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Space and Launch Requirements Addendum to AS9100D Quality Management Systems

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This technical report has been reviewed and is approved for publication. Publication of this report is not authoritative unless and until adopted or otherwise implemented by the Government. It is published only for the exchange and stimulation of ideas.

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14. ABSTRACT

This document is an addendum to AS9100 and specifies the additional quality management systems and space and launch requirements. It is intended to be flowed down through the contractor to subcontractors and suppliers so that a uniform set of requirements is used for the particular mission. The standard may be tailored for the program. The document preserves industry lessons learned that appeared in now cancelled military specifications and incorporates best practices so that new suppliers to the space industry may gain insight into methods for implementing the requirements.

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--	Initial release: The Aerospace Corporation Technical Operating Report TOR 2013-00393 Proposed Requirements – Quality Space and Launch Requirements Addendum to AS9100C This is an update to the Aerospace Corporation Technical Operating Report TOR-2005(8583)-3859 Quality Assurance Requirements for Space and Launch Vehicles dated 1 December 2005 [also published as SMC-S-003 (2008)]	15-Jul-2013
A	The Aerospace Corporation Technical Operating Report TOR 2013-00393 Rev A Proposed Requirements – Quality Space and Launch Requirements Addendum to AS9100C • Section 1.2: Eliminates requirement for prime contractor to perform a "registrar" audit on suppliers that are not registered to ISO9001 or AS9100 • Section 1.5.3: Adds a table of related standards that overlap with this standard • Section 4.2: Specifies that this standard is implemented on a program specific basis • Section 4.4.4: Clarifies that time limit for data storage is to agree with program requirements • Section 7.2b: Allows for successive inspection in lieu of a second quality inspection • Section 7.4.2b: Clarified "qualified and demonstrated inspection and test techniques" to mean "proven" techniques • Section 7.4.2d: Clarified "unnecessary and unrealistic design complexity" to be tied to inspectability and manufacturability • Section 7.6.3.1: Change required survey of suppliers prior to start of contract from "new" supplier to "non-approved" suppliers and opened window from 12 months to 18 months • Section 7.6.4.1.1.1: Relaxed requirement that lead auditor be certified to AS9100 to only requiring that the lead auditor complete a lead auditor course • Section 7.6.4.1.1.3: Clarified auditor performance to be evaluated by requirements in prime contractor's procedures • Section 7.6.6.1: Clarify oversight requirements at a supplier to apply only if prime contractor stations personnel at the supplier • Section 7.6.7: Expand options for receiving inspection to require inspection at a time after receipt of items as long as it does not violate supplier's warranty period • Section 8.1.3.1b: Clarify use-as-is disposition to include recommended documentation changes and the methods for accomplishing the changes	15-Jan-2014

Rev No	Description of Change	Effective Date
--	Initial release: The Aerospace Corporation Technical Report TR-RS-2015-00003 Quality Space and Launch Requirements Addendum to AS9100C. Includes requirements section of TOR 2013-00393 Rev A and adds the following: • Foreword: Add the note that references to ISO9001 and AS9100 refer to the latest versions of these standards • Section 1.2: Clarifies that the standard applies to suppliers of space and launch vehicles; not all suppliers need be certified to ISO9001 or AS9100; and auditing may be used to monitor these suppliers • Section 1.5.3: Corrected references in reference standard table • Section 3.2: Added or updated definitions for supplier, critical item, critical supplier, major supplier, certification, subcontractor • Section 4.1: Clarified that this standard augments the QMS of the supplier if the supplier is not certified to AS9100 • Section 4.2: Reverted back to the wording of TOR-2005(8583)-3859 regarding personnel involved in MRB and CAB for clarity • Section 4.2.3: Revise to clarify that the controls over work performed at field locations be the same as those at the home location • Section 4.4.1: Change title from "Records" to "Documentation Requirements" • Section 7.6.7: Correct grammar • Section 7.6.8: Add new section on Delegation of Product Verification • Section 7.7.1.1.1: Adds an implementation box identifying the steps that a contractor, subcontractor, or supplier may use when a change in production source occurs • Section 8.1.3.2a: Move SRP comments listed in 8.1.3.2 Repair Dispositions to 8.1.3.2.1 Standard Repair Procedures. Add clarifying comments to SRP to align with definition of SRP. • Attachment 1: Update document reference on Data Item Description	27-Aug-2014
	• Section 3.2: replace the definitions of Quality Assurance and Product Assurance with more standard definitions • Section 3.2: add definitions of Quality Control and Quality Management • Section 5.1: Re-write 5.1 and 5.1.1 to clarify the functions of quality management addressed by this standard include quality assurance, quality control, and product assurance	4-Mar-2015
	• Clarify meaning of phrases "program quality" and "quality program" • Update references to TORs • Restore section 5.2	27-Mar-2015
This Document	The Aerospace Corporation Technical Report TR-RS-2018-00028, Quality Space and Launch Requirements Addendum to AS9100D. [also published as SMC-T-009 (2018)].	4-July-2018

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	Reorganized legacy requirements to align with AS9100D content/structure. Requirements were streamlined to remove duplication with current industry and space development standards: • The following sections were deleted. Duplicates AS9100D requirements. ▪ 4.2.3, Program Quality Approach at Field Locations. ▪ 4.3.3, Supplier Requirements. ▪ 4.4, Records ▪ 5.1, Quality Management ▪ 5.1.3, Product Assurance (PA) ▪ 5.1.4, Documenting Responsibility ▪ 7.3, Workmanship ▪ 7.3.2, Visual Aids ▪ 7.6.1, Control of Purchases – General Requirements ▪ 7.7.2, Completed Item Inspection and Test ▪ 7.8, Measuring and Testing Equipment: deleted first 3 sentences only ▪ 8.1, Disposition of Nonconformities ▪ 8.1.3.3, Scrapped Materials ▪ 8.7.1, Identification and Segregation of Nonconforming Material: deleted first sentence only ▪ 8.3, Control of Nonconforming Material ▪ 8.4.1, Discrepant Products ▪ 8.6.3, Analysis of Records ▪ 8.7, Addressing Systemic Issues • The following sections were amended. ▪ Manufacturing and Test Planning. Title changed to Manufacturing and Test Instructions ▪ Quality Program Plan. Flow of quality requirements to subcontractors and suppliers added • The following sections were deleted. Redundant with requirements in IEEE 15288.2, *IEEE Standard for Technical Reviews and Audits on Defense Programs,* with no additional QA-unique content. ▪ 7.1, Planned Reviews ▪ 7.1.1, Preliminary and Critical Design Reviews (PDR and CDR) ▪ 7.1.3, Test Readiness Reviews (TRR) • The following sections were deleted. Redundant with requirements in SAE International AS6500, *Manufacturing Management Program*, with no additional QA-unique content.	

Rev No	Description of Change	Effective Date
	▪ 7.1.2, Manufacturing Readiness Reviews (MRR) • The following sections were deleted. Redundant with requirements in Aerospace Report Number TR-RS-2015-00012/SMC-S-012, *Software Development*, with no QA-unique content. ▪ 7.6.5.2.2, Software Purchases • Throughout: ▪ Grammatical corrections as required for correctness ▪ Minor rewording of requirements language for clarity with no change to the requirement's intent	

Contents

1. Introduction (tailored)

SAE International AS9100D "Introduction" shall apply as stated with the following additions:

0.1 Foreword

From the early years of the space program, a set of military quality standards were developed and put on contract to mitigate any failures while the spacecraft or launch vehicle was still on the ground. As the government transitioned to commercial standards, AS9100 emerged as the quality standard for aviation, space, and defense organizations.

Throughout this document the documents ISO9001 and AS9100 will refer to the latest version of these documents (currently ISO9001:2015 and AS9100 Rev. D).

The highly complex nature of satellites and launch vehicles, coupled with the inability to repair vehicles on orbit, drives the Air Force Space Command, Space and Missile Systems Center (AFSPC/SMC) to impose stringent quality and reliability requirements on contractors to ensure products will meet their intended lifecycle.

AS9100 is a set of Quality Management System (QMS) requirements common to the entire Aerospace Industry. As a result, AS9100 lacks requirements specific to military space and launch vehicle programs, such as:

- Government access to the data and the controls necessary to perform independent verification and validation of services and products, which originated in MIL-Q-9858A, *Quality Program Requirements*

- A method for flowing down government requirements to suppliers, which originated in MIL-STD-1586A, *Quality Program Requirements for Space and Launch Vehicles*

Most importantly, the AS9100 standard by design describes what requirements to include in a QMS without specifying how to implement these requirements so contractors have flexibility in developing "how to" practices that satisfy these "what" requirements. However, this approach often inadvertently risks omitting military space best practices that ensure mission success.

The Air Force Space and Missile Systems Center realized the risk in relying solely on AS9100 and released a quality standard in 2005 to reinstate those specific requirements and best practices. This document maintains the requirements heritage, aligns with the restructure of AS9100, eliminates duplicate requirements in other SMC standards, and updates some requirements to better support current business practices.

0.2 Intended Application

The requirements of this standard, either in full or as appropriately tailored, is intended to be levied on prime contractors and flowed to subcontractors, and their sub-tier suppliers of space and launch vehicles.

Certification to these standards is encouraged, but will depend on the product being supplied, uniqueness of the capability of the supplier, costs of acquiring certification, and the criticality of the work.

In the event the subcontractor/supplier is not certified to ISO9001 or AS9100, the contractor should focus on verifying that subcontractor/supplier quality system meets the technical intent of AS9100 for the

intended contract. The contractor assumes the responsibility for satisfying ISO9001 or AS9100 requirements for purchased materials and parts from a supplier not certified to either standard. This may be accomplished through record keeping, additional testing, purchasing documentation, contractor second party audits, etc.

0.3 Tailoring

This standard is applied at the discretion of the customer in accordance with contractual direction. In each application, this standard may be tailored to the specific requirements of a particular program, program phase, or contractual structure as directed by the customer. Tailoring takes the form of deletion (removal of tasks not applicable or when willing to take more risk), modification (altering tasks to more explicitly reflect the application to a particular effort), or addition (adding tasks to satisfy program requirements).

The quality requirements discussed in this standard are applicable to all programs, irrespective of complexity, risk, or scope. However, the extent of QMS requirements will vary depending on the specific system being developed as well as contractual requirements. Tailoring of this guidance informs the customer of the contractor's choice of tools, measurements, metrics, and specific quality assurance methods and tasks. The contractor's tailoring of this guidance shall be subject to the customer's direction and approval. The objectives of the contract define the breadth and depth of the quality assurance process for each specific procurement.

The Aerospace Corporation realized the vacuum that was created by relying solely on AS9100 and released a quality standard in 2005 to reinstate those best practices. This document maintains that requirements heritage and aligns with AS9100, eliminates duplicate requirements, and updates some requirements to better support current day business practices.

1.1 Scope (tailored)

This SMC standard applies SAE International AS9100D as stated and adds requirements, definitions, and notes for military space and launch vehicle programs.

2. Normative References (tailored)

SAE International AS9100D "Normative References" shall apply with the following additions, to the extent specified herein:

SAE International AS5553B, *Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition*. 2012.

SMC-S-019 Revision A. *Program and Subcontractor Management*. 11 August 2008.

SAE International EIA-649-1, *Configuration Management Requirements for Defense Contracts*. 2014.

ANSI/NCSL Z540.3-2016, *Requirements for the Calibration of Measuring and Test Equipment.* 2006. (Reaffirmed 2013.)

SMC-S-009, *Parts, Materials, and Processes Control Program for Space Vehicles*. 12 April 2013. (Originally published as The Aerospace Corporation Report Number TR-RS-2013-00009.)

SMC-S-011, *Parts, Materials, and Processes Control Program for Expendable Launch Vehicles*. 31 July 2015. (Originally published as The Aerospace Corporation Report Number TR-RS-2015-00011.)

SMC-S-012, *Software Development*. 16 January 2015. (Originally published as The Aerospace Corporation Report Number TR-RS-2015-00012.)

SMC-S-013, *Reliability Program for Space Systems*. 13 June 2008. (Originally published as The Aerospace Corporation Report Number TOR-2007(8583)-6889.)

3. Terms and Definitions (tailored)

SAE International AS9100D "Terms and Definitions" shall apply with the following additions:

Contractor: For the purpose of this standard, contractor is synonymous with the AS9100 term "organization" and the term "prime contractor."

Subcontractor: For the purpose of this standard, subcontractor is synonymous with the AS9100 term "external provider."

Supplier: For the purpose of this standard, supplier is synonymous with the AS9100 term "external provider."

4. Context of the Organization

4.1 Understanding the Organization and its Context

SAE International AS9100D "Understanding the Organization and its Context" shall apply as stated.

4.2 Understanding the Needs and Expectations of Interested Parties

SAE International AS9100D "Understanding the Needs and Expectations of Interested Parties" shall apply as stated.

4.3 Determining the Scope of the Quality Management System (tailored)

SAE International AS9100D "Determining the Scope of the Quality Management System" shall apply with the following additions:

The contractor shall describe in a quality program plan (QPP) the scope and the approach for managing and implementing the quality requirements of this addendum. The requirements of this addendum shall be implemented and flowed down to their subcontractors on a project-specific basis by the contractor through the preparation, publication, and maintenance of detailed written procedures in a QPP.

4.3d Quality Program Plan (QPP)

If a QPP is requested as a deliverable data item, use Appendix A, "Quality Program Plan Data Item Description."

4.3e Software Quality

The software quality program approach shall be managed as a part of, and be consistent with, the general requirements for the overall quality program plan. For deliverable software, the contractor's approach to the program's software quality requirements shall comply with customer-approved software quality requirements. For contractor-developed non-deliverable software used to manufacture or test deliverable hardware or software, the contractor shall implement a disciplined management system for the validation and maintenance of such non-deliverable software. See SMC-S-012 for detailed software development requirements.

NOTE: The QPP often addresses design reviews, fabrication, audits (internal and external), failure reporting, and the corrective action system. It usually will address the approach for the control of parts, materials, processes, reliability, software, supplier control, quality, test, and delivery. Depending on the program. it may also identify launch site activities as well as integrated ground control activities. The quality program plan is a top-level document intended to describe how necessary functions will be organized and activities accomplished.

4.4 Quality Management System and Its Processes

SAE International AS9100D "Quality Management System and Its Processes" shall apply as stated.

5. Leadership

5.1 Leadership and Commitment

SAE International AS9100D "Leadership and Commitment" shall apply as stated.

5.2 Policy (tailored)

SAE International AS9100D "Policy" shall apply with the following addition:

5.2.2d be reflected in the QPP.

5.3 Organizational Roles, Responsibilities, and Authorities (tailored)

SAE International AS9100D "Organizational Roles, Responsibilities, and Authorities" shall apply with the following addition:

5.3.1 Quality functions, including software quality, shall be organizationally independent of realization functions responsible for contractually required products. However, if the contractor determines quality functions reporting directly to other realization functions (e.g., design, production planning, purchasing, production, test) achieves efficiencies, then the contractor shall demonstrate, using metrics, audits, or other verification activities, that this reporting structure does not compromise either the independence of those quality functions or the quality of the product. Furthermore, there shall be a documented process for quality personnel to alert the management representative to undue influence or pressure (e.g., cost and schedule) by the other functions.

6. Planning

SAE International AS9100D “Planning” shall apply as stated.

7. Support (tailored)

7.1 Resources (tailored)

SAE International AS9100D "Resources" shall apply with the following additions:

7.1.5.3 Measuring and Test Equipment

The contractor shall ensure the use of only subcontractor and supplier sources that have calibration systems that effectively control the accuracy of measuring and testing equipment. ANSI/NCSL Z540-3, *Requirements for the Calibration of Measuring and Test*, is applicable to the contractor and all subcontractors.

Note: Older contracts may specify MIL-STD-45662, *Calibration Systems Requirements*, and the contractor may not be able to justify the cost to re-negotiate these contracts. Note that this standard is cancelled. ISO17025 may be invoked for foreign suppliers, as they may not follow an American standard. ANSI/NCSL Z540.3 is replacing ANSI/NCSL Z540-1. Clause 7.8 should be tailored to agree with contractor practices, but the intent is to upgrade the measuring and testing equipment requirements to ANSI/NCSL Z540.3.

7.2 Competence (tailored)

SAE International AS9100D "Competence" shall apply with the following additions:

7.2.1 Personnel Certification

Contractor personnel performing or verifying complex or critical operations and processes requiring a high degree of skill shall be certified. Certification shall be based upon objective criteria, which include work experience, training, and testing. Certified personnel shall provide evidence of certification, which shall specify the period of effectivity. When possible, personnel shall show proficiency on non-flight hardware which is representative of flight hardware before being allowed to work on flight hardware.

7.2.2 Personnel Recertification

When certification expires, personnel shall be recertified by testing or review of objective evidence that supports satisfactory performance. The contractor shall also recertify each individual whenever significant changes are made in processes, techniques, or skill parameters, or when physical relocation or interruption of the work period would result in degradation of quality. Whenever inspections, tests, or quality audits identify that individual manufacturing or inspection personnel need additional training, they shall be removed from the operation, provided with additional training, and demonstrate the required proficiency before returning to work.

7.2.3 Skill Requirements

During initial quality planning, the contractor shall identify and provide for the physical requirements and skills needed to perform/verify critical processing and manufacturing operations. Requirements for manufacturing and inspection personnel shall include the levels of visual acuity and color perception needed to perform operational functions.

7.2.4 Training Program

The contractor shall maintain a training program to provide adequate skill levels, including formal and on-the-job training. There shall be sufficient formal training to ensure proficiency of persons performing complex or critical operations. The training program shall include indoctrination regarding reliability and quality requirements of the product. The contractor shall implement procedures to prevent untrained personnel from performing the processes.

7.2.5 Training Records

The contractor shall maintain records of the training, testing, and certification status of personnel. These records shall be accessible so that managers may expeditiously verify the status of each person.

NOTE: Managers know best the training requirements of personnel that work for them, whether they are the company's requirements (i.e., ethics, safety, security, etc.) or the specifics of the employee task (i.e., soldering, crane operation, welding, etc.). Managers can identify the specific training requirements for each employee. Best records management systems for training consists of the following five components:

- The first is a mechanism for the manager to identify the training required for each employee. This information is entered into a corporate training database.

- The second component is the corporate database which holds requirements and training or certifications recorded for each employee. This information is fed back to the employee in a timely fashion so that the employee can recertify or update training before certifications expire.

- The third component is a parallel reminder system to the manager, so that the manager is aware of any employee lapses in training.

- The fourth component is a lock out mechanism that prevents an employee from working on a program if he or she lacks the current training requirements for the task.

- The final component is ~~a~~ local records management that is conducted by the manager which records any on-the-job training (OJT). These records include who was trained, when the person was trained, and a copy of the material presented to each employee.

Weaknesses in the system can be identified by audits. Systems that divide training records, for instance by using separate databases for corporate human resource type training and technical training, add an extra layer of complexity which may allow a violation to occur.

7.3 Awareness

SAE International AS9100D "Awareness" shall apply as stated.

7.4 Communication (tailored)

SAE International AS9100D "Communication" shall apply with the following addition:

7.4.1 Shift Change Coordination

The contractor shall provide for adequate exchange of information between work shifts so production and test activities can proceed without interruption or delay. Exchange of information includes, as applicable,

test results and status, test failures, production status, equipment status and environmental controls, preliminary and material review status, staffing levels (such as the number of inspectors available), schedule changes, etc. This coordination can be accomplished by either overlapping the start and stop times of the two shifts involved or by documenting the information.

7.5 Documented Information (tailored)

SAE International AS9100D "Documented Information" shall apply with the following addition:

7.5.3.1c Tracking Requirements

All program policies and procedures addressing quality shall be readily available to all affected contractor personnel. The contractor shall verify that all requirements of this addendum are met by their quality management system. Tailoring of this addendum is permitted if deviations are documented and recorded in the contract.

8. Operation

8.1 Operational Planning and Control (tailored)

SAE International AS9100D "Operational Planning and Control" shall apply with the following additions:

k. Verify that the following activities are included for controlling work transfers and product work relocation:

1. Technical review
2. Risk assessment
3. Knowledge transfer
4. First and last article inspections
5. Production readiness reviews

8.1.2c If not specified by contract or tailoring, the contractor's configuration management shall conform to EIA-649-1, *Configuration Management Requirements for Defense Contracts*.

8.1.4.1 SAE International AS5553 shall be used as the basis for counterfeit management.

8.1.5 Process Variability Control

The contractor shall develop techniques to control process variability, and apply those techniques to processes affecting product key characteristics. Qualified, independent personnel from design, manufacturing, and test functions shall evaluate process variability controls and the accompanying documentation. As a minimum, the following shall be included in a process variability control activity:

a. Critical quality characteristics are identified, measured, and verified

b. Sufficient data is collected over a time frame that will ensure statistical validity of the variability analysis

c. Procedures and methods are established for preventive and corrective actions, and feedback is provided to design, manufacturing, and test operations

d. Process variability is measured by noting document uniformity, defect creation, time studies, incoming and delivered product acceptance, or other appropriate studies. The measurement may, but usually does not, involve a statistical analysis of results

Note: Process variability control is often a part of preventive action and may involve very simple process improvements.

8.1.5.1 Statistical Process Control (SPC)

When applying SPC to the control of processes or product, control limits shall be based upon documented statistical history of the process capability. Limits shall be established statistically or by other methods which take into account the accepted variability of the product. Data in the form of control charts or process histograms shall be available to production workers in realtime.

8.1.5.2 Out of Control Action Plan (OCAP)

The contractor shall document in an OCAP the actions to be taken when an out-of-control condition (OCC) is detected. These actions shall include as a minimum the definition of an OCC, the functional members of the team designated to investigate an OCC, when this activity will occur, and what actions the team is empowered to take. The OCAP shall document the steps to be taken should the process need to be halted because of excessive OCCs. The process shall be documented prior to the full implementation of the SPC application.

8.1.6 Program-Specific Requirements

The contractor shall develop a method to track and satisfy quality management requirements specific to and imposed by the contract. The method shall allow personnel to easily distinguish unique program quality management requirements from those of other programs.

8.1.7 Drawings, Documents, and Changes

The contractor shall ensure that drawings, specifications, and technical documents and changes thereto contain the design information necessary to ensure the quality of all items purchased or produced by the contractor. Engineering documentation errors shall be identified and corrected.

8.2 Requirements for Products and Services

SAE International AS9100D "Requirements for Products and Services" shall apply as stated.

8.3 Design and Development of Products and Services (tailored)

SAE International AS9100D "Design and Development of Products and Services" shall apply with the following additions:

8.3.4.2 Design Reviews

The contractor's internal design review process shall include participation of quality management, manufacturing management, specialty engineering, and other activities that use design documentation. This process should consist of review and approval of all design disclosure technical documentation and changes thereto prior to formal document release.

The review shall provide for independent evaluation by personnel knowledgeable and experienced in the quality aspects of the manufacturing process. For all new and modified designs, at the configuration Item level and above as defined by the contract, the appropriate customer representatives shall be notified of the design reviews and allowed to participate. At a minimum, the following characteristics shall be assessed:

a. Features that enhance or diminish the practicality of inspection, measurement, and verification of conformance to design requirements, including acceptance requirements

b. Proven and demonstrated inspection and test techniques to verify the adequacy of the design. Appropriateness of inspection and test procedures, as well as performance of personnel using the designated equipment, is demonstrated to detect design flaws in representative samples

c. Effectiveness of test points

d. Identification of unnecessary and unrealistic design complexity as judged by inspectibility and manufacturability

e. Evaluation of the extent to which single-point failure modes and mechanisms have been eliminated or compensating features included

f. Features that enhance ease of manufacturing

g. Unique or new tooling requirements

h. Complete, clear, accurate, and unambiguous display of technical requirements in drawings, specifications, other engineering documentation, and process standards

i. Specification of nominal useful life and identification of limited-life items and storage limits

j. Necessity and feasibility of special evaluation or inspection methods, including destructive and nondestructive evaluations

8.4 Control of Externally Provided Processes, Products, and Services (tailored)

SAE International AS9100D "Control of Externally Provided Processes, Products, and Services" shall apply with the following additions:

NOTE: To ensure that all quality requirements will be met, a common practice is to complete a requirements matrix which cross-references each paragraph of this standard with the quality requirements paragraphs in the contractor's policy and procedure documents, quality manual, and/or quality assurance plan. In addition, the matrix tracks contract-specific requirements. The matrix is then used to ensure contract-specific requirements are also met by each supplier.

8.4.1d All intra-contractor work transferred between departments, divisions, or other organizational segments shall be controlled to ensure compliance with the technical quality requirements of the contract in the same manner as if they were a supplier or subcontractor.

8.4.1.1f Prevent inadvertent products and/or services from being acquired from suppliers with unsatisfactory or unacceptable quality ratings or disapproved approval status

8.4.1.2 Determining Capability of Prospective Suppliers

The contractor shall perform pre-award surveys within the 18 months prior to contract start for prospective suppliers of flight hardware, whether these suppliers are new or have existing approvals for other complex flight hardware.

8.4.1.3 Pre-Award Survey of Prospective Suppliers

When the contractor performs a pre-award survey of the supplier's facility, the results shall be documented, available for review, and serve as a basis for required corrective action upon receipt of the subcontract. In surveying capability of an existing supplier to produce other/new flight hardware, the contractor may focus the survey on the unique factors related to the other/new flight hardware.

8.4.1.4 Survey Elements

The following factors, appropriate to the products or services to be furnished, shall be addressed during the survey:

a. Management organization and approach, especially significant changes in management

b. Inspection planning, controls, capability, and management

c. Product/commodity visibility and defect prevention program

d. Product/commodity performance analysis

e. Past experience with the type of product or service to be supplied

f. Configuration management system

g. Procedural control of hardware/software design and development documents and associated changes

h. Control of nonconforming products

i. Corrective action/continuous improvement program

j. Product technology and processing controls

k. Personnel availability/qualifications/certification, especially significant changes in personnel

l. Review/audit capabilities

m. Calibration capability and resources

n. Relevant industry alerts associated with the products or services to be provided by the supplier

8.4.1.5 Hardware Specific

The following factors apply only to hardware products and shall be addressed during the survey:

a. Manufacturing facilities, especially significant changes in facilities such as a move, merger, or acquisition

b. Capability/condition of manufacturing equipment

c. Control and maintenance of inspection equipment and production tools used as a medium of inspection

d. Material storage and handling

e. Control of nondestructive testing and special processes

f. Control of destructive testing

8.4.1.6 Software Specific

Software survey elements are discussed in more detail in TR-RS-2015-00012/SMC-S-012, *Software Development Standard for Mission Critical Systems*. The following factors apply to software/firmware products including source software to the extent that they are specified in the software quality assurance program plan and shall be addressed during the survey:

a. Software media controls

b. Software development standards and procedures

c. Existing software development, test and support tools, methods and measurements

d. Software validation/verification methodologies

e. Software library controls

f. Independence and qualification of evaluators

8.4.3n Immediate notification of any significant changes at a supplier's facility (e.g., facility moves, top-level management change, etc.)

8.4.4 Periodic Audit of Suppliers

Each active supplier of flight hardware shall be subjected to a periodic review/audit of their quality management system. The contractor's procedures shall define the type, frequency, and scope of reviews/audits to determine the continued capability of the supplier to control the quality of the products or services specified by the contract. Any significant changes at a supplier's facility (e.g., facility moves, top-level management change, etc.) or any evidence of poor quality shall trigger an immediate contractor audit. The contractor shall notify the customer representative of the audit schedule for suppliers of major/critical items and any changes to those schedules.

The contractor shall make use of relevant audits performed by other qualified organizations to satisfy the periodic review/audit requirement. However, when there is a technical concern, the contractor shall use program personnel with the necessary process specialists to investigate potential shortcomings of the supplier.

NOTE: It is recognized that audits are an expense and logistical challenge for suppliers, particularly when the supplier is dealing with multiple contractors. Therefore, the contractor is encouraged to use the results of other qualified organizations to satisfy the requirement. Typical audit results that may be used to satisfy the requirement are the following: registrar audits, supplier internal audits, and audits performed by different programs. The contractor may explore teaming with the supplier's internal audit effort to perform a joint audit to reduce the audit burden on the supplier.

8.4.4.1 Contractor Auditing Approach

Periodic audits addressing the quality management system shall be conducted in a structured manner.

8.4.4.2 Audit Team Training

The contractor shall establish auditor training and experience requirements for all members of the audit team. This training shall consist of a certification process to address technical audits as well as quality

management system audits. When a lead auditor conducts a quality management system audit, the lead auditor shall have completed a lead auditor course addressing the current standard of AS9100. The American Society for Quality (ASQ) Certified Auditor course completion is also suggested.

8.4.4.3 Checklist

A checklist shall be prepared to explain the scope and detail of the proposed audit. This checklist shall be shared with the supplier at least one week in advance of the audit with one exception: if the audit is an unannounced audit because of a technical issue, the checklist does not need to be shared with the supplier.

8.4.4.4 Evaluation by Supplier Management

Audit team performance shall be evaluated by management as defined in the contractor's procedures. The evaluation shall be used to determine if the auditors are qualified to participate in future audits. If auditors are no longer considered qualified, they shall receive additional training and mentoring before continuing the audit activity.

NOTE: Possible alternative ways to evaluate auditors would be performance reports by the lead auditor or evaluation of the audit team by the supplier. In addition, auditor training should be coordinated between the contractor and the supplier. The lead auditor may be evaluated by the quality and timeliness of the final report as well as evaluation by participating auditors or supplier evaluation.

8.4.4.5 Supplier Requirements

The supplier shall provide an introduction of its quality management system to the contractor or subcontractor prior to the visit so the audit team may use this information during the course of the audit. At minimum, this introduction shall include descriptions of work order and build paper work systems, databases, and contact personnel.

NOTE: Suppliers may consider sharing their results of registrar audit reports or audit reports from other programs of the same contractor or subcontractor. The purpose of the sharing would be to eliminate duplication of audits if the contractor or major subcontractor plans to audit a process that has recently been audited by another team.

8.4.4.6 Virtual Audits

Except for critical items, the contractor may consider the use of virtual audits when all supplier data to be reviewed is stored electronically. If a virtual audit is used, the contractor shall send one or more auditor(s) to be on site while the virtual audit is conducted so that a physical examination of the facility and product may still be made.

8.4.4.7 Supplier Rating System

A supplier rating system shall be devised by the contractor and described in written procedures. For each supplier and for each type of commodity/product being purchased the system shall:

1. Yield basic data for visibility of supplier quality performance and trends.

2. Rate each supplier for quality of performance for each type of commodity/product purchased.

    a. Consider applicable inspection and test results, when available, from verification activities in addition to other quality performance (i.e., delivery, field returns, timely reporting, etc.).

3. Establish range and separation for each distinct rating category (e.g., satisfactory, marginal, unsatisfactory, or unacceptable).

4. Influence supplier approval status (e.g., approved, conditional, disapproved**)**

5. Implement and track additional verification activities and other precautions when purchasing products from suppliers rated below the satisfactory rating and/or below the approved status level.

6. Report ratings to suppliers, and allow suppliers to offer objective evidence on their behalf to counter mistakes or misinterpretations of data that form the basis of the ratings.

7. Periodically (minimum quarterly) update ratings of each supplier.

8.4.4.8 Purchasing Data; Responsibility

The contractor's supplier quality assurance program shall provide for a review of purchase documents to ensure applicable quality requirements are included or referenced in the documentation for compliance by the supplier. The review shall be accomplished as early as possible in the procurement cycle to ensure the incorporation of all requirements applicable to the specific purchase. The office responsible for this review shall be identified in the contractor's procedures.

8.4.4.9 Purchase Documentation Evaluation

Contractor evaluation of the purchase documents shall be accomplished under control of the quality organization to ensure that an adequate description for the products to be provided is included in the documentation.

8.4.4.10 All Purchases

The evaluation shall ensure instructions are included in all purchase documents for the following as appropriate:

a. Manufacturing requirements and controls
b. Inspection and testing
c. PM&P specifications/standards
d. Control of critical items
e. Special qualifications, approval, or certifications
f. Nondestructive and destructive test controls and record keeping
g. Control of hardware/computer software documentation and changes
h. Applicable product and process specifications
i. Reliability and maintainability
j. Safety factors
k. Packaging, handling, storage, and transportation (PHS&T)
l. Contractor source quality control inspections
m. Government-Industry Data Exchange Program (GIDEP) participation

n. Age control/limited shelf life materials and products
o. Customer-furnished equipment
p. Contractor-furnished equipment
q. Data retention
r. Control of tool and test equipment
s. Nonconforming products
t. Reviews/audits
u. Identification of hardware and software deliverables
v. Unique Identification Designator (UID)
w. Variability reduction and/or SPC program
x. Trace between purchased product/service and project requirements for hardware and software, including embedded software

8.4.4.11 [Reserved]

8.4.4.12 Control of Quality

The contractor shall be responsible for the following functions at the supplier's facilities when the contractor stations personnel at the supplier because of the criticality or volume of the work:

a. Perform complete or sampling inspection of product characteristic

b. Ensure the adequacy of, and conformance to, the controls for special manufacturing processes

c. Ensure the adequacy of, and conformance to, the controls for inspection and test equipment

d. Verify conformance to configuration management procedures for engineering drawings and computer software

e. Determine conformance to the supplier's established approach to quality requirements and their inspection system

f. Evaluate the methods for controlling nonconforming products and ensuring the correction of the cause of nonconformance

g. Document results of evaluations and inspection performed

h. Indicate acceptability of products contained in each shipment, as applicable

i. Verify that qualification and acceptance tests are conducted to contractually specified procedures

j. Verify compliance with contractual requirements to include timely notification to management when discrepancies/deficiencies are discovered

8.4.4.13 Control of Critical Items

When the contractor assigns permanent representatives at the supplier, the contractor shall maintain strict control of critical items and their processing regardless of manufacturing/process location. Purchase orders for critical items shall specify special PHS&T requirements. The following documentation shall be

submitted to the contractor as part of the supplier's quality assurance plan or in a critical item control plan.

a. The methods and the type of critical processing to be used (subject to limitations imposed because of proprietary information)

b. The location within the processing cycle where inspections, audits, or walk-throughs will take place

c. The attributes of the products that will be inspected at each inspection point

8.4.4.14 Source Inspection

When surveillance and/or an examination of customer-purchased product is required at the supplier's facility to ensure product integrity and conformance to specified requirements, the contractor shall provide resident or itinerant quality assurance representative(s) to perform this activity at the subcontractor's or supplier's facility. The requirement for a resident quality assurance representative shall be based on item design, mission criticality, and subcontractor or supplier past performance. The contractor shall have instructions provided prior to the inspection for each resident or itinerant quality assurance representative to delineate their responsibility and authority at the subcontractor's or supplier's facility.

8.4.4.15 Unit Source Inspection

The contractor shall inspect all supplied flight units and critical items at the supplier's facility unless otherwise specified in the contract. These inspections shall use configuration-controlled, product-specific inspection plans that identify surveillance points and sampling plans for product design characteristics.

8.4.4.16 Receiving Inspection

Products and services produced by outside sources for incorporation in the contract end item shall be subject to inspection/audit at time of receipt or if further processing is required for acceptance, at a time that does not violate the supplier's contractually specified warranty period. In either case, the product shall be accepted prior to full integration of the product. A contractor, in lieu of receiving inspection/audit, may use objective quality evidence submitted by the supplier. The use of such evidence does not relieve the contractor of responsibility to meet all contract requirements. In addition to verifying that the products and services comply with requirements of the purchase document, the products and services shall be verified against the latest applicable engineering changes or software specifications.

8.4.4.17 Delegation of Product Verification

When a contractor delegates product verification, the contractor shall conform to the requirements of AS9015, *Supplier Self Verification Process Delegation Programs*. The contractor may reserve the right to conduct surveillance of the supplier's facility to determine if the supplier is compliant to AS9015. The contractor's receiving inspection may reserve the right to re-inspect/retest the supplied products if deemed critical for system performance.

8.5 Production and Service Provision (tailored)

SAE International AS9100D "Production and Service Provision" shall apply with the following additions:

8.5.1r

The contractor shall establish workmanship standards if the standards are not specified by contract or statement of work (SOW). These standards can be part of design specifications, drawings, work instructions, or other readily available specifications and standards. These standards shall be derived from industry-accepted workmanship standards and also be based on the contractor's manufacturing experience. All standards shall be aimed at delivering the highest quality and most reliable hardware to the customer possible within the constraints of the contract. All standards shall define specific detailed acceptance or rejection criteria.

8.5.1s Cleanliness, Contamination, and Corrosion Control

The contractor shall review and identify the cleanliness, contamination, and corrosion control requirements derived from hardware specifications and ensure that procedures are developed to adequately protect the hardware during manufacturing, test, and PHS&T. Implementation of controls shall be monitored by quality assurance on a regular basis.

8.5.1t Control of Physical Environment

The contractor shall ensure through periodic audits or automatic control and warning systems that the physical environment (such as temperature, humidity, light, arrangement of work areas, or arrangement of machines and equipment) is controlled to preclude inadvertent damage to hardware and to prevent unsafe conditions in all work and storage areas.

8.5.1.1a Equipment Validation

The contractor shall establish a method to validate the machines, equipment, and procedures prior to use in complex, critical operations. Records shall be maintained of the validation performed. Machines, equipment, and procedures shall be revalidated as indicated by the results of quality trends or when major process changes are made (i.e., such items as material thickness, design, power source, capacity, voltage, density, swap out of equipment, move of facilities).

8.5.1.1b Production Tooling used as a Media of Inspection

The contractor shall control production tooling used as a media of inspection to ensure continued accuracy between periods of tool proofing.

8.5.1.1c Tooling Records

The contractor shall maintain records of tool proofing which provide for each tool the date last proofed, condition found, maintenance performed, and date of next proofing.

8.5.1.1d Tool Proofing Intervals

The contractor shall analyze the records of tool proofing to shorten intervals as required to ensure continued accuracy, or to lengthen intervals when the results of previous tool proofing provide definite indications that such action does not adversely affect the accuracy of the tool.

8.5.1.4 First Article inspections shall be performed to requirements in AS9102, *Aerospace First Article Inspection Requirement*.

8.5.1.4.1 Critical Item Quality Control Requirements

The contractor shall establish and maintain appropriate critical item control. Manufacturing shall include any special instructions in the appropriate planning shop folders, process plans, log books, and related documents controlling the manufacturing and movement applicable to in-house manufacturing. Components or materials selected for preferential treatment shall be conspicuously marked or tagged to alert personnel of special requirements unless such marking or the process of marking increases the likelihood of damage to the critical item. These items shall be segregated or have distinctively marked fixtures and locations in all stock rooms, holding, and staging areas. Such items shall be regularly and systematically inspected for condition of expired time, cycle, or calendar life. Items with expired time, cycle, or calendar life shall be identified as nonconforming and properly dispositioned. Reviews of selected critical items shall be periodically conducted to verify the adequacy of work instructions and standards being used. If virtual marking is used, the contractor's quality organization shall periodically review the effectiveness of electronic tagging rather than physical tagging.

8.5.1.4.2 Critical Item Verification

For each critical item, beginning at the start of assembly and at progressive levels of assembly and test, the contractor's quality organization shall verify that the contract, drawing, and specification requirements have been met on all such articles and materials, procured or produced. Anomalies, including trends, deviations from expected norms, and marginal conditions shall be identified. Detailed assessment of the quality of these items and their manufacture shall include:

a. Identification of potential design and layout problems which could cause latent defects or marginal performance

b. Verification that current manufacturing test methods and controls are producing repeatable products

c. A review of manufacturing problems, if any, which could be alleviated by additional (or revision of) engineering information

d. Verification that critical parameters are measured and verified by applicable test procedures

e. Decisions, dispositions, corrective actions, or recommendations are evaluated against appropriate criteria and previous history data

f. Anomalies noted or observed during review are analyzed, evaluated, and dispositioned

g. Records are progressively reviewed and made part of the overall acceptance criteria

h. Identification and resolution of the differences between as-built and design documentation

i. Evaluation of failure and discrepancy reports to verify that reports identify underlying causes (symptoms or manifestations) and a summary of overstress and induced secondary failures

8.5.1.4.3 Manufacturing and Test Instructions

The contractor shall develop manufacturing, inspection, and test instructions for all segments of the manufacturing cycle, which shall include flow charts or other effective alternative methods of identifying all inspection and test points. The contractor's quality organization shall participate in the planning development and shall review and approve the instructions prior to release. Instructions shall include or reference engineering requirements, such as drawings, material specifications, process specifications, and workmanship standards, to ensure that necessary tests and inspections are effectively performed to verify that the product meets technical requirements. Test instructions shall identify the characteristics to be measured, the methods of measurement, and the point at which the test is to be performed. Any changes made to production processes, equipment, and/or test equipment/tooling shall be documented. Results of such changes shall be assessed. The contractor shall address the following in developing the required manufacturing inspection and test instructions:

a. Sequence of all manufacturing, inspection, and test points to ensure continuity and effectiveness of all operations

b. Inspection and test performance at the optimum item indenture level to minimize repair or rework at higher indenture levels. All workmanship shall be inspected at least once and preferably twice before being covered up by subsequent operations. If a second inspection is employed, the inspection approach should not be an exact duplicate of the first inspection. For instance, it could be at a higher level or involve a different approach than the first. Successive inspection is also a suitable approach in lieu of one of the quality inspections.

c. Sufficient module-level environmental testing and burn-in

d. Cleanliness/contamination control to include foreign object control

e. The adequacy of in-house handling and packaging, including provisions for protection of electrostatic discharge sensitive items

f. Availability and utilization of applicable drawings, specifications, and standards

g. Clearly defined acceptance or rejection criteria for each inspection or test

h. Special attention to monitor and document critical items and their characteristics

i. Visual aids for inspection and assembly personnel

j. Appropriate selection, application, use, and control of substances, chemicals, shop aids, clothing, and expendable materials specified and used in the manufacturing process (cleaning materials, adhesives, joining material, solvents, rags, etc.)

k. Test equipment, tooling, jigs, fixtures, and other fabrication equipment to be utilized

l. Insertion of appropriate mandatory inspection points for manufacturing and quality organizations

m. Inclusion of manufacturing readiness reviews (MRRs), test readiness reviews (TRRs), and hardware acceptance reviews for units and other configuration items

n. Provisions to record process data, e.g., start and stop times, temperatures, torque values, etc.

8.5.1.4.4 Electronic Sign-off of Operational Instructions

When using computerized systems for electronic sign-off (buy-off) of operational instructions, the contractor shall:

a. Ensure the system cannot bypass discrete tasks in a prescribed work sequence

b. Document a method for operators positively accounting for multiple operations performed when access to data entry terminals is impractical from the work location, and subsequently verifying after-the-fact completion of discrete operations in electronic sign-offs

c. Cross-check the training records to ensure only qualified and trained personnel can perform the prescribed tasks

8.5.1.5 Electrostatic Discharge (ESD) Control Program

Procedures shall be established for the surveillance of the ESD control program. This shall include identification of items susceptible to electrostatic discharge and protective features to prevent such damage, including, as a minimum:

a. ESD control levels
b. Protected work areas and protective clothing
c. Process controls and workmanship standards
d. Packaging, handling, storage, and transportation (PHS&T)
e. Training
f. Marking of documentation and hardware
g. Audit plan for certified ESD workstations

8.5.1.6 Nondestructive and Destructive Evaluation

Nondestructive evaluation methods and verification techniques (and attendant equipment and facilities), which are used to perform quantitative measurements, integrity analysis, and nondestructive testing, shall be controlled and integrated into the contractor's qualification, calibration, certification, and standards procedures. Nondestructive evaluations for flight hardware shall be performed by certified personnel (e.g., American Society for Nondestructive Testing (ASNT) certification). Destructive evaluation methods shall be controlled in a similar method to nondestructive evaluation methods.

8.5.2.1 Documentation Process

The contractor shall establish a system for identification, traceability, and control of parts, materials, and assemblies from acquisition (purchasing), including special screening tests through manufacturing/production, assembly, and delivery. Flight units and specified critical items shall require individual identification and data retrieval, which includes design and manufacturing documentation traceable to their origin. This will provide the capability of tracing backward from fabricated hardware to the records or material from which the item, part, and material originated. Identification and retrieval shall be required through all levels of higher assembly. The system shall provide for identification and suitable marking of flight hardware.

8.6 Release of Products and Services (tailored)

SAE International AS9100D "Release of Products and Services" shall apply with the following additions:

8.6.1 Hardware Acceptance Reviews (HAR)

Before integrating units or other configuration items into subsystems or systems at the contractor, subcontractor, or other facility, the contractor shall conduct a HAR to ensure the quality and reliability of the hardware. The data package contents described below shall be available for review prior to and during the HAR.

Personnel assigned to perform a HAR should be familiar with the basic design, construction, and test of the spacecraft or launch vehicle hardware in addition to the particular subject matter associated with the unit(s) under review. While the conduct of HARs is often viewed as a Quality function, composition of the review team may have a variety of disciplines including systems engineering; design; test; manufacturing; reliability; and parts, materials and processes (PM&P). The appropriate customer representatives shall be invited to HARs and allowed to participate.

The minimum data review shall include the following:

- Final inspection and acceptance test records showing unit acceptability
- Complete unit-level nonconformance reports, MRB actions, failure reports and test/failure review board actions, and associated analyses (e.g., overstress analyses, summary-level rework and repair)
- Complete test history records with environments seen and sequence of testing
- Identification of any unverified failures encountered with an associated risk analysis, including analysis of worst-case repairs, as applicable, as well as out-of-family test results
- Cumulative unit operating time/cycles, vibration, and temperature exposure logs and data
- Unit as-built versus as-designed configuration records with appropriate reconciliation or any deltas
- All waivers and deviations requested and approved for the unit
- History of the unit from the time it is first integrated into its next higher assembly, including installation and removal data
- Storage environment and length of storage if stored for longer than six months

A more comprehensive HAR may include the following:

- Complete unit build history starting at the lowest level of assembly
- Identification of manufacturing instructions and processes used to build the unit
- Complete chronological build, inspection, and test records, including physical and functional discrepancies, their resolution, and detailed repair and rework history

- Analysis of trend data across the unit being tested and comparison with other like units
- Complete identification of associated test equipment and test software, where applicable, along with critical calibration results
- Bill of materials or component/part trace records reflecting traceability of parts, materials, and subassemblies installed
- Complete storage history
- Product photographs and drawings

8.6.2 Recording and Retrieval of Records

Provisions shall be made to record and retrieve information relating to the specific tests performed, test results, and processes on each lot of parts and materials including pre-screening or lot retests. When serialization is required, controls shall be established to ensure that identification serial numbers are assigned in a consecutive manner. Records shall indicate applicable part or material identity and associated detailed information.

8.6.3 Unit-Level Data Packages

The contractor shall establish and maintain data packages for all units, including all subcontracted units. The packages shall contain the complete chronological history from the beginning of unit build through final acceptance of the unit. A fully integrated data package shall be available for customer review. It is required for each serialized unit of the flight as well as qualification items, including spares. The package shall include, as a minimum, the following:

a. Complete unit build history starting at the lowest level of assembly

b. Identification of manufacturing instructions and processes used to build the unit

c. Complete build inspection and test records, including physical and functional discrepancies, their resolution, and repair and rework history

d. Material review board (MRB) actions, waivers, and deviations, where applicable

e. Test history, including environmental test exposure and related measurements, where applicable; trend data across the testing; accumulative trend data across family of units; failures and anomalies during unit test; resolution; and retest

f. Identification of associated test equipment and test software, where applicable, along with critical test calibration results

g. Associated failure reports, including failure analyses leading to identification of root cause, disposition, and corrective action

h. Identification of any unverified failure (a failure in which the root cause has not been clearly established) and analysis of worst-case repair, if applicable. If, in subsequent testing, the failure never occurs again, rationale should be given for ascribing the failure to a cause other than flight hardware

i. Cumulative operating time or number of cycles and accumulative vibration and temperature exposures when applicable

j. Unit as-built configuration description including a configuration status accounting for the as-built versus as-designed configuration at the time of unit delivery

k. Records reflecting traceability of parts, materials, and subassemblies installed

l. Storage history

m. History of the unit from the time it is first integrated into a higher assembly, to include initial installation date; removal date(s); reason for removal; discrepancy and failure history; and traceability references to all inspection, discrepancy, failure, rework, repair, and retest paperwork

n. High resolution of product photographs from before conformal coating, after conformal coating, and before enclosure closing, as appropriate.

8.6.4 Vehicle-Level Data Packages

The contractor shall establish and maintain a data package for each serial numbered vehicle. (See implementation at end of section.) An end item data package shall be delivered in accordance with the contract data requirements list (CDRL). The data package shall contain the complete integration and test history starting with subsystem integration and continuing through final acceptance test of the vehicle. The data package contents shall be available for review by the customer. Each package shall contain, at a minimum, the following:

a. Build log

b. Inspection history

c. Chronological test history, including all out-of-sequence operations

d. Configuration status accounting of the as-built versus the as-designed configuration

e. A record of failure, anomalies, variations, and deviations identified during vehicle-level or system-level test (including any retest) and their resolution, including root cause determination and corrective action

f. Identification of any unverified failure (a failure in which the root cause has not been clearly established) and analysis of worst-case repair, if applicable. If, in subsequent testing, the failure never occurs again, rationale should be given for ascribing the failure to a cause other than flight hardware

g. Test history including environmental test exposure and related measurements, trend data across the testing, and accumulative trend data across family of vehicles, where applicable

h. Applicable waivers, deviations, and vehicle-level MRB actions

i. Component/equipment time recorded, status of on-time, or number of cycles for cycle-sensitive items

j. Modification history, including a list and description on any modification approved and scheduled for retrofit

k. Installation history of traceable components, including removal and replacement history

l. Connector mate/demate logs

Note: In recent years, contractors and suppliers have moved toward storing on computer systems all quality records associated with unit- and vehicle-level data packages. In this approach, the data package is usually not a collocated set of data, but rather consists of a series of separate links to the relevant data. If this approach is used, the contractor should ensure that the data is still retrievable and consistent with program data retention requirements under any future data system updates, changes in software, or system failures. Furthermore, the contractor makes the data accessible to any customer representative performing a review or audit of the data. In addition, the contractor should maintain a map or instruction set as to where the data is stored and how it can be accessed. This requirement ensures that when the program is at its end, a person can locate the necessary data without special knowledge of the program or how the data were organized.

8.7 Control of Nonconforming Outputs (tailored)

SAE International AS9100D "Control of Nonconforming Outputs" shall apply with the following additions:

8.7.3 Segregation of Nonconforming Material

Nonconforming material to be submitted to the MRB shall be moved to a controlled area designated for storage of nonconforming material unless not practical due to size, configuration, environmental requirements, or other conditions authorized by the customer. The designated area shall be protected to preclude unauthorized removal of nonconforming material. Explicit containment assessment shall be performed and documented for other inventoried components that are suspect for the same nonconformance (e.g., other lots of the same part number, similar parts utilizing the same nonconforming process, same operator, same tooling processes).

8.7.4 Discrepant Purchase Documents

Products received that conform to requirements of the purchase document, but fail to conform to the latest applicable engineering revision, shall be placed in "hold status" pending resolution of the conflicting purchase/engineering documents. Subsequent handling of the product, if nonconforming, shall be in accordance with the contractor's established procedures. The contractor shall notify the customer representative when the decision is made to continue processing nonconforming items.

8.7.5 Nonconforming Material Documentation

The contractor system shall maintain records of all nonconforming material, dispositions, assignable causes, corrective actions, and effectiveness of corrective actions. These records shall be organized to permit efficient retrieval for summarization, knowledge of previous dispositions, and corrective action monitoring. The contractor shall ensure that documentation of nonconformance includes the following:

a. Identification name or number which is traceable to the contract number

b. Initiator of the document

c. Date of the initiation and closure

d. Identification of the document for traceability purposes

e. Specific identification (e. g., part number, name, national stock number) of the nonconforming material

f. Quantity of items involved

g. Number of occurrences

h. The place in the manufacturing process where the nonconformance was detected

i. A detailed description of the nonconformance

j. Identification of the affected specification, drawing, or other document

k. A description of the cause(s)

l. Disposition of the nonconforming item (return to supplier, rework, use of an SRP, scrap, or refer to MRB)

m. Identification of personnel responsible for making the disposition decision

n. A description or reference to document containing a description of the issue resolution, workaround, or risk mitigation (alternative reference to a document with information)

8.7.6 Material Review (MR)

Contractor-appointed personnel shall conduct a material review, in a timely manner, of all nonconforming material. The contractor shall ensure that the customer is kept informed of its investigation and deliberations on these potential dispositions so that the customer may act upon material review recommendations in a timely manner. When a material review board (MRB) is constituted, a designated customer representative shall be a member of any MRB. To expedite the review and disposition process, the contractor, with MRB concurrence, may elect to implement a preliminary review as defined below. MR shall address the following:

a. Review and concur in all proposed use-as-is and repair dispositions and justifications

b. Review and concur in all proposed SRPs

c. Ensure that a written engineering analysis accompanies proposed use-as-is and repair unless a SRP is applicable

d. Disposition of nonconforming material into one of the following categories:

    1. Scrap

    2. Return to supplier

    3. Repair and/or rework by an approved standard repair/rework procedure (SRP)

4. Repair and/or rework by other than an SRP

5. Use-as-is

6. Request a waiver from the contracting officer

e. Review hardware repair and rework histories to ensure that hardware is still fit for use

Note: Traditionally, MR has been performed by a formalized MRB, which should meet on a periodic basis. A MRB should be chaired by a representative of the contractor's quality organization and may include, as required, personnel representing other contractor technical functions necessary to determine appropriate disposition of nonconforming material. As a minimum, the MRB should include the chairman and a representative of the contractor's engineering organization responsible for product design.

MRB members may call upon other contractor personnel and customer representatives for technical advice. If warranted by the volume of nonconforming material or the diversity of work operations, more than one MRB may be established. A designated customer representative should be considered a member of the MRB. The appropriate customer representative should be notified of all MRB meetings.

When the volume of nonconforming material is small, a MRB structure may not be warranted. In this case, the contractor may opt for a "tiger team" approach to each significant nonconformity. For any alternative to an MRB, the contractor must demonstrate all requirements of this clause are met by the alternative approach.

8.7.7 Preliminary Review (PR)

When material is initially found to be nonconforming, it may be dispositioned through the approved PR process by contractor-appointed quality personnel, assisted by other contractor personnel as necessary. PR process is an expedited implementation of the MRB process using pre-determined and MRB pre-approved way of dispositioning nonconformances and does not negate the requirement for identification, documentation, and corrective action associated with nonconformance. It does recognize that some nonconformances can be handled more economically at the location of initial detection through use of approved standard repair or rework procedures. PR disposition shall be one of the following:

a. Scrap the material because it is obviously unfit for use and cannot be economically repaired or reworked

b. Repair and/or rework using an approved standard repair/rework procedure (SRP)

c. Return of the material to the supplier

Note: The MRB is the only contractor-constituted board authorized to determine or recommend disposition of nonconforming material as specified in the contractor's directive documents. Directive documents may also extend limited disposition authority to the PR and MR functions.

8.7.7.1 Delegation of MR Authority

The contractor may delegate all or a specified part of MR authority to a subcontractor or supplier. Delegation shall be with customer agreement and be specified in the contract. The contract shall also specify under what conditions the delegation is revoked.

8.7.8 Use-as-is Dispositions

Requirements pertaining to use-as-is dispositions are as follows:

a. When a designated customer technical representative resides at the contractor, subcontractor, or supplier's facility, the representative shall participate in all use-as-is dispositions as a member of the MRB. If no designated customer technical representative is on site, the customer reserves the right to subsequently review such dispositions

b. All use-as-is dispositions shall include any recommended documentation change and the method for accomplishing the change (i.e., design change; changes to technical documentation including drawings, specifications, and technical orders; or recommended changes to customer specifications)

c. Contractual agreements shall exist with the System Program Office (SPO) and Defense Contract Management Agency (DCMA) for a customer representative to participate in use-as-is dispositions

8.7.8.1 Repair Dispositions

Requirements pertaining to repair dispositions are as follows:

a. When a designated customer technical representative resides at the contractor, subcontractor, or supplier's facility, the customer shall participate in all repair dispositions as a member of the MRB. If no designated customer technical representative is on site, the customer reserves the right to subsequently review such dispositions

b. Instructions for reprocessing of material after completion of repair and before its release shall be included in the SRP or other repair procedure. These procedures shall include the requirement for contractor inspection and test, as required

c. Contractual agreements shall exist with the SPO and DCMA for a customer representative to participate in repair dispositions

Note: The purpose of repair is to reduce the effect of the nonconformance. Repair is distinguished from rework in that the characteristic after repair still does not completely conform to the applicable drawings, specifications, or contract requirements. Except for standard repair procedures (see below), proposed repairs approved by the customer should be authorized for use on a one-time basis only.

8.7.8.2 Standard Repair/Rework Procedures (SRP)

SRPs allow a repair or rework disposition to be made by PR rather than MR. The contractor shall implement measures to detect repeated nonconformities requiring repair or rework, track their frequency, and establish a documented technique for setting the threshold for establishing a SRP. The threshold may depend on a number of factors such as frequency of occurrence, severity of the nonconformity, cost to redesign to eliminate the nonconformity, etc. The SRP shall be used when it is a cost-effective approach for addressing a repeated nonconformity. Requirements pertaining to the approval and use of a SRP include the following:

a. The SRP shall be developed by the contractor, reviewed and concurred by the MRB

b. The SRP shall be used only if the customer, as a member of the MRB (or equivalent body), concurs and approves of the SRP

c. Approval of a SRP shall include the establishing of the duration of use and/or frequency of use before the SRP must be re-evaluated

d. The contractor shall maintain records detailing the dates of use and number of applications of the SRP

e. The contractor shall review SRPs periodically to ensure that they are complete, up to date relative to current process capability and state of the art, and are being properly applied under the conditions defined for their use

Note: This standard suggests that a proactive method to address repeated nonconformities is to install a system that can detect repeated nonconformities. Often this is a subjective process and therefore cannot be fully implemented by an automated system. Repeated nonconformities may be detected by similar failure points, similar repair/rework procedures, or operator or inspector observation.

Sometimes work instructions are created by copying and pasting repair steps from a previous and similar repair/rework. The weakness in this nondocumented method is copying and pasting is subject to errors, particularly if the copying is not done from a common source. If a significant effort is being made to copy and paste repair/rework processes, the contractor should implement a standard repair/rework to ensure the repair/rework is well thought out and consistently applied.

9. Performance Evaluation

9.1 Monitoring, Measurement, Analysis, and Evaluation (tailored)

SAE International AS9100D "Monitoring, Measurement, Analysis, and Evaluation" shall apply with the following additions:

9.1.1.1 Construction of Metrics

Metrics used to report quality status shall be constructed to be actionable, consistent, and used to make decisions.

Note: Contractors have found it useful to publish with the metric the following: person who assembled the metric, explanation of the calculations involved when they are not obvious, conclusion, and recommendation for action, if any.

9.1.1.2 Cost of Poor Quality

The contractor and subcontractors shall collect nonconformance cost data consisting of a minimum of scrap, rework, and repair costs as specified in the contractor's directive documents.

9.1.2.1 Customer Rights

The customer reserves the right to review all contractor procedures developed to implement this standard; observe PR, CAB, and QIP activities; participate in MRB activities; and review documents or other data required by this standard.

9.1.4 Minimum Data Summarization Requirements

The contractor shall analyze nonconformance data from section 8.7.5 to determine the need for and effectiveness of corrective actions. The contractor shall summarize nonconformance data, including linkage to specific nonconformances, on a minimum quarterly frequency. The summarization shall include the following data:

a. Quantity of nonconforming items
b. Number and type of nonconformances
c. Number and type of dispositions
d. Cause determinations
e. Type of corrective actions and status
f. Delinquent corrective actions
g. Nonconformances recurring after implemented corrective actions
h. Cost of poor quality, per Section 9.1.1.2
i. Trend information and analysis thereof

9.2 Internal Audit (tailored)

SAE International AS9100D "Internal Audit" shall apply with the following addition:

9.2.2g Schedule and conduct audits of personnel, procedures, and operations to determine if the QPP is properly implemented. Each audit shall include examination of selected operations and documentation and an evaluation of actual operations as compared with established requirements (i.e., process

compliance). Audits also include recommendations, as appropriate, for remedial and preventive action, and follow-up verification to assess effectiveness of actions taken in response to audit findings. Audits include examination of articles, materials, and products to verify effectiveness of the contractor's processes and practices regarding technical and/or contractual requirements, as appropriate. The appropriate customer representative shall be informed of audits scheduled and be allowed to participate in the audits as contractually required:

a. Audit plans, checklists, and other such tools shall be prepared to guide the audit. They shall be based on customer and contractor requirements.

b. The results of audits in each area shall be documented with appropriate responses for correction of deficiencies. Management action shall be taken to ensure effective correction of the reported deficiencies.

9.3 Management Review (tailored)

SAE International AS9100D "Management Review" shall apply with the following addition:

9.3.4 Reviews

Top management shall monitor the effectiveness of the quality management system through periodic quality reviews in the following areas as a minimum:

a. Failure/discrepancy data

b. Process trend data

c. Status of internal and external (subcontractor/supplier) process/product improvement, preventive, and corrective actions implementation and closure

d. Scrap/rework/repair internal and external (subcontractor/supplier) metrics and trends

e. Costs and quality status for in-plant, intra-contractor operations, subcontractors, and major suppliers

f. Follow-up actions from previous reviews

g. Recent changes that could affect the quality management system

Records shall be kept of these reviews and recommendations. The frequency of these reviews shall be specified in the contractor's Quality Program Plan.

10. Improvement

10.1 General

SAE International AS9100D "General" shall apply as stated.

10.2 Nonconformity and Corrective Action (tailored)

SAE International AS9100D "Nonconformity and Corrective Action" shall apply with the following additions:

10.2.3 Corrective Action Board (CAB)

The CAB shall ensure that an effective corrective action system is in place to improve product quality. This function shall be performed through review and analysis of nonconformance data. The CAB shall ensure that records of causes of nonconformance, trends, and individual causes acted upon are maintained and that individual records and summaries of actions taken are prepared. The appropriate customer representative shall be notified of all CAB meetings and be invited to attend.

10.2.4 CAB Authority and Responsibilities

The CAB shall:

a. Have authority to ensure implementation of corrective actions to all contractor operations affecting product quality

b. Have the authority to require investigations and studies by other contractor organizations necessary to define essential corrective actions that will result in reducing nonconformance costs and reducing the amount of nonconformance

c. Ensure that documentation required by clause 8.7.5 is maintained

d. Ensure that summary data of nonconformance and associated costs are analyzed and areas of high potential payoff, adverse trends, exceeding control limits, or out-of-control recurrence of nonconformance are thoroughly investigated to identify appropriate corrective actions and to identify potential Quality Improvement Projects (QIPs).

e. Be responsible for ensuring that follow-up systems are maintained to ensure that timely and effective corrective actions are taken

f. Ensure that reviews of nonconformance data and PR and MRB disposition decisions are conducted periodically to determine that PR and MRB actions are effective and in compliance with the requirements of this addendum

g. Ensure that a process evaluation is accomplished and that specific corrective actions are taken to bring the process back into acceptable limits when control limit techniques are used and analysis of cumulative data for an applicable nonconformance reveals that the established limits are being or will be exceeded

h. Ensure that the contractor documents nonconformance and monitors yield requirement development, documentation, and evaluation; the process control system for compliance;

process improvement activity as it relates to trends; and recurrences of nonconformance when corrective action is required due to inadequate process controls or control limit techniques and until such time as it has been demonstrated that the corrective action has been effective

10.2.5 Failure Review Boards (FRBs)

FRBs shall operate essentially the same as MRBs. FRB requirements are discussed in more detail in TR-RS-2007-00013 (also published as SMC-S-013), *Reliability Program Requirements for Space Systems*. Details on the failure analysis to be presented at a FRB are given in TR-RS-2013-00009 (also published as SMC-S-009), *Parts, Materials, and Processes Control Program for Space Vehicles*, and TR-RS-2015-00011 (also published as SMC-S-011), *Parts, Materials, and Processes Control Program for Expendable Launch Vehicles*.

10.3 Continual Improvement

SAE International AS9100D "Continual Improvement" shall apply as stated.

Appendix A. Quality Program Plan Data Item Description (DID)

DATA ITEM DESCRIPTION

Title QUALITY PROGRAM PLAN	Identification Number TBD
Description/Purpose 3.1 This plan describes how the Quality Program will be conducted. It describes the specific techniques and activities to be performed and their integration and development in conjunction with other specified related plans. The principal use of this item is to provide a detailed description of a contractor's program to be accomplished under the contract.	
Approval Date (YYMMDD) TBD	Office of Primary Responsibility (OPR) SMC/NRO
Application/Interrelationship 7.1 This DID contains the format and content preparation instructions for the Quality Program Plan required by Paragraph 4.4 of the Quality Space and Launch Requirements Addendum to AS9100D. 7.2 This data item is provided to permit preparation of a separate Quality Program Plan or integration of the plan within a consolidated Product Assurance/System Effectiveness Program Plan (PA/SEPP) which normally includes Software Quality; Reliability; Parts, Materials and Processes; and other related disciplines. Cost, system integration and methods of contracting are considerations in preparation of a single PA/SEPP or separate coordinated plans.	
Approval	
Preparation Instructions 10.1 Reference Documents. The Aerospace Corporation Report Number TR-RS-2018-00028; SMC-T-009; SAE AS9100D. 10.2 Methods and Techniques. The plan shall outline the methods and techniques for incorporating quality into design and for conducting a comprehensive quality program in accordance with the contract scope of work and specifications as listed in the contract. It shall portray how quality will be achieved in sufficient detail to include schedule, technique, procedures, and responsibilities for each specific task. 10.3 Program Definition. The plan shall define the scope and depth of the contractor's efforts, including the management, organization, staffing, planning, and technical aspects, and the relationship of the Quality Program to the contractor's other administrative and technical programs. The plan shall include a statement that it does not take precedence over AS9100, *Supplemental Quality Requirements Standard*, or other contractual requirements. 10.4 Special Considerations. The plan shall identify unusual or special areas of hardware and data products requiring unique quality assurance considerations, and detail or reference the unique quality assurance procedures that will be utilized to ensure a quality product. The plan shall detail the inspection work in process to substantiate compliance of critical and major attributes which will not be substantiated by subsequent inspections. 10.5 Flow Chart Requirements. The plan shall contain flow charts showing the flow of supplies, materials, and data together with the quality assurance functions performed. All areas of contract performance shall be specified, for example, design, development, fabrication, processing, assembly, inspection, test, maintenance, packaging, shipping, storage, and site installation. 10.6 Matrix Requirements. The plan shall contain a cross-index (matrix) which identifies the relationship between the program plan; applicable contract specifications and standards; and contractor policies, procedures, instructions, and controls used to implement the requirements. 10.7 Detailed Requirements. The Quality Program Plan shall address the requirements of AS9100, Revision D and the Supplemental Quality Requirements of this standard.	

External Distribution

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Space and Launch Requirements Addendum to AS9100D Quality Management Systems

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