Standard Issues

PRODUCT DEVELOPMENT

Planning For Quality

How to enhance product development in the aviation, space and defense industry

by Deborah Oberhausen

It's no secret that today's society is becoming more globalized every year. This globalization has affected businesses, family units, vacation destinations and even our daily shopping—all of which are driving a need for increased capacity in air transportation for passengers and freight. Some studies predict that air transportation will double in the next 20 years, with an estimated need for more than 35,000 new aircraft.

Not only must the aviation space and defense (AS&D) industry increase capacity, it also must do so with newer, safer, environmentally friendly technologies, such as safety systems that allow for lower fuel burn and lower noise.

The question is: Can the AS&D industry meet these demands using its current product development methods? Maybe—but will these products be on quality, on time and on cost?

The automotive industry has been using an effective structured method for product development for many years. While the method is recognized as a best practice and suits that industry well, it was believed to have limited application in the AS&D industry due to long life cycles and low volumes of AS&D products. The changing business environment, including volume growth and increasing quality expectations, however, has caused major players in the AS&D industry to rethink that position. The industry has decided to take the lessons learned from their automotive colleagues and adapt their methods.

About five years ago, several major AS&D organizations collaborated to author and publish the "Advanced Product Quality Planning Manual" in the *International Aerospace Quality Group (IAQG) Supply Chain Management Handbook*. Two years later, the internationally harmonized standard was published. *AS9145: Aerospace Series—Requirements for Advanced Product Quality Planning and Production Part Approval Process* is the Americas' version published by the Society of Automotive Engineers (SAE) in 2016.

What is AS9145?

AS9145 is the harmonized AS&D requirements document that has standardized the industry's approach to product development. This standard combines advanced product quality planning (APQP) and the production part approval process (PPAP). Briefly stated, the process defined in AS9145 is based on the five phases of product development:

1. Planning.
2. Product design and development.
3. Process design and development.
4. Product and process validation.
5. Ongoing production, use and post-delivery service.

It should be noted that these phases progress concurrently, as shown later.

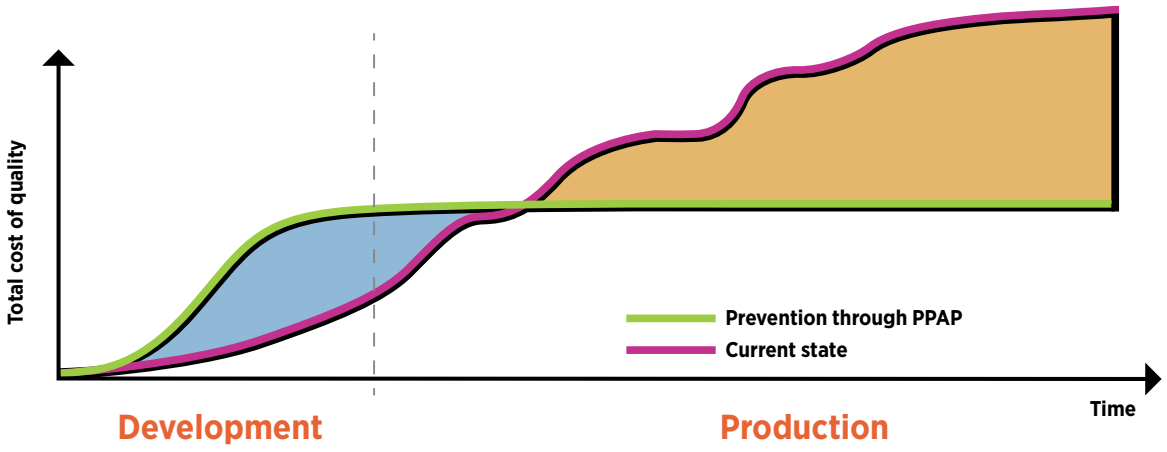
The key drivers for completing these five phases successfully are: leadership engagement, establishing cross-functional teams and managing the project to ensure on-time completion of defined deliverables and outputs. These will be introduced as the pillars of success later.

Why AS9145?

The primary objective of AS9145 is to improve quality and reduce cost (see Online Figure 1, which can be found on this column's webpage at qualityprogress.com). Noteworthy here is that across the AS&D industry, higher quality is synonymous with increased product safety. With better planning, products can reach maturity faster with fewer engineering changes and defects in the early stages of production and product use. These reductions result in higher quality products and lower life cycle costs. The incorporation of proactive tools focuses cross-functional teams on risk identification and mitigation early in the process. Many AS&D organizations have or are

FIGURE 1

Cost comparison of programs with and without PPAP



PPAP = *product part approval process*

in the process of incorporating APQP into their product development process and are flowing these requirements down to their suppliers.

What does AS9145 do for AS&D?

First and foremost, AS9145 standardizes the product development process across the AS&D industry. It strengthens collaboration, driving faster resolution of issues using tools that proactively identify risks and promote early risk mitigation. AS9145 has defined phases to ensure tasks are accomplished at the right time. To achieve the benefits of proactive tools, they must be applied early in the process. Process failure mode and effects analysis, for example, can only help mitigate risks proactively if it's completed while the process is being designed and before production is initiated.

AS9145 also enhances final product and process verification—the step just before entering into production—by applying the PPAP as a method to ensure the process is capable of producing a conforming product at the customer's demand rate. Historically, AS&D relied on the first article inspection report (FAIR) to verify product conformance. PPAP, which includes FAIR, brings focus to product conformance and process capability. This is accomplished by verifying product produced in the planned production environment at the customer's demand rate. It often is said that PPAP provides the evidence that the key deliverables of APQP have been completed.

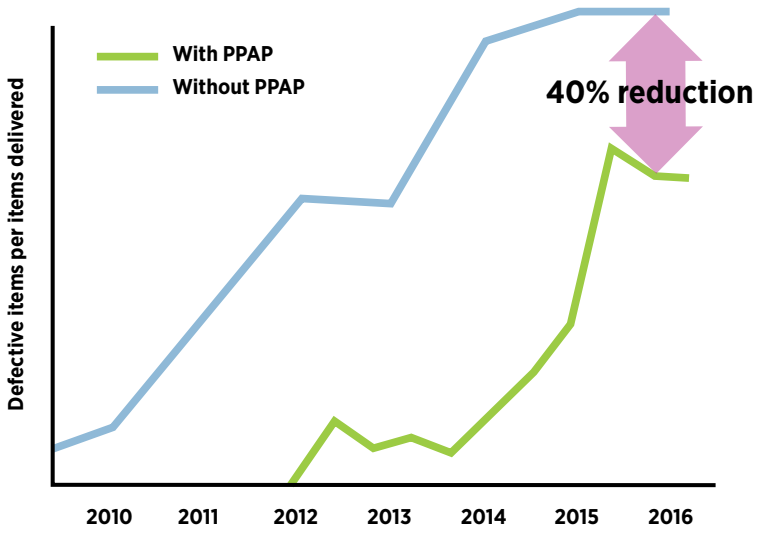
How are AS9145 benefits achieved?

The integration of APQP into the product development process can seem daunting and costly. As depicted in Online Figure 2, however, experience shows that the increased cost of prevention is significantly offset by reductions in inspection and external failure costs. The APQP process delivers this result because it is designed to:

+ Shift the product development process from a reactive to a proactive approach.
+ Deliver higher quality and safer products at launch (faster product maturity).
+ Reduce failure costs through prevention.
+ Increase customer satisfaction with on-time, on-quality products.

FIGURE 2

New product introduction with and without PPAP



PPAP = *product part approval process*

Now that we've looked at the cost savings of APQP as they relate to elements of the cost of quality (CoQ), let's look at the effect on the product life cycle. When customers' expectations are truly understood and there is a detailed plan to meet customer requirements, costs and risks can be managed early in the product development process. Additionally, late changes can be avoided by developing robust product and process designs, accomplished through the collaboration of cross-functional teams, leadership support and the use of proactive tools.

Data from another industry show how the CoQ is distributed throughout the product life cycle. Figure 1 (p. 53) is a cost comparison of programs with and without PPAP—a critical step in the APQP process. The red and green lines in Figure 1 show that when PPAP is applied, the costs are higher in the development phase but stabilize quickly at a lower level in the production phase. This data indicate that APQP provides a faster rate of product maturity, which is a key opportunity for the AS&D industry. Unfortunately, this shift in cost can be a hard sell in organizations because APQP often is viewed as a cost avoidance strategy rather than a program cost savings strategy.

Some early APQP adopters in the AS&D industry are working on collecting additional data to generate an AS&D cost profile. Figure 2 illustrates the application of PPAP on two different new product introduction programs of comparable volume and complexity.

The first program (shown in blue) illustrates a steady increase in nonconformances (measured in defective items per items delivered) through the first four years of production before it started to stabilize. The second program (shown in green) illustrates a similar increase in nonconformances that peaked in three years and then started to decline. In addition to reaching its peak sooner, the second program demonstrated a 40% reduction in nonconformances compared to the first program. This early AS&D industry data demonstrates the potential benefits of PPAP.

As we know, fewer nonconformances directly equate to reduced costs and an improved quality signature. This particular application of PPAP was imposed outside of the APQP framework. Again, the biggest benefits come from completing the deliverables, included in PPAP, much earlier in the development cycle, as defined in the APQP process. Had APQP been in place, it's likely this organization would have experienced even further reductions in nonconformances along with some of the other benefits of APQP previously mentioned.

APQP overview

APQP provides structure to the product development process in a manner that ensures customer satisfaction by planning and scheduling the tasks to be done, monitoring the timely and effective completion of tasks, and communicating, escalating and resolving issues. In essence, APQP combines project management with the use of proactive product development tools applied at the right time. Effective implementation depends on the pillars of success (see Online Figure 3):

Pillar one—Organizational commitment and management support. The information generated through the APQP process allows management to track and pace product development activities for new and modified products. The process highlights risks and monitors the status of APQP deliverables. It promotes the execution of relevant actions needed to remove roadblocks that may jeopardize completing tasks necessary for on-time product delivery.

More specifically, top management ensures that top and middle managers are engaged and trained

in APQP, that resources have been allocated and that supporting personnel are properly trained in APQP tools and methods. Top management's ongoing engagement in program reviews is critical to ensuring the process is applied consistently across programs and products, and that it is delivering the expected results on time, on cost, and to quality standards.

Pillar two—Cross-functional teams. Cross-functional teams build unity of purpose across the business. They support commitment and alignment with program timing, and ensure effective communication across the various business functions. Clearly defined roles and responsibilities ensure timely completion of tasks in support of the overall project plan.

Pillar three—Effective project planning. The project plan is based on customers' needs. Key target dates are cascaded throughout the value stream, which may include internal and external parties. All information is formalized into a project plan, and progress is tracked and reported on a planned schedule.

The five phases of APQP

APQP should be viewed as an enhancement to a typical product development process. Figure 3 shows how the typical product development checkpoints align with the APQP phases. You can see how the five phases, mentioned earlier, are not start-stop, but rather overlapping and transitional. This illustration also shows the five key milestones of APQP:

1. Product concept.
2. Design validation and verification.
3. Process validation and production readiness review.
4. First article inspection.
5. PPAP.

These milestones mark the end or the beginning of a phase and, in some cases, align with the traditional product development checkpoints. A summary of the phase activities and the associated outputs are included in Table 1 (p. 56).[1]

Implementing APQP

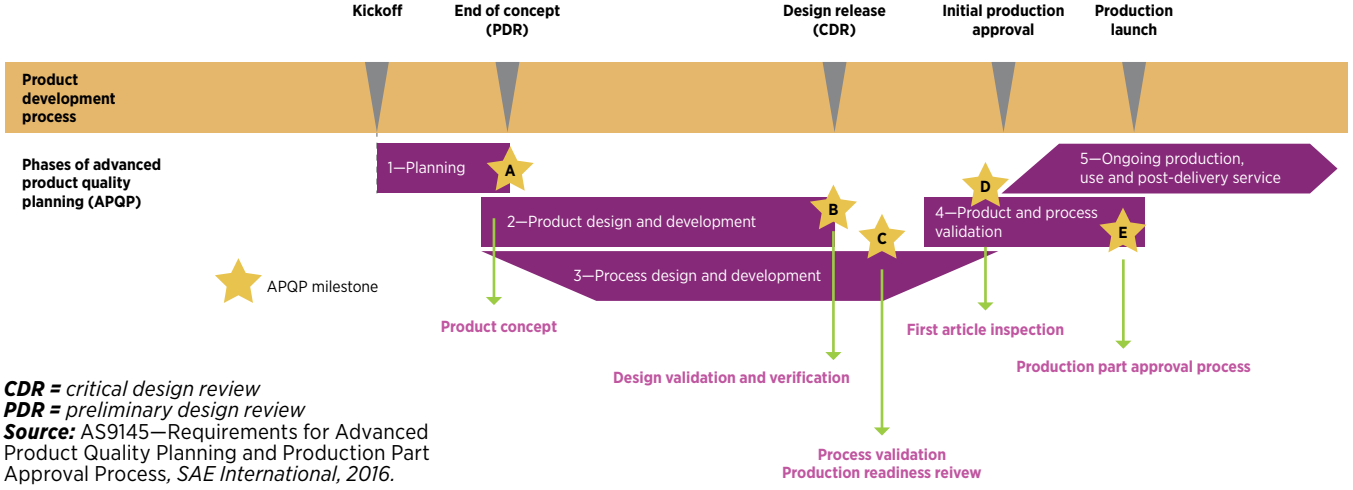
Organizations starting from a good foundation for product development may find it easier to enhance their existing process—provided there is a willingness to rally around the use of the proactive methods established in AS9145. However, any strategy for implementation should start by educating the management team. Remember: Management engagement and commitment is the first pillar of success.

After the requirements are understood, develop an implementation strategy. Begin by identifying the functional organization responsible for defining and executing the APQP process, also known as the process owner. A holistic approach must be adopted—what function will manage the process from product inception to final delivery?

Next, perform a gap assessment between the existing process and the AS9145 requirements. After these three steps are completed, the implementation

FIGURE 3

Alignment of product development checkpoints with APQP process



CDR = *critical design review*
PDR = *preliminary design review*
Source: AS9145—Requirements for Advanced Product Quality Planning and Production Part Approval Process, *SAE International, 2016.*

TABLE 1

Phase activities and associated outputs

Phase	Phase activities	Phase outputs
Phase one: Planning	+ Identifies and gathers all inputs applicable to the product + Collects technical and nontechnical requirements applicable to the project/product. + Defines product and project goals. + Ensures the organization makes the key make-buy decisions. + Establishes timing for deliverables for each APQP element.	+ Product concept is finalized (milestone A) and a predesign is available. + Concurrent product design and process design can start.
Phase two: Product design and development	+ Turns product specifications into a robust product definition. + Design risk analysis (design failure mode and effects analysis). + Provides verified product design. + Team commits to product manufacturability.	+ Design record and bill of materials are available. + Product design is verified and validated (milestone B) by the design organization.
Phase three: Process design and development	+ Creates robust manufacturing process that meets product quality and quantity requirements. + Defines the means to control manufacturing process and its outputs.	+ Process is defined, established, verified (production readiness review—milestone C) and ready for validation.

Phase four: Product and process validation	+ Launches initial production run.
	+ Collects data to demonstrate the manufacturing and assembly processes can produce conforming product at the required rate.
	+ Management determines process readiness for entry into serial production by reviewing the results of:
	  + Product and process design as validated by the organization.
	  + Production readiness evaluation.
	  + Corrective actions taken for any issues identified to date.
		+ Start of production and first article inspection (FAI) (milestone D) verify that the initial product made using all full production means conforms to specified requirements.
		+ FAI is compiled, approved and available for customer review.
		+ Production part approval process (milestone E) is compiled, approved and available for customer review.

Phase five: Ongoing production, use and delivery service	+ Evaluate whether project objectives have been achieved. + Record lessons learned to drive robust product realization processes. + Implement actions to increase customer satisfaction.	+ Project goals are achieved, including reliability, quality and customer satisfaction. + On-time, on-quality, on-cost production and service.

plan can be established. The plan should consider:

+ The organizational structure needed to support the process and ensure effective cross-functional teams.
+ The resources and training needed for process deployment.
+ The capability of suppliers to meet the requirements of AS9145 when imposed.
+ The development of standard work that supports consistent completion of tasks.
+ Where to start with implementation (new or existing programs).

A lot of energy and cross-functional engagement will go into developing the implementation plan. Top management can sustain that energy and engagement by demonstrating a commitment to the process.[2] QP

NOTES

1. A more detailed summary of the phase activities and associated outputs can be found in *AS9145: Aerospace Series—Requirements for Advanced Product Quality Planning and Production Part Approval Process*, Appendix B.
2. Further details regarding APQP for AS&D can be found in the *International Aerospace Quality Group (IAQG) Supply Chain Management Handbook*, chapter 7, www.sae.org/scmh.

Deborah Oberhausen is a quality systems fellow at Pratt & Whitney. She is an active member of the International Aerospace Quality Group (IAQG) and plays a lead role in authoring and developing guidance material for the *International Aerospace Quality Group (IAQG) Supply Chain Management Handbook*. Oberhausen also led the development of the *"Advance Product Quality Planning Manual"* in the *IAQG Supply Chain Management Handbook* and *AS9145: Aerospace Series—Requirements for Advanced Product Quality Planning and Production Part Approval Process*.