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Aviation Risk Management

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In an increasingly complex global ecosystem, organizations face a growing number of risk factors. While risk is inherent in all industries, aviation projects are subject to enhanced scrutiny given the necessity to ensure safe, timely, and fiscally responsible outcomes. As a result, the acceptance of project management concepts within aviation projects has been widely adopted (Flouris & Lock, 2016). Failure to manage risk factors is observed in examples of unsuccessful projects – some with catastrophic outcomes involving NASA's Space Shuttle Challenger and the Boeing 737 MAX, and the delayed open of Berlin's Brandenburg airport. In the two instances tragically, lives were lost (Allen et al., 2016; Herkert et al., 2020), and the second example the airport's $7 billion cost was three times more than the original project budget (Wagner, 2017). These examples underscore the importance of improved risk management practice throughout the aviation supply chain – from manufacturing to airport design and beyond. In an industry fraught with high-stakes risk factors, the inconsistent implementation of risk management practices (Taroun, 2014) suggests the need for focused research into how risk is managed within aviation projects. This focused examination of risk management in aviation projects provides practical insight in an industry where the unknown must be managed to minimize tragedy and capitalize on opportunity.

Literature Review

The aviation ecosystem involves a complex network of organizations (Ermakova et al., 2019) undertaking risk-sensitive projects (Flouris & Lock, 2009). Risk events in aviation run the gamut from those that are favorable to that which, though infrequent, have the potential to result in catastrophic outcomes. For that reason and amidst heightened uncertainty in the air transport industry, there exists an immediate need to explore and understand the implications and management of risk in aviation projects. The literature review examines the body of knowledge regarding risk management and the extent to which it is observed in research involving aviation-oriented organizations.

Uncertainty in Projects

All organizations face risk. Risk, within the context of project management is described as "an uncertain event or condition, that if it occurs, has a positive or negative effect on a project's objective" (Project Management Institute, 2021, p. 117). Understanding that risks cannot be eliminated (Rios Insua, 2018; Weaver, 2008) and in some cases should be exploited, successful project oversight involves managing risk (Padalkar & Gopinath, 2016). Underpinning risk management is the complexity theory which concedes the impossible task of accurately predicting the future (Turner & Baker, 2019; Weaver, 2008). Given this challenge, effective risk management involves the use of tools and techniques designed to identify and manage future risks that could potentially impact the project (Gerstein et al., 2016).

Risk Management Strategies

The practice of risk management – that is risk identification, analysis, response, and monitoring – is challenging, yet critical at every stage of the project (Szymański, 2017). Examples of tools and methods used within the risk management cycle include: (a) brain storming, (b) Delphi method, (c) SWOT analysis, (d) Ichikawa method, (e) sensitivity method, (f) modelling and computer simulations, (g) risk matrix, (h) PERT method, (i) decision trees, (j) probabilistic methods and probability theory, (k) Fuzzy sets, and (l) artificial neural networks. Scholars have gone to great length to evaluate and compare risk assessment tools and techniques (Afzal et al. 2021; Cioaca, 2011; Kanki & Hobbs, 2010; Ostrom et al. 2019), yet according to Taroun (2014) there are gaps between the theory and the actual practice of risk management.

Just as no two projects are the same, it goes to reason project risk factors and management also differ. Prabhakar (2009) surmised that projects vary according to the industry, as well as the organization's type, size, and location. For instance, some industries such as banking and insurance are more readily concerned and prepared to manage risk. The question follows, to what extent does risk management differ in aviation-oriented projects?

Managing Risk in Aviation Projects

The aviation value delivery chain is comprised of multiple entities each playing a role in ensuring a safe and efficient air transport service. From aircraft production to airport construction efforts and the information technology systems involved, the number of projects within the aviation industry are plentiful (Flouris & Lock, 2009). Burdina and Bondarenko (2022) recommend the use of project management practices to increase the likelihood of project success. Uncertain events or factors impacting aviation projects stem from the following: a) supply chain risk, b) financial and schedule risk, c) human capital risk, d) organization and management risk, e) external dependency risk, f) political risk, and g) technical risk (Gerstein et al., 2016).

Given the nature of risk and its consequences, there is an opportunity to further explore the factors that lead to project success and failure (Padalkar & Gopinath, 2016) and how those risk events are managed in aviation projects (Flouris & Lock, 2009). Managing risk through qualitative and quantitative analysis techniques is common, however, projects often rely on human inputs including but not limited to estimates, assumptions, and judgement (Flouris & Lock, 2009). This challenge supports the call to examine risk management lessons in aviation projects, with a keen focus on project recovery and project failures. A discovery into these topics will advance the body of knowledge around the similarities and differences of risk management in aviation projects.

Methodology

This study applied the constructivist paradigm using a phenomenological strategy to explain the aviation project manager's experience with risk management. The primary purpose of this research was to understand risk management in the aviation industry and what can be learned by asking practitioners. The 56 participant's experiences and feedback provided key information and insight to the research questions.

By using the constructivist mindset, the authors used the aviation project managers' perceptions to reconstruct a risk management framework (Guba & Lincoln, 1994). Additionally, the phenomenological approach was utilized. The authors identified both researcher and participant presuppositions about aviation risk management to set them aside to understand the true phenomenon impacting risk management in aviation (Osborne, 1994). For this study, interviews were conducted with 56 practicing project managers who self-identified in the aviation industry. The data gathered was analyzed to understand and create participant perceptions of aviation risk management. The interviews with professional project managers solicited answers to questions regarding both risk management and successful and failed project execution, examples of project failure (in the context of risk), and opinions about what makes aviation unique with respect to risk and execution. For this paper, the results of project risk are included. The methodology was based on the primary research question:

What Lessons Can You Share About Project Risk Management?

The research design adopted the key informant technique to identify participants, who were individually recruited by project management graduate students, based on position in organizations and aviation expertise to provide insight into the roles of a project manager (Marshall, 1996). The series of one-to-one semi-structured interviews was conducted using the study's theoretical and foundational knowledge and the observations of experience explored with the participant (Schmidt, 2004). The interviewers collected data in the form of field notes to minimize personal bias and unintentional errors of omission due to memory lapse (Hofisi et al., 2014). The researchers acknowledge that professional experience as project managers could influence data interpretation (Mehra, 2002). To minimized personal bias, the researchers conducted peer debriefing (Seale, 1999) and substantiated findings with relevant quotes.

The literature suggests that qualitative research sample size is to be small (Miles et al., 2019) with recommended ranges from 5 to 25 participants (Creswell, 2017). Qualitative research sample size seeks "saturation", the point at which additional participants uncover no new information (Strauss & Corbin, 1998). Consistent with qualitative research practice, the number may be increased to reach saturation (Marshall, 1996; Strauss & Corbin, 1998), but in this case, it was not necessary.

Interview analysis was organized in three phases. First, the interview transcripts were examined, noting persistent themes, quotes, and examples significant to aviation risk management (Merriam & Tisdell, 2015). The researchers individually performed multiple transcript reviews and jointly assessed themes for distinction and consistency (Merriam & Tisdell, 2015). Second, the unstructured interview data was organized and analyzed using nVivo qualitative coding software and hierarchical coding (Ozkan, 2004). The proximity of emerging themes was identified using frequency analysis. The thematic analysis led to the development of a conceptual framework emerging from the interview transcripts of aviation project managers involved in managing project risks. 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 topics from text documents using the dimension reduction methodology of Singular Value Decomposition (SVD) (Albright, 2004). The results of the SAS Text Miner were used to ground the nVivo analysis with a neutral and objective generation of topics that are used to compare with researcher-generated text coding associated with qualitative data analysis.

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 risk managers working within aviation projects. The themes were ranked according to the number of interviews in which they appeared along with the overall number of instances in which they appeared. The themes identified themes used in this study were limited to the top ten themes, Table 1.

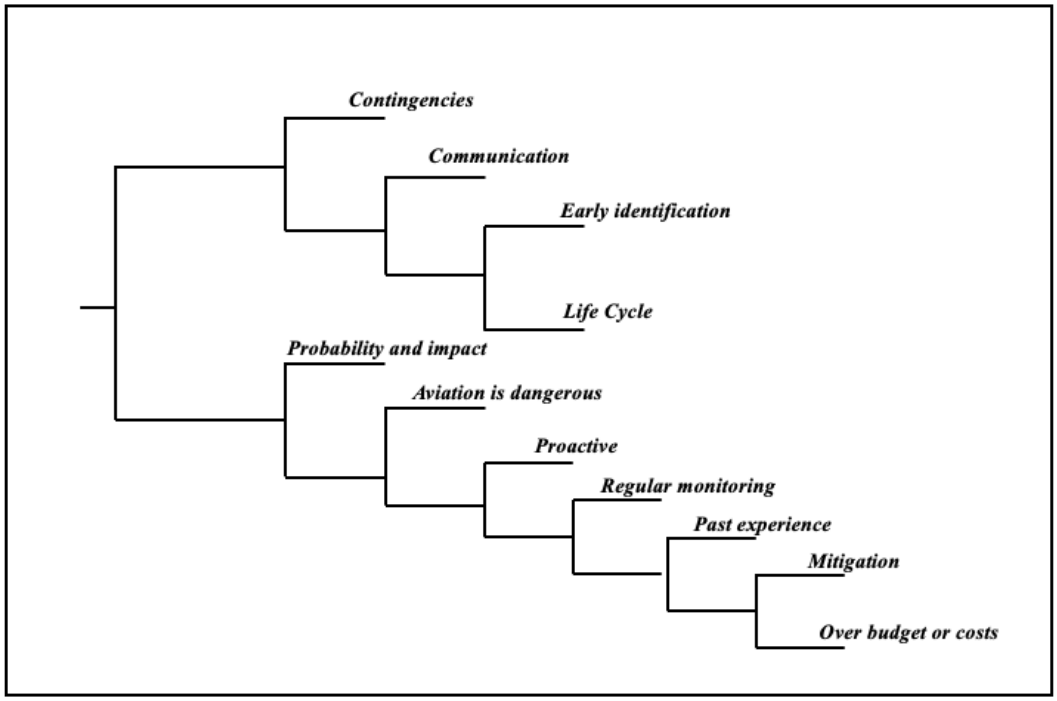
Table 1

Top Ten Themes Ranked by Frequency of Appearance

Themes	Documents	Instances	Rank
Mitigation	28	39	1092
Early identification	20	22	440
Communication	17	18	306
Regular monitoring	12	13	156
Prob and impact	11	15	165
Contigencies	11	13	143
Aviation is dangerous	11	12	132
Over budget or costs	10	10	100
Life Cycle	9	9	81
Past experience and projs	8	10	80
Proactive	8	9	72

After the themes were ranked, nVivo was then used to determine the word similarity of each code. In this cluster analysis generated by NVivo (Version 10, QSR International, 2018), the correlation coefficients measuring the relationships of common words found between themes are illustrated in Figure 1. For example, in the dendrogram, it is observed that the themes fall into two major streams. The first stream is associated with risk identification early in the project followed by communication of risks and contingency plans to project stakeholders. The second stream of related themes involves the intense focus on the assessment of risk within a capital-intensive and inherently dangerous industry.

Figure 1
nVivo Themes and Excerpts: Stream 1-Early Risk Identification and Communication



This stream of related themes highlights the important of early identification as well as the preparation of plans for addressing risk to minimize impact there possible.

Contingencies (11 documents [20% of respondents] / 13 instances / ranking 143)

The risk strategy of contingency planning is a focus of this identified theme. Given the severe impact of risk in the aviation industry, project managers actively seek to either blunt the impact of the risk or eliminate it altogether using contingency planning. The following interview excerpts from this theme capture this intent as follows:

"Risks need to be carefully analyzed and appropriately measured to ensure the proper contingencies are in place for a project."

"…a great majority of risks can be captured and communicated to the stakeholders to ensure proper contingencies or mitigations are in place…"

Communication (17 documents [30% of respondents] / 18 instances / ranking 306)

Risks in the world of aviation can be insidious. Often something very small creates a cascading chain of events that could lead to disaster. Constant

communication by team members seeking out such risk is paramount as illustrated by interview excerpts as follows:

"You manage risks by communication. Under-communicating leads to failure."

"Sometimes, we don't see a risk until it hits us – so having regularly conversations about observations and quality assurance measures (proactive, consistent, evolving) – brings risk management into the conversation regularly. "

Early Identification (20 documents [36% of respondents] / 22 instances / ranking 440)

Continuing with the idea of aggressive seeking out of risk, the focus of this theme stresses the importance of identifying risk at a very early stage. Excerpts from transcripts associated with this theme described this.

"Risks are to be identified and dealt with as early as possible in the project."

"…good management structure identifies risk as early as possible and manages it every single day…"

Life Cycle (9 documents [16% of respondents] / 9 instances / ranking 81)

The project lifecycle is an important area of focus—particularly considering that risk identified early in the lifecycle may be minimized and cost less to manage than risks that arrive later in the project. Yet, the possibility of risk emergence always exists throughout the project lifecycle and this idea is expressed in excerpts associated with this theme.

"Formalized risk management exists as a deliberate process that spans the life cycle of a project, from concept to grave…"

"Project risk management now includes not only identifying, mitigating, and controlling risks but also identifying, exploiting, and utilizing opportunities that may arise throughout the project life cycle. "

nVivo Themes and Excerpts: Stream 2-Intensive Risk Assessment Within an Inherently Dangerous Industry

The inherent danger involved with aviation puts aviation project managers and team members on guard throughout the project lifecycle. This places a clear focus on being alert, constantly scanning the project environment, and frequent assessment of risks.

Probability and Impact (11 documents [20% of respondents] / 15 instances / ranking 165)

The impact of aviation project risks comes in the form of cost as well as danger. The identified risks are carefully assessed and classified according to probability and impact so that the risk with the highest likelihood and most severe impact remain in clear focus. The excerpts from this theme attest to this.

"…ensuring that the primary threats the crews encountered routinely could be captured and weighted accordingly. The final "risk number" then drives risk acceptance to the appropriate level of command authority…"

"…sometimes we have a lot of inputs, so we break them down between the likelihood and impact and assigning each a probability/score of Low, Medium, and High. "

Aviation is Dangerous (11 documents [20% of respondents] / 12 instances / ranking 132)

The significant responsibility associated with aviation project managers make risk management and aspect of project management that is given more emphasis than in other project categories. Theme excerpts captured in interviews illustrate the overriding concern with the lives of passengers and crews.

"Risk management is a massive part of any aviation project. It is understood that there is an inherent risk involved in any project. Still, in aviation operations, it is paramount that risk is held to the lowest possible levels as it can put people's lives in danger."

"Under FAA guidelines risk management is important because we are responsible for million-dollar assets (planes), and people's lives…"

Proactive (8 documents [14% of respondents] / 9 instances / ranking 72)

Risks, by definition, differ from issues in that they have yet to happen. However, the significance of risk impact in aviation puts significant focus on constantly looking ahead and being prepared. This emphasis emerges clearly in excerpts from this theme.

"The lesson from all this like in most any aspect of the PM line of work is not waiting for something to happen and reacting in haste, but the be preemptive and try as best you can to foresee all possible scenario's and develop a plan to attack if any scenarios were to occur."

"Risk managers look at things before they happen."

Regular Monitoring (12 documents [21% of respondents] / 13 instances / ranking 156)

It is common practice for project teams to monitor risks and adjust the risk register and contingency plans as necessary. Aviation projects are not different in this respect—albeit possibly more intensive as the theme excerpts suggest.

"Risk management meetings are done on a bi-monthly time frame with new risks being added to the matrix constantly as the project moves along the timeline. Trackers, written down everything, and being open to past failures is key to a successful project."

"Periodic meetings to review and monitor mitigation plans to completion is critical to successful project execution."

Past Experience and Projects (8 documents [14% of respondents] / 10 instances / ranking 80)

The experience of the project manager within the aviation industry as well as in previous projects is essential for the identification and management of aviation project risks. It is the experience of the project manager and team members that

focus the project effort to identify, assess, communicate, monitor, and mitigate. This emphasis is clearly observed in the excerpts from this theme.

"We conduct research to see if we have done similar projects in the past to help guide us."

"With that all being said, efficient and effective project risk management is a skill that takes experience and time to master. "

Over Budget or Costs (10 documents [20% of respondents] / 10 instances / ranking 100)

Aviation is not only dangerous—it is also very costly. Developing, manufacturing, and maintaining airplanes is extremely expensive. Also, risk management and contingency plans lead to significant costs that must be factored into the project budget as the theme excerpts illustrate.

"I worked for a large aerospace company that approved projects based on the estimated cost plus the projected overrun as modeled by a 56 question "red flag" assessment of risk."

"Reducing risk, though, normally costs money, so there is a struggle between those dedicated to profit and cost management, and those dedicated to risk reduction."

Mitigation (28 documents [50% of respondents] / 39 instances / ranking 1092)

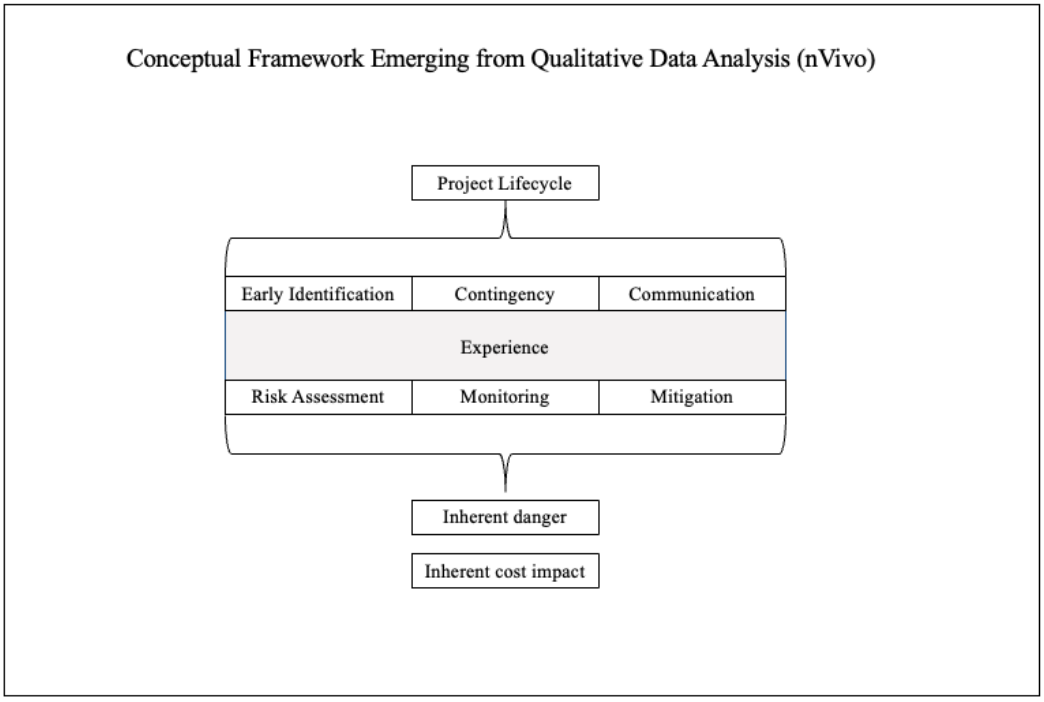
The focus on risk in aviation is active rather than passive with intensive focus on the reduction of risk likelihood and impact via the use of mitigation plans. As the theme excerpts suggest, the focus is continuous.

"Mitigating risks during a project requires the manager to develop many layers of their response plan in an effort to lower the risk to the lowest possible level without impact mission effectiveness".

"…good management structure identifies risk as early as possible and manages it every single day with solid mitigation strategies…"

nVivo QDA Resulting Conceptual Framework

Figure 2
nVivo QDA Resulting Conceptual Framework



Phase 2: SAS Text Miner Analysis

The SAS Text Miner uncovered five 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.

Table 2

SAS Topics Ranked by Frequency of Appearance

Topic ID	Topic	Number of Terms	# Docs	Rank
1	+issue,scope,+opportunity,+arise,government	15	10	150
2	+mitigation,always,+plan,+risk,+time	16	8	128
3	+manage,+company,training,+employee,+area	17	7	119
4	+occur,analysis,+understand,+strategy,+cost	18	6	108
5	risk,aviation,+level,+develop,+job	11	7	77

Text Miner Topic #1: Response to issues and opportunities constrained by scope and regulation

Text Miner Clustered Terms: +issue,scope,+opportunity,+arise,government

As uncovered in the qualitative data analysis, aviation projects are costly. This can be a source of constraints for project risk management. Also, government regulation is also a significant source of project risk management constraints.

"My aviation projects have a great deal of risk inherently, but a cost risk is less frequent, unless a new requirement arises, but in that event, there is usually a delta scope proposal issued. Since they are service contracts, all of the risk is mitigated by us or the government somehow".

Text Miner Topic #2: Planning to minimize risk impact

Text Miner Clustered Terms: +mitigation,always,+plan,+risk,+time

The text mining algorithms identified a focus on planning for risk as well as the creation of mitigation plans. The emphasis, as was the case in themes identified in the nVivo qualitative data analysis, is on looking ahead and being proactive.

"Properly identifying, mitigation, and controlling a risk before it even happens will greatly increase the projects chances of success. Just like in the Army, although it may be tough, being proactive is always better than being reactive".

Text Miner Topic #3: Company activities to minimize risk impact

Text Miner Clustered Terms: +manage,+company,training,+employee,+area

The company sponsoring aviation projects bears the ultimate responsibility for the impact of risks should they occur. This leads to company activities to better prepare employees for the significant risks associated with aviation.

"…these areas have additional hazards that can affect the employee, so we attempt to manage those risks to the best of our ability by providing training and working in groups. Also, my company goes to great lengths to train employees on the proper techniques to practice in order to avoid damaging customer owned aircraft…"

Text Miner Topic #4: Understanding context to determine likelihood and impact

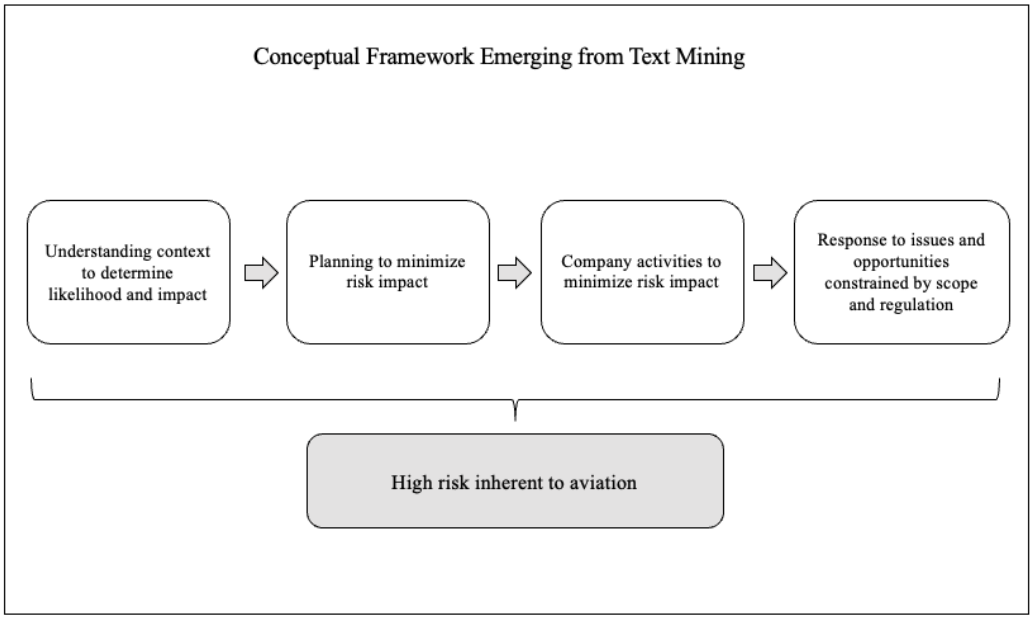
Text Miner Clustered Terms: +occur,analysis,+understand,+strategy,+cost

One of the themes identified in nVivo Qualitative Data Analysis was associated with the importance of experience. Text miner topic #3 exposes one of the underlying reasons for this importance. Experience enables an understanding of the overall context and supports a holistic understanding of the risk environment.
"Risk management is not just a check in the box. It is about understanding your project, the things that can occur and derail your project, and having risk reduction and mitigation techniques available".

Text Miner Topic #5: High risk inherent to aviation
Text Miner Clustered Terms: risk,aviation,+level,+develop,+job

As in the case of themes emerging from qualitative data analysis, the text miner topic #4 captures the fact of underlying danger with respect to aviation projects.
"There are always times when the risk could be catastrophic but is very unlikely for the project. This can be true in a construction or aviation project as they are all high risk"

Figure 3
Overview of Text Miner Analysis Themes



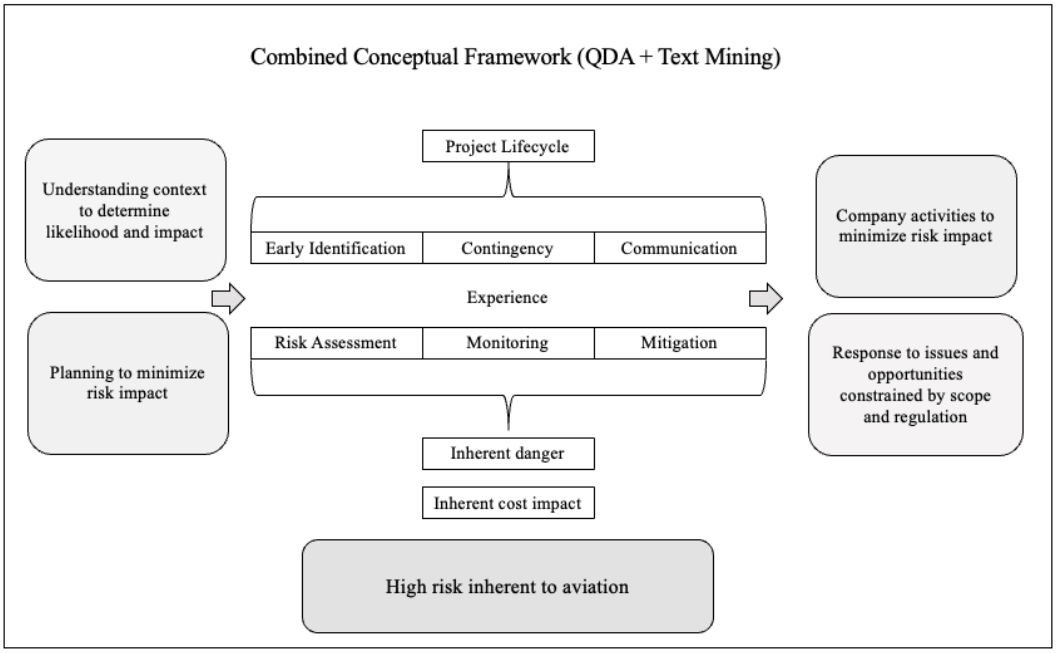
Combined Conceptual Framework

The combined conceptual framework, Figure 4, 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.

Figure 4

Combined Conceptual Framework



Discussion

The challenging environment of the aviation industry places project risk management in a position of prominence that may not exist to the same degree in other industries. The cost and the potential danger to human lives forces project managers and team to take a proactive role in risk and to take steps to minimize cost and danger. The themes and topics emerging from interviews with aviation project managers illustrate how important it is in aviation projects to think ahead, to understand the context, to communicate and seek to mitigate these risks where possible. The risks faced by aviation project teams is also recognized by sponsoring companies who seek to prepare employees to deal with the extreme cost and danger inherent in aviation project risks.

Conclusion

This current study will benefit aviation project management practitioners, mentors of project managers, and the collective project management profession. The following paragraphs suggest a series of aspects about aviation risk, which, if

studied further, will continue to fortify the theoretical foundation of project management.

This research effort involved a qualitative study to understand risk management in the aviation industry. The results align with literature, confirming the high stakes involved in aviation projects given their costly and risky nature. Thus, risk assessment and planning play an integral role in forecasting the impact of uncertain events. Throughout the project life cycle, communication and proactive mitigation strategies are necessary to continuously manage emerging threats and opportunities. In aviation, risk management must be more than just "a check in the box" and theory, rather it must be embraced within the organization.

It is further observed in that aviation is guided by a rigorous set of regulatory and industry requirements. Current events inform us that lives are at stake when such requirements are not met. History serves as a harsh reminder of the consequences associated with aviation project failures such as NASA's Challenger and, more recently, the human and economic loss associated with Boeing's 737 MAX, suggesting that future research is needed in aviation project risk management designing a new lens for managing project risk and avoid a surface-level adoption of regulatory. The continued effort to understand the factors influencing project risk will better inform the oversight of aviation projects, thereby increasing the likelihood of success.

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