Tailoring of GEIA-STD-0009, Rev A, "Reliability Program Standard for Systems Design, Development, and Manufacturing," for Ground Systems

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Prepared for:
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This technical report has been reviewed and is approved for publication. Publication of this report does not constitute Air Force approval of the report's findings or conclusions. It is published only for the exchange and stimulation of ideas until adopted or otherwise implemented by the government.

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14. ABSTRACT

The objective was to implement the industry consensus reliability program standard while overlaying a limited number of DOD space-system unique requirements of implementation approaches to facilitate more effective implementation on the ground systems. This tailoring (addendum/amplification) of SAE International GEIA-0009, Rev A, Reliability Program Standard for Systems Design, Development, and Manufacturing, provides an effective reliability program baseline for the ground segment of space systems, which are also referred to as "ground systems". GEIA-0009, Rev A and this tailoring document, together in combination, are intended for use in acquisition and study contracts for ground systems. The SMC standard tailored by this document (hereafter referred to as the "tailored SMC standard") is intended to be used as a compliance document to specify reliability program requirements for ground systems.

15. SUBJECT TERMS

Reliability; Reliability Program; Space Systems; Standards; Tailoring

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Foreword

This tailoring (addendum/amplification) of SAE International GEIA-0009, Rev A, "Reliability Program Standard for Systems Design, Development, and Manufacturing", provides an effective reliability program baseline for the ground segment of space systems, which are also referred to as "ground systems"

GEIA-0009, Rev A and this tailoring document, together in combination, are intended for use in acquisition and study contracts for ground systems. The standard tailored by this document (hereafter referred to as the "tailored standard") is intended to be used as a compliance document to specify reliability program requirements for ground systems.

Tailoring Intent

The objective was to implement the industry consensus reliability program standard while overlaying a limited number of DOD space-system unique requirements of implementation approaches to facilitate more effective implementation on the ground systems.

Formatting of This Tailoring Document

The organization in this tailoring document is consistent with GEIA-0009, Rev A.

Summary of Tailoring

The following is a comprehensive list of the changes that this document imposes on GEIA-0009, Rev A:

Section	Title	Change Summary
N/A	Foreword	Added background for this tailoring.
1.3	Tailoring	Defined tailoring and provided additional tailoring process details
2	Informative References	Specified DOD Data Item Descriptions that support documentation of Reliability Program Plan and Reliability Case
9	Data Item: Reliability Case	Specified the content/data elements for the Reliability Case Report throughout the lifecycle

Editorial note: To avoid any potential ambiguity, the formatting, section title capitalization, and section numbering of SAE International report number GEIA-STD-0009, Rev A, has been preserved as originally published. To avoid ambiguity, this includes differences from The Aerospace Corporation editorial style such as capitalization and the spelling of words such as "Life-Cycle".

Contents

1. SCOPE

REVISE AS FOLLOWS. Otherwise use GEIA-STD-0009, Rev A verbatim.

1.1 Approach

There are no changes to this section. Use GEIA-STD-0009, Rev A verbatim.

1.2 Reliability Program Plan and Reliability Case

There are no changes to this section. Use GEIA-STD-0009, Rev A verbatim.

1.3 Tailoring

ADD THE FOLLOWING:

Tailoring is a process by which individual requirements from specifications, standards, or related documents are evaluated and applied to a specific program by deletion, modification, or addition of requirements. Tailoring of requirements must be undertaken with consultation and approval of the procuring authority and reliability engineering subject matter expert to align the standard with the acquisition authority's requirements and the mission needs. The diversity of missions, buses, payloads, environments, ground systems, and unique approaches of contractors, makes tailoring of standard requirements mandatory.

This tailored standard establishes a baseline for requirements, which in turn may be further tailored or revised with rationale for specific project needs upon approval by the procuring authority.

1.4 Organization

There are no changes to this section. Use GEIA-STD-0009, Rev A verbatim.

2. INFORMATIVE REFERENCES

ADD THE FOLLOWING. Otherwise use GEIA-STD-0009, Rev A verbatim.

Department of Defense Data Item Descriptions (DIDs):
DI-SESS-81585C A Reliability and Maintainability Test Plan
DI-SESS-81495B A Failure Modes, Effects, and Criticality Analysis
DI-SESS-81497B A Reliability and Maintainability Predictions Report

These documents can be obtained at the Defense Logistics Agency single-source repository, ASSIST:

https://assist.dla.mil/online/start/ [DOD personal identity verification (PIV) authentication required]

https://quicksearch.dla.mil/qsSearch.aspx [Public website]

3. DEFINITIONS

There are no changes to this section. Use GEIA-STD-0009, Rev A verbatim.

4. OBJECTIVE 1: UNDERSTAND CUSTOMER/USER REQUIREMENTS AND CONSTRAINTS

REVISE AS FOLLOWS. Otherwise use GEIA-STD-0009, Rev A verbatim.

4.1 Introduction (Informative)

There are no changes to this section. Use GEIA-STD-0009, Rev A verbatim.

4.2 Mission and Goals (Informative)

There are no changes to this section. Use GEIA-STD-0009, Rev A verbatim.

4.3 People and Organizations (Normative)

There are no changes to this section. Use GEIA-STD-0009, Rev A verbatim.

4.4 Supporting Information (Normative)

There are no changes to this section. Use GEIA-STD-0009, Rev A verbatim.

4.5 Activities, Methods, and Tools

There are no changes to this section. Use GEIA-STD-0009, Rev A verbatim.

5.   OBJECTIVE 2: DESIGN AND REDESIGN FOR RELIABILITY

REVISE AS FOLLOWS. Otherwise use GEIA-STD-0009, Rev A verbatim.

5.1   Introduction (Informative)

There are no changes to this section. Use GEIA-STD-0009, Rev A verbatim.

5.2   Mission and Goals (Informative)

There are no changes to this section. Use GEIA-STD-0009, Rev A verbatim.

5.3   People and Organizations (Normative)

There are no changes to this section. Use GEIA-STD-0009, Rev A verbatim.

5.4   Supporting Information (Normative)

There are no changes to this section. Use GEIA-STD-0009, Rev A verbatim.

5.5   Activities, Methods, and Tools

There are no changes to this section. Use GEIA-STD-0009, Rev A verbatim.

6.   OBJECTIVE 3: PRODUCE RELIABLE SYSTEMS/PRODUCTS

REVISE AS FOLLOWS. Otherwise use GEIA-STD-0009, Rev A verbatim.

6.1   Introduction (Informative)

There are no changes to this section. Use GEIA-STD-0009, Rev A verbatim.

6.2   Mission and Goals (Informative)

There are no changes to this section. Use GEIA-STD-0009, Rev A verbatim.

6.3   People and Organizations (Normative)

There are no changes to this section. Use GEIA-STD-0009, Rev A verbatim.

6.4   Supporting Information (Normative)

There are no changes to this section. Use GEIA-STD-0009, Rev A verbatim.

6.5   Activities, Methods, and Tools

There are no changes to this section. Use GEIA-STD-0009, Rev A verbatim.

7.   OBJECTIVE 4: MONITOR AND ASSESS USER RELIABILITY

REVISE AS FOLLOWS. Otherwise use GEIA-STD-0009, Rev A verbatim.

7.1   Introduction (Informative)

There are no changes to this section. Use GEIA-STD-0009, Rev A verbatim.

7.2   Mission and Goals (Informative)

There are no changes to this section. Use GEIA-STD-0009, Rev A verbatim.

7.3   People and Organizations (Normative)

There are no changes to this section. Use GEIA-STD-0009, Rev A verbatim.

7.4   Supporting Information (Normative)

There are no changes to this section. Use GEIA-STD-0009, Rev A verbatim.

7.5   Activities, Methods, and Tools

There are no changes to this section. Use GEIA-STD-0009, Rev A verbatim.

8.   NOTES

Use GEIA-STD-0009, Rev A verbatim
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9. DATA ITEM: Reliability Case (INFORMATIVE until specified by contract)

ADD THE FOLLOWING:

Use/Relationship

The Reliability Case Report is a justification of the approach and documents evidence which verifies that the System/Product meets its reliability requirements. This includes evidence that the System/Product reliability requirements are achievable and are properly understood by the developer. The Reliability Case Report evolves from the direction of the customer and the supplier as the project matures.

The Reliability Case Report is based on a variety of types of evidence, but they must be within the bounds of the stated assumptions and consistent with the System/Product Reliability Program Plan. The method used in a particular instance may be chosen at the supplier's discretion, as appropriate to the nature of each requirement addressed. Suitable approaches are described below and commonly used in combination to provide a more robust Reliability Case Report.

- Quantitative Evidence. This approach is based on defined methods of analysis to generate metrics that demonstrate the required (or desirable) reliability features in the target System/Product. This type of evidence also includes the results of testing or demonstrations conducted as part of a Reliability Program Plan.

- Qualitative Evidence. This approach focuses on processes used for development and support of the System/Product. Qualitative evidence assures satisfaction of reliability requirements by demonstrating quality, maturity, and integrity of the underlying engineering and management processes.

- Historical or Comparative Evidence. This approach includes Systems/Products already in use and supported for other customers. Comparative evidence could be relevant for a System/Product that is a variant of an existing System/Product or is similar to an existing System/Product produced by the same supplier. The information provided might include both quantitative and qualitative aspects of the System/Product as well as associated support services.

The Reliability Case Report is an input for activities defined in GEIA-STD-0009 to achieve Objectives 1 through 4 and generated at corresponding acquisition or project milestones when those activities are started.

Reference Documents:

[1] ANSI GEIA-STD-0009 Rev A, Reliability Program Standard for Systems Design, Development, and Manufacturing, May 2020.

[2] SAE TAHB0009 Rev B, SAE Systems Management Recommended Practice (PROPOSED DRAFT), February 2017.

[3] DoD Guide for Achieving Reliability, Availability, and Maintainability, August 3, 2005.

Format:

The document shall be in contractor's format.

Content Requirements:

The numbers shown designate the paragraph number to be used in the document.

1.   Scope. This section shall be divided into the following paragraphs.

1.1   Identification. This paragraph shall contain a full identification of the System/Product to which this Report applies, including the following as applicable:

   a.   part number(s)/manufacturing drawing number(s)
   b.   serial number(s)
   c.   hardware and software revision level(s)/modification level(s)
   d.   physical characteristics
   e.   drawing number(s)
   f.   block diagram(s)
   g.   interface boundaries

This paragraph shall provide the period of reporting.

1.2   System Overview. This paragraph shall briefly state the purpose of the System/Product to which this Report applies. It shall: a) describe the general nature of the System/Product; b) summarize the history of system/product development, operation, and maintenance; c) identify the customer, user, developer, and support organizations; and d) identify current and planned operating sites.

1.3   Document Overview. This paragraph shall summarize the purpose and contents of this document. This paragraph shall describe any security or privacy considerations associated with its use.

1.4   Relationship to Other Documents and Plans. This paragraph shall describe the relationship, if any, of the Reliability Case Report with other program plans and reports.

2.   Referenced Documents. This paragraph shall list the number, title, revision, and date of all documents referenced in this Report.

3.   System/Product Reliability Requirements. This paragraph shall list all reliability requirements for the System/Product. At a minimum, the following shall be provided for each reliability requirement:

   a.   Project unique identifier for the requirement
   b.   Requirement text
   c.   Requirement verification method (Inspection, Analysis, Demonstration, and/or Test; Other is also acceptable)
   d.   Brief summary of the approach for requirements verification.
   e.   If needed or applicable, explanatory text to clarify the interpretation of the requirement

If any requirement has a verification method other than Inspection, Analysis, Demonstration, or Test, this paragraph shall provide a brief description for this verification approach.

4.   Applied Methods. This paragraph shall list all analysis, demonstration, test, and risk management methods utilized, or to be utilized, for verifying that System/Product reliability requirements are met or continue to be met. (See Annex A of Ref. [1]) At a minimum, the following shall be provided for each method identified:

   a. Brief description of the method
   b. If applicable, reference(s) to any standards or publications followed when applying the method, and a description to what extent that standard or publication was followed
   c. List of System/Product reliability requirement(s) for which the method will be applied for verification
   d. If applicable, how the System/Product-Level User and Environmental Life Cycle Loads are accounted for by the method
   e. If applicable, how the Life-Cycle Loads on Assemblies, Subassemblies, and Components are accounted for by the method
   f. The expected output from the method and the list of configuration managed document(s) where the output from the method will be, or is, documented

5.   System/Product Reliability Model. This paragraph shall describe the System/Product Reliability Model, provide an estimate of the System/Product reliability performance over the expected System/Product-Level User and Environmental Life Cycle Loads, and how that performance was estimated using the System/Product Reliability Model.

For Objective 1 only (see Section 4.5.1.2 of Reference [1] and Section 2.5 of Reference [2]): This paragraph also shall describe:

   a. which of the Applied Methods identified in Paragraph 4, and how outputs from those Applied Methods, will be used to develop the System/Product Reliability Model and generate a reliability performance estimate
   b. all Assemblies, Subassemblies, and Components, either known or under consideration, to which reliability requirements will be allocated
   c. the functional interdependencies, redundancies, and degraded modes of operation for Assemblies, Subassemblies, and/or Components, either known or under consideration

For Objectives 2-4 only (see Section 5.5.1.2 of Reference [1] and Section 2.7 of Reference [2]): This paragraph also shall list all single point failures and critical components and explain how System/Product reliability requirements are met even in the presence of these single point failure and critical components. As needed to explain the reliability performance estimate, this paragraph also shall describe:

   a. which of the Applied Methods identified in Paragraph 4, and how outputs from those Applied Methods, were used to develop the System/Product Reliability Model and generate a System/Product reliability performance estimate
   b. the functional interdependencies, redundancies, and degraded modes of operation for Assemblies, Subassemblies, and/or Components
   c. if applicable, manufacturing processes used to produce and integrate Assemblies, Subassemblies, and/or Components
   d. if applicable, maintainability strategies for the System/Product when in operation

6.   System/Product-Level User and Environmental Life Cycle Loads. This paragraph shall describe the total life-cycle environment that the System/Product is expected to encounter in actual usage throughout its life cycle. At a minimum, this description shall include:

a. which Applied Methods identified in Paragraph 4, and how outputs from those Applied Methods, will be or were used to estimate the user and environmental loads
b. estimates of the user and environmental loads
c. if available, measurements or substantiating data sources for the estimates of user and environmental loads
d. if applicable, assets or information required by the developer to measure user and environmental loads

7. Life-Cycle Loads on Assemblies, Subassemblies, and Components. This paragraph shall describe the total life-cycle environment that the Assemblies, Subassemblies, and Components are expected to encounter in actual usage throughout the System/Product life cycle. At a minimum, this description shall include:

a. which Applied Methods identified in Paragraph 4, and how outputs from those Applied Methods, will be or were used to estimate life-cycle loads on Assemblies, Subassemblies, and Components
b. if available, estimates of life-cycle loads on Assemblies, Subassemblies, and Components
c. if available, measurements or substantiating data sources for the estimates of life-cycle loads on Assemblies, Subassemblies, and Components
d. if applicable, assets or information required by the developer to measure life-cycle loads on Assemblies, Subassemblies, and Components

8. Reliability Cases. This section shall be divided into paragraphs according to all System/Product reliability requirements.

8.*x* Reliability Case for *x*. This section shall be divided into paragraphs.

8.*x*.1 Reliability Requirements. For System/Product reliability requirement *x* and all allocated Assembly, Subassembly, and Component requirements, this paragraph shall list:

a. Project unique identifier for the requirement
b. Requirement text
c. Requirement verification method (Inspection, Analysis, Demonstration, Test, or Other, if applicable)
d. (For Assembly, Subassembly, and Component requirements only) Traceability from the Assembly, Subassembly, or Component requirement to the System/Product reliability requirement *x*.

8.*x*.2 Verification Approach. This paragraph shall describe in detail how System/Product reliability requirement *x* and its allocated Assembly, Subassembly, and Component requirements will be, or are, verified. At a minimum, the description shall include the following:

a. list of evidence needed for requirements verification
b. detailed explanation for why the evidence will show, or shows, that the requirement is verified
c. how the outputs of Applied Methods will be, or are, used for requirements verification
d. if applicable, how the outputs from the Conceptual System/Product Reliability Model will be, or are, used for requirements verification
e. how System/Product-Level User and Environmental Life Cycle Loads and Life-Cycle Loads on Assemblies, Subassemblies, and Components will be, or are, accounted for in requirements verification

8.*x*.3   <u>Verification Status</u>. This shall paragraph shall describe the current status of the verification of System/Product reliability requirement *x* and its allocated Assembly, Subassembly, and Component requirements.

For each requirement that is considered <u>not</u> verified, at the minimum the description shall include the following:

a. status of the evidence supporting requirements verification and, for evidence that is pending, a statement of when the evidence will be available
b. if the requirement is quantitative, the estimated performance of the System/Product, Assembly, Subsystem, or Component
c. if the requirement is quantitative and the expected performance differs from the required performance, the expected performance, and an explanation for why this level of performance is acceptable when this Report was written, of the System/Product, Assembly, Subsystem, or Component

For each requirement that is considered verified, at the minimum the description shall include the following:

a. specific references to the evidence (e.g., test reports, analysis reports) supporting requirements verification
b. if the requirement is quantitative, the estimated performance of the System/Product, Assembly, Subsystem, or Component

8.x.4   (For Objectives 1-3 Only) <u>Reliability Requirement Risk Assessment.</u> This paragraph shall describe risk areas associated with the System/Product satisfying System/Product Reliability requirement *x*. If there are no identified risk areas, this paragraph shall explain why there none. For any identified risk areas, at a minimum the description shall include the following:

a. A brief description of the risk area and its impact to the System/Product possibly not achieving System/Product Reliability requirement *x*.
b. Assessments of the severity of the consequence and the likelihood of occurrence for the risk
c. A brief description of how the risk is being managed

8.x.5   (For Objective 4 Only) <u>Monitoring and Assessing User Reliability</u>. This paragraph shall describe field reliability issues observed with the use and operation of the System/Product that is related to System/Product Reliability requirement *x*. At a minimum, the description shall include the following:

a. which Applied Methods identified in Paragraph 4, and how outputs from those Applied Methods, were used to monitor the System/Product reliability requirement *x* after the System/Product was fielded
b. most recent outputs from those Applied Methods applicable to System/Product requirement *x*
c. summary of updates made to the Verification Status of System/Product as required in Paragraph 8.x.3 due to those most recent outputs

Appendix A.   <u>System/Product Reliability Requirement Allocations.</u> This paragraph shall

a. identify the Assemblies, Subassemblies, and Components of the System/Product for which a specification will be or is provided.
b. show the static (such as "consists of") relationship(s) of the Assemblies, Subassemblies, and Components.

c. state the purpose or function of each Assembly, Subassembly, and Component.

d. either, list all Assembly, Subassembly, and Component requirements allocated from the System/Product reliability requirements or, if the required information is stored in a requirements management database that is delivered in electronic form with the System/Product, provide instructions on how to extract the list of all Assembly, Subassembly, and Component requirements allocated from the System/Product reliability requirements from the requirements management database. At a minimum, the following shall be provided for requirement:

1) project unique identifier for the Assembly, Subassembly, or Component requirement
2) Assembly, Subassembly, or Component requirement text
3) Assembly, Subassembly, or Component requirement verification method (Inspection, Analysis, Demonstration, Test, or Other, if applicable)
4) if needed or applicable, explanatory text to clarify the interpretation of the Assembly, Subassembly, or Component requirement
5) traceability from the Assembly, Subassembly, or Component requirement to the System/Product reliability requirement(s)

End of DATA ITEM: Reliability Case

ANNEX A - METHODS MATRIX (INFORMATIVE)

Use GEIA-STD-0009, Rev A verbatim.

ANNEX B - RELIABILITY BEST PRACTICES LIST (INFORMATIVE)

Use GEIA-STD-0009, Rev A verbatim.

ANNEX C - KEY DOCUMENTS MATRIX (INFORMATIVE)

Use GEIA-STD-0009, Rev A verbatim.

ANNEX D - KNOWN FAILURE DEFINITION AND SCORING CRITERIA (NORMATIVE)

Use GEIA-STD-0009, Rev A verbatim.

ANNEX E - ACRONYMS (INFORMATIVE)

Use GEIA-STD-0009, Rev A verbatim.

External Distribution

REPORT TITLE

Tailoring of GEIA-STD-0009, Rev A, "Reliability Program Standard for Systems Design, Development, and Manufacturing," for Ground Systems

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Tailoring of GEIA-STD-0009, Rev A, "Reliability Program Standard for Systems Design, Development, and Manufacturing," for Ground Systems

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