2-8-2021

Managing Quality in Aviation Projects

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Scholarly Commons Citation

Marion, J. W., Richardson, T. M., & Anantatmula, V. (2021). Managing Quality in Aviation Projects. *Engineering Management Journal,* (). https://doi.org/10.1080/10429247.2020.1858642

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Abstract

From aircraft manufacturing, product customization, aircraft maintenance, and aircraft launch and recovery, project management is threaded through all aspects of aviation. Given the supreme importance of quality to every aircraft manufacturer, airline, and passenger, it would be expected that quality management, within the context of project management, would be a construct that is clearly defined. The aim of this mixed-methods research seeks to understand how quality is managed and assured in aviation projects, whether or not the current quality management framework is applicable to the aviation industry, and how quality should ultimately be managed in aviation projects. The results of this study suggest that aviation project management could benefit by adopting a new lens for managing project quality and avoid a surface-level adoption of quality tools designed primarily for the mass production context.

Keywords: Project management quality management, Aviation quality management, Aviation projects

EMJ Focus Areas: Project quality management, Program and project management, System Requirements

Introduction

In the current global economy, customers demand high quality products and services at affordable prices and organizations are compelled to offer these products and services faster, better, and cheaper than their competitors (Anantatmula, 2016). Consequently, quality management assumes greater importance now more than ever. As such, the need to integrate quality management practices into many business processes and projects is not an option, but a necessity (Gray & Anantatmula, 2009). Despite the obvious necessity for strict project quality practices, the aviation sector has come under scrutiny as evidenced by the Boeing's Dreamliner and the 737 Max, Lockheed Martin's F-35, and Airbus's decision to terminate its A380 superjumbo jet program (Shenhar, Holzmann, Melamed, & Zhan, 2016; Casadesus-Masanell, & Elterman, 2019; Johnston, & Harris, 2019; Cameron, D. 2018; Flottau, J., 2019).

Because its consequences are so high, quality is critical within aviation. Airline passengers seek a comfortable, on time, and safe experience. Airlines seek to receive aircraft from manufacturers that are free of defects and efficiently maintained. Since project management techniques are employed significantly within the aviation industry (Flouris & Lock, 2016; Vieira, Rebaiaia, & Chain, 2016; Gwosch, Steck, Dörr, & Matthiesen, 2020), it would be expected that quality management within the context of project management would be a clearly defined construct. However, it appears that quality management within aviation project management is less clear-cut than the industry circumstances seem to demand. Consequently, it may be appropriate to Study how project managers actually manage quality in projects. This research effort is specifically focused on its relevance in the field of aviation given the importance of flawless product and service delivery where life is at stake on a daily basis.

Literature Review

Quality Management in Project Management

The three leading global standards on project management include the International Organization for Standardization's, *ISO 21500 Guidance on project management*; the International Project Management Association's (IPMA) *Project Excellence Baseline*, and the Project Management Institute's *Project Management Body of Knowledge* (PMBOK®). *ISO 21500 Guidance on project management* describes three quality processes: Plan quality, Perform quality assurance, and perform quality control (para. 4.3.32). IPMA's *Project Excellence Baseline* aligns its approach with Total Quality Management practices (2016). The most detailed approach to project quality is found in the Project Management Institute's Project Management Body of Knowledge (PMBOK®) (2017) which outlines quality management and quality control tools, which are nearly identical with the list of tools presented in the American Society for Quality (ASQ) Website (2019).

Exhibit 1: Quality Tools

Quality Tools

The observed limitations of traditional quality management tools have support within the academic literature. Papke & Shields et. al (2010) concluded that project management quality practices ranked among those least used by practitioners. Additionally, Besner & Hobbs (2012) found that the PMBOK® quality management practices ranked 17 out of 19 identified project management toolsets overall. If evidence exists that project managers do not emphasize traditional quality tools (Besner & Hobbs, 2013) and that these tools appear to have been extracted from an entirely different historical operational context, then perhaps project managers

are managing project quality in a manner different from that traditionally done in manufacturing operations.

Perform Quality Control

Quality control is described by Kerzner (2017) to "…include continually monitoring processes, identifying and eliminating problem causes, use of statistical process control to reduce the variability and to increase the efficiency of processes" (pg. 705). The PMBOK® (2017) defines it as "the processes of monitoring and recording results of executing the quality management activities in order to assess performance and ensure the project outputs are complete, correct, and, meet customer expectations" (p. 298). It is also worth noting that the PMBOK® recognizes quality in terms of "inherent characteristics" and "fulfilling requirements," and that the project lifecycle and associated process framework is the process used to implement quality deliverables.

What Process is Being Controlled?

If process control is the aim of quality management, then it must be asked, "What process is (or should be) controlled in project management?" Since much of project management is associated with the integration of technologies that have already been tempered with quality management tools, it seems reasonable that the overall project quality and assurance plan should emphasize the control of a process (or processes) that results in meeting requirements to the satisfaction of the client. Project quality planning therefore involves deciding upon what standards need to be met in order to satisfy the client as well as how the project will assure that such standards are met (Winch, 2001). This is fundamentally an exercise in eliciting requirements, defining specifications, and meeting them through project execution (IEEE Standard 1233-1996). Given the many layers of customers found within the aviation industry, as

well as the regulatory environment, a focus on requirements collection and validation by translating them into specifications is well placed (Baumann, Becker, & Horrmann, 2020; Abbasi, & Nikbakht, 2018). It appears that there would be a limited role to play for the quality management and control tools as given in the PMBOK® and ASQ with respect to determining how a project will manage quality, since quality in projects—including aviation projects—is defined as determining and delivering requirements. In fact, quality tools appear to be grafted in place from a different operational context.

Are There Alternatives to These Tools?

Winch (2003) observed that mass production and its associated quality systems is not the only method of production currently and historically practiced. Winch noted that production — like commercial construction, electrical, or telecommunication systems — are in effect, projects. Winch outlined the need for a quality plan that consists primarily of design reviews and quality audits. In this case, quality is ensured by confirming that the system under development meets the requirements of the client at various stages or gates of the project.

Project Versus Underlying Technologies

The project deliverables are subjected to testing, verification, and validation. The use of quality control tools that are normally applied within the particular applied discipline may be employed when the quality of the deliverables is assured and controlled (ASQ, 2019). However, in the complex systems development of aircraft manufacturing, integrated system components such as navigation systems, cabling, communications equipment, and components are subject to quality compliance at the component-level manufacturing process (Flouris & Lock, 2016; Vieira, Vieira, Chain, & Bravo, 2017; Feng, Huang, Jin, Li, He, & Yu, 2020). Quality tools associated with corresponding manufacturing tasks therefore have already been utilized prior to the

acquisition of the components by the project. The quality question in systems production and projects therefore is, “does the unique interconnection of and quality checks associated with these system components meet the quality requirements of the client?”

The literature review and analysis suggest that quality requirements are identified while eliciting the client’s requirements in a project and that they are incorporated in the scope definition and project plan. Executing the project so that quality goals are achieved is primarily an exercise of ensuring that client, industry, and regulatory requirements are met. Traditional quality tools may not play an important part of project planning and execution in the aviation industry due to stringent regulatory and industry-based requirements and policies and the overriding goal of meeting these requirements.

Research Method

Evidence from the literature and practice of project management poses the following research questions:

1. What kinds of projects are executed within the aviation industry?
2. How do project managers actually manage quality in aviation projects?
3. What tools do aviation project managers use when managing quality in projects?
4. Do project managers use the two sets of seven quality tools? If so, which do they use more? Which do they use less?
5. Do aviation project managers employ statistical process control when managing quality in aviation projects? If so, what processes do they seek to control?
6. Do aviation project managers perceive that quality management practice within project management is (or should be) the same as quality management within operations?

The research was conducted in three phases. In Phase one, 18 interviews were conducted with project managers working in the field of aviation. An interview guide was used to structure the interviews. The following questions were asked and the open-ended discussion and follow up questions were recorded.

1. What kinds of projects are executed within the aviation industry?
2. How do you manage quality in aviation projects?
3. What tools do aviation project managers use when managing quality in projects?
4. Do project managers use the two sets of seven quality tools? If so, which do they use more? Which do they use less? (Interview subjects in this question were presented with images of quality management tools taken from the PMBOK®).
5. Considering statistical process control assumes long runs of data and projects are temporary and may not produce long runs of data in the same way that mass production does, do aviation project managers employ statistical process control when managing quality in aviation projects? If so, what processes do they seek to control? If not, why not?
6. Do aviation project managers perceive that quality management practice within project management is (or should be) the same as quality management within operations?

The resulting interview data was then analyzed using qualitative data analysis techniques using nVivo software and hierarchical coding. The thematic analysis led to the development of a conceptual framework emerging from the interview transcripts of project quality managers. Following the nVivo qualitative data analysis, the interview transcripts were systematically analyzed using the SAS Enterprise Text Miner. The SAS Text Miner applies advanced mathematical techniques to extract underlying meaning from text documents. The results of the

SAS Text Miner were used to ground the nVivo analysis with a neutral and objective generation of underlying themes.

In Phases two and three of the research, a short electronic survey was distributed to two sets of project managers to add validation associated with quality processes employed by project managers in the field of aviation and to confirm preferences of quality management tool usage. The two stages of qualitative data analysis, along with two sets of quantitative survey results, were employed to create a holistic understanding of how quality is managed within aviation projects.

Analysis of Research Results

Phase One: nVivo Qualitative Analysis

To begin the qualitative data analysis, a word frequency analysis was performed within nVivo to gain an understanding of words most frequently employed by project managers as they articulate how quality is managed within aviation projects. The top five most frequently used words are not surprisingly related to the primary topics of the study. The bottom five of the top ten appear to reflect an emphasis on those elements essential to the nature of projects such as completing the work of the project along with an accompanying emphasis on quality with respect to product design and requirements.

Insert Exhibit 2 Here

nVivo Coding Categories

Following the overall word frequency analysis, all interview transcripts were manually coded for validation. Initially, the transcripts were coded using higher-level categorical codes followed by subordinate coding levels to each category. The codes were scored by multiplying together the number of source transcripts in which the number of times they appeared. The

scores were used to rank the codes according to their frequency. nVivo was then used to determine the word similarity of each code. It is observed that the code "SPC" (Statistical Process Control) is related to the use of "Charts and Tools." Likewise, aviation projects are linked to the management of people as they focus on managing project requirements. nVivo determines the relationship between one code versus another by performing Pearson's correlation between the words found in each collection of coded passages.

Insert Exhibit 3 Here

Once the initial code categories were identified using nVivo, each major code was sub-coded to identify specific references to important issues raised by the interview subject.

Aviation Project Sub-Coding. Several different project types were identified in the sub-coding of passages interview transcripts coded as "aviation projects". The first three topics centered upon the types of projects performed within aviation including the development of airplane components and systems, customization of planes, and outsourcing. The final four topics were linked to management themes associated with aviation projects. The similarity analysis of the sub-codes in aviation project management is of interest. Product development and the management of the project lifecycle is observed to be related to the management of the project supply chain whereas outsourcing of components is linked to project portfolio management.

Insert Exhibit 4 Here

Transcript Excerpt. The following excerpt is a typical example of the recorded comments and is observed to capture the essence of the code set. *"There are other systems where are completely outsourced. The cockpit for example is [produced by unnamed] The engines in our case …. are [produced by unnamed] … on the [unnamed aircraft product] ... [we used unnamed supplier].*

Landing gear we also outsource. I would say for the main mechanical systems we outsource. Mechanical and avionics systems. All [of the] the structure is mostly [developed] in house…"

People-Project Team Coding. A wide range of topics are observed in the "People-Project team" code category. It is of interest that the highest scoring code is communication followed by training, team acquisition, and team management difficulties. The relationship between codes reveals a bundle of hard skills to be applied within the project team (resource, schedule, metrics, after-action reviews), soft skills (team acquisition, team member responsibilities, communication, and team management difficulties), and finally, the role of training and the assigning of responsibilities.

Insert Exhibit 5 Here

Transcript Excerpts. "…One guy can't do anything. One program manager can't. There's no way we can keep up. So, we have a lot of smart people. As long as they understand what we're asking, they'll go do it." "…But you set the vision. You try to get everybody to buy into the vision. You take input on what we could be doing better or what we should be doing better this time around. Set the goals and then try to influence the groups to achieve those goals at the same, again, to get to the point we need to get…"

Statistical Process Control Coding. The sub-codes associated with statistical process control suggest a possible weak utility of using statistical process control within the project environment. Further, the bulk of the coded passages suggest that when statistical process control is used it is used for the purpose of managing the project lifecycle. Finally, several tools are referred to that are observed to be useful for managing quality including the fishbone tool and the check sheet. The code similarity analysis supports the code frequency in Exhibit 6. Note that statistical process control is linked to its apparent limited applicability for use in the project environment.

Insert Exhibit 6 Here

Transcript Excerpt. "…you will find [at unnamed aircraft product development organization] and I don't know if you will find the same on other OEMs that we do very little statistical process control in projects" … "…Flow chart …. You know, this is just, check sheets, there's probably other names for that, that's just- it's just like a list. Don't do a lot of statistical process control, in terms of sampling charts and control charts, because the volume [is low]…"

Charts and Tools Coding. The sub-codes in the charts and tools category emphasize typical quality tools most widely used in managing quality in aviation projects. It is observed that cause and effect analysis along with the flowchart rank significantly higher than other quality tools. The code association analysis performed by nVivo supports the code frequency analysis results. It is observed that tools related to problem solving (flowchart, cause and effect, root cause, tree diagram) are linked, whereas the Pareto chart is more distantly related.

Insert Exhibit 7 Here

Transcript Excerpt. "…Cause-and-effect diagram. In my mind comes up with if something fails, how do you figure out why it failed. Recall analysis. We use that all the time at the lower level with the working design engineers. Flowcharts. Engineers love flowcharts. We use those all the time. Pick a group, they've got a flowchart…." "So top three would probably be control charts, but in the context that I stated earlier with regards ***to management controls, resources, budget, the schedule*** *... allowables that we can control. Checklists. And the third one would be hard to choose amongst them but probably something along the lines of flowcharts or Paretos…"*

Quality as Requirements Management. The code frequency analysis emphasizes the role of change control, but also points to internal and external standards as well as internally developed

specifications. The code similarity analysis illustrates the close relationship between internal standards and specifications with external regulation.

Insert Exhibit 8 Here

Transcript Excerpt. "…the statement of work calls out what my requirements are and, like I said, we break those down into individual requirements. And then my ... actually I have a weekly meeting that we go through and check on status every week to figure out where we are and what requirements we haven't met yet." "…Then we create a team…get the requirements, and then we track them via our tools. Our [tracking method] is the tool that we track the different milestones and gates that each piece has to go through…"

nVivo Qualitative Analysis Conceptual Framework

What then results from an in-depth analysis of the codes, code frequency and relationships, and interview excerpts? Based on the interview coding, the *nVivo Qualitative Analysis Conceptual Framework* is a visual representation of the relationships of how quality project management is performed in aviation.

Insert Exhibit 9 Here

SAS Text Miner Analysis

The SAS Text Miner uncovered three major topics based upon mathematical analysis of word clustering and strength of associated topics. Each topic is presented by the text miner application as a cluster of terms that exhibit strong relationships and appear often together. The clustered words identified by the text miner algorithm (SVD-Singular Value Decomposition) vary the most from the remaining text in the documents thereby together comprising the essence of a distilled topic. The + symbol in the string of terms indicates the presence of stem words.

SAS identifies related words that may be spelled differently or appear in different combinations of other words. SAS then uses a single term along with the + symbol to identify the collection.

Text Miner Topic #1: Quality defined as performance aligned with industry standards.

Text Miner Clustered Terms: +perform, +standard, +qualify, aerospace, and torque

The sense conveyed by the collection of related themes in the text miner is that quality management in aviation projects is focused on industry standards that are unique to the airline industry. One such is the unique characteristics of each aviation development project. Airplanes are developed and manufactured in lower volumes and have specific industry requirements. One project manager stated:

> …the unique thing I've found in aerospace for managing projects is that we do have a lot more projects than maybe automotive, for example. [Airplane development projects] aren't cookie cutter projects, because in automotive, they've been doing it for so long. The projects they perform, things they do, a lot of them are the same thing over and over and over. Whereas in aerospace, it's always something different…. And the struggle there in aerospace is that we don't spit out thousands of cars a day.

Aviation project managers also indicated that although industry standards are a given, internal standards go beyond that which is required by industry, further stating that emphasis on industry standards naturally leads to the focus of quality management as "performance to specification."

Text Miner Topic #2: Quality defined as internal systems and change control

Text Miner Clustered Terms: ecr ("engineering change requests"), ecrs, +wing, +class, and +percentage

The aviation industry requires a strong audit trail for all changes to designs as well as engineering processes and procedures. This focus therefore creates the need for process

discipline as well as an internal change management control. When discussing the origins of an Engineering Change Request (ECR), an aviation project manager indicated that the requests typically come from engineering or operations,

> Usually it's either an engineer looking at a release model sees an error, creates an ECR. The other is operations. [A] Guy is trying to assemble. It doesn't work. Those both originate an ECR.

Change requests in development projects are carefully reviewed and then classified according to the nature of the issue. According to one project manager,

> The [engineer responsible for] the team is the one that reviews an ECR, categorizes it, gives it a class. Is it a design error? Is it a safety issue? Is it clerical? That's where the ECR gets its class.

Engineering change requests in aviation projects must also be linked to client and industry requirements as outlined by this project manager,

> It's basically a closed loop system where you create your requirements. You find issues. You come back. You sometimes update requirements, or you update the aircraft.

Text Miner Topic #3: Quality defined as meeting regulatory requirements

Text Miner Clustered Terms: "+program, aircraft, FAA (Federal Aviation Administration), +airplane, and +perspective

Aviation project managers acknowledge that a key constraint in projects is the certification process required by the Federal Aviation Administration (FAA), the regulatory body governing the aviation industry:

> It's primarily a development program, and so the project for me, the most concrete finish line is certification and then we transition into the program taking on the next role,

> delivering the product, supporting the product ... at that point my role [might] change to go to the next development program to try and get [it] up to certification.

Deliverables linked to customer requirements often go beyond the regulatory requirements of the airplane design. As one project manager stated, “We have a lot more options for the customers. Cockpit printer. XM weather. Aircraft health and trend monitoring system. Those are all optional systems. They're not part of the baseline TC [Type Certificate] of the aircraft.”

Overview of Text Miner Analysis Themes

The topics distilled from the text miner analysis overwhelmingly support the role of requirements in the definition and management of quality in aviation projects. The unique characteristics of aviation projects and associated product development is the role of industry standards—particularly as it relates to the consideration of customer safety and airline requirements for novel features and efficiency. Another significant source of requirements arises from the regulatory environment. The challenge for project managers in aviation is therefore developing and complying with strong internal controls that ensure that industry and regulatory requirements are not compromised during the project lifecycle.

Insert Exhibit 10 Here

Summary of Phase One

It is observed that the nVivo qualitative data analysis and the SAS text miner analysis complement each other. The text miner analysis captures the importance of requirements and their source originating from industry as well as the regulatory environment. The text miner additionally highlights the importance of the change control process. This fits well with the focus on “quality as meeting requirements” and “statistical process control as a means for lifecycle, budget, and resource control”.

Combined Conceptual Framework

The combined conceptual framework places the topics produced by the text mining analysis in the context of the nVivo qualitative data analysis derived conceptual framework. It is observed that no contradictions are evident. Rather, both methodologies appear to complement and reinforce each other.

Insert Exhibit 11 Here

Phase Two: Qualitative Validation Via Project Manager Survey

A sample of 400 project managers responded to a nine-question survey that asked them to state their level of agreement with statements associated with quality management. The quantitative survey was conducted as a means of validating the text miner and nVivo thematic analysis extracted from the interview transcripts. The survey results suggest that the emphasis on requirements management identified in the aviation project manager interviews is well placed. It is of interest that the most strongly positive response is associated with meeting client requirements.

Insert Exhibit 12 Here

Of the 400 project managers surveyed, 78% agreed with the first statement, "managing quality in project management primarily involves confirming that project deliverables meet the requirements of the client." It is also of interest to understand "how" project managers seek to meet client requirements as they manage projects. The next two responses that were strongly positive were Questions 2 (75% agreement) and Question 4 (74% agreement) which identified the project lifecycle as the process that is the focus of the project quality management system. Further, check sheets are considered a primary quality management tool consistent with methods for use in the confirmation of requirements at each phase of the project lifecycle.

The remaining questions focused on the use of quality tools in project management. It is observed that the most positive responses suggest that project managers make little distinction between managing quality in projects and in operations—particularly with respect to the use of tools. The control chart question exhibited the strongest positive response among all quality management tools. Given that the lifecycle is the primary process controlled when managing project quality (Question 4), then it follows that the control chart is one such mechanism for tracking the performance to plan within the project lifecycle perhaps by using indices and measures of conformance to client requirements (Questions 5 and 6). While project managers state explicitly that quality *tools* in operations are equally applicable to project management (Question 8), it is interesting to note that responses regarding *how* quality is managed in projects versus ongoing operations is far less positive and trending very close to a neutral response. The implication and possible subject for future research is further understanding the difference between how project managers versus operations managers use quality tools as well as for what purpose they use them.

The remaining tool-related questions (Questions 7, 9, and 10 in order of positive response) demonstrate a lesser degree of emphasis on the use of the use of traditional quality tools derived from their origins in operations management. 60% of project managers indicated that they use SPC in projects they manage, while only 49% indicated they use histograms in projects they manage, and only 47% indicated the use of cause and effect diagrams in their projects.

Phase Three: Qualitative Validation Survey—Importance Ranking Activities and Tools

As a final validation step, a sample of 400 project managers responded to a ranking survey instrument which asked project managers to rank project quality tools, activities, factors,

definitions, processes, and statements. The highest ranked choices in the 400 survey responses are consistent with the view that project quality management is an exercise in meeting client and industry requirements—and that the process of ensuring and controlling the meeting of client requirement involves confirmation of compliance to requirements with checklists throughout a lifecycle defined by process flows.

Insert Exhibit 13 Here

Answering the Research Questions

The mixed-method study began with a number of research questions and sought to answer them with multiple interviews, two forms of qualitative data analysis, and surveys to two project manager samples, n=400 for each. The data suggests the following answers to the research questions:

1. What kind of projects are executed within the aviation industry?

Development of aircraft, systems and components associated with aircraft, outsourcing projects, and tool development. (Source: Analysis of interview transcripts)

2. How do project managers actually manage quality in aviation projects?

The overriding focus is on meeting requirements including client, industry, regulatory, and internal requirements. The project lifecycle phases are used as checks to ensure that requirements are being met. (Source: Analysis of interview transcripts, project manager surveys)

3. What tools do aviation project managers use when managing quality in projects?

The data suggests that check sheets, flow charts, cause and effect, and fishbone diagrams are the primary tools used for managing quality in aviation projects. Such tools are consistent with the natural problem-solving associated with managing requirements throughout the project lifecycle. (Source: Analysis of interview transcripts, project manager surveys)

4. Do project managers use the two sets of seven tools in the PMBOK®? If so, which do they use more? Which do they use less?

The data suggests that check sheets, flow charts, cause and effect, and fishbone diagrams are used more, and statistical tools associated with the long runs of data associated with mass production are used less. (Source: Analysis of interview transcripts, project manager surveys)

5. Do aviation project managers employ statistical process control when managing quality in aviation projects? If so, what processes do they seek to control?

The data suggests that they do, however, the project lifecycle including budget and resource control is its focus. (Source: Analysis of interview transcripts, project manager surveys)

6. Do aviation project managers perceive that quality management practice within project management is (or should be) the same as quality management within operations?

The data suggests that they do. However, there are observed differences in the description of how such quality practices are employed in managing quality in projects as opposed to ongoing operations. (Source: Analysis of interview transcripts, project manager surveys)

Conclusions

The quantitative survey results are observed to reinforce and validate the findings from the qualitative data analysis. Both sets of results are in agreement with the quality management statements. The ranked tool preferences illustrate a focus on managing the project lifecycle to ensure that project deliverables meeting client requirements. This approach appears to be consistent with the direct, one-time-only, short time window focus of projects. This is in contrast with the manufacturing environment tailored to produce long runs of product over a lengthy time horizon.

Insert Exhibit 14 Here

It is further observed in this study that the aircraft product development and manufacturing must fulfill a rigorous set of regulatory and industry requirements. Current events inform us that lives are at stake when such requirements are not met. This suggests that aviation project management could benefit by adopting a new lens for managing project quality and avoid a surface-level adoption of quality tools designed primarily for the mass production context.

Practical Implications for Engineering Managers

The project management profession is integral to the engineering industry, specifically the aviation engineering industry. Design, maintenance, and quality aspects of aircraft depend heavily on engineering disciplines such as aeronautical, metallurgy, mechanical, instrumentation, electrical, and communications. Needless to say, these research findings are relevant for any engineering management profession and apply to engineering managers representing various disciplines and industries. These results suggest that engineering managers, often with a greater focus on engineering functions, should also pay attention to quality assurance and formalized project management processes. Further, the results imply that it might be an added advantage for the engineering industry to encourage its managers to pursue professional certifications in quality and project management from professional associations such as ASQ and PMI.

References

Abbasi, A., & Nikbakht, M. (2018). Identification and Clustering Outsourcing Risks of Aviation Part-Manufacturing Projects in Aviation Industries Organization Using Kmeans Method. *Journal of Modern Processes in Manufacturing and Production*, 7(4), 17-30.

Anantatmula, V. S. (2016). *Project teams: A structured development approach.* New York, NY: Business Expert Press.

Aole, R. M. (2013). Quality gurus: Philosophy and teachings. *International Journal of Research in Aeronautical and Mechanical Engineering*, *1*(8), 46-52.

American Society for Quality. (2019). Retrieved from https://asq.org

Baumann, O., Becker, M. C., & Horrmann, I. (2020). Ensuring Adaptation While Seeking Efficiency: Tiered Outsourcing and Skip-Level Supplier Ties in the Airbus A350 Program. *Organization Science.*

Besner, C., & Hobbs, B. (2012). An empirical identification of project management toolsets and a comparison among project types. *Project Management Journal, 43*(5), 24-46. doi:10.1002/pmj.21292

Besner, C., & Hobbs, B. (2013). Contextualized project management practice: A cluster analysis of practices and best practices. *Project Management Journal*, 44(1), 17-34.

Cameron, D. “Pentagon Presses Lockheed for Lower-Priced F-35 Jets.” The Wall Street Journal 1 Oct 2018: https://www.wsj.com/articles/pentagon-presses-lockheed-for-lower-priced-f-35-jets-1538432965

Casadesus-Masanell, R., & Elterman, K. (2019). Airbus vs. Boeing (L): Discontinuing the A380 (February 2019).

Feng, L., Huang, D., Jin, M., Li, W., He, Z., & Yu, A. J. (2020). Quality Control Scheme Selection with a Case of Aviation Equipment Development. *Engineering Management Journal*, 32(1), 14-25.

Flottau, J. (2019). 'Too much testosterone': Airbus terminates A380 program only 12 years after service entry; last aircraft will be delivered in 2021; Emirates cuts back key order by 39 aircraft. *Aviation Week & Space Technology.*

Flouris, T. G., & Lock, D. (2016). *Managing aviation projects from concept to completion*. Farnham: Taylor & Francis.

Gray, J., & Anantatmula, V. (2009). Managing six sigma projects through the integration of six sigma and project management processes. *International Journal of Six Sigma and Competitive Advantage, 5*(2), 127–143. doi: 10.1504/ijssca.2009.025165

Gwosch, T., Steck, M., Dörr, M., & Matthiesen, S. (2020). Frontloading in Aircraft Development Process by Integration of a new Validation Method.

IEEE Guide for Developing System Requirements Specifications," in *IEEE Std 1233-1996* , vol., no., pp.1-30, 22 Dec. 1996, doi: 10.1109/IEEESTD.1996.81000.

International Organization for Standardization. (2012). *Guidance on project management (ISO Standard No. 21500:2012)*. https://www.iso.org/

International Project Management Association. (2018). *Project excellence baseline for achieving excellence in projects and programmes.* https://www.ipma.world/individuals/standard/

Johnston, P., & Harris, R. (2019). The Boeing 737 MAX saga: lessons for software organizations. *Software Quality Professional*, 21(3), 4-12.

Kerzner, H. (2017). *Project management: a systems approach to planning, scheduling, and controlling*. John Wiley & Sons.

Project Management Institute. (2017). A guide to the project management body of knowledge. Newton Square, PA.

Papke-Shields, K. E., Beise, C., & Quan, J. (2010). Do project managers practice what they preach, and does it matter to project success? *International Journal of Project Management, 28*(7), 650–662. doi: 10.1016/j.ijproman.2009.11.00

Shenhar, A. J., Holzmann, V., Melamed, B., & Zhao, Y. (2016). The challenge of innovation in highly complex projects: What can we learn from Boeing's Dreamliner experience?. *Project Management Journal*, 47(2), 62-78.

Tague, N. R. (2005). *The quality toolbox (Vol. 600).* ASQ Quality Press: Milwaukee, WI.

Vieira, D. R., Rebaiaia, M. L., & Chain, M. C. (2016). The application of reliability methods for aircraft design project management. *American Journal of Industrial and Business Management,* 6(9), 967-992.

Vieira, D. R., Vieira, R. K., Chain, M. C., & Bravo, A. (2017). Model for managing uncertainty in aeronautics projects. *International Journal of Product Lifecycle Management*, 10(3), 258-278.

Winch, G. M. (2001). Governing the project process: A conceptual framework. *Construction Management & Economics, 19*(8), 799-808. doi:10.1080/01446190110074264

Winch, G. M. (2003). Models of manufacturing and the construction process: The genesis of re-engineering construction. *Building Research & Information, 31*(2), 107-118. doi: 10.1080/09613210301995

Winch, G. M. (2006). Towards a theory of construction as production by projects. *Building Research & Information, 34*(2), 154-163. doi:10.1080/09613210500491472