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Risk Management Practices in the Aviation Industry: Lessons Learned and Effective Tools… A Mixed Method Approach

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Risk Management Practices in the Aviation Industry: Lessons Learned and Effective Tools… A Mixed Method Approach

Cover Page Footnote

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This paper delves into the multifaceted world of risk management in the aviation industry. It begins by defining risk management and its significance within aviation, emphasizing safety and economic viability. The paper then explores risk management in project management, highlighting its role throughout the project lifecycle. Key concepts and processes in risk management, such as risk identification, analysis, and monitoring, are discussed, along with tools and techniques used in each phase. The research questions addressed in this paper focus on lessons learned from aviation project risk management and the most useful tools for risk identification, analysis, and monitoring.

The study involves qualitative interviews with 56 aviation project managers and a quantitative survey of 240 project managers. The research identifies several key themes, including the importance of timely planning and response to risks, the significance of risk identification and analysis, effective management and communication as key success factors, the emphasis on minimizing aviation risks due to the industry's unique challenges, and the tools favored by aviation project managers for risk management.

Literature Review

Risk Management Overview

Risk management is commonly accepted as a foundational management process to increase the likelihood of project success. While risk management likely grew out of the insurance management function in the 1950s (Hopkin, 2017), project risk management was first mentioned in the Project Management Institute (PMI) literature in 1987, which was a full seven years before the publication of the first Project Management Body of Knowledge (PMBOK Guide, 1996). From the early days of risk management, the definition expanded from one that focused on the likelihood of a negative outcome, to an assessment of both negative and positive outcomes. By 2015, the definition changed to “an uncertain future event or condition, that, if it occurs, has a positive or negative effect on at least one project objective” (ASEM, 2015, p. 145). Others (Association of Project Management [APM], 2015, 2017; Hillson, 2016; Kerzner, 2013; Lark, 2015; PMI, 2013) provide similar definitions. To broaden the perspective, several authors (Al Nahyan et al., 2018, 2019; Farooq et al., 2018; Samset et al., 2014) discuss project risk management as part of an overall decision-making system.

Significance of Risk Management in Aviation

Risk management plays a crucial role in the aviation industry and is widely accepted in aviation projects (Flouris & Lock, 2016). Risks in the aviation sector can range from benign but can lead to potentially catastrophic events. The Richardson et al. (2022) literature review emphasized the complexity and necessity of risk management in project management, highlighting various tools and methods. Despite extensive evaluations of these techniques, a gap exists between theoretical risk management and its practical application, as noted by Taroun (2014).

Project Lifecycle and Risk Management

While the titles of the phases for project and aviation risk management may vary by author or by professional organization, the concepts are the same. This process is typically divided into these key stages: identify, analyze (both qualitative and quantitative), prioritize, handle/plan response, and monitoring and control (APM, 2017; DOD, 2015; Hillson, 2018). PMI (2019) provides one of the most comprehensive discussions of tools and techniques used throughout the project lifecycle.

Risk Identification

The process of identifying risks involves a systematic approach to uncover potential threats and opportunities that could impact the project. This step includes both internal and external factors, such as resource constraints, technological challenges, and market volatility. Becker and Smidt (2015) noted that the identification phase generally lacks rigor or discussed a specific methodology that might be used for risk identification. Kendrick (2015) provided a comprehensive summary of the types of scope and schedule risks encountered during identification.

Qualitative and Quantitative Risk Analysis

Often, risks analysis consists of two separate parts (Hillson, 2018; PMI, 2019), although depending on the project complexity and tools used, this may be combined into a single phase. During qualitative analysis, risks are assessed based on their likelihood of occurring and their potential impact on the project. This qualitative analysis helps in prioritizing risks, focusing attention on the most critical ones. The process involves a subjective evaluation of risks, categorizing them based on their severity. During quantitative risk analysis, numerical data, and techniques such as Monte Carlo simulations, sensitivity analysis, and expected monetary value analysis are used to gain a deeper understanding of risks. This quantitative approach provides insights into the probability of risks and their potential effects on key project objectives like time, cost, and quality. Marion (2019) provided an excellent common-sense approach to comparing qualitative vs. quantitative risk analysis. Al Nahyan et al. (2019) provided an excellent discussion on the need for a continuous, qualitative focus on decision-making. Entacher and Sander (2018) advocated a need for both qualitative and quantitative risk decision analysis and an excellent discussion on the need for risk prioritization.

Risk Response Planning and Implementation

Developing strategies to handle identified risks is crucial. The selection of a strategy is based on the nature and impact of the risk on the project. Denney and Powell (2020) compared response strategies from multiple sources (APM, 2017; DOD Guide, 2015, Kendrick, 2015; PMI, 2017) and documented how the terminology is far from universal. For negative risks (threats), strategies such as avoidance, mitigation, transfer, and acceptance are the most common responses. For positive risks (opportunities), responses often include exploitation, enhancement, sharing, or acceptance.

Risk Monitoring and Control

The final stage in the risk management process involves constant monitoring of identified risks, tracking of residual risks, and identification of new risks as the project evolves. This requires vigilance and adaptability to changing project circumstances. The process ensures that risk management plans are effectively implemented and adjusted as necessary, and that risks are communicated to all stakeholders. Sanchez and Robert (2010) used key performance indicators for monitoring but only once risks and opportunities had materialized. Waiting for risks to materialize likely means that risk management had not effectively achieved the desired proactive effect. Loosemore (2010) discussed the illusion of control by simply transferring a risk and references the cost of controlling risks.

Research Method

Overall Research Methodology

The literature highlights a plethora of tools and techniques in project risk management. Given this abundance, our research adopts an inductive approach to comprehend project risk management, aiming to construct a conceptual framework rather than validate existing theories (Creswell, 2017; Miles et al., 2019; Strauss & Corbin, 1998). This approach aligns with project management practice research, which seeks insights into the actions of project managers, contributing to a theory grounded in project management practices (Harvey et al., 2007). The research paradigm underlying this work is phenomenological, supporting a mixed methods approach.

Employing a phenomenological, inductive methodology involves repeated measures to grasp a phenomenon, leading to the development of a conceptual framework or general theory (Miles et al., 2019; Stake, 2010). In this study, we aim to comprehend the phenomenon manifested when aviation project managers engage in risk management within projects. Consequently, interviews with experienced project managers are considered a valuable source of information and lived experiences related to this phenomenon. For this research, individuals fitting this criterion are defined as currently employed aviation project managers with a minimum of five years of experience.

This study follows a process similar to Stevenson and Starkweather (2010), where researchers defined and validated project management competence criteria through a literature review followed by interviews with project managers. Similarly, our investigation into project risk management involves multiple rounds of interviews and electronic surveys for validation to address the research questions. This validation, utilizing diverse data sources, is referred to as triangulation (Miles et al., 2019), allowing for the comparison of various "imperfect measures" characterizing a phenomenon to derive a more comprehensive understanding.

Research Questions

Research Questions

Evidence from the literature illustrates that, with respect to the management of risk in project management, there is no clear practice posturing the following research questions:

Phase 1: Qualitative interviews

RQ1: What lessons can you share about project risk management? (n = 56)

Phase 2: Quantitative Survey

What tools are the most useful for Risk Identification, Risk analysis, and Risk Monitoring? (n = 240)

RQ2a: What tools do project managers use when **identifying risks**?

RQ2b: What tools do project managers use for **risk analysis**?

RQ2c: What tools do project managers use when **monitoring risks**?

Phases one: Qualitative Interviews

During the initial phase, 56 interviews were carried out with project managers actively practicing. While qualitative research permits modifications to the sample size to attain saturation (Boddy, 2016; Strauss & Corbin, 1998), such adjustments were unnecessary in this instance. The interviews were organized using a predefined interview guide.

Qualitative research question: What lessons can you share about project risk management?

The interview data obtained was subjected to qualitative data analysis techniques through NVivo software, employing hierarchical coding (QSR International, 2014). The thematic analysis facilitated the construction of a conceptual framework derived from interview transcripts of project risk managers. Subsequent to the qualitative data analysis in NVivo, the interview transcripts underwent systematic examination via Singular Value Decomposition using Python software. Python utilizes sophisticated mathematical techniques to discern inherent meaning from textual documents. The outcomes of Singular Value Decomposition in Python were utilized to underpin the NVivo analysis, providing a neutral and objective generation of underlying themes.

Phases two: Quantitative Surveys

During the second phase of the research, an electronic survey was disseminated among project managers. This aimed to validate the risk processes utilized in aviation project management and confirm the preferences for the use of risk management tools. A total of 260 survey responses were gathered to affirm the conceptual framework derived from the interview themes. The outcomes of qualitative data analysis, coupled with the quantitative survey results, were integrated to form a comprehensive understanding of the approaches to risk management within projects.

Analysis: **RQ1: What Lessons Can You Share About Project Risk Management**

A Dual Approach To Analyzing The Interview Transcripts

The conversations with project risk managers underwent transcription for analysis, employing conventional qualitative data analysis techniques like coding, thematic analysis, and word counts. nVivo served as the qualitative data analysis tool for capturing, organizing, and establishing relationships between themes. Although this textual analysis method has faced criticism due to the perceived subjectivity of researchers identifying themes, an additional layer of analysis was introduced. The interview data underwent analysis using computerized algorithmic methods to extract themes, addressing concerns related to subjectivity. This method employs packages in Python that perform the following activities:

1. Breaking all documents into words
2. Using term frequency and inverse document frequency to create a large matrix consisting of words (in rows) and documents (in columns).
3. Decomposing the resulting matrix three matrices of smaller dimension using Singular Value Decomposition. The three matrices are identified as. U, Σ, and V.
4. In SVD analysis, the U matrix is referred to as the “term-topic” matrix that may be interpreted as the key themes present in the corpus of documents used in the analysis.

The use of both traditional qualitative data analysis in concert with an algorithmic approach to thematic analysis provides a means to ground the analysis so that the perceived subjectivity of qualitative data analysis is minimized. In addition, combining the two approaches provides a more comprehensive view of the themes and their relationship to aid at drawing valid conclusions.

nVivo Thematic Analysis

The nVivo analysis began with coding each of the interview transcripts by identifying and labeling key passages. Having done so, the number of documents in which the themes appear (“Sources” in the table) as well as the number of times the themes appear (“References” in the table) are captured and multiplied together to form a score used to rank the themes in order of importance. For the purposes of the study, the top 10 ranked themes were employed for further analysis.

Table 1
Quantification of Themes from Interview Transcripts

Name	Sources	References	Score
Mitigation	28	39	1092.00
Early identification	20	22	440.00
Communication	17	18	306.00
Regular monitoring	12	13	156.00
Prob and impact	11	15	165.00
Contingencies	11	13	143.00
Aviation is dangerous	11	12	132.00
Over budget or costs	10	10	100.00
Life Cycle	9	9	81.00
Past experience and projects	8	10	80.00
Proactive	8	9	72.00
Opportunities	7	9	63.00
Reluctance to manage risk	6	6	36.00
Regulations and procedures	5	5	25.00
Training	4	5	20.00
Appetite	4	4	16.00
Tools	3	3	9.00

Interview Transcript Excerpts

Excerpts from each of the identified themes were captured and are presented to aid in understanding of each of them.

Mitigation. While the term "mitigation" has a specific usage within the field of risk management, it is often used as a generic term to refer to action taken to address risk. This becomes apparent when examining the interview excerpt of the "Mitigation" theme.

When I say mitigation tools, it may be servers, software, licenses, etc…would we spend $100K to protect information that's only valued at $10K? No, we wouldn't therefore we accept the risk. However, if the value of the information was $1M then of course we would.

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 impacting mission effectiveness.

Early identification. The literature of project risk management suggests that identifying and addressing risk early rather than later leads to stronger plans and less expensive risk treatments. This is born out in the transcript excerpts.

Risk assessment should be done for the first time at the proposal/planning phase of the project and re-visited throughout the project lifecycle.

Risk management shouldn't just be reactive but should be assessed at the beginning of a project to be proactive.

Communication. Risks may be intangible and difficult to envision among project stakeholders. It is for this reason that communication with a wide array of stakeholders is recommended.

…clear, quick, open communication across all involved will keep this process running smoothly…

Involve everyone in your risk discussion, interview colleagues, and SME's.

Regular Monitoring. Risk management is observed to be an ongoing rather than "one time only" activity. Excerpts from the interviews reinforce this with examples of continual risk monitoring throughout the project.

We have several phasing meetings to review changes in airfield configurations and safety concerns to come up with an agreed upon plan of action for construction.

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.

Probability and Impact. Project risks are typically assessed using both probability as well as impact. This is also the case in aviation projects as born out in the interview excerpt.

As you can imagine 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.

I like to rank risks with a two-axis system ranging from low to high impact (costs, schedule, etc) and low to high probability clearly time and available resources.

Contingencies. As in the case of the term "mitigation", the term "contingency" tends to connote "taking some alternative action to address risk". This informal meaning is born out in the transcript excerpt.

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

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

Aviation is Dangerous. The fact that human life is at stake in the field of aviation makes risk management a serious and pressing concern. The seriousness of aviation risks is apparently well understood by aviation project managers.

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.

Over Budget or Costs. Aviation is known for its inherent danger. It is also a very costly field and the focus on cost and budgets emerge from the interviews with aviation project risk managers.
The Government took a risk, without a solidified plan, and incurred additional cost that were not budgeted for. If the project management team would have been proactive regarding risks this issue would have been mitigated.
The question is how much risk and is it the "juice worth the squeeze"?

Lifecycle. The continuous nature of risk management is reflected in the emphasis on risk throughout the project lifecycle. This is a recurring theme in the interview transcripts.
Risk identification is done throughout the project life cycle, with special emphasis during the key milestones.
Formalized risk management exists as a deliberate process that spans the life cycle of a project, from concept to grave.

Past experiences and projects. A sound base of experience in previous projects inform risk management in current projects. Project risk managers in the interviews illustrate this.
I identify all suspected and unsuspected risks that we as a team can think of from past experiences.
We conduct research to see if we have done similar projects in the past to help guide us.

Count of Key Words

nVivo was used to capture the count of frequently used words found within the interview transcripts. The top ten words in terms of frequency revealed an emphasis on taking a proactive approach towards risk. It is of interest that the term “act” is observed to be the most frequently used term. This is followed by other key action words reflecting the effort to characterize, communicate, and measure the risk.

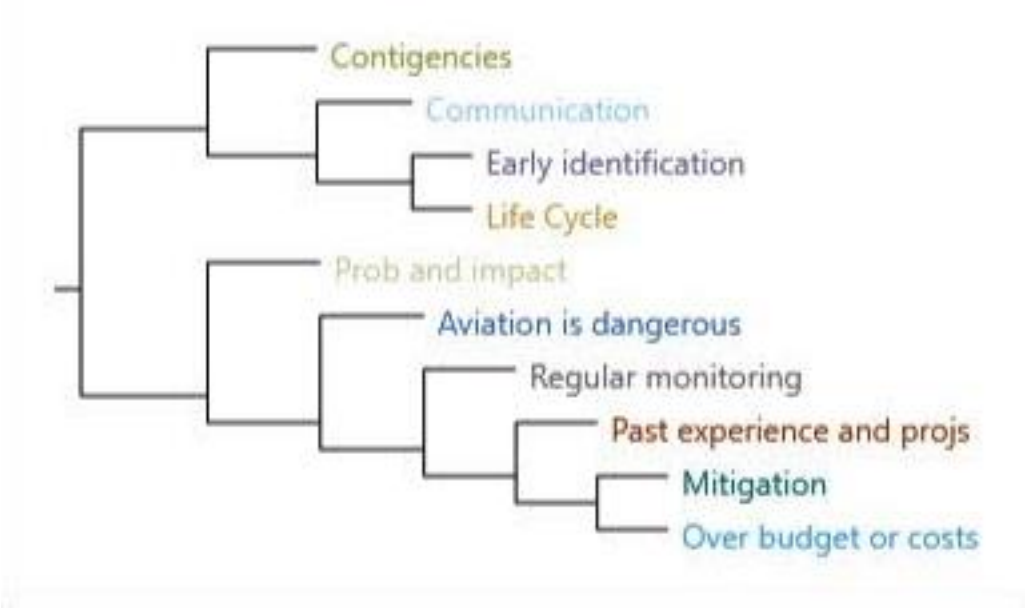
Table 2
Top Ten Words from Transcripts Using nVivo

Word	Count
act	659
work	411
change	364
event	350
communicate	348
activities	329
think	316
creating	226
evaluate	225
measures	209

Themes Clustered By Similarity

The identified themes in the project risk manager interview transcripts were compared by the nVivo application using a comparison of the words within each theme and evaluating the similarity of the themes using Pearson's R correlation coefficient. The result of the theme similarity identifies two clear strata of topics. In the first strata, the focus on planning and communicating contingencies early in the project lifecycle. The second strata of topics are concerned with assessing the inherent risks associated with aviation using continuous monitoring and judgement from past experience. The judgement associated with risk assessment is impacted by the associated mitigation plans and budget.

Figure 1
Themes from Interview Transcripts Using nVivo Analysis



Themes Emerging From Algorithmic Topic Modeling

Text processing including the tokenization of the interview transcripts, the removal of stop words, the calculation of "term-frequency/inverse document frequency" was carried out in Python to produce a large document-term matrix. The resulting matrix dimensions were reduced by employing Singular Value Decomposition. The "topics" that emerge from this process are essentially bundles or clusters of words that frequently co-occur across the documents. These clusters can be thought of as representing underlying themes or concepts within the data. In the resulting decomposition, four topics emerged in the term/topics matrix and are described in the following analysis.

Topic 1. Timely planning for and responding to risks.

Topic 1 Keywords*:* 'plan mitigation lessons projects time important work'. Each topic emerging from SVD analysis is associated with a cluster of words. The word cluster is provided in a simple word cloud that illustrates importance and number of term appearances by the size of the word. In Topic 1, the theme emerging is focused on risk planning and response with the added emphasis of time.

Figure 2

Topic 1 Word Cloud

Topic 1 Transcript Excerpts. Excerpts from the interview transcripts illustrate the importance not only of planning for and determining risk responses but doing so early in the project.

There are always going to be parts of a project where stakeholders need to be engaged in managing risks and offering workarounds, risk mitigation plans,

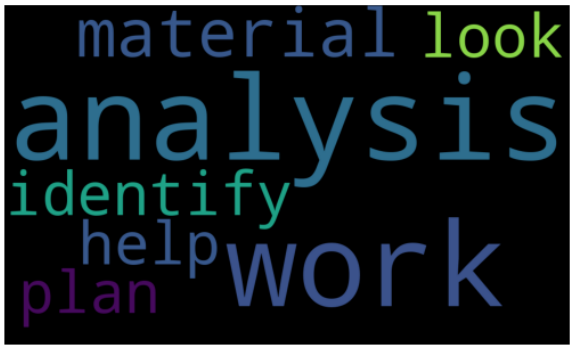
When anything unexpected happens in a project or a work package is falling behind and starts causing delays, immediately we need to start implementing a plan for risk management and mitigation.

It's up to the project manager to be out ahead of the project team....removing roadblocks....determining if plan B or plan C needs to be put into motion, etc. Identify your riskiest activities early and determine which ones require budget to be set aside.

Topic 2. Importance of risk identification and analysis

Topic 2 Keywords: ‘analysis work material identify look help plan.' The second topic emerging from SVD analysis emphasizes the importance of risk identification and analysis. Such analysis includes both qualitative as well as quantitative analysis for both risks as well as opportunities.

Figure 3
Topic 2 Word Cloud



Topic 2 Transcript Excerpts. The forms of risk analysis are clearly identified and discussed in the second topic. In addition, such analysis methods are also employed to consider opportunities.

It is best to plan ahead, identify risks, and do an analysis. Quantitative analysis: collect and analyze data, numbers etc. Qualitative analysis: look at connections, stakeholder analysis.

Project risk management can be ever changing depending on the complexity of the project. In my case this can be a vendor that fails to meet the deadline on material… can be late to get government furnished material.

…there is also a weird paradox about risk – it can also be an opportunity – so when we identify it early, we can adjust the sails and navigate the risk but then use it to inform other work or use it as a "success" story in the work we are doing at hand. This type of approach helps secure projects and also becomes things like "key features" that we can use when going after new work…

Topic 3. Management and communication as key to successful risk management

Topic 3 Keywords: 'going key successful manage meetings projects difficult. ' The subject that emerges in Topic 3 is the fact that difficult situations will arise—but that project may still be successful with the appropriate communication methods.

Figure 4
Topic 3 Word Cloud

Topic 3 Transcript Excerpts: The feeling that emerges from the interview transcripts is it is beneficial to "overcommunicate" in the high-risk project environment associated with the aviation industry.

There are always going to be little traps that just catch you unawares, but a good management structure identifies risk as early as possible and manages it every single day with solid mitigation strategies and – as we have discussed – communicate, communicate, communicate.

Communication is key. The more frequent that we communicate with all of the relevant parties, the better off we all are.

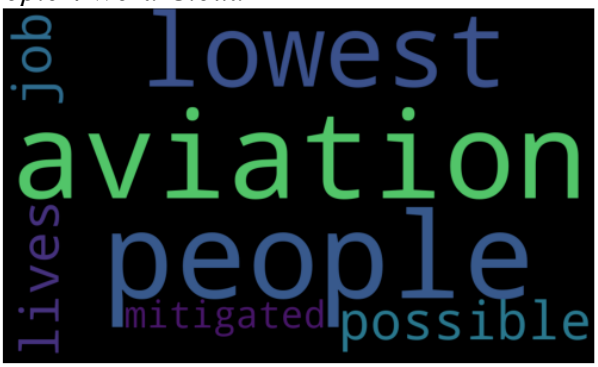
How you manage risk dictates how successful or unsuccessful your project will be. Keep in mind that "risk" means both "threats" (bad things) and "opportunities" (good things).

Topic 4. Importance of minimizing aviation risks

Topic 4 Keywords: 'aviation people lowest possible lives job mitigated.' Project risk managers in the aviation industry recognize that lives are at stake and that because of this, risk management is a high priority.

Figure 5

Topic 4 Word Cloud



The inherent risk associated with aviation emerges as a serious concern. One area of focus is the need to reduce risks where possible and to avoid neglecting the risk communication due to fear of reprisal.

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.

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.

A lot of the time people will not paint the whole picture as to how bad something truly is because they don't want to be the guy who has to tell the boss things are/aren't as off track as they are.

Conceptual Framework

The themes identified in the interview transcripts and their associated relationships may be brought together to paint a picture describing the underlying phenomena under study. Further, the resulting conceptual framework derived from the nVivo Qualitative Data Analysis, and the themes captured in the Python algorithmic analysis are brought together to form a more complete picture. In addition, the layer of analysis generated algorithmically using Singular Value Decomposition in Python provides additional grounding of the study by complementing the more subjective theme identification employed in qualitative data analysis performed by researchers.

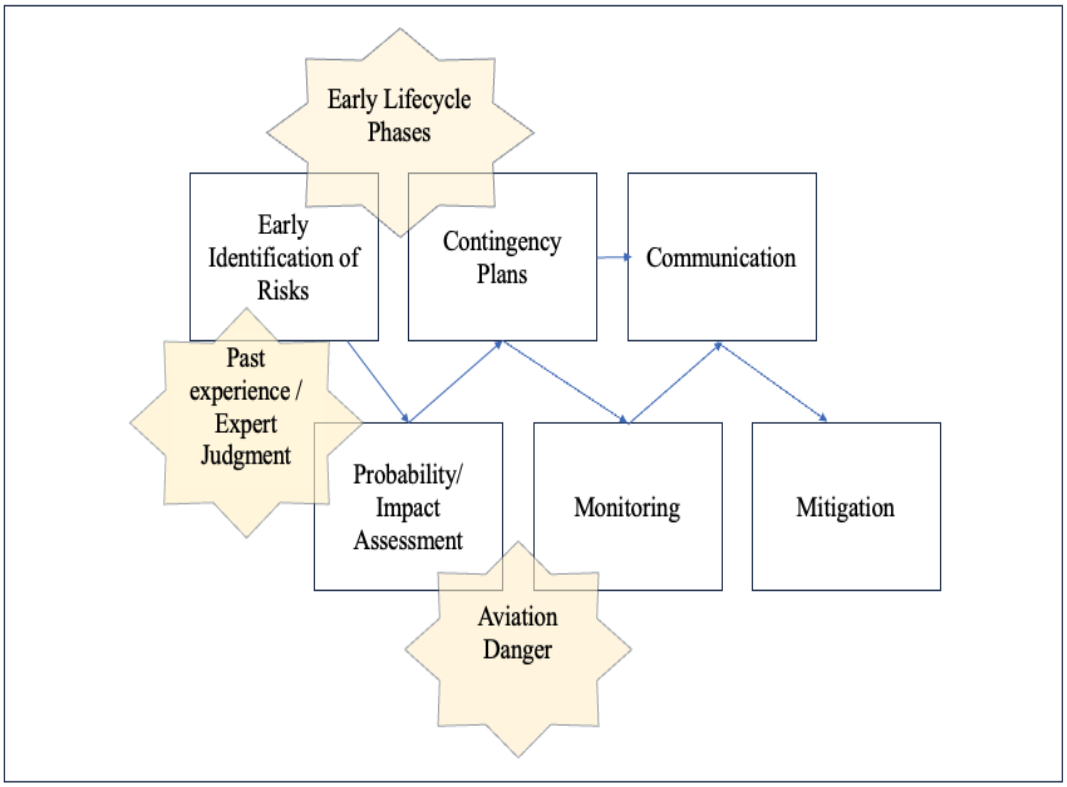
Conceptual Framework: nVivo Qualitative Data Analysis

The themes identified using qualitative data analysis capture the progression of risk management activities carried out in aviation projects. The conceptual framework begins with early risk identification and proceeds to risk assessment, response planning and communication, risk monitoring, and risk and

risk impact reduction using risk mitigation practices. Additional themes support the importance for early implementation of risk management activities while applying expert judgment. This is a response to the notable inherent danger associated with aviation.

Figure 6

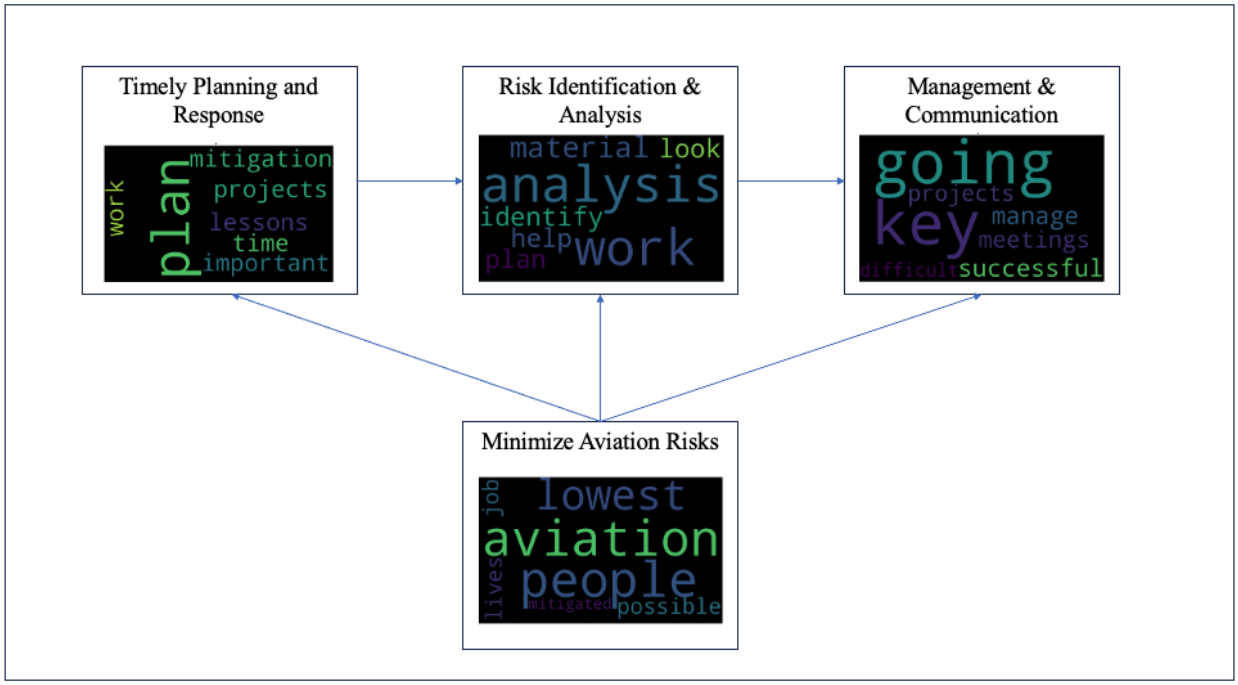
Conceptual Framework from Qualitative Analysis nVivo



Conceptual Framework: Singular Value Decomposition using Python

The topics identified in the text using Singular Value Decomposition (SVD) align well with the themes identified in the nVivo qualitative data analysis. The topics illustrate a process that begins with timely planning, risk assessment, and communication of risks. Further, ongoing management and communication are employed throughout the process for the purpose of minimizing aviation risks.

Figure 7
Conceptual Framework with SVD using Python

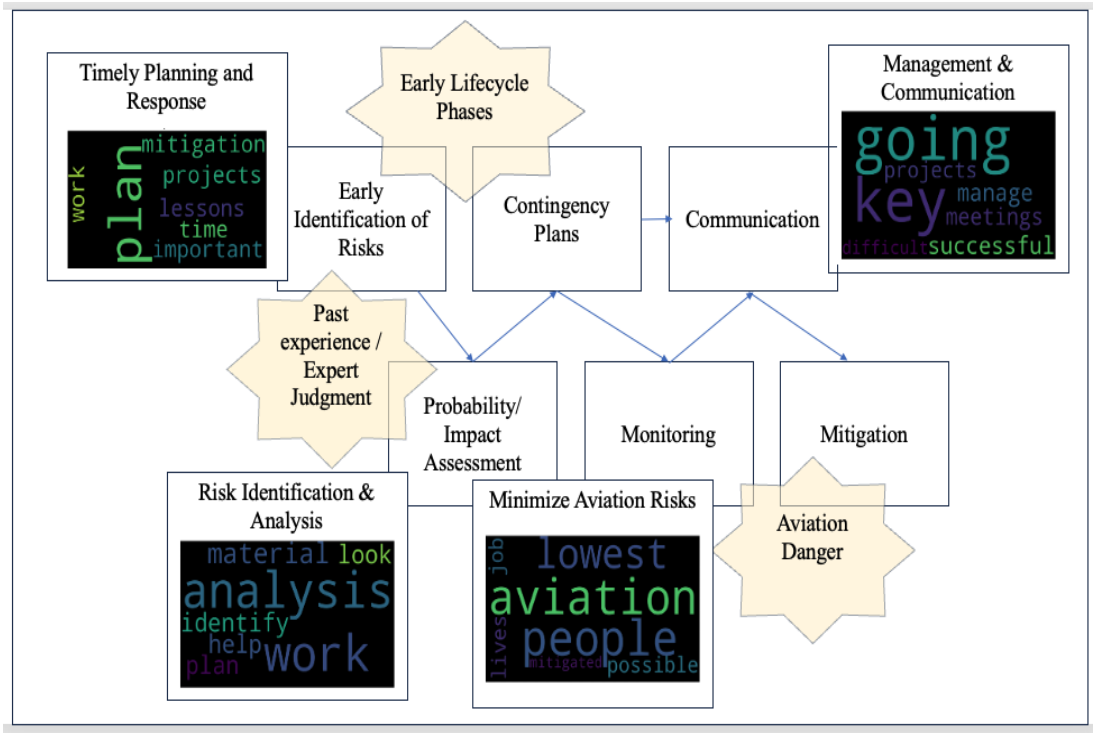


Combined Framework: nVivo QD A Plus Python SVD

The combined conceptual framework demonstrates the harmony between the more subjective qualitative data analysis (QDA) and the the algorithmic singular value decomposition approach (SVD). The SVD topics are observed to anchor the combined conceptual framework with with topics that align with key steps in the aviation project risk management process. The QDA themes aid in filling in detail for a more complete picture of the phenomenon.

Figure 8

Combined Framework nVivo and SVD



RQ1 Summary: What Lessons Can You Share About Project Risk Management?

The lessons that aviation project risk managers have learned and employ in projects revolve around the core elements of early identification, rigorous risk identification and analysis, and a focus on reducing the risks inherent within aviation. Experience plays a key role along with a clear focus on communicating risk to stakeholders. While the process flow emerging from the conceptual framework is consistent with best practices in project risk management—the emphasis on dealing with the danger associated with aviation focused risk management attention on its minimization.

RQ2: What tools are the most useful for Risk Identification, Risk analysis, and Risk Monitoring?

Project managers were surveyed electronically and asked to rank their preferred tools for use in risk identification. The ranked tools are listed below with the top three being Document review, Checklists or taxonomies and Retrospection. The choices of tool suggest that aviation project managers adopt a wide view of risk possibilities and as a result, employ tools that lend themselves to researching risk and risk triggers.

Identifying Risks.

The ranking of the preferred risk management tools are highlighted in the table below.

Table 3
Ranking of Preferred Risk Management Tools

Rank	Tool
1	Document review
2	Checklists or taxonomies
3	Retrospection
4	Assumptions and constraints analysis
5	SWOT
6	Risk Breakdown Structure
7	Prompt Lists
8	Cause and Effect Analaysis

It is further observed that aviation project risk managers favor the same tools employed in risk identification for the qualitative risk analysis and risk management. The insidious nature of aviation risk makes it essential to go beyond surface analysis and to conduct research and deep retrospection. The top three tools used routinely for qualitative risk assessment and management match the same tools used in risk identification.

Managing Risks.

Aviation project managers are observed to favor similar tools in risk management that are employed in risk identification. The percentages of routine use in responses from project managers are provided in the table below.

Table 4
Routine Use of Risk Management Tools

Tool	% Routine Use
Document Review	53%
Checklists or Taxonomies	41%
Retrospection (including historical information, post project reviews or lessons learned)	39%
SWOT (Strengths, Weaknesses, Opportunities & Threat) Analysis	29%
Assumptions and Constraints Analysis	28%
Risk Breakdown Structure (RBS)	28%

While all project risk management utilizes qualitative risk assessment, not all carry out quantitative risk assessment. The ranked list of tools employed in quantitative risk analysis emphasizes the use of other risk parameters as well as a focus on confirming the accuracy of the data used in quantitative analysis. Outside of the top three ranked tools, the remaining tools reflect typical project risk management practice as outlined in the PMBOK and in industry practice.

Quantitative Risk Analysis.

The ranking of quantitative risks tools aligns with steps taken in qualitative risk assessment. Additionally, given that data lies at the core of quantitative risk assessment—the quality of data employed in the analysis is observed to be a key concern.

Table 5
Ranking of Qualitative Risk Tools

Rank	Tool
1	Assessment of other risk parameters…**
2	Risk data quality assessment
3	Probability and Impact Matrix & assessment
4	Value Stream Mapping
5	Affinity analysis/ diagram
6	Influence Diagrams
7	System Dynamics (as a specific type of Influence Diagram)
8	Analytic Hierarchy Process (AHP)

Aviation project risk managers were surveyed to understand which tools were most frequently used in monitoring risks. It is observed that the top five

responses are closely related in favorability and emphasize tools that track risk on an ongoing basis.

Monitoring Risks and Risk Reassessment.

Aviation project managements are observed to employ a broad range of tools for monitoring and reassessing risks. This can be seen by the relatively even dispersion of percentages associated with each tool.

Table 6

Ranking of Risk Monitoring and Reassessment Tools

	Tool	%
1	Data Analytics	14.73%
2	Status Meeting Results	14.23%
3	Risk Reassessment Analysis	12.78%
4	Risk Audit Results	12.44%
5	Trend Analysis	12.39%
6	Reserve (Funding/Schedule/Performance) Analysis	11.66%
7	Variance Analysis	11.22%
8	Residual Impact Analysis	10.55%

RQ2 Summary: What tools are the most useful for Risk Identification, Risk analysis, and Risk Monitoring?

The top three tools employed in risk identification, qualitative, quantitative analysis, and monitoring illustrate the seriousness and depth of focus involved in identifying and assessing risks. Further, risk management is a never-ending responsibility for project managers, and this is reflected in the tools used in risk monitoring.

Table 7
Top Three Tools for Risk ID, Analysis and Monitoring Discussion

Identifying	**Qualitative**	**Quantitative**	**Monitoring**
Document review	Document review	Assessment of other risk parameters	Data analytics
Checklists/ Taxonomies	Checklists/ Taxonomies	Risk data quality	Status Meeting result
Retrospection	Retrospection	Probability/ Impact	Risk reassessment
Depth	**Depth**	**Depth and Data Quality**	**Continuous monitoring**

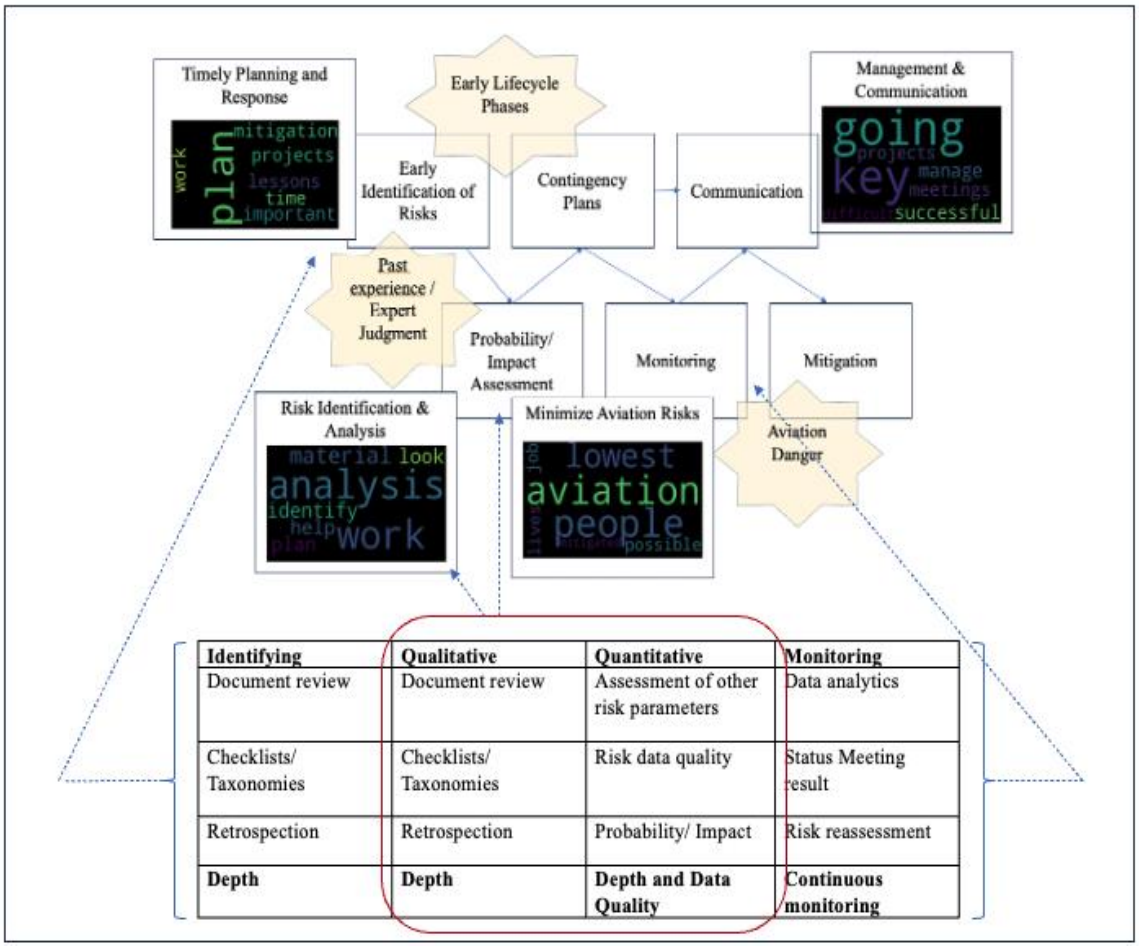
The conceptual framework generated by both QDA and SVD analysis are further complemented by the specific tools employed within key phases of the risk management process. The combined conceptual framework thereby answers *what* occurs in aviation project risk management, *when* it occurs, and finally, the *how* in terms of the tools employed to carry out each form of analysis within the overall risk management cycle.

For example, in figure 9 below one can see that the event (*what*) "Probability Impact Assessment" occurs after (*when*) the "Risk Identification" using the preferred tool for quantitative risk analysis (*what*) "Probability / Impact".

Therefore, following this combined conceptual framework can quickly help aviation project managers quickly execute based on where they are in the project lifecycle and their task at hand. The can confidently move forward based on this research that uses data collected from a lot of experts in the field and their collective experience.

Figure 9

Big Picture: Framework and How the Analysis Fits Within It Research Questions 1 and 2: The Big Picture



Identifying	Qualitative	Quantitative	Monitoring
Document review	Document review	Assessment of other risk parameters	Data analytics
Checklists/ Taxonomies	Checklists/ Taxonomies	Risk data quality	Status Meeting result
Retrospection	Retrospection	Probability/ Impact	Risk reassessment
Depth	**Depth**	**Depth and Data Quality**	**Continuous monitoring**

Areas For Further/Additional Research

This research lends itself to being a baseline of project risk management; a continuous improvement system that allows for implementation of these lessons learned and then iterates them on a consistent basis. Lessons learned and comparison incorporating with other highly-regulated industries such as nuclear power or pharmaceutical is also an appropriate complimentary direction for this research.

Moreover, the impact of emerging technologies will certainly help any researcher understand and modify this approach to project risk management. For instance, could Artificial Intelligence (AI) do a metadata analysis on project risks across the industry? Maybe the algorithm can find patterns of failures or recurring failures in projects and recognize them during root cause analysis.

Conclusion

This paper presented an analysis of lessons learned for Project Risk Management within the complexity of the aviation industry. The structure of this paper conventionally began with definitions of risk management within the scope of the industry and their relevant significance with a particular focus on safety and economics. Next, the paper dived into the details of the project and the relevance of a risk management methodology within the project lifecycle. Most importantly, it presented a novel approach to quantify qualitative data through the use surveys, word clouds and analysis through NVivo and Singular Value Decomposition (SVD). This was accomplished by conducting qualitative interviews with 56 aviation project managers and a quantitative survey of 240 project managers.

The research identified several key themes, including the importance of timely planning and response to risks, the significance of risk identification and analysis, effective management and communication as key success factors, the emphasis on minimizing aviation risks due to the industry's unique challenges, and the tools favored by aviation project managers for risk management.

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