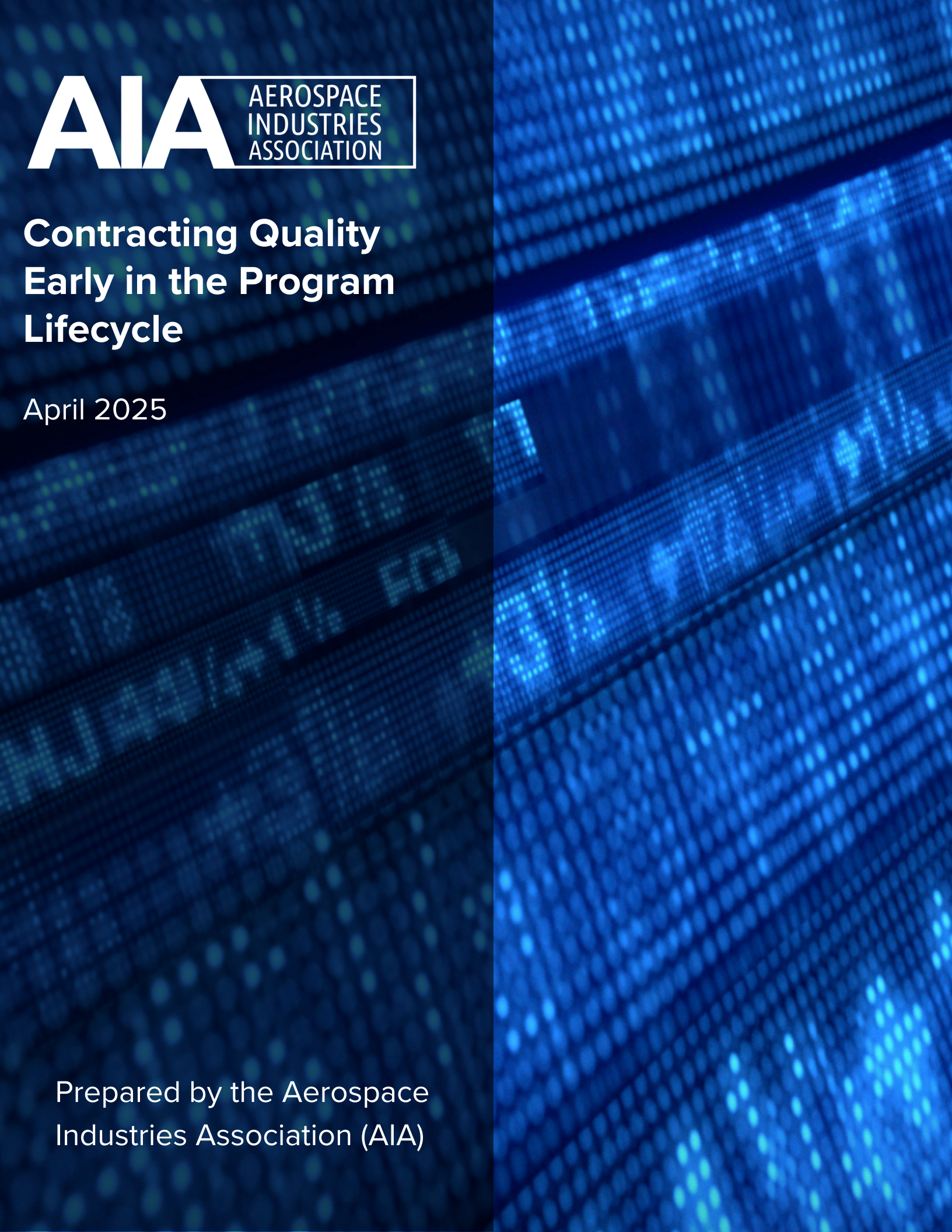

AIA AEROSPACE INDUSTRIES ASSOCIATION

Contracting Quality Early in the Program Lifecycle

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Contracting Quality Early in the Program Lifecycle

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Executive Summary

The importance of including Quality Engineering resources early in the program lifecycle cannot be overstated. Currently, there is no standard government contracting methodology that ensures sufficient attention is placed on quality early in a program's life cycle. This often results in unnecessary defects and process failures as the program progresses into the manufacturing phases, leading to schedule delays, increased costs, and reduced product safety.

One practical step programs can take is to implement AS9145, which defines Advanced Product Quality Planning (APQP) and the Production Part Approval Process (PPAP). The AS9145 content and these associated processes contain the recommended activities that comprise early lifecycle quality assurance

activities, ensuring that product and process design considerations are addressed well before manufacturing begins, thereby reducing defects, schedule risks, and overall costs.

This paper advocates the use of AS9145 in its entirety. However, should the contracting office decide not to implement the full standard, this paper proposes five new Data Item Descriptions (DIDs) to provide objective evidence of a maturing product development. These DIDs can also be utilized where the full AS9145 standard is contracted. These DIDs include:

1. Industrial Base and Supply Chain Risk Inventory
2. Manufacturability Risk Inventory
3. Engineering/Design Adequacy
4. Design-to-Manufacturing Plan
5. Statistical Process Control

The recommendations in this paper are intended to provide options for program managers as they consider how to best allocate scarce resources during the program lifecycle.

Introduction and Background

Product users and suppliers within the aeronautics, space, and defense (AS&D) sector recognize that formal quality management techniques improve the probability of delivering conforming hardware, software, and services. Cost and schedule conformity are also central measures of mission success and are related to manufacturing quality predictability. Allocating resources to specific activities and functional areas remains a programmatic challenge because of the lack of clarity on the return on investment as well as the appropriate timing of such investment.

Quality practitioners have long advocated that early investment in quality processes will yield tangible benefits in decreased nonconformances, decreased schedule extension, and increased program predictability. Knowing which quality processes to implement, and when to implement them has been open to interpretation.

To answer these questions, AS9145, *Requirements for Advanced Product Quality Planning (APQP) and Production Part Approval Process (PPAP),* was created. The standard is written to define industry-accepted approaches to hardware design and production planning that occur early in the lifecycle. AS9145 addresses considerations of planning for product and process design as well as manufacturing capability early in the lifecycle by promoting tools that ensure adequate attention is paid to the manufacturability of the product and realization of quality controls well before manufacturing begins.

AS9145 has been embraced in the automotive sector, where production volumes are high compared to AS&D systems. Adoption throughout AS&D has been less successful due to the buying entities (i.e., government agencies and prime contractors) not having sufficient experience transferring cost-planning for Quality Assurance (QA) labor engagement and QA risk management earlier in the lifecycle. In May of 2024 the Department of Defense's Office of the Under Secretary of Defense for Research and Engineering published the document *DoD Producibility and Manufacturability Engineering Guide* to promote the use of the AS9145 approach and included recommended text for contract Statements of Work (SOWs) and companion DIDs applicable to full adoption of the standard. To lower the barrier to adoption of AS9145 by the AS&D community, the Joint Strategic Quality Council (JSQC) stood up a task group to create an incremental approach. Outputs of JSQC projects endeavor to create improvements within the QA domain for AS&D stakeholders.

At the end of 2023 a new AIA-sponsored JSQC team was established to "Ensure quality early in a program in order to reduce defects, schedule risk, and ultimately lower total cost of execution." The team has participation from industry representatives, NASA Headquarters Office of Safety and Mission Assurance (OSMA) and the Defense Contract Management Agency (DCMA) Headquarters. The goals of the AIA JSQC Task Team include the creation or revision of a quality standard for use by the government to define minimum contracting requirements ensuring quality early in a program's life cycle. The JSQC is a noncompetitive, consensus-based body whose scope of interest is QA in the AS&D sector for both civil and defense interests. The Contracting Quality Early team not only desires to produce value-added information and tools but is also committed to providing a document(s) that will be acted on by the target audience.

Early discussions demonstrate that within the QA subject matter expert community, there was no disagreement that to achieve these improvements to a degree that would be worth all the parties' efforts; QA must be strengthened as early as possible in the lifecycle. The cost and quality impact of reactive quality tools (for example redesign, requalification, repair and rework) and quality escapes are significant. Most importantly, quality escapes may represent an increase in safety risk to the customer. Proactive quality tools introduced earlier in the project lifecycle are proven to reduce the necessity of these reactive tools while improving quality, timing, and cost while reducing the risk to safety.

Scope and Depth of AS9145

While AS9100 focuses on Quality Management System (QMS) requirements to establish a robust system to improve an organizations overall quality performance, AS9145 provides a proven structured framework to plan and execute a product realization cycle that is capable of meeting project quality, cost, and timing targets. The Advanced Product Quality Planning (APQP) process provides a phased planning process emphasizing multi-disciplinary team participation to highlight and mitigate project risks (supply chain, design, manufacturing, etc.) early in the project lifecycle. The Production Part Approval Process (PPAP) is an output of APQP which confirms that the product and process have demonstrated the ability to consistently be produced to meet customer quality and demand requirements. Figure 1 provides a notional comparison of the total cost of quality over the life of a product utilizing the proactive tools of APQP and PPAP versus the current state which relies on the high cost (and potentially increased risk) of relying on reactive tools of quality management.

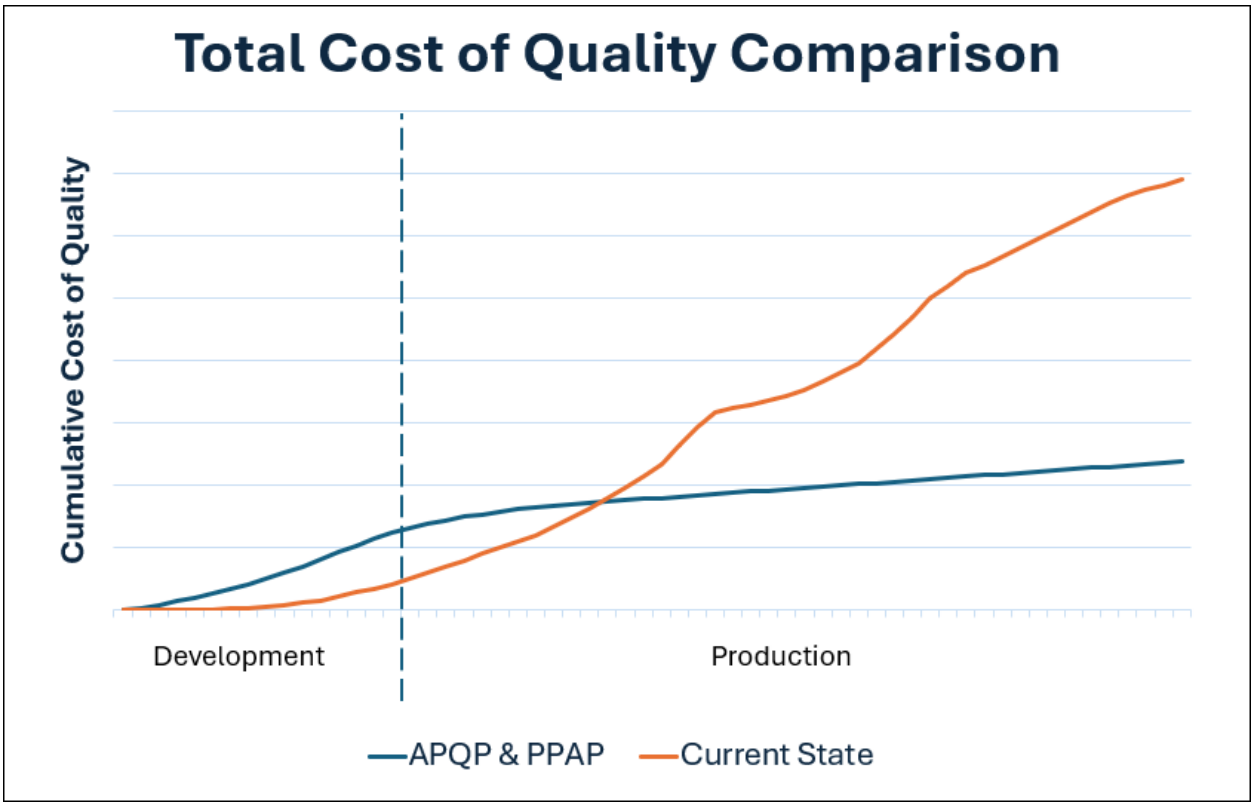

Figure 1: Notional comparison of long-term costs of the current state focus on reactive processes vs. the proactive APQP/PPAP processes within AS9145.

Five New Standard DIDs for Quality Assurance

Five standard DIDs were drafted for use both in government contracts and for flow down procurements to sub-tier suppliers. Their titles and AS9145 paragraph references are shown in Table 1. These five DIDs do not represent the maximum number of deliverables that might precipitate from the use of AS9145, as can be found in the DOD handbook referenced above. These five are intended to create an encouragement to both the buyer and the supplier to begin to adopt the techniques into their internal processes. This provides an incremental approach that can demonstrate value added with lower cost risk.

Table 1.

No.	Title	Relevant Requirements in AS9145
1	**Industrial Base and Supply Chain Risk Inventory**	4.1.5
2	**Manufacturability Risk Inventory**	4.3.2.2, 4.4.6, 4.5.4 (PFMEA)
3	**Engineering/Design Adequacy**	4.4.4.1(DFMEA), 4.4.3 (Design V&V Plan)
4	**Design-to-Manufacturing Plan**	4.5.5(Process KC identification) 4.5.9 (PRR) 4.6.3(MSA)
5	**Statistical Process Control**	4.6.5 (SPC)

It is not possible to dictate the exact wording of DID requirements and thereby achieve complete standardization because government requirements development teams have autonomy to make requirements determinations based their project's unique objectives and risks, when not constrained by the FAR or FAR addenda. The various DOD services and civil authorities (e.g., NASA, FAA) also retain control of their format; NASA for example typically uses a specific form for each DID that is located in a dedicated appendix and not integrated with the SOW. By adopting the language shown herein as a guide, variation across the supply chain, and thus the cost of ameliorating alignment gaps post-RFP-release can be reduced. AIA and JSQC provides the recommended wording herein and is collaborating with the Office of the Undersecretary of Defense and NASA to encourage its adoption into their respective acquisition work aids.

For each DID, the recommended text includes a description of what plan, report, data, or other item is to be delivered including indications of the purpose and intended scope. Constraints or exceptions are

also described. Each recommends a delivery schedule, either one-time or recurring, in accordance with specific lifecycle milestones.

1. Industrial Base and Supply Chain Risk Inventory

The contractor shall submit evidence of a supply chain risk assessment in the form of a documented Supply Chain Management Plan and Risk Assessment in accordance with AS9145 Section 4.1.5. The plan and assessment shall include a source plan for each part, including software. Each source that is identified as high risk (e.g. few or no mature suppliers, logistics risks such as long lead-time or capacity limitations, mergers and acquisition potential, offshore ownership, political instability or other force majeure, legal and fiduciary concerns, multi-year past performance) must have an associated risk assessment. Special attention should be given to any producer whose design may be new (unique and/or difficult) or outside their normal or typical design/operating limits. Include any source that is manufacturing a part with immature parts or materials definition. The sourcing risk assessment shall include likelihood and consequence severity ratings (e.g. 1 to 5) with rationale, and a summary of planned risk mitigations for each high risk. Industrial base risks that are of particular relevance should be considered for inclusion. The assessment shall identify the methods used for internally identifying / eliciting risks, the associated criteria for assessment, and any requirements detailing when risks require associated handling / mitigation actions. The supplier shall present this content at each Milestone Review.

The supply chain risk baseline shall be updated and reported at major program milestone reviews or as specified. In addition, the supplier shall provide detailed status to the customer of any mitigation steps that are not meeting plan. The supplier shall flow down this supply chain risk management requirement to their subtier suppliers who are purchasing parts or services.

Deliverable	Milestone Review Presentation
Specification	Contractor format
Date of First Submittal	At Systems Requirements Review
Date of Subsequent Submittal	At each Milestone Review

Reference:

AS9145 Section 4.1.5

Department of Defense Manufacturing and Quality Body of Knowledge **-** Section G.3 Understand Supply Chain Management Requirements

Department of Defense Early Manufacturing and Quality Engineering Guide – Section 3.5 Industrial Base Assessments

Department of Defense Producibility and Manufacturability Engineering Guide -

AESQ RM13145 APQP and PPAP within Aerospace – Section 4.11 Supply Chain Risk Management Process

2: Manufacturability Risk Inventory

The contractor shall submit evidence of a manufacturability risk assessment in the form of a documented Manufacturability Risk Assessment (AS9145 Section 4.4.6). The assessment shall include an assessment for each assembly or raw material; COTS parts do not need to be assessed. Each part that is identified as high risk (e.g., immature verification and validation methods for raw or processed materials, unknown reliability for novel constructions, immature or lack of verification methods or metrology, immature or low availability of capital equipment or fixturing, or a new assembly that is more than 50% different from something already produced) must have risk assessment. Include parts where production capacity cannot be verified to meet requirements. The manufacturability risk assessment shall include likelihood and consequence severity ratings (e.g., 1 to 5), and a summary of planned risk mitigations for each risk. The assessment shall identify the methods used for internally identifying / eliciting risks, the associated criteria for assessment, and any requirements detailing when risks require associated handling / mitigation actions. The supplier shall present the Manufacturability Risk Assessment at each Milestone Review. Products deemed high risk must have an associated risk analysis/assessment (AS9145 Section 4.5.4).

The manufacturability risk baseline shall be updated and reported at quarterly technical reviews and at each major program review as long as high-risk items remain. In addition, the supplier shall provide detailed status to the customer of any mitigation steps that are not meeting plan. The supplier shall flow down this manufacturability risk management requirement to their sub-tier suppliers who are producing raw materials or assemblies.

Deliverable	Milestone Review Presentation
Specification	Contractor format
Date of First Submittal	At Systems Requirements Review
Date of Subsequent Submittal	At each Milestone Review

Reference:

Department of Defense Manufacturing and Quality Body of Knowledge **-** Section L.1 Manufacturing Management Requirements

Department of Defense Early Manufacturing and Quality Engineering Guide – Section 1.2 Early Manufacturing Overview

Department of Defense Early Manufacturing and Quality Engineering Guide – Section 3.7 Manufacturing Feasibility Assessments

Department of Defense Producibility and Manufacturability Engineering Guide – Section 6.1.1 Manufacturing Feasibility Assessments

AESQ RM13145 APQP and PPAP within Aerospace – Section 5.10 Assess Feasibility

AS9145 Sections 4.3.2.2, 4.4.6, 4.5.4 (PFMEA)

3: Engineering/Design Adequacy

The contractor shall submit evidence of a plan for ensuring the contractor will meet contract requirements that include meeting future production needs during the product design phase. This plan shall include:

- The analytical techniques to identify potential failure modes related to product performance (i.e., fit, form, and function), durability, manufacturability, and costs, such as those determined in a DFMEA.
- the detailed description of inspection and test activities (e.g., tolerances, methods, gages, Measurement Systems Analysis) for features or attributes to be performed during specific manufacturing operations.
- The project's drawing and software code review/verification processes, including list of approvers.
- The project's design review process, including review plan.
- The project's root cause corrective action process.
- The project's work instruction review process, including review plan.

The list of reviewers should include all appropriate departments (e.g. Supply Chain, Manufacturing, Engineering, Quality).

The Design Quality Plan baseline shall be updated as changes occur. The supplier shall flow down this Design Quality Plan requirement to their sub-tier suppliers who are performing engineering tasks that produce drawings or code. The execution of the plan will be reviewed at each milestone review.

SDRL is for notification.

Deliverable	Document
Specification	Contractor format
Date of First Submittal	Preliminary 180 days after contract award
Date of Subsequent Submittal	As needed

Reference:

Department of Defense Manufacturing and Quality Body of Knowledge **-** Section E. Design

Department of Defense Early Manufacturing and Quality Engineering Guide – Section 3.14 Reliability, Availability, and Maintainability

AESQ RM13145 APQP and PPAP within Aerospace – Section 5.12 Conduct Design and Development Activities

AS9017 Control Aviation Critical Safety Items

AS9103 Variation Management of Key Characteristics

AS9145 4.4.4.1 DFMEA, 4.4.3 Design V&V Plan

4: Design-to-Manufacturing Quality Plan

The contractor shall submit evidence of a plan for ensuring the contractor's production rate and yield will meet the contract's delivery schedule requirements.

This plan shall include:

- The use of assessments and analytical techniques to determine process key characteristics.
- The techniques used to associate critical items and attributes to process key characteristics.
- The use of standard and custom monitoring, inspection, and test methods for verifying key characteristics during or immediately following specific manufacturing operations.
- The project's work instruction review process, including review plan.
- The drawing and software code review/verification processes, including list of approvers and controls used for redlines.
- The materials review board (MRB) and root cause corrective action processes.

The list of reviewers should include all appropriate departments (e.g. Supply Chain Management, Manufacturing, Engineering, Quality).

The Design-to-Manufacturing Quality Plan baseline shall be updated as changes occur. The supplier shall flow down this Design-to-Manufacturing Quality Plan requirement to their sub-tier suppliers who are performing engineering tasks that produce drawings or software code. The execution of the plan will be reviewed at each milestone review.

SDRL is for notification.

Deliverable	Document
Specification	Contractor format
Date of First Submittal	Preliminary 180 days after contract award
Date of Subsequent Submittal	As needed

Reference:

AS9145 4.5.5(Process KC identification), 4.5.9 PRR, 4.6.3(MSA)

5: Statistical Process Control

The Supplier shall describe the statistical analysis methods used to surveil the variation of process key characteristics and the actions used when production trends towards an exceedance of those limits. Where applicable, and when relevant for the production schedule, process control distribution parameters (e.g., Cpk) and associated mitigation will be included in milestone reviews. Utilize AS9145 and AS9103 as references.

Deliverable	Milestone Presentation
Specification	Contractor format
Date of First Submittal	Systems Requirements Review
Date of Subsequent Submittal	Each Milestone

Reference:

AS9145 4.6.5 (SPC)

Conclusion

Prioritizing quality as in input to the program plan early in the lifecycle is essential to reduce the risk and impact of safety, quality, cost, and schedule related issues. It has been proven that a more in-depth proactive focus on quality earlier in the development phases of a program helps to reduce the overall cost of quality throughout the life of the program by reducing the cost of reactive approaches. AS9145 outlines the APQP and PPAP process which has been proven over decades in industry to provide a reliable framework to appropriately integrate quality and risk management throughout all stages of the program lifecycle. Although the adoption of AS9145 in the AS&D industry is in its infancy, it is widely agreed that the principles of APQP and PPAP are requirements that should begin to be flowed to the supply base to support improvements in safety, quality, cost, and project success. The DIDs described in

this publication are an attempt to flow key items that are integral to ensuring quality is prioritized early on in the program lifecycle.

References:

AS9145 *Requirements for Advanced Product Quality Planning and Production Part Approval Process*

AESQ RM13145 Advanced Product Quality Planning (APQP) and Production Part Approval Process (PPAP) within Aerospace

Department of Defense Producibility and Manufacturability Engineering Guide

Department of Defense Early Manufacturing and Quality Engineering Guide

Department of Defense Manufacturing and Quality Body f Knowledge

AFI 63-145 Acquisition Manufacturing and Quality Management

AFMCI 23-110 Air Force Materiel Command Instruction – Post Award Part Verification and Approval

AS9103 Variation Management of Key Characteristics

AS9017 Control of Aviation Critical Safety Items

AS9102 Aerospace First Article Inspection Requirement

AS6500 Manufacturing Management Program

AS9100, *Quality Management Systems - Requirements for Aviation, Space and Defense Organizations*