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The Analysis of Quality Escapes in the Aerospace & Defense Industry

White Paper

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Executive Summary

In recent years, the aerospace & defense industry has experienced significant shifts in the dynamics of the supply chain. These shifts have placed a premium on the accurate and efficient flow of complex technical requirements. There are many consequences from these major shifts in the nature of the aerospace & defense industry. Prominent among these impacts is an increase in the quantity and awareness of quality escapes.

In gross terms, quality escapes are nothing more than inability to manage the details. Not surprisingly, the root causes of numerous quality escapes are found in the flow and interpretation of technical requirements. These root causes often take the form of ambiguity in the original requirements, failure to adequately evaluate the results of requirements interpretation, or simply overlooking the requirements.

Introduction

The program for Electronic Industry-wide Network for Characteristics & Specifications (e-LINCS) was launched by the Air Force Research Laboratories (AFRL) Manufacturing Technology Division with the stated purpose: "establish and implement universally accessible tools for the flow of detailed technical requirements to every level of the aerospace and defense supply chain."

This purpose is based on the dynamics of the current aerospace & defense supply chain, which has experienced significant shifts in recent years. These shifts, which have placed a premium on the accurate and efficient flow of complex technical requirements, include the following:

Changes in Military Acquisition - During the 1990s, the Department of Defense began to reform its acquisition processes. First, through the Mil-Spec Reform Initiative, military specifications and standards were systematically eliminated, and replaced with more commercially-oriented practices and standards. Second, greater emphasis was placed on performance specifications at the system level. By specifying broad system expectations, the military moved away from detailed "how to" requirements to performance driven criteria. While this approach enabled innovation and affordability, it effectively shifted more responsibility and risk to the designer and producer of the system.

Increased Dependence on the Supply Chain - Concurrent with acquisition reform, the aerospace industry began to consolidate at the prime contractor level. As this consolidation took place, other fundamental changes occurred in the industry's structure. Capacity was dramatically reduced as redundant capabilities were eliminated. Core competencies were re-evaluated and such basic capabilities as machining and component fabrication were greatly reduced in favor of "systems integration", in which the prime contractor serves primarily as the designer and assembler of the final system. This in turn created a much higher degree of dependence on the supply chain. The flow of design intent, the management of material and components, and adherence to quality expectations became more important than ever. To handle the increased flow of data, electronic systems became essential. However, the effective electronic flow and interpretation of specifications and related technical requirements (which impact realization of design intent) went largely unchanged.

Emphasis on Sustainment – The useful lives of military systems' are being extended longer than ever. As operational use has become more widespread and extended (e.g., Balkans, Afghanistan, Middle East, other deployments) the need for spares and support continues to grow. Components must be produced to sustain numerous systems that have been out of production for years, but which remain critical to national defense and military capability. Moreover, reduced staffing levels at the Military spares acquisition centers, expanded dependence on lower tier suppliers, and emphasis on lower inventory levels in military warehouses have driven the need for more efficient and accurate purchases that must often ship directly to remote field locations.

System Complexity - The differentiator for all of US industry in the global market place is its ability to develop and produce complex, highly engineered products. The aerospace & defense industries are at the forefront of delivering the most advanced products in the world. These products have enabled US military forces to stand alone among their global counterparts. However, the very complexity of these systems places an inordinate premium on the generation and flow of design intent to all levels of the supply chain. The combined factors of acquisition reform and increased reliance on the supply chain demand that technical requirements be delivered and understood in a clear and unambiguous fashion.

There are multiple consequences of these major shifts in the supply chain. Prominent among them is an increase in the quantity and awareness of quality escapes.

e-LINCS and Quality Escapes

From the start, quality escapes and their prevention have been an important focus of e-LINCS. This focus is based on the prior experiences of the e-LINCS prime contractor, Renaissance Services. The founders of Renaissance Services have performed extensive research and analyses on quality escapes over the course of both government-sponsored and commercial projects.

From its founding, Renaissance Services has used these experiences and the resulting expertise to better understand the causes of quality escapes, and to establish and implement tools that ensure accurate management of technical requirements at the characteristic level. Understanding the importance and pursuing the accuracy of requirements at this detailed level can dramatically reduce quality escapes. This insight was a fundamental element in the establishment of the e-LINCS program.

Escapes and the Quality Imperative

When the e-LINCS program was first launched, quality escapes were a given, but they were no longer accepted as simply a cost of doing business. In fact, the current quality imperative across all industry sectors has focused a harsh light on quality escapes. Six Sigma has become the stated objective of prime contractors and their suppliers across the aerospace supply chain. Industry-sponsored organizations which formulate quality policies and procedures have instituted strict standards (e.g., AS9100) which exceed ISO in their requirements. This is particularly true in areas such as management of characteristics, control of manufacturing processes, adherence to specifications, and configuration management.

Aerospace prime contractors are increasingly requiring their suppliers to achieve AS9100 registration. The industry is also applying the first article inspection methodology prescribed in AS9102 which places strong emphasis on characteristic accountability. This emphasis is largely based on the recognition that many quality escapes happen with the very first production unit as a result of an inadequate first article inspection.

With all of this emphasis on quality, the continued occurrence of escapes is a driving factor in the establishment of programs such as e-LINCS. While AS9100 and related standards seek to legislate a certain level of quality behavior, the tools needed to ensure confidence in their compliance are largely absent from the primes and their supply chain.

Exploring Root Cause

Not surprisingly, the root causes of numerous quality escapes are found in the flow and interpretation of technical requirements. These often take the form of ambiguity in the original requirements, failure to adequately evaluate the results of requirements interpretation, or simply overlooking requirements.

Ambiguity may be the result of conflicting requirements or the lack of clarity in definitions. For example, a misunderstanding of how to measure a particular characteristic such as “flatness” or “hardness” or “surface finish” can lead to non-conforming hardware and an escape.

Failing to adequately evaluate results can be based on the assumption that a given process is adequate without a clear method for systematically documenting the outcome of that process. For example, if a weld is required by specification to have a certain dimension or bead feature, and those requirements are not properly identified in the reporting documents for a first article inspection, the requirement can be missed, leading to a potential escape.

Requirements can be overlooked if they are contained in a reference document that is not called out on the original drawing. Similarly, if a change has occurred, but is not accounted for during the identification of characteristics, an escape can result.

The technical data package (TDP) is yet another area where quality escapes can occur. The way a TDP is constructed should really be scrutinized for opportunities in which defects can occur.

As Figure 1 illustrates, something as simple as a too restrictive tolerance can lead to an escape. The e-LINCS needs analysis found that 96% of suppliers still receive over 50% of their technical requirements on paper in serial fashion. This condition can greatly reduce the opportunities for collaboration within the supply chain, as well as the ability to make real-time assessments of areas of restrictive requirements or ambiguity. It is for this reason that tools seeking to address escapes must provide the capability for primes and their suppliers to collaborate and coordinate on requirements before hardware is produced.

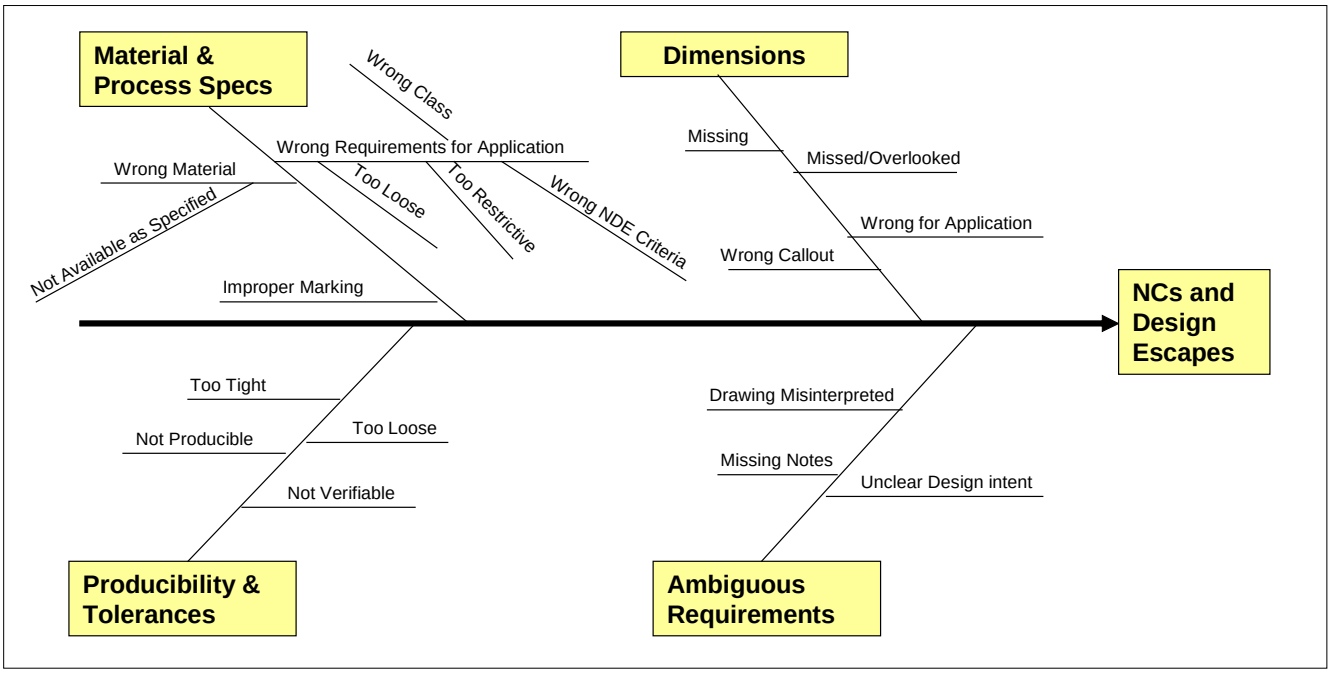

Figure 1 – Root Cause Fishbone for Escapes

The Impact of Processes

It is somewhat intuitive that processes, particularly special processes, would be key contributors to escapes. This is intuition is well supported by data. In examining several hundred escapes over a number of years and programs, it is clear that special processes such as heat treat, welding, coating, and brazing play a significant role in escapes. The many and varied reasons for this include:

- Special processes are largely driven by specifications which require interpretation
- Special processes are frequently performed by sources outside the direct control of either the primes or their suppliers
- Special processes are dependent on tight process control which can be affected by a number of variables
- Seemingly subtle changes in special processes can lead to significant impacts on hardware
- Special processes are often performed at intermediate stages in the production process and can lead to downstream defects which are not immediately apparent

To illustrate the degree to which special processes can affect one grouping of escapes, consider Figure 2.

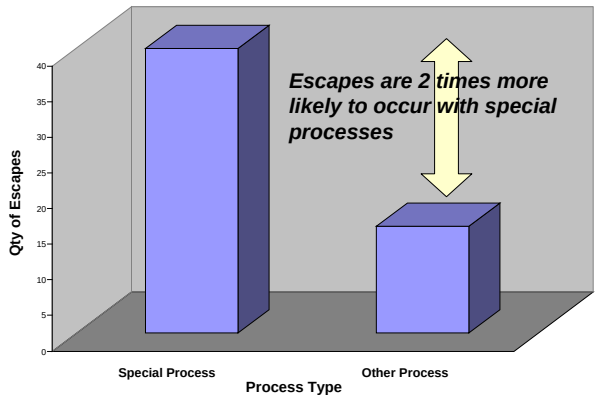

Figure 2 – Escapes & Special Processes

Derived from several hundred escape assessments, Figure 2 shows that two-thirds of the escapes were driven by special processes. Special processes require a high degree of interpretation; they rely heavily on specifications; and their inclusion of multiple requirements can be improperly evaluated or overlooked. These reasons make them a key component of the root causes of escapes.

Volume of Activity and Escapes

First article inspections are an acknowledged starting point for quality escapes. One major aerospace company found "inadequate first article inspections [to be] . . . the number one cause for rejected parts in [the company's] supplier base." In an ironic twist, the process that is often the last line of defense in identifying and stopping quality escapes is also where many of those escapes begin.

As shifts in the supply chain continue there is an ongoing churn of suppliers as prime contractors globalize and compete on all levels. This translates into a never-ending flow of first articles.

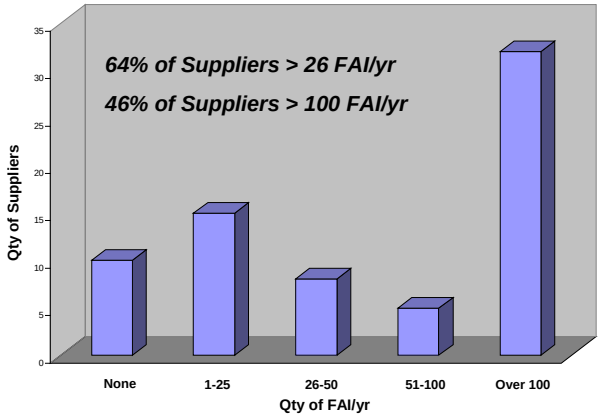

Figure 3 – First Article Inspection Volume at Suppliers

A typical prime contractor will require 5,000 to 10,000 first article inspections every year. During the e-LINCS needs analysis, when suppliers were asked how many first article inspections they perform, nearly two-thirds reported performing at least two first article inspections per month. Almost one-half of the suppliers perform two *per week*. With this volume of activity, it is no surprise that non-conforming hardware eludes the first article process. First article inspections are performed by humans who typically operate at no better than a two sigma rate. Even if the first article process is performed at three sigma, an organization performing 3,000 first article inspections will have some 200 with non-conformances that elude detection.

The current first article process is manual and quite labor intensive. It was the recognition of this high volume and the likelihood of escapes in this high volume environment that provided impetus for e-LINCS and its suite of tools to dramatically lower the potential for defects in the first article process.

Escapes and Cost

Escapes are clearly an important cost factor for much of the aerospace industry. Escapes are a driving element in the cost of quality (COQ) at primes and suppliers alike. COQ data for primes and suppliers is limited and not definitive. Anecdotally, however, COQ rates approaching 10% of revenues have been observed within some parts of the aerospace industry. Moreover, companies that track defects per million opportunities have publicly admitted to rates in the thousands which is in direct contrast to six sigma objectives, which would yield single-digit rates.

The cost of escapes is manifested in a number of areas. The most obvious are field fixes and warranty replacements. More subtle, and perhaps even more costly, is the level of engineering effort that must be expended to analyze non-conformances, defects, and escapes. Engineering analysis may determine that a part is usable as is, or that it can remain in the field with some limitation on its application or life. This analysis is quite expensive, typically requiring thousands of dollars of engineering time, and keeps parts from users in the field.

Based on data gathered concerning the cost of escapes and using a very conservative COQ rate of only one percent, it is estimated that every US commercial aircraft produced has an added cost of $700,000. Every military aircraft has an added cost of $300,000 due to quality escapes, non-conformances, and defects.

Providing Solutions

In gross terms, quality escapes are nothing more than an inability to manage details. As this white paper illustrates, managing these details is a highly complex process performed in a dynamic, high volume environment. The process of identifying characteristics, documenting them, and measuring and reporting them has remained unchanged for over a half century. This archaic process does not support an environment that aspires to six sigma quality.

For this reason, the e-LINCS program was established. As a web-based system, it offers real-time collaboration between primes and their suppliers. Its core technologies make it easier to manage the details while making the process more efficient and removing many opportunities for defects. The e-LINCS characteristic identification tools offer dramatic improvements in efficiency while minimizing the potential for errors. When applied by the aerospace industry, the e-LINCS core technologies have demonstrated the capability to reduce quality escapes by more than 50%.

Conclusion

Quality escapes remain an issue across the aerospace industry. Identifying the root causes of escapes and acknowledging the need to better manage characteristics is a start at reducing them. The e-LINCS integrated suite of tools provides primes and suppliers alike the ability to manage characteristics at the detail level and dramatically reduce escapes. To learn more about how it can work for you, contact:

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