDA) as to the state of readiness of the program to enter the next phase.

Man-made Space Threats/Environments. The possible man-made threats include electro-optical (lasers) (ground, airborne and space based), radio frequency (radars – tracking and targeting, and communication link jammers), ground, airborne and space based endo (and) exo-atmospheric nuclear weapon detonation, direct ascent anti-satellite weapon (kinetic energy), and space-based kinetic energy interceptors.

Natural Space Environment. The natural environment includes atomic oxygen, neutral atmosphere, plasma, energetic charged particles, meteoroids, geomagnetic field, electromagnetic radiation, gravitational field, cosmic rays, and solar energetic particles. The geosynchronous environment and the ionosphere are treated in detail. The trapped radiation belts, drag due to the neutral density, atomic oxygen, and particle impacts are treated as well.

Prime Item Development Specification (PIDS). One of the 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.

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

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.

Survivability and Vulnerability Program Plan (SVPP). The SVPP documents survivability engineering management and technical approaches essential for the cost-effective development of a survivable system. The SPP is the quantifier, by use of 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.

Survivability Working Group (SWG). A multi-discipline group of key contractor personnel (it may also include SPO, and/or subcontractor and supplier personnel) whose primary function is to address hardness, survivability, and vulnerability matters in an interactive and concurrent fashion with other parties that are stake-holders to actions that are under consideration by the SWG. The engineering functions that are generally represented in the SWG are mechanical and electrical design, manufacturing, as well as reliability, quality, and parts engineering. Other disciplines may be represented as needed. Ordinarily, the lead survivability engineer for the system is appointed as chairman.

Susceptibility. A specific feature of the system that potentially weakens the system's ability to resist an attack designed to counter the system's mission effectiveness regardless of whether or not the threat currently exists to exploit the feature.

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.

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.

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

System Design Review (SDR). One of the three mandated design reviews for CIs. 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.

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."

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

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.

Threat. Any natural or man-made event or system with the ability to exploit a susceptibility of any part of the space system (including its supporting infrastructure) resulting in the potential denial, degradation, or destruction of the system or its ability to execute its primary function

Vulnerability. System vulnerability is a specific feature(s) of the system that could be exploited effectively by an adversary seeking to degrade or destroy the system's mission effectiveness. Vulnerability assessments should identify risks

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

General survivability program control and management tasks are described in this section, as well as organization, functions, interfaces, and allocation of responsibilities. The specific program phase survivability management requirements are delineated in Section 5. Table 1 in Section 4 provides an overall sequence of events and periods of execution.

4.1 Survivability and Vulnerability Program

The prime contractor shall have a survivability and vulnerability program that establishes a survivability engineering organization. The prime contractor shall define and implement a survivability program consisting of engineering disciplines intended for survivability of a system consisting of the ground, link, and space segments. Typically, survivability engineering is a discipline within the systems engineering organization.

The contractor's survivability engineering organization is responsible for preparation, implementation and maintenances of a survivability and vulnerability program which shall include definition, management and execution of all the survivability and vulnerability program tasks. These include: customer interfacing; establishment of subcontractor liaison activities; establishment of point-of-contact for survivability activities; development of survivability system specification requirements; flow down of survivability requirements to box level; sub-assembly level and piece-part level; development of design guidelines; development of test methodology; review and assistance in survivability/hardening designs; performing threat and trade/cost studies; participating in formal design reviews; and conducting survivability tests, analyses vulnerability assessments, and inspections.

4.1.1 Survivability and Vulnerability Program Plan

The contractor shall, during Phase A, initiate the development of a SVPP. The SVPP shall address both the survival aspects, as well as the operational aspects of all segments. When the system requires the ground segment to be hardened, the SVPP shall address both the space and ground segment elements of the system. An example of SVPP outline template is shown in Appendix A. The first formal submittal of the SVPP shall be during Phase A prior to system requirements review (SRR), with updates before preliminary design review (PDR), and critical design review (CDR) respectively. Explicit application of this document will be accomplished by the implementation of the SVPP. The SVPP 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), technical tasks, hardening approach for each applicable threat environment, method for hardness verification assurance for, validation of system vulnerability and survivability data bases, etc.

The SVPP shall be consistent with 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 test. The SVPP shall define the hardness processes and their methodology for implementation. Application of these hardness processes shall assure compliance with the system's survivability and vulnerability requirements.

4.1.2 Survivability Working Group

Early in Phase A, the contractor shall establish a survivability working group (SWG). A Chairman shall be appointed by the contractor and shall invite a government member as part of the SWG. Generally, the period of performance of the SWG covers the completion of Phase A, but it may extend into Phase B and into the PDR and CDR milestones.

A primary purpose of the SWG is to provide a forum for survivability engineering and monitoring. If programs already have an established survivability control board (SCB) then in the context of this document, the terms SWG and SCB shall be interchangeable.

The charter and functions of the SWG shall be described in the SVPP. 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: threat specifications, design tradeoffs/options, operational survivability measures, inherent shielding, optimal hardening designs and/or approaches, developmental and verification testing (procedures and/or plans, facilities, scheduling, etc.), requirement tailoring, system specification development, vulnerability assessment, and other systems engineering and management concerns.

The SWG interfaces with the appropriate in-house prime contractor organizations, e.g. parts, materials, and processes control board (PMPCB); configuration management (configuration control board); quality assurance; reliability; maintainability; and the EMC/EMI organization. On an “as needed” basis, designated personnel from subcontractor and/or supplier organizations will be members of the SWG. Minutes and attendance shall be generated and maintained. Survivability issue watch lists will be created, maintained, and reported to the government periodically, depending on phase and criticality to program execution.

4.1.3 Technical Interchange Meetings and Design Reviews

The contractor's survivability organization shall be integrated into all relevant aspects of design, development, procurement, fabrication, and test of the particular system. This may include active participation in all integrated product team (IPT) meetings and subcontractor meetings. Additionally, the contractor's survivability organization shall present and discuss all mandated material at program design reviews, including status of survivability tasks, design approach for satisfying survival and/or operational requirements of the system, and methodology for verification of survival and operational capabilities. Due to the sensitivity of these topics from a system vulnerability standpoint, these survivability reviews will necessarily be conducted at the appropriate security levels.

4.1.4 Subcontractor Management

The prime contractor shall carry out appropriate flowdown of survivability requirements to associate contractors and subcontractors to the extent necessary to satisfy and assure compliance to system level survivability/operability requirements. The prime contractor shall require the major subcontractors and/or associate contractors to establish a survivability program and to generate a SVPP. The SVPP shall be consistent with the size and complexity of the hardening and engineering tasks. This flowdown should result in their SVPP being consistent with the prime contractor’s SVPP. These subordinate SVPPs shall be reviewed and approved by the prime contractor’s survivability organization. If and when appropriate associate and subcontractors shall be required to attend SWG 1 meetings.

4.1.5 System Life Cycle Survivability Requirements

The contractor shall implement the SVPP tasks that are applicable to: (1) the program role performed by the contractor, (2) the particular system life-cycle phase(s) under contract, and (3) the particular categories of equipments utilized, as applicable. Fundamental life-cycle survivability (LCS) program requirements, which are listed in Table 1 of this standard, shall be the basis of program tasks delineated and expanded in detail subtasks (as applicable) in the SVPP.

Table 1. Sequence of Events

Seq. No.	Task Description	Period of Execution	Remarks
1.	The contractor shall have or establish a Survivability Engineering Organization.	Period leading to Phase A.	Survivability should be a discipline within the System Engineering Organization
2.	The contractor shall carry out the following tasks: • Perform survivability and vulnerability threat assessments for each design concept to establish allowable margins for each threat. • Establish KDP's for each assessed threat and define categories of expected threats, threat environments, and likelihood of occurrence. • Define survivability characteristics that are critical to the system meeting its mission objectives. • Derive/identify survivability attributes of the system. Define initial baseline for survivability. • Trade-offs shall be demonstrated for candidate and alternative technologies.	Period leading to Phase A. (SRR)	Per Paragraphs 5.1.1 and 5.1.2 This activity may continue during Phase A paragraph 5.13
3.	• The contractor shall develop a Survivability Program. • The contractor shall write a Survivability and Vulnerability Program Plan (SPVP).	Phase A (SRR)	The SVPP shall be revised and updated as necessary during subsequent phases of life cycle Paragraph 5.2.1
4.	• The contractor shall establish a Survivability Working Group (SWG). • The SWG shall address/resolve survivability and hardness issues in accordance with the SPVP.	Phase A (SRR)	Charter and duties of SWG are defined in the SPVP. paragraph 5.2.1

Seq. No.	Task Description	Period of Execution	Remarks
5.	Subcontractor Management • The prime contractor shall require major subcontractors and associated contractors to establish a Survivability Program and to develop and implement a Survivability Program Plan. The prime contractor shall carry out appropriate flow down of survivability requirements to associated contractors and major subcontractors to the extent necessary to meet system level survivability and operability requirements.	Phases A and B (SDR/PDR)	paragraph 4.1.4
6.	The contractor shall investigate and fully assess the most cost-effective means to achieve survivability.	Prior to SDR	paragraph 5.2.2
7.	For systems that include survivable ground elements, the contractor shall devise an integrated logistic support (ILS) plan that includes hardness surveillance (HS) and hardness maintenance (HM). In addition, • The ILS scheme shall be included in the SPP. • The contractor shall carry out the HM and HS tasks called out in the SVPP.	During Phase A, (SRR) the contractor develops the ILS Plan. During the Sustainment Phase, the contractor executes the ILS, HS, and HM tasks	
8.	The contractor shall identify to the government critical survivability technology shortfalls so that research requirements may be established.	As early as possible during Phase A (SRR)	The contractor shall present possible alternative solutions to technology shortfalls and identify any penalties and risks incurred paragraph 5.1.3

Seq. No.	Task Description	Period of Execution	Remarks
9.	Systems Threat Assessment and Environmental Effects Analysis • The contractor shall perform a systems threat assessment analysis and document the results in a Systems Threat Analysis Report (STAR) • When the government's STAR becomes available, the contractor shall update the contractor's own analysis report and make it consistent with the Government's STAR • The contractor shall perform a system threat interaction analysis for each of the threats identified in the STAR	Phase A (SRR/SDR)	paragraph 5.2.4
10.	The contractor shall perform survivability trade studies to evaluate the efficacy of available threat mitigation and survivability enhancement options. The results shall be the basis for selection of optimal survivability and operability options in the presence of specified threats.	Phase A and Phase B (SDR/PDR)	All survivability trade studies shall be completed by PDR paragraphs 5.2.5 5.3.2.1
11.	The contractor shall perform system requirements analysis (SRA) and allocations. The primary products of the SRA process are the development of system's survivability and operability requirement, and the breakdown, allocation and flow down of system level requirements down to segment and component level.	Phase A and Phase B (SDR/PDR) All SRA activities shall be completed by PDR	Inputs to the SRA are the STAR, the system threat interaction analysis, the survivability trade vulnerability assessments studies, etc. paragraph 5.3.2.2 APPX D
12.	The contractor shall develop, document and implement Survivability Design Guidelines.	Issue Design Guidelines by PDR	Disseminate among designers. Flow down to subcontractors paragraph 5.3.2.3
13.	Survivability/Operability Test Planning: • The contractor shall carry out a comprehensive survivability test program to demonstrate and verify survival and operate-thru capabilities • The contractor shall prepare a comprehensive test plan that includes test dates, test article, facilities, and traceability	Issue Plan by PDR. Update as necessary. Testing of selected designs for validation. Shall be completed prior to CDR	The test plan may be a standalone document, or it may be part of the SPP. paragraph 5.3.2.4 The contractor shall ensure close integration of testing between Manufacturing, Quality Assurance, Reliability and Design engineering

Seq. No.	Task Description	Period of Execution	Remarks
	to system level requirements. A responsible engineer shall be identified • Testing shall start at the lowest level of integration (piece part). Testing shall also be done at the highest possible level of integration. Example: Box-level flash X-Ray test, box, level current injection test (CIT).	All box, sub-system, and system test plans, shall be approved by CDR	
14.	Piece Parts and Materials Test Program: • The contractor shall perform piece part and materials characterization testing to the extent necessary to validate margins for operate-thru and survival capabilities; and to the extent necessary to support system level analyses (Examples: SEU analysis, system's operate-thru, circumvention, recovery analyses, system's EMP/SGEMP analysis). • The contractor shall ensure that hardness assurance testing is performed on wafer lots intended for flight use	During design and build phases	Characterization test is done during Design Phase. Hardness Assurance lot acceptance testing HALAT Paragraph 5.3.2.5
15.	Hardness Assurance	Post CDR	Paragraph 5.4.2.1 The contractor shall ensure that the designed hardness is not degraded by design changes or manufacturing processes.
16.	Deliverable Survivability Data: • The contractor shall prepare and deliver a Survivability and Vulnerability Program Plan (SVPP) • The contractor shall prepare a Survivability Trade Study (STS) Report • The contractor shall prepare and deliver a Hardness Assurance Plan (HAP) • The contractor shall prepare and deliver (if applicable) a Hardness Maintenance/Hardness Surveillance (HM/HS) Plan • The contractor shall prepare and deliver a System Survivability Test/Analysis (SSTA) Report	Per applicable DID	The STS Report shall be made available at PDR and CDR

5. Pre KDP-A Activities (Prior to SRR)

5.1 Contractor Responsibilities

During the period leading to Phase A, the contractor shall work with the SPO and support the SPO's activities of: (1) definition of the system concept and architecture; (2) definition of system's survivability attributes**;** (3) definition of system threats and bounds; (4) derivation of survivability, design criteria, and application of the system threat assessment report (STAR); and (5) Refinement of system's initial baseline. This initial contractor support shall be in preparation for entrance to Phase A activities.

5.1.2 Critical Survivability Characteristics

As part of the pre KDP-A activities, the contractor shall identify and define survivability characteristics that are critical to the mission. Mission criticality is defined in terms of the system meeting operational and survival objectives as defined in the government's system-level concept of operations (CONOPS) and initial capabilities document (ICD). Definition of these critical survivability characteristics must lead to identification of objectives for survivability which shall be the basis for preparation of an effective survivability program to be implemented during the system's life cycle. 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,

(d) amenable to validation .test and/or analysis at component, subsystem, system and constellation levels, and

(e) exhibit no single-point failure vulnerabilities.

The set of attributes that characterize system performance, operations, and architecture will form an explicit part of the survivability characteristics. Survivability criteria will be balanced among the different weapon effects, mission critical elements, and personnel capabilities and limitations. Critical survivability characteristics are the basis for developing survivability design criteria. Critical survivability characteristics shall be appropriately included in the survivability design baselines.

5.1.3 Candidate Technologies

Depending on the mission, orbit, and the vulnerabilities of the technologies any selection will require careful evaluation.

a. Candidate technologies shall be assessed for their capability to survive and operate in specified threat environments.
   i. Thresholds for operation within tolerable degradation boundaries are tested and measured. Capability margins of existing technologies are similarly evaluated.
   ii. Potential suppliers and continued availability of hardened products are evaluated with associated risks
b. When existing technologies lack required hardness levels (including margins). The contractor shall identify critical survivability technology shortfalls to the SPO and request that research requirements and provisions be established.
c. Alternative technology solutions to be traded to optimize a design solution

5.2 Phase A—(Study Phase) Concept/Architecture Development

5.2.1 Contractor Responsibilities

The task of defining critical survivability/vulnerability characteristics (See Paragraph 5.1.2), if not finished during Pre KDP-A period, shall be executed and completed at the start of Phase A.

During Phase A, the contractor shall establish a survivability program and develop a draft SVPP. The SVPP shall comprehensively describe the survivability engineering management and technical approaches and be consistent with the contractor's SEMP.

The SPP ground segment section (as applicable) shall include an approach to survivability engineering hardness maintenance (HM) and hardness surveillance (HS) which shall be implemented during the second half (sustainment) of Phase C.

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

5.2.2 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 the system design review (SDR) milestone.

(1) Hardware design for nuclear, biological, and chemical contamination will include hardness, decontamination capabilities, and compatibility characteristics. Hardness designs shall permit effective use of equipment by people in full protective ensemble when appropriate.
(2) Mission-critical electronic satellite and link equipment in a predicted threat shall, as a minimum, be survivable to high-altitude electromagnetic pulse (HEMP).
(3) Mission-critical electronic satellite and link equipment in a predicted threat environment shall, as a minimum, be survivable in an electronic countermeasures environment.

5.2.3 Survivability Program Plan Tasks

The subtasks under this section shall be initiated by the contractor in Phase A and coordinated with the government. Most of the tasks initiated in Phase A will continue into the design phase (Phase B) and, optimally, should be completed early in Phase C.

5.2.4 Threat Assessment/Environmental Effects Analysis

The contractor, working with the government, shall prepare (in Phase A) an initial system threat assessment and analysis that specifically addresses the threat categories. This assessment should result in specific statements for or against the expected likelihood of threats. Results of the contractor's threat assessment and analysis shall be considered preliminary, pending release by the government of the system threat analysis report (STAR). When the Government's STAR is released, the contractor's threat assessment and analysis shall be updated and made consistent with the government's STAR. If a STAR is not provided by the acquisition activity, the contractor shall derive the survivability and vulnerability requirements from the orbital requirements (altitude and inclination), projected date of launch mission life and other requirements as agreed to between the acquisition authority and the contractor.

Once the top-level threats are finalized for the space system, the contractor shall prepare a system threat interaction analyses for each of the natural and/or hostile threat environments and associated effects. The interaction analysis shall take into consideration the operational concepts as defined in the initial capabilities document (ICD) (including the deployment phase) and in the system level CONOPS top-level mission requirements and shall define whether survival only, or survival plus operational requirements apply for each of the threat environments. Results of these analyses will be used in the system requirements analysis (SRA) to derive survivability and operability design, performance and verification requirements for all system components (piece parts, boxes, surfaces, etc.).

5.2.5 Survivability Trade Studies

The contractor (the SPO may participate in these trade exercises) shall perform trade studies to evaluate the efficacy of various survivability and vulnerability enhancement options. The option selected shall provide the optimum performance in the prescribed threat environments and scenarios. Potential costs over the lifetime of the system will be identified as integral to the trade studies.

The trade studies shall take into consideration the operational concepts as defined in the ICD and in the system level CONOPS top-level mission requirements. Results of the trade studies shall be used in the survivability requirements allocation process

5.2.6 Systems Requirements and Allocations

The contractor shall perform SRA and develop a methodology for allocating system survivability specification requirements.

Formal survivability requirements allocation for sub system and box level specifications are derived by performing an SRA. Various types of SVPP 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 (as applicable) in the system and/or segment specifications (Type A specifications), development specifications (Type B specifications), box and/or product specifications (Type C specifications), process specifications (Type D specifications), and material specifications (Type E specifications).

5.2.7 Verification of Survivability Requirements by Test and/or Analysis

a. The contractor shall use the following guide to validate and verify system level survivability and operability:
    i. Piece Parts hardness assurance tests,
    ii. Circuit or box level operate-thru/survive flash x-ray tests/analyses,
    iii. Piece part upset/survive Single Event Effects (SEE) tests and Analyses,
    iv. System Generated Electromagnetic Pulse (SGEMP), Internal Electromagnetic Pulse (IEMP) , Dispersed Electromagnetic Pulse (DEMP), tests and analyses of structures, boxes, cables and sensitive interfaces,
    v. Ionizing radiation induced Electrostatic Discharge (ESD) effects analyses,
    vi. Circuit nodes worst case analyses.
b. The contractor shall identify and select test facilities that are capable of simulating threat environments. Cost and availability will be identified
c. System vulnerability studies shall be reviewed and updated.
d. The contractor may propose alternate tests and analyses for approval by the acquisitions activity.

5.2.8 Hardness Assurance

Ideally, planning for the production and deployment phase (Phase C) hardness assurance (HA) shall be initiated in Phase A.

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

Critical path analyses shall be performed to identify potential issues, identify tracking metrics, and alternative paths for resolution, if needed.

5.3 Phase B—(Design Phase) Risk Reduction and Design Development

5.3.1 Contractor Responsibilities

During the design phase, the contractor shall complete applicable survivability engineering SPP tasks initiated in Phase A. It is essential that survivability specification requirements (design, performance, and verification) be maturely developed and documented (specifications) by preliminary design review (PDR). By PDR, survivability specification requirements, as well as systems requirements analysis (SRA) and survivability allocations down to the box level shall be completed. Each box specification shall incorporate standalone survivability requirements and their method for verification. By CDR, all analyses intended to demonstrate a system's operational and survival capabilities shall be completed. Additionally, during the design phase, the needs for box-level flash x-ray testing and supporting analyses shall be systematically addressed by all contractors; for example, analyses shall be performed for likely combinations of predicted threats (see Para 5.2.7).

5.3.2 Survivability Program Plan Tasks

Identified in the following subparagraphs are primary SVPP tasks that the contractor shall perform. Additional supporting and/or secondary SVPP tasks shall also be performed and described in the work breakdown structure (WBS), which is an element of the SVPP.

5.3.2.1 Survivability Trade Studies

During the design phase, the contractor shall complete all survivability trade studies initiated in Phase A. By PDR, all survivability trade studies shall be completed. Specific methodologies and objectives of the trade studies will be described in the SVPP. Limited testing shall be initiated to reduce program risks or validate approaches.

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

5.3.2.2 System Requirements Analysis and Allocations

The SRA task (see Appendix D) initiated in Phase A shall be refined and completed by PDR. Once a comprehensive survivability SRA has been completed, survivability specification requirements can be allocated. Finalization of survivability specification requirements should be completed by PDR which is a design-phase milestone.

Single point failure analyses and trades shall have been conducted, identified, and eliminated by PDR, if possible, and analyses continued into all phases.

5.3.2.3 Survivability Design Guidelines

The contractor shall develop and document system-specific survivability design guidelines by the PDR milestone. Development of survivability design guidelines will facilitate the implementation of hardening techniques and/or designs. Verification of incorporation of these guidelines in the design and fabrication documentation shall be the responsibility of the contractor's survivability organization.

5.3.2.4 Survivability Test Planning

The contractor shall prepare and maintain a comprehensive survivability engineering test plan. The test plan may be a standalone document, or it may be part of the SVPP. The contractor’s survivability test plan shall be consistent with the test philosophy and test objectives called out in the government’s 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, validation of operational and/or survival requirements, validation of survivability and vulnerability characteristics, elimination of unnecessary redundancy, efficient scheduling of test facilities and other resources, and integration with other program activities. Additionally, the plan provides traceability from operational and survival requirements in system specifications to individual tests, test plans, procedures, and test reports.

5.3.2.4.1 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 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. The types of tests, techniques, and procedures shall be determined by the SWG.

5.3.2.4.2 Piece Parts/Materials Characterization Tests

The contractor shall conduct piece parts and/or materials characterization tests that expose piece parts and/or materials to simulated environmental effects (transient ionizing radiation, neutrons, total ionizing dose, electromagnetic interference, etc.). The responses of piece parts and materials exposed to threat environments must be known to properly select parts and materials for the design and to perform the required analyses to qualify and validate box and system-level operational and/or survival capabilities. Results of these tests shall be used to determine survival and performance margins, to generate the part’s response database that is needed to support analyses at the circuit and box level, and to generate accept or reject criteria used for HA testing.

5.3.2.5 Hardness Assurance (HA)

The contractor shall generate and implement a hardness assurance plan (HAP) applicable to radiation sensitive EEEE parts. Hardness assurance of EEEE parts is a subtask described in the overall system-level

SPP, and it is intended to assure operational and survival capability of the system when exposed to the various threat environments.

HALAT as used in the context of this document relates to the exercising of hardness disciplines to verify that flight parts satisfy the specified hardness attributes. Acceptance of flight parts with respect to a particular threat environment may be on a part-by-part basis, or it may be on a lot-sampling basis. Acceptance on a sampling basis requires segregation of parts by “processing lots.” This refers to critical manufacturing processes. In the case of semiconductor parts, devices from the same wafer lot exhibit radiation performance characteristics that are clustered closely together. Therefore, sampling testing and statistical inference may be used to assure that the entire wafer lot behaves within the performance boundaries established by the sampling data. Acceptance on a part-by-part basis may be done only if the specific hardness assurance testing is classified as “non-destructive.”

The measures specified in the HAP must be cost-effectively implemented during Phase B and C. Where possible, hardness design margin (HDM) requirements for piece parts shall be established which minimize expensive lot sample tests and complex and/or costly production line screens and/or controls.

5.3.2.6 Hardness Maintenance (HM)/Hardness Surveillance (HS)

If the government requires ground segment elements to survive/operate in the specified threat environments, the SPP shall address ground segment life-cycle survivability/vulnerability. For systems hardened to meet a survivability requirement, Hardness assurance, maintenance, and surveillance (HAMS) provisions shall be developed to assure that maintenance and/or repair procedures, as well as spare parts procurement provisions and aging effects do not compromise the hardness capabilities of the system.

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

    (a) hardness assurance plans for maintaining the integrity of the hardened design during production;

    (b) hardness maintenance plans for maintaining the hardened system during its operational life; 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 decontamination capabilities as well as hardness.

Therefore, the contractor shall develop during Phase B a HM/HS Plan that is based upon the HAP tasks and addresses cost effective life cycle hardness maintenance and hardness surveillance of the various ground segments.

5.3.2.7 Integrated Logistics Support.

For ground segments having critical survivability characteristics, the contractor shall develop an integrated logistics support plan (ILSP). The ILS plan will define a program to ensure that critical survivability 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 decontamination capabilities and compatibility must also be defined.

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

(4) The ILSP will address the acquisition of manuals and training to ensure rapid return to operation of damaged systems, if appropriate. Hazard damage repair plans will address hardness maintenance and surveillance of hazard damage repair supplies, tools, and equipment.

The ILSP may be a standalone plan, or it may be incorporated into the HM/HS activities.

5.3.3 Deliverable Survivability Data

During the design phase, the contractor shall prepare and deliver survivability and vulnerability documentation, as formally listed on the contract data requirements list (CDRL). The data item description documents (DID) cited herein may correspond to cancelled (inactive) military specifications, but requirements delineated in these DIDs generally apply to any system required to comply with survivability specification requirements. It may be necessary to tailor these DIDs based upon unique system and/or program requirements. Delivery dates will be prior to PDR and CDR program milestones as specified in the contract, or in the particular DID.

5.3.3.1 Survivability Program Plan

The contractor shall prepare and deliver a survivability program plan in accordance with DI-NUOR-80156A (Nuclear Survivability Program Plan) and DI-NUOR-80928 (Nuclear Survivability Test Plan) that is consistent with the contractor's SEMP. Because development of the SVPP is fundamental and critical to the application of this document, a typical SVPP template applicable to a space system, can be found as an example in Appendix A. The initial delivery of the SVPP shall be prior to the system design review (SDR), with an update during Phase B, PDR milestone, and a final version to be completed by the time of CDR.

5.3.3.2 Survivability Trade Study Report

The contractor shall prepare and deliver a survivability trade study report using contractor format. This report will formally document all trade studies initiated in previous program phases. Initial delivery of the trade study report shall be prior to PDR with a final update by the time of CDR.

5.3.3.3 Hardness Assurance Plan

The contractor shall prepare and deliver a radiation hardness requirements and assurance plan for semiconductor parts in accordance with data item description DI-NUOR-80926 (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 PDR with an updated version by CDR. Implementation of the HAP shall take place in Phases B and C.

5.3.3.4 Hardness Maintenance/Hardness Surveillance Plan

The contractor shall develop a deliverable HM/HS Plan and an ILSP plan in accordance with data item descriptions DI-NUOR-80926 (Nuclear Survivability Assurance Plan) and DI-ENVR-80265 (Hardness Surveillance Plan). These DIDs shall be tailored to produce a combined HM, HS, or ILS plans for the ground segment. Delivery of the HM, HS, or ILS plans shall be prior to CDR. Implementation of the HM and HS plan for the ground segment shall take place in Phase C.

5.3.3.5 Survivability Analyses /Test Reports

Each box shall have its specified hardness attributes demonstrated and verified by inspection, analysis, or test as prescribed in the box-level specification. When the verification method is by analysis, this analysis shall be based on test data at a lower assembly level, generally, at the piece-part level and shall be supported by circuit models, computer models, simulations, etc. The contractor shall generate a survivability/operability analyses report for each threat environment. When specified in the statement of work (SOW), the contractor shall prepare analyses and/or test reports deliverable in accordance with data item descriptions DI-NUOR-80927 (Nuclear Survivability Design Parameters Report), and/or DI-ENVR-80266 (Nuclear Hardness and Survivability Design Analysis Report).

This DID shall be tailored based upon unique program and system considerations and requirements. This report will formally document all survivability tests, including those initiated in previous program phases. Delivery of the test report shall be prior to CDR.

5.4 Phase C—(Build, Test, Launch) Acquisition and Operation Support

5.4.1 Contractor Responsibilities

Generally, all survivability specifications will be completed during Phase B. Design features intended for survivability that are called out in the SVPP will be implemented during the design phase. Except for hardness assurance testing of piece parts, all survivability validation testing would have been completed during Phase B (prior to CDR). The contractor's responsibilities during Phase C consist of testing of piece part lots, verification of hardness maintenance and surveillance of all hardness critical design areas, and incorporation of survivability provisions on any major equipment upgrade plans.

5.4.2 Survivability and Vulnerability Program Plan Tasks

5.4.2.1 Hardness Assurance

During this phase, the contractor shall implement a survivability and vulnerability HA program in accordance with the HAP. The objective of the HA 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 a special emphasis shall be given to development of piece part specifications, piece part 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

5.4.2.2 Life-Cycle Survivability

HM, HS, and ILS procedures, inspections, and tests, delineated in the HM and HS plan, shall be initiated and implemented in Phase C to ensure system survivability and/or hardening designs are not degraded through operational use, maintenance actions, or logistic support. Also, the contracting agencies that are tasked with using, maintaining, and testing of the system will periodically reassess system survivability characteristics. These reassessments should occur at selected points in the system life-cycle, particularly:

(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.

The contracting agency tasked with operations and maintenance of the system shall communicate to the government the need to exercise and implement segment upgrades necessary to preserve survival capabilities that may have been compromised as a result of above changes.

5.4.2.3 Survivability Specifications

The contractor shall have completed during Phase B (by CDR) specification of all system survivability design, performance, and verification requirements

5.4.3 Survivability Test Reports

No later than 90 days into Phase C, the contractor shall submit an update to document all survivability testing not contained in the original submission (by CDR).

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 document 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 SVPP, which balances the management and technical aspects of survivability engineering. Because this document only addresses the management aspects of the contractor's survivability program, specific survivability specification requirements are only generally referred to.

Application of this document is primarily the responsibility of the prime contractor. However, other system contractors are encouraged to use this document as a survivability engineering management guidelines document. Additionally, representative SVPP section and subsection headings, are informative supplements to this document.

Contractor as used in this document implies either the prime contractor, associate contractor(s), subcontractors or suppliers and/or vendors. This document should be implemented in a manner that is consistent with AFR 80-38, AFR 57-1 and National Security Space Acquisition Policy Number 03-01 dated October 6, 2003.

6.2 Data Requirements

The data required by this document shall be prepared in accordance with the following Data Item Descriptions (DIDs):

- DI-NUOR-80156A (Nuclear Survivability Program Plan)
- DI- NUOR -80926 (Nuclear Survivability Assurance Plan)
- DI-NOUR-80927 (Nuclear Survivability Design Parameters Report)
- DI- NUOR -80928 (Nuclear Survivability Test Plan)
- DI- NUOR -80929A (Nuclear Survivability Test Report)
- DI-ENVR-80266 (Nuclear Hardness and Survivability Design Analysis Report)

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
CONOPS	Concept of Operations
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
HALAT	Hardness Assurance Lot Acceptance Test
HAMS	Hardness Assurance, Maintenance and Surveillance
HAP	Hardness Assurance Plan
HDM	Hardness Design Margin
HEMP	High-Altitude Electromagnetic Pulse
HM	Hardness Maintenance
HS	Hardness Surveillance
ICBM	Intercontinental Ballistic Missile
ICD	Initial Capabilities Document
ILSP	Integrated Logistics Support Plan
JROC	Joint Requirements Oversight Council
KDP	Key Decision Point
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
RF	Radio Frequency
SCB	Survivability Control Board
SDRL	Subcontractor Data Requirements List
SE	Systems Engineering
SEMP	System Engineering Management Plan
SGEMP	System-generated Electromagnetic Pulse
SPO	Systems Program Office
SVPP	Survivability and Vulnerability 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

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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 use this form 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
483 N. Aviation Blvd.
El Segundo, CA 91245
Attention: SMC/EAE