Exploring the challenges of implementing Risk Management Maturity models for megaprojects: a study of the aerospace industry in Canada

by

Haniyeh HOMAYOUNFARD

THESIS PRESENTED TO ÉCOLE DE TECHNOLOGIE SUPÉRIEURE IN PARTIAL FULFILLEMENT OF A MASTER'S DEGREE WITH THESIS IN ENGINEERING PROJECT MANAGEMENT
M.A.SC.

MONTREAL, JANUARY 31, 2022

ÉCOLE DE TECHNOLOGIE SUPÉRIEURE
UNIVERSITÉ DU QUÉBEC

BOARD OF EXAMINERS

THIS THESIS HAS BEEN EVALUATED

BY THE FOLLOWING BOARD OF EXAMINERS

Mr. Yvan Beauregard, Thesis Supervisor
Department of Mechanical Engineering, École de technologie supérieure

Mr. Silvio Melhado, President of the Board of Examiners
Department of Construction Engineering, École de technologie supérieure

Mr. Patrick Germain, External Independent Examiner
Department of Mechanical Engineering, École de technologie supérieure

THIS THESIS WAS PRENSENTED AND DEFENDED

IN THE PRESENCE OF A BOARD OF EXAMINERS AND PUBLIC

ON « JANUARY 31, 2022 »

AT ÉCOLE DE TECHNOLOGIE SUPÉRIEURE

ACKNOWLEDGMENTS

I would like to express my sincere and profound gratitude to everyone who assisted in any way with this research.

First and foremost, I wish to thank my supervisor, Professor Yvan Beauregard, for his always support during my studying, giving me direction to continue my thesis and providing me valuable and thoughtful guidance throughout the process.

I also wish to sincerely thank my parents for their constant moral and practical support. They have always helped and encouraged me throughout this long journey. I owe them a lot, and I have no words to express my gratitude and my love for them.

My special thank is to my brother Dr. Amir Homayounfard, for his patience, compassion, and help, and I appreciate it more than I can say.

Finally, I would not have been able to do my research and complete my master degree without my supervisor's patience and family's support in all aspects.

L’étude des défis de la mise en œuvre des modèles de maturation de gestion des risques pour les mégaprojets : une étude de l'industrie aérospatiale au Canada

Haniyeh HOMAYOUNFARD

RÉSUMÉ

La complexité inhérente au contrôle et à l'évaluation des processus de gestion des risques dans les mégaprojets dans tous les secteurs peut être un défi majeur qui pourrait entraîner l'échec et la dépréciation du projet. Ainsi, il existe un besoin pour une approche mesurable progressive et efficace pour les processus de gestion des risques, qui traitent de la complexité et des caractéristiques uniques des mégaprojets. En particulier, les modèles de maturité de la gestion des risques permettent aux entreprises de comprendre et d'identifier les défis et opportunités potentiels qui se présentent dans les mégaprojets concernant les processus de gestion des risques. Cela permet aux entreprises de gérer correctement les risques et les problèmes imprévus dans les mégaprojets. Les modèles de maturité de la gestion des risques peut également mener au succès en gérant la complexité et les défis des risques dans le développement de produits et des projets d'ingénierie de haute technologie tels que l'aérospatiale. Bien que la littérature antérieure ait identifié et soutenu les meilleures pratiques pour la maturité de la gestion des risques, leur fiabilité n'est pas toujours soutenue empiriquement. En fait, la littérature existante n'a pas exploré les différents défis, opportunités et solutions potentielles qui peuvent conduire à des modèles de maturité de gestion des risques, en particulier dans les mégaprojets dans l’industrie aérospatiale. Ainsi, plusieurs lacunes subsistent dans la littérature.

Premièrement, il reste difficile d'évaluer les processus de gestion des risques, d'interpréter les résultats et d'identifier le bon ensemble de défis qui peuvent affecter le succès des gestions des risques dans les mégaprojets. Deuxièmement, souvent les gestionnaires qui visent à mettre en œuvre les processus de gestion des risques ne parviennent pas à identifier et à tirer parti des modèles de maturité de la gestion des risques car ils ne connaissent pas leurs avantages de ces modèles. Il est essentiel pour les chefs de projet d'identifier les défis et les solutions potentielles de la maturité de la gestion des risques en plus des autres facteurs tels que les calendriers, les coûts et les délais en mettant en œuvre des stratégies globales, en réseau et en ayant une vision large des modèles de maturité de la gestion des risques, en particulier pour ceux dans les mégaprojets.

Par conséquent, cette étude vise à étudier les principaux obstacles, défis et solutions potentielles qui doivent être pris en compte pour mettre en œuvre efficacement les modèles de maturité de la gestion des risques pour les mégaprojets de l’industrie aérospatiale. Il répond à la question suivante : quels sont les défis et les solutions qui ont un impact sur la mise en œuvre de modèles de maturité de gestion des risques pour les mégaprojets de l’industrie aérospatiale? La recherche suit une approche de recherche inductive et bénéficie d'entretiens semi-structurés ainsi que de sources de données secondaires. Il identifie sept défis clés, qui peuvent être des domaines d'amélioration potentiels, s'ils sont gérés correctement. Ils incluent un modèle

d'évaluation systématique pour les processus de gestion des risques, la profondeur de sécurité de la conception et de la planification du projet, le niveau de communication, les leçons apprises, le degré de connaissances et d'expertise, la capacité organisationnelle, et analyse des fournisseurs. L'étude actuelle fournit également une discussion en comparant ses résultats à la littérature pertinente tout en discutant des similitudes et des différences. Il discute ensuite les implications et les contributions de cette recherche pour sa littérature existante. Il aborde également les nouvelles connaissances théoriques qui ont été générées par cette étude. À la fin, les implications managériales pour les gestionnaires et les décideurs sont mises en évidence. Des réflexions personnelles sur les limites de la portée et de la qualité de l'analyse entreprise sont présentées. Enfin, des recommandations et des orientations pour de futures recherches sont proposées.

Mots-clés: gestion des risques, mégaprojets, maturité, la maturité de la gestion des risques

Exploring the challenges of implementing risk management maturity models for megaprojects: a study of the aerospace industry in Canada

Haniyeh HOMAYOUNFARD

ABSTRACT

The inherent complexity of control and evaluation of the risk management processes in megaprojects across sectors can be a major challenge with the potential to result in project failure and impairment. Thus, there is a need for a measurable progressive and effective approach for risk management processes, which deal with megaprojects complexity and unique characteristics. In particular, risk management maturity models enable firms to understand and identify potential challenges and opportunities that arise in megaprojects concerning risk management processes. Doing so enables firms to properly manage risks and unforeseen issues in megaprojects. Risk management maturity models can also lead to success by managing the complexity and challenges of risks in product development and high-tech engineering projects such as aerospace. Although prior literature has identified and supported best practices for risk management maturity, their reliability is not always supported empirically. In fact, extant literature has not explored different challenges, opportunities, and potential solutions that can drive risk management maturity models, particularly megaprojects in the aerospace industry. Thus, several gaps remain in the literature.

First, there remains difficulty assessing the risk management processes, interpreting the results, and identifying the right set of challenges that can affect the success of risk management in megaprojects. Second, managers who aim to implement the risk management processes, often fail to identify and benefit from risk management maturity models because they are unfamiliar with the benefits of such models. It is essential for project leaders to identify the challenges, and potential solutions, of risk management maturity besides the other factors such as schedules, costs, and deadlines by implementing comprehensive strategies, networking, and having a broad vision of risk management maturity models, particularly for those in megaprojects.

Therefore, this study aims to investigate key barriers, challenges, and potential solutions that need to be considered to effectively implement the risk management maturity models for megaprojects in the aerospace industry. It answers the following research question: What are the challenges and solutions that impact the implementation of risk management maturity models for megaprojects in the aerospace industry? The research follows an inductive research approach and benefits from semi-structured interviews alongside secondary sources of data. It identifies seven key challenges, which, can be potential areas for improvement if managed properly. These include systematic assessment model for risk management processes, safety depth of project design and planning, level of communications, lessons learned, degree of knowledge and expertise, organizational capability, and supplier analysis. The current study also provides discussion by comparing its findings back to the relevant literature while discussing similarities and differences. It then discusses the implications and contributions of this research for its extant literature. It also discusses new theoretical insights that have been generated through this study. By the end, managerial implications for managers and policymakers are highlighted. Personal reflections on limitations of the scope and quality of the analysis undertaken are presented. Finally, recommendations and directions for future research are offered.

Keywords: risk Management, megaprojects, maturity, risk management maturity

TABLE OF CONTENTS

Page

LIST OF TABLES

Page

LIST OF FIGURES

Page

LIST OF ABREVIATIONS

A&AP	Aircraft and Aircraft Part manufacturers
A&D	Aerospace and Defense
AD	Aggregate Dimension
AI	Artificial Intelligent
AIAC	Aerospace Industry Association Canada
ARP	Aerospace Recommended Practice
BRM3	Business Relationship Management Maturity Model
BRMMM	Business Relationship Management Maturity Model
CAS	Civil Aerospace Sector
CMM	Capability Maturity Model
CMMI	Capability Maturity Model Integration
CoPS	Complex Product Systems
CRMMM	Construction Risk Management Maturity Model
E&EP	Engine and Engine Part manufacturers
EFQM	European Foundation for Quality Management
ERM	Enterprise Risk Management
ETS	École de Technologie Supérieure
GDP	Gross Domestic Product
HSE	Health, Safety, and Environment
IACCM	International Association for Contract and Commercial Management
IATA	International Air Transport Association
INCOSE	International Council on Systems Engineering
IQ	Interview Question

IRM	Institute of Risk Management
ISACA	Information Systems Audit and Control Association
ISED	Innovation, Science and Economic Development Canada
ISO	International Organization for Standardization
KI	Key Informant
KPI	Key Performance Indicator
MA&D	Military Aerospace and Defense
MAS	Military Aerospace Sector
MMGRSeg	Risk Management Maturity Model In Information Security
MPCM	Multi-Processor Communication Mode
MRO	Maintenance, Repair, and Overhaul
OGC	Office of Government Commerce
OPM3	Project Management Maturity Model
P2MM	PRINCE2 Maturity Model
P3M3	Portfolio, Program, and Project Management Maturity Model
PEMM	Process and Enterprise Maturity Model
PM	Project Management
PMBOK	Project Management Body Of Knowledge
PMI	Project Management Institute of USA
PMM	Project Management Maturity
PMMM	Project Management Maturity Model
PMS-PMMM	Project Management Solutions' Project Management Maturity Model
PRMM	Project Risk Management Maturity
ProMMM	Project Management Maturity Model

R&D	Research and Development
RIMI	Risk and Insurance Management Inc.
RIMS	Risk and Insurance Management Society
RM	Risk Management
RM3	Risk Management Maturity Model
RMC	Risk Management Capability
RMCMM	Risk Management Capability Maturity Model
RM-CMM	Risk Management Capability Maturity Model
RMM	Risk Management Maturity
RMMM	Risk Management Maturity Model
RMRDPC	Risk Management Research Development Program Collaboration
RO	Research Objectives
ROI	Return On Investment
SMS	Safety Management System
TC	Transport Canada
TSB	Transport Safety Board

INTRODUCTION

0.1 Research background

No one can rule out the growing importance of carrying out the "project-based" businesses on various aspects of development, including planning, large-scale investment, and production based on the latest technology advancements and extensive project planning (Williams, 2017). In an expanding global network, where managing businesses has got far more complex and led to higher failure rates, contributing factors to successful businesses should be taken into close consideration by focusing on "megaprojects"[1] (Kardes, Ozturk, Cavusgil, & Cavusgil, 2013).

In such a growing landscape, megaprojects have been defined in several ways in the literature (Irimia-Diéguez, Sanchez-Cazorla, & Alfalla-Luque, 2014). Since megaprojects are hard to manage and control, even when reasonably complete information about the megaproject system has been provided, they are considered as the most complex set of projects (Vidal, Marle, & Bocquet, 2011). A diverse range of sectors, including mining, oil and gas, aerospace and defense, benefit from megaprojects, which involve a budget between US$0.5 million to billions (per megaproject**)**, extraordinary complexity, high uncertainty[2], considerable risks, and appealing long-lasting features and benefits (Eweje, Turner, & Müller, 2012; Flyvbjerg, 2007;

---

[1] Complex projects cause to define a new categorization of the projects like major **programs**, capital projects, major projects, or **megaprojects** (De Rezende et al., 2018). Several definitions of megaprojects can be found in the literature (Irimia-Diéguez et al., 2014). Megaprojects are large-scale, complex ventures and mega-infrastructure projects (Flyvbjerg, 2007, 2014; Koppenjan, 2005; Pollack et al., 2018; Söderlund et al., 2017).

[2] Uncertainty is a rich and multi-faceted phenomenon that has been studied across several intellectual disciplines, including mathematical mind, psychology concepts and strategic decisions made by business executives (Attewell, 2012; F. C. Saunders, Gale, & Sherry, 2016). Uncertainty can cause a project manager to fear the consequences of an uncertain future generated by a company restructure, or in contrast, help an entrepreneur to look favorably on uncertainties within a particular market that he can exploit (F. C. Saunders et al., 2016). Within the project management concept, the possible sources of uncertainties in projects include complexity arising from product requirements, the technology choices made, the variety of stakeholders involved in the project, organizational context and management processes (Gao, Lechler, & PMP, 2013) or in terms of the inherent properties of a project (complexity, complicatedness, dynamism and interconnectedness) (F. C. Saunders et al., 2016). Uncertainty is one of the main characteristics of a project, which can also lead to risk (Koltveit, Karlsen, & Gronhaug, 2005; R. L. Yim, Castaneda, Doolen, Tumer, & Malak, 2015). The amount of risk in a project rises with the amount of uncertainty in a project, which is inherently present in all design projects (Howell, Windahl, & Seidel, 2010; R. L. Yim et al., 2015).

Irimia-Diéguez et al., 2014; Söderlund, Sankaran, & Biesenthal, 2017; Zhai, Xin, & Cheng, 2009). For example, the total budget of Airbus A380-900 as the latest and largest member of the Airbus A380 family was US$445.6 million in 2018 (while Airbus launched the $10.7 billion A380 program in 2000) (Airbus, 2012, 2018).

Such characteristics[3] of megaprojects significantly impact the economic and technological aspects of these sectors (Söderlund et al., 2017; Zhai et al., 2009). Due to the inherent complexities of megaprojects and unexpected challenges, the executive planning of the project needs to be actively modified considering elements such as risks[4] associated with the incurred changes in the project (Park, Park, Cha, & Hyun, 2016).

Meanwhile, different studies have illustrated the importance of different approaches for risks concerning the vital role of megaprojects, including internal or environmental changes that can lead to risks and unforeseen issues with significant impact on organization business (Acharyya, 2008). Studies have revealed that the results of a project in different industries can be influenced by the project risks (Olechowski, Oehmen, Seering, & Ben-Daya, 2016). Risk factors in a megaproject can lead to some failures and delays in the project processes (Flyvbjerg, 2006; Irimia-Diéguez et al., 2014). Moreover, risks in a project can affect many factors, including technical feasibility, project cost and time, strategic goals, and performance (Jeffrey Thieme, Michael Song, & Shin, 2003; Loch, Solt, & Bailey, 2008; H. Thamhain, 2013). Although it is difficult to deal with them, they should be managed to be successful in

[3] The main differences between a common project and a megaproject could include (Zhai et al., 2009): 1- a large volume of investment (ranging from US$0.5 million to billions), 2- greater community involvement, 3- higher number of investors and stakeholders, 4- more intricate decision-making processes, 5- the number of human resources, 6- structures, extreme complexity and abundant complex tasks, 7- size and long duration, 8- technological development, and 9- substantial risks and high uncertainty (Eweje et al., 2012; Flyvbjerg, 2007; Kardes et al., 2013; Sanchez-Cazorla et al., 2016; Söderlund et al., 2017; A. Van Marrewijk et al., 2008).

[4] Risk is a possible event that would hinder the ability of a system to complete its purpose if the event transpires (R. L. Yim et al., 2015). Risk is also explained as an uncertain event with a positive or negative impact on project and organizational objectives (Atkinson et al., 2006; Project Management Institute, 2017a; Zhang, 2011). In the literature, there are different risk classifications, among which the most common ones include 1- risk on the macro level as external factors (such as political, economic, natural, industrial, etc.) with their indirect impact are the obstacles of project success, 2- risk on the micro level is internal and related to the factors including stakeholders interaction as well as the technical and operational aspects of the project, and 3- market risks related to the demand, supply and financial markets (Bing et al., 2005; Kardes et al., 2013).

an increasingly competitive world (Patil, Grantham, & Steele, 2012; Srivannaboon & Milosevic, 2006; H. Thamhain, 2013). A project might be failed if the project risks are not managed or reduced (R. Yim, Castaneda, Doolen, Tumer, & Malak, 2015). Risk Management (RM) can also lead to success by managing the complexity and challenges in product development and large engineering projects (Kardes et al., 2013; Olechowski et al., 2016). Thus, risk management has been considered as one of the critical areas in projects (Irimia-Diéguez et al., 2014; Lehtiranta, 2014), and it is quite an important issue in complex projects, where evaluating risk remains a vital challenge (Williams, 2017).

Overall, risk management as a systematic process of identifying, analyzing, and responding to a project risks can be vital to project (Maytorena, Winch, Freeman, & Kiely, 2007; R. Yim et al., 2015) and megaproject success, and prevent future loss (Irimia-Diéguez et al., 2014; Wu & Olson, 2008). In various project sizes, the risk management processes recognize and assess risks, which is one of the factors that lead to effective Project Management (PM) (Mojtahedi, Mousavi, & Aminian, 2008). While small projects require efficient risk management, mega scale projects require risk management processes that add value (Dimitriou, Ward, & Wright, 2013; Flyvbjerg, 2014; Kardes et al., 2013; Lehtiranta, 2014; Söderlund et al., 2017). Since the complexity in such a fast changing world makes executives and leaders worried, they need to spend too much time and effort coping with such problems related to risk effectively[5] and wisely in diverse areas, including organizational, technological and even cultural as well as social (De Bakker, Boonstra, & Wortmann, 2010; H. Thamhain, 2013; Zou, Chen, & Chan, 2010). Thus, it is expected to do risk management in projects according to the professionals' claims and the project management guidelines (De Bakker et al., 2010). It is concluded that a high rate of productivity and success can be achieved in megaprojects by implementing

[5] Whatever the size of the project, the risk management process seeks to identify and assess risks so that they can be understood clearly and managed effectively (Mojtahedi et al., 2008). Since megaprojects as a research area are getting popular thus, it is justifiable to study risk management in megaprojects, due to a host of reasons, including their specific features, the significant effect of risk management in the management of megaprojects, the need to consider all sorts of risks to achieve a comprehensive point of view; the megaprojects growth in number and value, and the significant dissimilarity identified in recent studies on megaprojects, which avoids creating a specific framework and it is totally different from smaller-scale projects (Dimitriou et al., 2013; Esty, 2004; Flyvbjerg, 2014; Lehtiranta, 2014). The bigger the size and the more complex a project is, the more efforts for risk management need to be made (Flyvbjerg, 2014; Sanchez-Cazorla et al., 2016).

appropriate risk management approaches (Kardes et al., 2013; H. Thamhain, 2013). To determine if the risk management approach is appropriately implemented, it is required to establish an effective and practical mechanism to recognize and evaluate the risk management system (Heravi & Gholami, 2018; D. A. Hillson, 1997). In this regard, an effective approach for project-based organizations is a portfolio view for managing risks properly (Farrell & Gallagher, 2015) which means expanding management attention from a single project to managing the way the organization is applying projects to attain its objectives (Nenni, Arnone, Boccardelli, & Napolitano, 2014). Accordingly, in the sectors such as construction and engineering organizations, the rate of perceived risks strongly relies on the maturity[6] level of the organizational processes and managers' experiences (Ibbs & Kwak, 2000; Zwikael & Ahn, 2011; Zwikael & Globerson, 2004). If an organization is well matured in managing risk events on projects, it will reduce project risks (Salawu & Abdullah, 2015). In fact, there are maturity models which can systematically measure and efficiently evaluate the organizational or project processes (Zwikael & Ahn, 2011).

0.2 Research rationale: Risk Management Maturity (RMM) in megaprojects

0.2.1 Theoretical justification

Risk management tools and techniques have been extensively argued in the literature, which make project results more predictable (Cooper, Grey, Raymond, & Walker, 2021; D. A. Hillson, 1997; Jeffrey Thieme et al., 2003; Raz & Michael, 2001; H. Thamhain, 2013). Prior literature has developed different risk management tools according to need analysis, specifically in new product development, concurrent engineering, and agile concepts (Olechowski et al., 2016; H. Thamhain, 2013). Overall, an effective risk management method is one of the factors that will lead the organization in achieving sustainable competitive

[6] Mature means being grown or developed at the maximum level, and Maturity is the quality or state of being mature (Andersen & Jessen, 2003). So, if it is said that an organization is mature, it means it is in the best situation to achieve its goals (Andersen & Jessen, 2003; Katuu, 2016). A maturity model is a management tool which helps to identify a project or organizational strengths and weaknesses employing techniques and accepted premises such as improving business processes (Khoshgoftar & Osman, 2009).

advantage (Khameneh, Taheri, & Ershadi, 2016). It is a standard procedure for project leaders to analyze the sources of risks alongside decisive factors such as schedules, costs, and deadlines by implementing comprehensive strategies, networking, and having a broad vision of risk management practices (De Bakker et al., 2010; H. Thamhain, 2013). In this regard, there are specific business guidelines such as DOD Directive 5000.1, the International Organization for Standardization (ISO), and Guide to the Project Management Body Of Knowledge (PMBOK), which are contributing to the knowledge-based risk management processes (H. Thamhain, 2013). To have a straightforward view of the current RM approach in an organization and a description of its objectives (which would be also helpful for RM managers) (Heravi & Gholami, 2018; D. A. Hillson, 1997; Jia et al., 2013; Yeo & Ren, 2009), the organization must be able to evaluate its current capability of managing risks based on a set of guidelines (D. A. Hillson, 1997). Organizations that are willing to operate with a formal structured approach to control RM processes are required to consider apparent goal setting, success criteria, appropriate planning and resourcing as well as effective monitoring and control (D. A. Hillson, 1997; Yeo & Ren, 2009).

One of the controlling and assessment tools that recently has been popular is the maturity model, although the concept of maturity models was accepted and expanded sooner in the literature (D. A. Hillson, 1997; Mullaly, 2006).

Maturity models in a project-based organization are applied as a management instrument for company appraisal, ranking measurement, implementation progress control, and continuous improvement (Antunes, Carreira, & da Silva, 2014; De Bruin, Rosemann, Freeze, & Kaulkarni, 2005; Nenni et al., 2014). Also, implementing maturity models in a project by taking empirical evidence and close attention will enhance project performance (Brookes, Butler, Dey, & Clark, 2014). Thus, the number of organizations applying such models has been increasing over the past decade (Antunes et al., 2014; Becker, Niehaves, Poeppelbuss, & Simons, 2010; Katuu, 2016). Regarding risk management, more performing maturity, better-defined projects, and greater application of tools, all result in the better use of risk management (Besner & Hobbs, 2013).

Meanwhile, there is a growing concern regarding the effectiveness of maturity alongside risk management systems in projects (Fortune & White, 2006; Zwikael & Ahn, 2011; Zwikael & Sadeh, 2007). Whereas some organizations benefit from a high rate of success because of effective execution of risk management and application of maturity model in their projects, others miss it due to lack of a vivid understanding of risk management processes implementation despite a unanimous verdict of the value of risk management (D. A. Hillson, 1997). Moreover, prior studies have revealed that project managers are weak at implementing a successful maturity model of risk management practices (Ibbs & Kwak, 2000; Kutsch & Hall, 2009; Olechowski et al., 2016; Papke-Shields, Beise, & Quan, 2010; Raz, Shenhar, & Dvir, 2002).

Overall, despite the huge body of literature on RM alongside the application of maturity in small- and medium-scale projects, the RMM of megaprojects has received relatively less attention due to the difficulty in studying large-scale projects (Marcelino-Sádaba, Pérez-Ezcurdia, Lazcano, & Villanueva, 2014; Olechowski et al., 2016; Sanchez-Cazorla, Alfalla-Luque, & Irimia-Dieguez, 2016). Although prior literature has identified different maturity models based on best practices, their reliability and challenges that they face have not always been supported empirically (Görög, 2016; Jugdev, 2004). In fact, exploring the importance and impacts of maturity models on project success, particularly for those in megaprojects, have been rare themes within the literature (Albrecht & Spang, 2014; Besner & Hobbs, 2008).

0.2.2 Practical justification

Risk management maturity models play a significant role in project-based organizations with comprehensive infrastructure, as they can cover the essential methods, tools, techniques, governance structure, and people competencies (Nenni et al., 2014). Since different levels of risks and complexity are of great importance in megaprojects across different sectors, RMM models have the potential to affect profitability, productivity, and sustainability (Kleindorfer & Saad, 2005; Zwikael & Ahn, 2011). Overall, RMM models can make megaproject organizations implement successful strategies to achieve more effective management of risk (D. A. Hillson, 1997). Proper application of RMM models across sectors facilitates evaluation of RM processes and improves risk culture in projects and organizations (D. A. Hillson, 1997; Mu, Cheng, Chohr, & Peng, 2014; Yeo & Ren, 2009; Zou et al., 2010). In fact, a toxic risk culture leads to various risks for a business and project, for instance: a 2018 survey of 400 US chief executives by Deloitte found that whereas leaders focused on the risks of technological disruption and digital transformation, fewer than half (42 percent) had discussed risks to brand reputation in the previous year, and 53 percent could not even identify what those risks were (Raconteur, 2019). Thus, it is the proper time for chief executives to establish and develop the risk culture in their business (Raconteur-2, 2018; Raconteur, 2019). Further, as project managers regard control of risks as one of the crucial goals (Kardes et al., 2013; Sanchez-Cazorla et al., 2016), it is required to establish an effective framework to recognize and evaluate RM processes to deal with the risks and uncertainties, which megaprojects encounter (Heravi & Gholami, 2018; D. A. Hillson, 1997). On the other hand, since organizations allocate a large amount of budget on the assessment and improvement of their project management processes (including risk management), it is essential to know about the appropriate framework in advance, which not only leads to a more significant improvement of their processes but also causes to be financially feasible (Farrokh & Mansur, 2013). This assessment and improvement are made based on some conceptual frameworks, named Maturity Models (Brookes et al., 2014; Farrokh & Mansur, 2013; Görög, 2016; Katuu, 2016; Pasian, 2014). In this regard, the effectiveness of implementing RM processes in megaprojects which allows project managers to better anticipate and manage risks (Grant, Cashman, & Christensen, 2006; Lehtiranta, 2014), is measured by risk management maturity to achieve project goals (Heravi & Gholami, 2018). Moreover, due to the constantly changing nature of megaprojects, frequently assessing and managing risk remains of higher importance in industries engaged with megaprojects (Raconteur-1, 2017). In this sense, the aerospace industry has been at the forefront of managing a diverse range of megaprojects (Airbus, 2019). A key strategy within this sector is the development of several measures and controlling approaches in a highly uncertain, regulated, and competitive market, which include the application of proactive risk management principles through engaging in monitoring, mitigation, and reporting of risk into the firm processes and deploying internal policies (Airbus, 2019; Raconteur-2, 2018). Doing so enables firms in this sector to identify product safety and quality as well as reporting issues to top management which all could lead to growth and cultural development beyond its certification and airworthiness duties (Raconteur-2, 2018; Raconteur, 2019).

0.3 Research contribution

The risk management maturity should be placed in a sufficiently broad framework, ensuring that the outcome and main event spaces are complete, and sufficient focus is placed on the assumptions supporting the detailed scenarios that are identified (Aven, 2016a; Heravi & Gholami, 2018). A controlling risk management maturity system is a wide-ranging area from informal processes and usage of risk techniques to specific projects and formal processes, used broadly in the cultures with risk-awareness and dynamic risk management (D. A. Hillson, 1997; Zou et al., 2010).

This study concentrates on megaprojects since, despite their critical importance, they fail to achieve their expected performance due to their complexities, unpredictable challenges, and the fact that firms involved in megaprojects operate in a complex and industry-specific environment, which is influenced by different processes such as risk management processes (Kardes et al., 2013). While the importance of risk management in general and risk management maturity has been highlighted before, limited studies have identified challenges and potential solutions that emerge from megaprojects. In fact, there are very few studies aiming at the cross-functional collaboration between wider project communities to identify, reduce, and manage challenges of risk management maturity within their management practices (D. Hillson, 2003; Jaafari, 2003; H. Thamhain, 2013). It is worth noting that a reliable method for managing risk management maturity in megaprojects has also been overlooked in the later stages of infrastructure projects (Salawu & Abdullah, 2015; H. Thamhain, 2013). Identifying these challenges, and potential solutions, can affect the overall project success, minimize production costs, and improve execution time (De Palma, Picard, & Andrieu, 2012). Doing so also enables modifying the project planning processes and considering the changes that occurred by different risks (Irimia-Diéguez et al., 2014; Park et al., 2016). By reviewing the extant literature, the researcher tried to establish an evolved view of the most critical issues and factors for implementing the RMM models, particularly in megaprojects in the aerospace industry.

0.4 Research aim, objective, and question

The current study aimed to explore the challenges of RMM execution scenarios, particularly for organizations involved in megaprojects in the Canadian aerospace industry. It will study key barriers and potential solutions that need to be considered to implement RMM models in megaprojects in aerospace effectively. This project seeks to explore two objectives:

1. To understand and explore the effectiveness of RMM models in megaprojects in the Canadian aerospace industry.
2. To identify challenges and solutions for implementing RMM models in megaprojects in the Canadian aerospace industry.

Finally, in order to address the research aim and objectives, as identified above, this study answered the following research question:

- What are the challenges and solutions that impact the implementation of risk management maturity models in megaprojects in the Canadian aerospace industry?

0.5 Conclusion

The remainder of this research is organized as follows. Chapter one discusses the research context and presents an overview of the aerospace industry in Canada. Chapter two reviews the literature on risk management, megaprojects, maturity and risk management maturity. Chapter three discusses the methodology and data analysis process, chapter four presents findings, and chapter five offers key discussions. Finally, the researcher presents the theoretical and managerial implications, recommendations and limitations of the study in chapter conclusion and recommendations.

CHAPITRE 1

RESEARCH CONTEXT

1.1 Introduction

This chapter is aimed at elaborating on the aerospace industry and market. A brief description of the sector overview and the international Key actors (companies) in this industry is presented. Next, the desired market, competitive environment and conditions of the aerospace sector are determined. Then, the Canadian aerospace industry and its key challenges and opportunities are considered. Eventually, the researcher looks ahead and discusses the future potentials of Canadian aerospace.

In general, before the literature review (next chapter), the researcher has attempted to illustrate the practical understanding and evidence of the aerospace sector conditions using facts, figures, and tables from reliable business sources. It is required to mention that according to the available valid analytical reports, the researcher has compared the statistical analysis of market growth almost for 10 years from 2009/2010 to 2020/2021. Also, the predicted vision of the industry based on the resources is within 2025, 2035, or 2037.

Moreover, the main drivers of the aerospace industry followed by this chapter are mostly about Gross Domestic Product (GDP), annual revenues, aircraft deliveries, productions, sales market, etc. The principal resources applied in the current chapter are mainly based upon the statistical reports from Canadian aerospace associations, global business magazines, related case studies such as PMI (Project Management Institute of USA) reports, and annual reports proposed by major aerospace manufacturing companies such as Boing and Bombardier. Please note the numbers mentioned in the reports should be kept the same. All currencies are nominal, US Dollar ($) or CAD Dollar (C$), depending on the international reports such as McKinsey, Raconteur, or the reports proposed by domestic institutes such as AIAC, AERO, etc.

1.2 Overview of the aerospace sector

The aerospace industry is categorized into the following segments and sub-segments (Aerospace Review by the Government of Canada, 2012; Deloitte-AIAC-1, 2010; Deloitte-AIAC-2, 2010):

The definitions and categorizations of the Civil Aerospace Sector (CAS) and the Military Aerospace Sector (MAS) are:

1. Aircraft and Aircraft Part manufacturers (A&AP) (including avionics and electronics),

2. Engine and Engine Part manufacturers (E&EP),

3. Maintenance, Repair, and Overhaul (MRO),

4. Space, including satellite and space vehicle manufacturing (guided missiles for the MAS is included), and launch service exclusively provided for the CAS,

5. Training and Simulation (T&S).

Moreover, all the aviation activities or services provided in four categories, including airlines, freight and shipping firms, private individuals and businesses, and public sector customers for non-military uses, are known as CAS (Deloitte-AIAC-2, 2010).

In addition, there are four main kinds of civil aircraft, including commercial aircraft used for the commercial transport of passengers and cargo, regional aircraft such as regional jet and regional turboprop, business jet, and rotorcraft applied in niche applications where landing and take-off space is at a premium (Deloitte-AIAC-1, 2010; Deloitte-AIAC-2, 2010).

On the other hand, the aviation or space services provided for military purposes as a sector in Military Aerospace and Defense (MA&D) where manufacturing of missiles can alter the flight path of the guided missiles and launch vehicles are defined as MAS (Deloitte-AIAC-1, 2010).

According to Deloitte-AIAC-2 (2010) report about global aerospace market outlook and forecast, and Deloitte-AIAC-1 (2010) report about profile of the Canadian aerospace industry, the global aerospace industry could gain revenues of around $382 billion in 2009, out of which around 54% was designated to global MAS; however, the 46%.2 was regarded in the CAS (Deloitte-AIAC-2, 2010). The aerospace industry encountered an unexpected financial crisis in 2008 after five years of growth (Deloitte-AIAC-1, 2010; Deloitte-AIAC-2, 2010). Since the global aerospace industry could earn only 1.3% in 2009, 15.3% less than the earnings in 2008, the industry profitability remained flat or negative because of debts, regulatory fines and loss of assets (Deloitte-AIAC-1, 2010). These were the four main players within 2010, dominating the global A&D market: EADS by 8.7% production of the global A&D revenue, Boeing by 8.5%, Lockheed Martin Corporation by 5.9%, and Northrop Grumman Corporation by 4.9% (Deloitte-AIAC-1, 2010; Deloitte-AIAC-2, 2010). Within 2019, the United States was a pioneer in the A&D industry while Asia and the Middle East were promoting in both commercial aerospace and defense sectors (Deloitte, 2019).

According to Deloitte (2018) report about global aerospace and defense industry outlook, it was expected as both commercial aircraft and the global military began to improve in 2019, commercial aircraft production and defense spending so the global A&D industry continued to rise; however, the Deloitte (2019) report about the A&D industry outlook, emphasized that global A&D industry decreased in 2019. Whereas the defense sector continued to rise, there was a decline in the commercial aerospace sector (Deloitte, 2018, 2019). Moreover, they predicted that in 2020, the A&D industry would grow again with the recovery of the commercial aerospace sector after its decline in 2019 (Deloitte, 2019). Thus, the global defense sector would grow from 2019 on by increasing global tensions and geopolitical risks, investing in the US defense and other main regional powers like China, India, and Japan (Deloitte, 2018).

On the commercial side, in spite of its long-cycle business and economic uncertainty, consumer travel would be likely to grow (Bishel & Hermans, 2020). Thus, it is essential for stakeholders to plan for the future (Boeing, 2020). Deloitte (2019) report about global aerospace and defense industry outlook, in 2019, reported that from 2020 on, there would be a rise in the commercial aerospace sector as the long-term demand, and it is expected that around 40,000 units would be produced during the following two decades. Furthermore, in 2020, it was predicted by International Air Transport Association (IATA) that the number of commercial airline passengers would globally double hitting 8.2 billion passengers every year within 2037 (Bishel & Hermans, 2020).

Putting emphasis on the above acknowledgments, in 2020, the global aerospace, regarding the COVID-19 pandemic (Boeing, 2021), have decided to enhance their efficiency, sustainability and strategies so as to achieve network flexibility, higher capability and fewer risks by renewing their fleets into versatile medium and longer-term (Boeing, 2020). Regarding the Deloitte (2021) aerospace and defense industry outlook, it is expected that the global A&D earnings will get better in 2021 after a tough year in 2020. Yet, this recovery will not be the same in two main sectors, commercial aerospace and defense (Deloitte, 2021). Due to the detrimental effect of the COVID-19 pandemic on the commercial aerospace sector resulting in less travel demand compared with pre–COVID-19 levels, it is expected that this sector is recovered far more slowly before 2024; however, it is most likely the defense sector remains unchanged in 2021 (except some defense programs in the complex global “supply chain”[7] which require minor higher cost and encounter schedule delays in 2021), because most countries have considered almost the same defense budgets and their military capabilities into account (Deloitte, 2020, 2021).

1.3 Key global actors in aerospace

In addition to the United States as a leader in A&D industry growth, other countries such as China, France, India, Japan, the Middle East, and the United Kingdom have also been expected to cooperate in this regard during recent years because of the rising demand for commercial aircraft (Deloitte, 2018). APPENDIX I demonstrates a detailed “2019 global A&D industry trends and outlook” of the key countries, proposed by Deloitte (2018), page nine, global aerospace and defense industry outlook of 2019 (see APPENDIX I, Figure-A I-1).

[7] There are many definitions for supply chain in the literature, such as integrated logistics, supplier integration, buyer/supplier partnerships, and supply base management, while "supply chain management" is the most widely used (Tan, 2001). Based on the literature, supply chain management is the chain linking each manufacturing and supply process element from raw materials to the end-user and incorporating different organizational boundaries (Tan, Lyman, & Wisner, 2002).

1.4 Sector global challenges and improvements

Increased production rates in the longer-term cause several hurdles for the manufacturers that would need to cross, including cost management and schedule overruns, suppliers risk management, certifications from regulators worldwide, and most importantly, setting up a safe and reliable track record - before they are widely accepted (Deloitte, 2018, 2021).

According to the different reports published in the field of aerospace and defense industry, some of the main challenges aerospace manufacturers face globally are as follows:

1. Due to the pandemic, which has led to lower aircraft demand, the limitations of people and goods transformation, and the disruption of a number of essential A&D supply chains, both commercial aerospace and defense have faced some challenges (Deloitte, 2020, 2021);

2. Since potential risks of establishing heavy industrial plants in different processes as well as stricter rules imposed by tough regulators might endanger a company share price, safety should be taken into close consideration which can lead to decreasing their down time and increasing their productivity and profitability (Raconteur-1, 2018). In an annual report published in 2019 by Airbus (as one of the main global leaders in the aerospace industry), it was mentioned that one of their strategies was rising the Airbus capacity by taking several measures in a highly uncertain, regulated and competitive market, including applying proactive risk management principles, deploying internal policies and management tools to perform the assessment, monitoring, mitigation, reporting of risk into the company culture and processes, providing product safety and quality of the company products as well as reporting issues to top management which all could lead to growth, substantial improvements for the Airbus safety of flight, and its culture beyond its certification and airworthiness duties (Airbus, 2019);

3. “Risk culture” was a controversial issue across different industries (including aerospace), from regulators to chief executives, due to so many scandals of employee misconduct and cultural failings in the headlines (Raconteur-2, 2018). Thus, it was wondering what organizations should have done in this regard and who had been responsible (Raconteur-2, 2018; Raconteur, 2019). An organization risk culture beyond rule books should be taken into

account to initially discover the employees' motivations, beliefs, behaviors and attitudes towards risk (Raconteur, 2019). Therefore, risk culture has been categorized into four practical pillars (by experts and business leaders of different industries sectors to perceive and develop the employees' day-to-day actions based upon the right risk culture), including:

- first pillar- tone from the top: initially, the level of risk tolerance should be determined by the leaders before assessing their effect on the organization risk culture so as to create a balance between growth and safe behaviors towards inspiring employees to understand their responsibilities for managing risk by the leaders as their key roles;
- second pillar- understanding employee opinion: since employees' viewpoints are of importance, the right tools should be offered to them in order to avoid them from developing their own processes to get the job done;
- third pillar- incentives: employees should primarily be promoted and rewarded according to their performance;
- fourth pillar- governance and controls: although most companies meet required compliance standards, such as Safety Management Systems ("Safety Management Systems in Aviation," 2020), in order to be admittedly controlled by regulations, the problem is in the implementation of these controls in the daily life of the company (Raconteur-2, 2018).

4. Another challenge is the cognitive bias of assessing risks in which humans often fail to logically decide due to mental shortcuts which hinder us from making the correct choice (Raconteur-1, 2017; Raconteur-2, 2018). Due to constant changes by different risk events in a project, frequently assessing and managing risks is of more importance (Raconteur-1, 2017). Moreover, applying the right tools is essential to structure and manage a project flexibly (Raconteur-1, 2017; Raconteur-2, 2018). Thus, project managers need to access the right tools to provide them with flexibility, visibility, control and accessibility in dealing with their clients in all project processes (Raconteur-1, 2017). It is a data-driven or measured and metric-driven approach that helps project managers and business stakeholders with decision-making confidently (Raconteur-1, 2017; Raconteur-2, 2018). Concerning the impact of using the **right tools** to better **structure** the **project management processes** in **all industries across the globe** (from products development to services), a survey with more than 550 project managers

from Europe, North America, and Asia was done, and over half declared there was nothing to monitor or evaluate the **management of their projects** (Raconteur-1, 2017);

5. In the current competitive era, the communication skill of the management team is so important in project-based organizations that failure in it puts the project at risk of failure (Raconteur, 2016);

6. In managing risks, technology, data gathering, analytics, and AI are of great importance (Raconteur, 2019). In a recent survey of project managers by AXELOS, a UK government and Capita joint venture, while 57 percent expect Artificial Intelligent (AI) and machine learning to greatly affect project management, 90 percent believed that new technologies would pose risks required to be managed meticulously (Raconteur-1, 2017).

7. The UK, the world ninth-largest industrial nation in 2018, which holds world-class manufacturers in the Airbus, GlaxoSmithKline and Rolls-Royce, believes that successful project managers need technical skills, interpersonal qualities and knowledge to be good leaders (Raconteur, 2015) and train the employees for a new future (Raconteur-3, 2018);

8. According to the significance of the "lessons learned"[8] in megaprojects such as aerospace, Boeing (2021), as one of the leading global aerospace companies, in its 2020 annual report about global aerospace resilience and resolve, illustrated that based on key lessons learned, some critical changes were made to improve the aviation safety by implementing stronger safety practices and culture. They confessed that sometimes they failed to meet their expectations, and it was necessary to clearly discuss everything with the regulators and stakeholders (Boeing, 2021).

[8] The lessons learned are intended to capture the results and experiences from successes, failures, and near misses and absorb them in to the organizational processes for future use (McClory, Read, & Labib, 2017). Literature review illustrated that lessons learned are often identified, captured, and even transferred successfully, while the implementation aspect is the main problem (Duffield & Whitty, 2015; McClory et al., 2017).

1.5 Aerospace in Canada

Eighty years ago, the political and industrial decision-makers of Canada, as visionaries, enacted a plan to make the country a global leader in aerospace and the aerospace industry has been an effective factor in Canadian profitability for decades (AIAC, 2018). From its earliest days, the aerospace industry in Canada was a pioneer in the employment of globally new technologies and skillful workers and rewarded competitively but collaboratively (Aerospace Review by the Government of Canada, 2012; AIAC, 2018). Consequently, industrial manufacturing in Canada got popular among industrial powers, first Great Britain and then the United States, and often undertook branch plants of British and American companies (Aerospace Review by the Government of Canada, 2012). Until 2012, the Canadian aerospace industry was the fifth-largest industry behind the United States, France, Germany, and Britain; and ahead of Japan, Russia, Brazil, and China (Aerospace Review by the Government of Canada, 2012; AIAC, 2018; Deloitte, 2018). According to ISED-AIAC (2019), the state of Canada aerospace industry report, Canada was the only country with a top-five rank in all categories, including civil flight simulators, engine manufacturing, and aircraft assembly. It was also labelled as the first global manufacture of flight simulators and the second worldwide in business aircraft production (AIAC, 2018). The Canadian aerospace industry plays a strategically important role in the Canadian economy in terms of employment, innovation, productivity, Research and Development (R&D), GDP, and trade (AIAC-1, 2015). The aerospace contribution to the Canadian economy requires vision, budget, and partnership among government, research institutions, the armed forces, industry, and Canadian employees (AIAC, 2018).

The government of Canada has an important role in the aerospace industry by providing an R&D budget, long period loans, the employment of innovative technologies and skilled employees regarding their high risks, which all can benefit other industries too (Aerospace Review by the Government of Canada, 2012; CanadaParliament, 2013). The Canadian federal government, just like other nations, has been a major stakeholder/supporter of Canada aerospace industry since the Second World War, and during the last four decades, it has been supported by tax credits, direct budgeting, or different kinds of contribution agreements in the programs of the aerospace industry such as Sustainable Development Technology Canada (CanadaParliament, 2013).

To be more specific, the current chapter followed by the state of some of the above important facts of Canada aerospace market since 2009.

Regarding Deloitte-AIAC-2 (2010), the global Aerospace market outlook and forecast report, and Deloitte-AIAC-1 (2010), profile of the Canadian Aerospace industry report, about C$22.2 billion could be earned in 2009 by the Canadian aerospace industry greatly affected by the A&AP sub-sectors. 50% of overall Canadian aerospace revenues generated by the A&AP sub-sector, only 15% of the total market players, confirmed the importance of the A&AP sub-sector (Deloitte-AIAC-1, 2010). The remaining market players controlling 50% of the market with 40 MRO companies and 12 E&P companies, could generate 19% and 14% of revenues, respectively (Deloitte-AIAC-2, 2010). There were 322 players within avionics and electrical systems, T&S, space and the other sub-sector (Deloitte-AIAC-1, 2010; Deloitte-AIAC-2, 2010).

Further, regarding the table below (see Table 1.1), the researcher illustrated the state of Canada aerospace industry from 2010 to 2019, contributing to the Canadian economy (Aerospace Review by the Government of Canada, 2012; AIAC-1, 2015; AIAC-2, 2015; AIAC, 2014, 2018, 2019; CanadaParliament, 2013; Investincanada-AIAC, 2018; ISED-AIAC, 2019).

Table 1.1 State of Canada aerospace industry (CAD)

Year	GDP-billion	Revenue-billion	Jobs
2010	-	$21	81,000
2011	-	$22.4	87,000
2012	-	$22	92000
2013	$28	-	172,000
2014	$29	$27 .7	180,000
2015	-	-	-
2016		>$27	208,000
2017	-	-	-
2018	> $25	$31	213,000
2019	$25.5	-	215,000

Also, regarding the detailed segmentation of the GDP and Jobs, the Canada aerospace state in 2018, followed by the Figure 1.1.

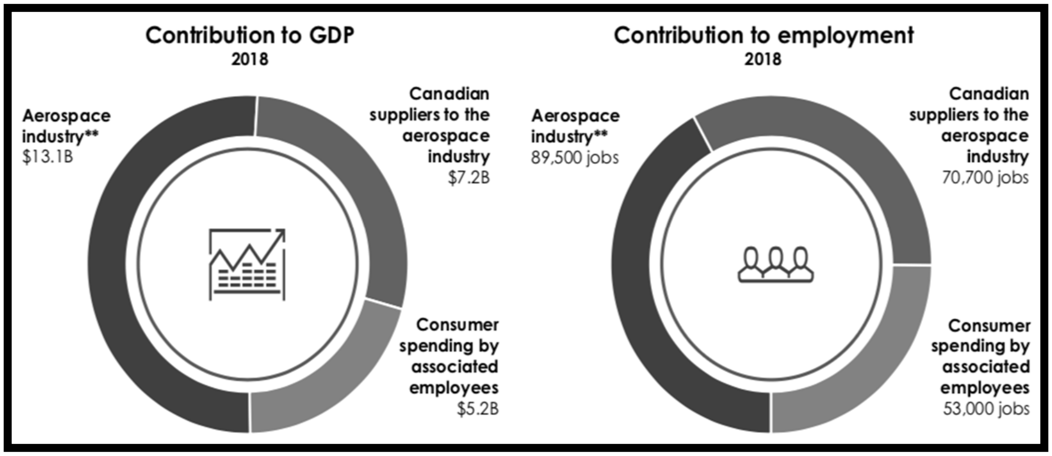

Figure 1.1 State of Canada aerospace industry in 2018
Taken from ISED-AIAC (2019, p. 4)

Furthermore, according to ISED-AIAC (2019) about the state of Canada aerospace industry, the Canadian aerospace ecosystem is associated with the defense and space industries. The aerospace and space systems manufacturing industries in Canada are civil-oriented, and more than a quarter of aerospace MRO revenues was related to defense (note: beyond space systems manufacturing, the space sector included many sub-sector service industries) (see Figure 1.2) (ISED-AIAC, 2019).

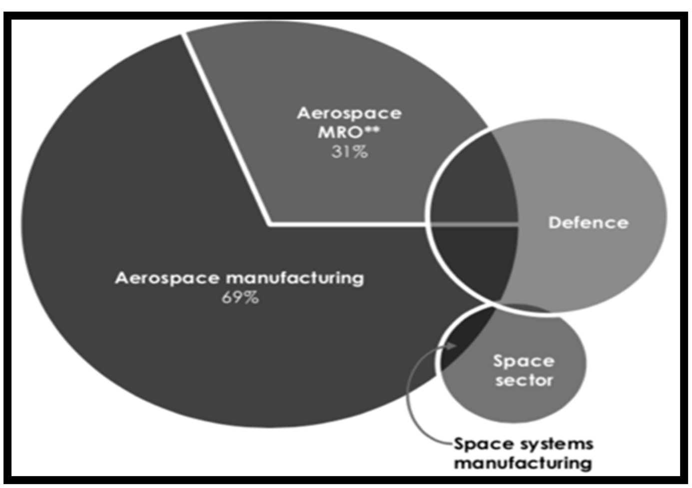

Figure 1.2 Share of GDP by industry segment in 2018
Taken from ISED-AIAC (2019, p. 5)

To be more specific, among Canadian aerospace markets, regarding the AERO (2020) report about the Quebec aerospace cluster, Montreal is among the three aerospace capitals of the world. More information about the state of Quebec aerospace industry compared with Canada aerospace state are specified in the below table (1.2) by researcher (AERO, 2012, 2016, 2017, 2019, 2020).

Table 1.2 State of Quebec aerospace industry compared with Canada aerospace

Year	Québec exports Rank	In sales billion	% of Canadian R&D	Employees	Companies	Exported Productions	Sales	Jobs
2011	-	$11.7	70%	42,000	212	60%	55%	-
2016	1st	$14.4	> 70%	39,130	205	80%	52%	45%
2017	1st	$14.4	> 70%	40,700	196	80%	53%	47%
2019	1st	$17.8	> 70%	43,400	240	80%	57%	49%

Moreover, the Canadian aerospace industry has been largely export-based (the largest customers are the US and Europe), and locally, aerospace sales have greatly focused in Quebec and Ontario respectively (Deloitte-AIAC-2, 2010).

Also, some Canadian-headquartered aerospace firms have been leaders globally in their markets (Aerospace Review by the Government of Canada, 2012). Canada is regarded as an ideal place for aerospace investment with world-class sectors in Montreal, Toronto, Vancouver, and other centers throughout the country (Investincanada-AIAC, 2018). According to the Conference Board of Canada, by 2010, the largest aerospace firms in Canada are followed in Figure 1.3 (Deloitte-AIAC-2, 2010).

Rank	Canadian company	Aerospace industry revenues (USD million)	Percent of total (%)[i]
1	Bombardier Aerospace	9,024	55.6
2	Pratt & Whitney Canada	2,880	17.8
3	CAE Inc.	1,596	9.8
4	Boeing Canada Inc.	660	4.1
5	Vector Aerospace Corp.	543	3.3
6	Boeing Canada Inc.	540	3.3
7	Textron Canada Ltd.	377	2.3
8	Heroux-Devtek Inc.	324	2.0
9	Northstar Aerospace Inc.	212	1.3
10	Avcorp Industries, Inc.	66	0.4

Figure 1.3 Canadian aerospace market leaders
Taken from Deloitte-AIAC-2 (2010, p. 12)

In 2012:

1. Bombardier got the third-largest commercial aircraft manufacturer in the globe, behind Boeing and the European Aeronautic Defense and Space Company (EADS), the parent company of Airbus;

2. CAE has been dominant in producing flight simulators and providing flight-training services;

3. Héroux-Devtek has competed globally in producing landing gear systems;

4. Viking Air has produced and maintained new versions of historic de Havilland aircraft and Magellan;

5. Avcorp and Noranco have provided complicated aerostructures to major aircraft manufacturers (Aerospace Review by the Government of Canada, 2012).

Recently, regarding the Bombardier (2021) financial results report, Bombardier could earn $5.6 billion revenues from business aircraft activities in 2020, improving at 3% annually to Global-7500 deliveries, which reached a record of 16 deliveries in the fourth quarter, partially offset by the significant impact of COVID-19 on other programs and services revenues; and it is expected that revenues from business aircraft activities in 2021 to be better than in 2020 because of a gradual economic recovery. Other aviation revenues from commercial aircraft and aerostructures activities, which were divested during the year, were $895 million; in addition, an initiative within the company can increase profitability and productivity, aiming at savings of around $400 million annually by 2023 (Bombardier, 2021).

Moreover, the Canadian aerospace industry has gained a lot of benefits from setting up local subsidiaries by firms from abroad. Its vibrancy can be improved by extra foreign direct investments, specifically in areas where the sectoral structure needs to be enhanced. Knowing its aerospace powers, unique position between the United States and Europe, stable business climate, and respect for diversity, Canada could gain substantial direct investment by main companies owned abroad (Aerospace Review by the Government of Canada, 2012; AIAC, 2019, 2021). The researcher in Table 1.3 illustrates a list of some of these major firms.

Table 1.3 Major foreign-owned aerospace companies in Canada.

Name	Based from	Products & Services
Pratt & Whitney Canada	U.S	Auxiliary Power Units; Turbofan Engines; Turboprop Engines; Turboshaft Engines
Boeing Canada Operations	U.S	Component Manufacturing & Processing; Composites & Plastics; Research & Development
Airbus	France	Commercial Aircraft: A220 Final Assembly Line; Programme Management; Engineering; Customer Support & Services. Helicopters: Aircraft Sales; Completions & Deliveries; Composite Manufacturing; Repair & Overhaul; Supplement Type Certificates /Options Development; Support & Services. Centre for Excellence for Composite Manufacturing. Defence and Space: Sales & Marketing
GE Canada	U.S	Auxiliary Power Units; Business Aircraft; Commuters & Regional Aircraft; Engine Nacelles; Engine Repair & Overhaul; Propellers & Equipment; Starters; Turbine Blades; Turbofan Engines; Turboprop Engines; Turboshaft Engines
Rolls-Royce Canada	U.K	Brazing; Engine Repair & Overhaul; Engine Test Cells; Field Service; Heat Treating; Machining; Non-destructive Testing; Research & Development; Shot Peening; Welding
General Dynamics Canada	U.S	Command & Control Systems; Data Handling & Processing Equipment; Helicopters; Signal Processing Equipment; Software Design & Development; Sonobuoys; Special Purpose Aircraft; Surveillance Systems; Systems Integration; Unmanned Vehicles
Honeywell Aerospace	U.S	Antennas; Communications Systems, Environmental Test Facilities; Radios & Equipment; Remote Sensing Equipment; Optical Systems; Satellites, Satellite Systems & Components; Signal Processing Equipment; Surveillance Systems
Thales Canada	France	Cockpit Display Systems; Command & Control Systems; Communications Systems, Radios & Equipment; Electronic Controls; Engineering & Management Support; Flight Control Repair & Overhaul; Flight Control Systems & Components; Satellites, Satellite Systems & Components; Software Design & Development; Systems Integration
MHI Canada Aerospace	Japan	Aircraft Structures & Subassembly; Component Manufacturing & Processing

Finally, the Canadian aerospace sector is at a critical time because if the sector is to keep gaining benefits for the whole country, all players, including companies, academic and research institutions, unions, and governments should understand and adapt to changing realities (as success relies on developing technologies for the future and having sales safety in a globally competitive era) (Aerospace Review by the Government of Canada, 2012).

1.6 Key challenges and opportunities in Canadian aerospace

Between 1992 and 2018, Canada ranking has fallen from 8th to 18th level globally in spending on space as a percentage of GDP and employment in the **aerospace manufacturing sector** of Canada has decreased by 5%, and aerospace contribution to GDP has decreased by 4% between 2012 and late 2018 (while competitor countries have invested heavily in the aerospace sector) (AIAC, 2018).

Another challenge in the aerospace industry, proposed by AERO (2018) about the industry 4.0 skill set, determined that a rare labor force has influenced **manufacturing aerospace industries**, and this lack of resources is making firms automate their processes to meet client demand which is more economical. Thus, it is required for organizations to enhance their productivity and risk management to stay competitive and accept offers and long-term agreements. Indeed, some firms which were adroit at transformation could not only maintain the jobs and create new ones but also add new skills and develop the full potential of their existing labor force in the employment of technologies related to productions (AERO, 2017, 2018). Besides, another challenge is collaborative internal equipment and networks such as the accessible virtual tools, which enable an engineer to speed up the design time, facilitate learning and reduce the risk of errors or variations (AERO, 2018).

Regarding the AIAC-1 (2015) and AIAC (2019) guides to the Canada aerospace industry, both proposed a comprehensive list of the company products and services in Canada, followed by their profile, mission and vision. The point is that almost most of them signify risks and the way to manage them as one of their future challenges/improvements (AIAC-1, 2015; AIAC, 2019, 2021). Also, in the Bombardier (2019) activity report, it was mentioned that over the year 2019, they could proceed towards their objectives focusing on three main areas, including visible leadership, preventive risk management, and Health-Safety-Environment (HSE) best practice. Therefore, they made an attempt to understand the site activities and processes better, which could lead to critical risks (Bombardier, 2019, 2021).

Another improvement in the Canada aerospace industry is about Artificial Intelligent challenges (AIAC, 2018). McKinsey did a survey on 120 leading Canadian executives and interviewed 31 business leaders in depth in order to discover whether Canada AI history could make technological advances in its own businesses, and according to the report, there was a considerable gap in business leaders' grasp of AI potential beside an encouraging drive for AI (McKinsey&Company, 2018). Providing that Canada cannot transform its wealth and talent, others will and Canadian businesses will risk finding themselves at an enduring competitive disadvantage (AIAC, 2018; McKinsey&Company, 2018). AI has positively affected Canadian industries in recent years (AIAC, 2018).

Last but not least, another challenge is about leveraging an advanced risk-based approach to managing acquisition programs (megaprojects). Because the complex operating environment can be overcome by developing an advanced risk-based approach to managing acquisition programs, program managers should analyze past data to identify and increase focus on those parts of the programs which are likely to experience challenges in the future based on empirical data (Deloitte, 2016).

1.7 Conclusion: Future of aerospace in Canada

Despite the above challenges for Canadian aerospace industry, the Canada government, in a report which was proposed in 2018, illustrated the main Canada advantages in aerospace sector, including high R&D intensity, export competitiveness, logistics and market access, an ideal place for aerospace investing, and duty-free manufacturing tariff regime as well as its strong, safe and innovative, business climate for investment and trade which benefit from a proper and efficient financial system supported by low taxes and business costs (Investincanada-AIAC, 2018).

The potential of aerospace to transform their economies and create new opportunities for the citizens is known for nations like Canada (AIAC, 2018). There are global companies out there that are going to do business here in Canada, and if Canada doesn't adapt its approach to represent this reality, it will not be supported despite working so hard for so long (AIAC, 2018, 2019, 2021). Regarding the vision 2025 report launched by AIAC (2018), if both government and industry cooperate, it will cause success in Canadian aerospace growth and leadership.

With the growth of the global middle class, the demand for aircraft is going to double in the following 15 years (AIAC, 2018, 2019). Canada vision is to be a world-leading creator of future technologies through cutting-edge R&D and a new partnership between stakeholders and governments, and it is also going to raise military spending and a greater global commitment to space, and by realizing this vision, AIAC is persuaded that Canada aerospace sector can achieve the following targets (see Figure 1.4) and earn its fair share of global aerospace growth (AIAC, 2018):

Figure 1.4 Canada aerospace 2025 targets
Taken from AIAC (2018, p. 8)

The AIAC (2018) also offered the priorities and areas to increase collaboration and make Vision 2025 a reality represented as following steps:

1. raise support for the most globally skillful workforce;

2. make small and medium-sized aerospace businesses develop and grow;

3. employ innovation to grasp new opportunities;

4. invest in preserving Transport Canada internationally well-known status for aircraft certification and regulation;

5. maximize Canada leadership as the space pioneer;

6. strengthen defense procurement and government partnerships to cause new industrial growth.

CHAPITRE 2

LITERATURE REVIEW

2.1 Introduction

This chapter reviews the literature on the study of the implementation of risk management maturity in megaprojects. Some of the crucial notions studied in this domain are risk management, megaprojects, maturity and risk management maturity. Figure 2.1 presents an overview of the literature. The researcher has categorized the literature in the following sub-sections.

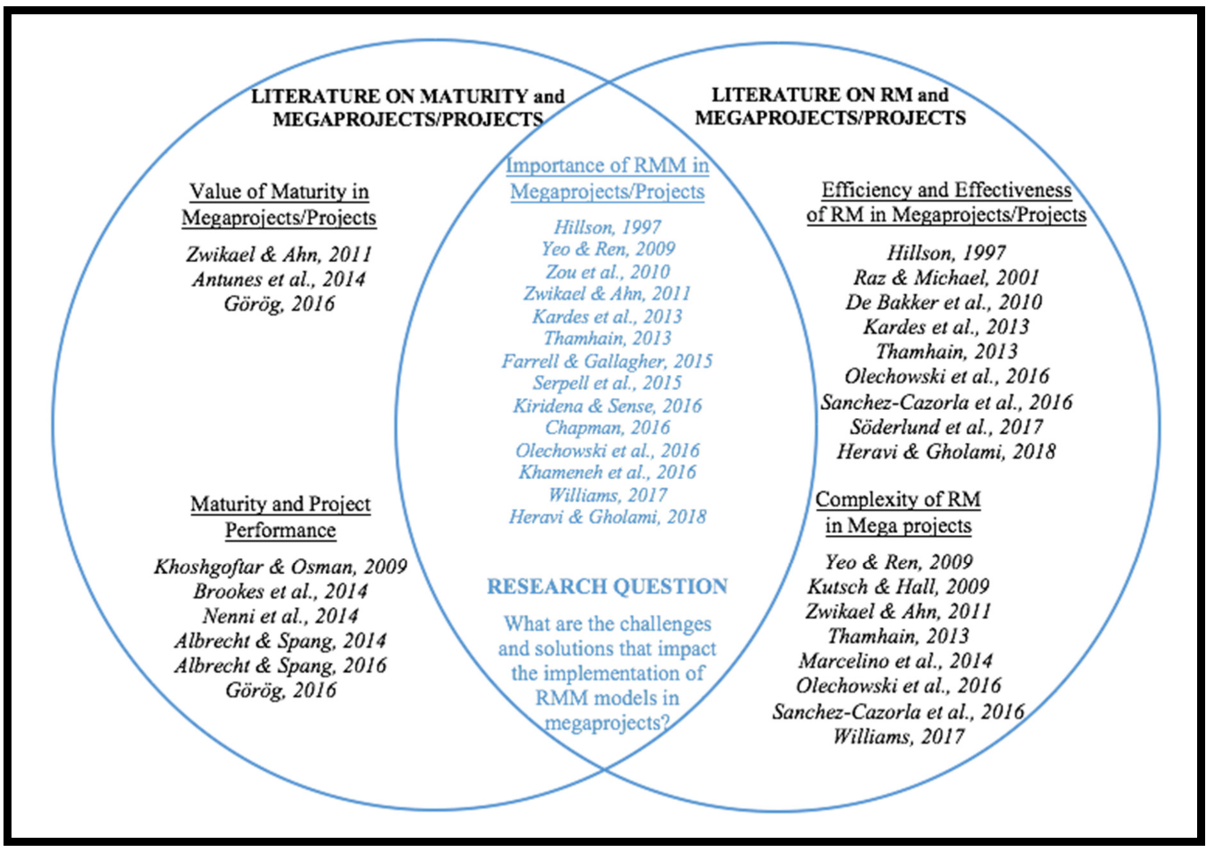

Figure 2.1 Venn-diagram: Summary of the review of the literature

2.2 Megaprojects

Complex projects cause to define a new categorization of the projects like capital projects, major projects, or megaprojects (De Rezende, Blackwell, & Pessanha Gonçalves, 2018). Moreover, according to Eweje et al. (2012), megaprojects are programs that combine several projects aligned with a strategic goal into one megaproject. In most cases, the program is used to describe a set of interrelated projects (Pellegrinelli, 1997), which also means a set of related projects, sub-programs, and program activities that are managed in a coordinated way to receive benefits not available from managing them individually (Project Management Institute, 2017b).

In the 1970s, the concept of megaproject was introduced to elaborate the cost and size of mega energy development and large capital projects being carried out throughout the globe (Dimitriou et al., 2013; Sanchez-Cazorla et al., 2016). Any single meaning to determine the elements of a megaproject cannot be found in the literature (Sanchez-Cazorla et al., 2016). Since megaprojects are quite significant, the number of megaprojects being undertaken and studies on them have been increasing in recent years (Sanchez-Cazorla et al., 2016; Söderlund et al., 2017). Abundant studies can be found in academic journals developing a number of literature about megaprojects, for instance, the International Journal of Project Management, Journal of Management and Engineering, and the International Journal of Managing Projects in Business (Söderlund et al., 2017). Thus, no one can deny the significant role that megaprojects play in organizational and managerial research and economic growth (Söderlund et al., 2017; A. H. van Marrewijk, 2015).

As megaprojects are massive with mega-infrastructure, it is expected to take many years to establish and develop quick, clear and deep landscape transformation (Flyvbjerg, 2014; Söderlund et al., 2017). Thus, it requires a large investment and the cooperation of a number of public and private stakeholders (Kardes et al., 2013; Koppenjan, 2005; Pollack, Biesenthal, Sankaran, & Clegg, 2018). Moreover, the government usually attribute responsibility for running and developing such uncertain and complex projects which are politically sensitive

(Clegg, Pitsis, Rura-Polley, & Marosszeky, 2002; Sanchez-Cazorla et al., 2016; Söderlund et al., 2017).

According to the literature, it is required to study large-scale projects as a vivid setting to investigate how managers handle the project technically and financially to deal with the defects of the megaprojects (Esty, 2004; Sanchez-Cazorla et al., 2016). Project management of megaprojects often encounters unique decision-making environment that generally does not apply to other types of projects (Eweje et al., 2012; Zhai et al., 2009). Some of the differences between project management in common projects and project management in megaprojects include (Zhai et al., 2009):

1. large volume of investment (ranging from US$0.5 million to billions),

2. greater community involvement,

3. higher number of investors and stakeholders,

4. more intricate decision-making processes,

5. the number of human resources,

6. high complexity and abundant complex tasks,

7. size and time,

8. structures,

9. substantial high uncertainty and risks (Eweje et al., 2012; Flyvbjerg, 2007; Kardes et al., 2013; Sanchez-Cazorla et al., 2016; Söderlund et al., 2017; A. Van Marrewijk, Clegg, Pitsis, & Veenswijk, 2008).

The complexity of megaprojects can also be analyzed based upon both technical and social complexity (Kardes et al., 2013). Technical complexity is relevant to the size of the project; however, social complexity refers to the interactions among the people participating in the project (Baccarini, 1996; A. Van Marrewijk et al., 2008). In addition, the more complex the projects are, the more risk level gets (Kardes et al., 2013). Also, Gellert and Lynch's (2003) conclusions, cited in Kardes et al. (2013) study, have introduced four categorizations for megaprojects: infrastructure (e.g., railroads); extraction (e.g., minerals, oil, and gas); consumption (e.g., tourist installations, and malls), and production (e.g., aircraft). There are a number of domains, including complex projects such as “Complex Product Systems” and “high-tech manufacturing” projects which are found in the A&D industry (Yeo & Ren, 2009).

Söderlund et al. (2017) highlighted the analysis of Tomas Frey from Da Vinci Institute that although creating megaprojects can be a sign of success, there are many challenges for those who consider megaprojects as a shortcut to success. There are some major challenges that are ignored by decision-makers and other actors who are implementing megaprojects, including:

1. megaprojects potential risks due to their long period of planning, nested interfaces, and complexity,

2. megaprojects are high-risk activities with extreme rare events that cause negative results,

3. megaprojects are created on misinformation about costs, schedules, benefits, and risks which cause in exceeding budget, delays, and spoiling the delivery of the projects (Flyvbjerg, 2006, 2014; Söderlund et al., 2017).

Overall, since there is no clear direction and shared ideas, megaprojects undermine as a basic problem, though (Söderlund et al., 2017).

It is stated in the literature that since every project is implemented differently, gauging project success needs to implement a specific and comprehensive approach (Ogunlana, 2010; Rodriguez-Segura, Ortiz-Marcos, Romero, & Tafur-Segura, 2016). For instance, in the specific domain of the **aerospace** and defense industries, some features, including a high-tech nature, large investment, and customer management, should be taken into account by the stakeholders to achieve success in the project development (Rodriguez-Segura et al., 2016).

On the other hand, there are no clear studies justified by critical requirements on the success factors and causes of failures in the megaprojects in **aerospace** industry, and the references of interest are not investigated recently (Rodriguez-Segura et al., 2016). In this term, previous studies pointed out that the analysis of **aerospace** projects success should rely on setting objectives and client's satisfaction with technological development, implementing the management methods and controlling processes such as strong management approach for risk processes (Ernst, 2002; Rodriguez-Segura et al., 2016).

2.3 Risk Management

In the literature, there are different risk classifications, among which the most common one is carried out at the macro level (which is related to inappropriate external factors affect project success indirectly) and micro levels (including internal risks such as the interaction between stakeholders and technical/operational sectors (Bing, Akintoye, Edwards, & Hardcastle, 2005; Kardes et al., 2013). Thus, a project might fail if the project risks are not managed or reduced appropriately (de Bakker, Boonstra, & Wortmann, 2012; Royer, 2000; R. Yim et al., 2015). For instance, in a study on a large engineering project, the RM strategies are evaluated based upon the level of control over risks and their degree to that specific project (Kardes et al., 2013).

Risk management in the earliest twentieth century has been revealed by some new approaches such as Enterprise Risk Management (ERM), which identifies, assesses and manages the risks in the portfolio level of the company (Kleffner, Lee, & McGannon, 2003). Moreover, risk management is currently considered a mandatory part of project management and an integral part of successful project management (Dunović, Radujković, & Vukomanović, 2013). Project risk management is a way to successfully determine project risks (Park, Park, Cha, & Hyun, 2016). The process of RM in project management has been universally investigated in different companies and institutes. For instance, PMI (the Project Management Institute), ISO (the International Organization for Standardization), and IRM (the Institute of Risk Management) all have published their guidelines or standards on the RM process (Jia et al., 2013). According to the comparison on RM process among those standards, it has been discovered that although there are some differences between the standards of RM processes, there are some similarities among the processes presented. Some typical RM processes include RM planning, risk identification, risk analysis and assessment, risk response, risk monitoring, and RM reporting (Jia et al., 2013; Sanchez-Cazorla et al., 2016). For instance, in recent PMI publications, risk management is entitled as the systematic process of identifying, analyzing and responding to project risks which has seven steps: plan RM, identify risks, perform a qualitative risk analysis, perform a quantitative risk analysis, plan risk responses, implement risk responses, and monitor risks (Irimia-Diéguez et al., 2014; Project Management Institute, 2017a; Sanchez-Cazorla et al., 2016).

As it has already been discussed, another objective of the risk management process, in some projects with specific sizes, is to recognize and assess risks in order to make the risks lead clearly in effective project management (Irimia-Diéguez et al., 2014; Mojtahedi et al., 2008). The RM approach is to decrease risk and increase opportunity factors by analyzing both risk and uncertain elements, which impact megaprojects (Park et al., 2016). According to new risks and opportunities which might be apparent during different project phases, it is expected to employ some changes in the project implementation processes, and thus, it is essential for project executives to have continuous monitoring for risk management (Kardes et al., 2013).

2.4 Maturity models

2.4.1 Maturity meaning and types

According to the literature, Mature means being grown or developed at the maximum level, and maturity is the quality or state of being mature (Andersen & Jessen, 2003). So, if it is said that an organization is mature, it means it is in the best situation to achieve its goals (Andersen & Jessen, 2003; Katuu, 2016).

A maturity model is a management tool, which is helpful for companies to execute the structured collection of processes and benefit from previous experience as an assessment approach (Simon, Schoeman, & Sohal, 2010). In addition, the tasks are prioritized to evaluate improvement by a common language and framework (Antunes et al., 2014; Katuu, 2016). One of the major outcomes of employing maturity techniques for the organizations is a continuous improvement (Khoshgoftar & Osman, 2009). Since the use of maturity models results in continuous improvement, the number of organizations applying it has increased, and its academic interest has been reinforced (Antunes et al., 2014; Becker et al., 2010; Katuu, 2016).

Although the concept of maturity models was accepted and expanded sooner, it has been getting popular as an assessment tool recently (D. A. Hillson, 1997; Mullaly, 2006). Therefore, it is not expected that maturity models in organizations or processes improve from the least capability to the most capability at once, but rather in the long time span of project improvements (Katuu, 2016). The general ability of organizational processes is evaluated by maturity models based on a framework developed (D. A. Hillson, 1997; Mullaly, 2006).

Since maturity models are commonly considered one-dimensional, they focus on either process maturity, people capability or other objects, but the majority of these models concentrate on a process-based approach (Antunes et al., 2014; Mettler & Rohner, 2009). Another view describes the characteristics of the maturity models: staged and continuous (Antunes et al., 2014). The models which follow the staged perspective represent the state of organization processes overall by applying maturity levels, while in the continuous approach, the capability levels are used to evaluate the situation of the organization processes (according to the individual process area) (Antunes et al., 2014; Görög, 2016; Pereira & Da Silva, 2011; Team, 2010). Broadly, there are many variables based on which maturity models can be compared:

1. their success,

2. the applied approach (staged or continuous),

3. the number of maturity levels the model employs,

4. their implementation scope (Antunes et al., 2014; Görög, 2016; Pereira & Da Silva, 2011).

Maturity models have the ability to transform the knowledge and experience of the company into procedures, plans, standards and databases, which leads to collective knowledge and understanding (de Carvalho, Patah, & de Souza Bido, 2015). They are also effective in assisting organizations to deal with some challenges such as project budget or quality improvement in the competitive market (Antunes et al., 2014). Moreover, they help to identify a project or organizational strengths and weaknesses employing techniques and accept continuous improvements regarding the business processes and staff capability, which cause organizations productivity (Khoshgoftar & Osman, 2009). There is a strong connection between the maturity improvement of the company and the project success (Harter, Krishnan, & Slaughter, 2000; Zwikael & Globerson, 2004).

A maturity model is a structured collection of elements that describe effective processes or products (Khoshgoftar & Osman, 2009). Maturity models can enhance the effectiveness and capability of the organizations as a tool that aid them to apply changes by a structured view (Jia et al., 2011; Mullaly, 2014). These models could be valuable if applied properly as analysis and positioning tools (Brookes et al., 2014). The assessment approach of maturity models is done continuously and provides persistent evaluations and outcomes by offering some standards to be compared with other organizations (Brookes et al., 2014; Mullaly, 2014).

Another essential comparative analysis between the maturity models is comparing the levels of maturity in the existing models (de Souza & Gomes, 2015). Maturity levels assign to a set of processes that organizations must execute as part of a defined improvement path (Becker et al., 2010). Since organizations advance in maturity level regarding a specific dimension of their activity, they will be operating more efficiently (Antunes et al., 2014; Becker et al., 2010). There are three to six levels for each maturity model, but most of them have five or six levels named differently based on their progression level with the common goal of continuous improvement (Katuu, 2016). Also, the level of maturity in project-based companies is broadly applied as an evaluation of project management excellence (Besner & Hobbs, 2013). Maturity is connected with a typical understanding of organization-wide and the application of project management processes (such as risk management processes); a fully mature organization concentrates on continuous improvement of these processes to improve project management effectiveness (Besner & Hobbs, 2013; Pasian, 2014).

Maturity models have been used to identify best practices and compare methods of working and the quality of outputs or outcomes (Pasian, 2014). One of the benefits that organizations have obtained from using particular maturity models is continually improving the performance of all projects undertaken by an organization (Khoshgoftar & Osman, 2009). Therefore, many models have been revealed they emerged in the project management area (Mullaly, 2006; Pasian, 2014).

According to the broad literature of the survey, Torres (2014), cited in Görög's (2016) study, also refers to three main roles of maturity models, including evaluating the present situation of maturity, developing guidelines to achieve a higher level of maturity, and comparing with other companies. Besides Torres (2014), some other writers also point out that understanding maturity is the only common characteristic of the current models (Görög, 2016).

Meanwhile, maturity is slowly applied beyond the software engineering domain and is widely employed in other industries (Petrochemical, Defense, Pharmaceutical R&D, Construction, Telecommunications, Financial Services) and particular domains (Cooke-Davies & Arzymanow, 2003; Jia et al., 2011). Generally, maturity models are being applied not only in project management but also in many domains, like software development, quality management, product development, people capability maturity model, business development maturity model, and risk management (Farrokh & Mansur, 2013; D. A. Hillson, 1997).

Mature organizations can have several benefits, including effectively managing all the organization projects taken on by the firm, being able to consistently enhance the performance of all the projects taken up by them, the creation of an organization high ability for managing projects based upon standard, specified project management processes that can be shaped to meet the particular needs of individual projects, and enabling the organization to improve its strategic objectives by the use of project management principles and practices (Farrokh & Mansur, 2013; Khosravi, Afshari, Ghorbanali, Borzabadi, & Valipour, 2011; Peterson, 2000; Project Management Institute, 2013).

Overall, since organizations allocate a large amount of budget on the assessment and improvement of their project management processes, it is essential to know about the appropriate framework in advance, which not only leads to the higher improvement of their processes but also causes to be financially feasible (Farrokh & Mansur, 2013). This assessment and improvement is made based on some conceptual frameworks, which are named Maturity

Models (Brookes et al., 2014; Farrokh & Mansur, 2013; Görög, 2016; Katuu, 2016; Pasian, 2014).

2.4.2 Maturity models background and history

Crosby and Free (1979), cited in Mullaly's (2014) research, introduced the first conceptual model for maturity models, including five levels by which the quality of organizational processes was assessed. According to the globally known five-level framework introduced and developed by Crosby and Free (1979), the maturity model which was used for the Capability Maturity Model in software (CMM) was established by Carnegie Mellon University (Brookes et al., 2014; D. A. Hillson, 1997; Mullaly, 2014). Also, Davenport (2005) vividly elaborated CMM specifically as a process standard and its impact on the five levels of performance related to process maturity. To be more precise, it is not feasible to go to the next level unless the whole areas are executed on the level below (process levels applied like a ladder, see Figure 2.2) (Brookes et al., 2014).

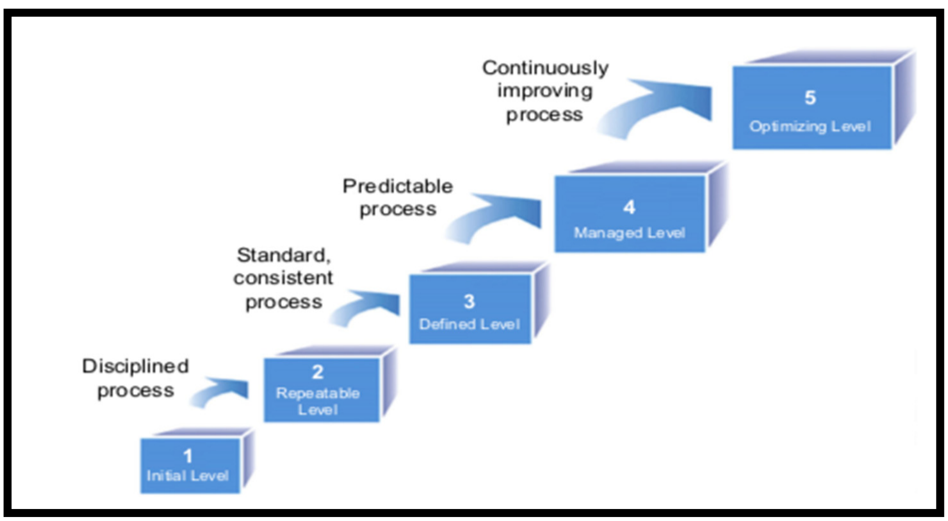

Figure 2.2 CMM five levels of maturity
Taken from Brookes et al. (2014)

The features of each level are evidently described to assist organizations in evaluating themselves based on a scale conquered (D. A. Hillson, 1997). After the CMM level is established, an organization objectives of improvement should be apparently specified in order to proceed to the next level of capability and maturity (D. A. Hillson, 1997; Yeo & Ren, 2009). Although the CMM is greatly developed, there are some restrictions in applying it in some organizations using software development processes (D. A. Hillson, 1997). There have been many efforts to expand the CMM to be applicable for other kinds of projects; it has not been accomplished yet, though (D. A. Hillson, 1997; Pasian, 2014; Spalek, 2015). Moreover, some other maturity models exist based on the ladder notion, such as Management Process Maturity Model, Organizational Project Management Maturity Model (OPM3), and Portfolio, Program, Project Management Maturity Model (P3M3) (Cooke-Davies & Arzymanow, 2003; Görög, 2016; Khoshgoftar & Osman, 2009).

According to a recent study, widely used IT models (e.g. SPICE, PRINCE, PMMM, Kerzner's Project Management Maturity Model) have originated from the CMM model (Spalek, 2015). While a large number of models are process-oriented (e.g. CMMI, Hammer's PEMM, Process Maturity Model), others define as organizational maturity (e.g. OPM3, OGC-P3M3, ProMMM) or project maturity (e.g. PMS-PMMM, OGC-P2MM, MPCM) (Farrokh & Mansur, 2013; Guangshe, Li, Jianguo, Shuisen, & Jin, 2008; Spalek, 2015).

Further, there is another typical useful model for benchmarking organizational performance named Business Excellence Model, which was proposed by European Foundation for Quality Management (EFQM), and followed by nine criteria for business excellence (Leadership, People Management, Policy and Strategy, Resources, Processes, People Satisfaction, Customer Satisfaction, Impact on Society, and Business Results) (D. A. Hillson, 1997). The CMM and the EFQM Model are general models of capability, maturity and business excellence (D. A. Hillson, 1997; Pasian, 2014). Neither model is helpful for an organization in implementing formal risk management processes, or wishing to enhance its current approach, although it has been reported that some primary work has been done to enhance the CMM to use to risk (D. A. Hillson, 1997; Spalek, 2015). Ultimately, the maturity model as a tool of assessment was created initially to evaluate the quality (as in the quality management maturity grid) or maturity (since the launch of the CMM along with reconsidering the meaning of maturity) (Pasian, 2014). A wide range of systems and subject domains such as strategic management, business process management, leadership, and project management, have applied maturity as a framework for assessing improvement (de Vries & Margaret, 2003; Hogan, 2008; Mullaly, 2014; Van Looy, De Backer, & Poels, 2011).

One of the significant areas to apply maturity models is project management (Nenni et al., 2014) that is clearly assessed in an organization against the perfection of the multi-processes or the association with knowledge areas in detail and assesses maturity challenging to be practically done (Spalek, 2015). Several PM maturity models have been introduced to improve organizations PM effectiveness (Kwak & Ibbs, 2002). According to the project management, PMI and the U.K. Office of Government Commerce have proposed main maturity models, including OPM3 and PMMM, respectively (Albrecht & Spang, 2014; Cooke-Davies & FAPM, 2004; Johansson, Hicks, Larsson, & Bertoni, 2011).

Overall, an organization can select and employ a maturity model that best suits its objectives and specific cases (Team, 2010).

2.5 Maturity and Megaprojects

As projects play a significant role in the success of any organization (Mullaly, 2006; Nenni et al., 2014; Pasian, 2014), project management as an improvement tool and a key strategy for projects success in today highly competitive market has been enthusiastically welcomed by a number of organizations, researchers and practitioners (Dietrich & Lehtonen, 2005; Nenni et al., 2014; Srivannaboon & Milosevic, 2006).

According to the studies and information, apparently, there are still so many obstacles in the path of effective implementation of the project processes, and it is essential to improve project management so as to be successful in this competitive environment (Dietrich & Lehtonen, 2005; Nenni et al., 2014). An effective approach for organizations in this regard is to expand their attention from studying a single project to studying how the organization is applying projects to attain its objectives (Nenni et al., 2014). Thus, it is essential for them to have the necessary infrastructure, including processes (methods and techniques), administrative structures, capabilities of people, and tools (Milosevic & Patanakul, 2005). This is usually when the value of a maturity assessment comes into play (Khoshgoftar & Osman, 2009; Milosevic & Patanakul, 2005; Nenni et al., 2014).

Maturity models have gained a lot of attention in the project management community, and almost every larger project management organization has published some kind of a maturity model (Khoshgoftar & Osman, 2009). On the other side, based on the number of studies, although maturity models in project management could be an answer or support to connect projects with strategy and organization, there is too little empirical evidence to link project maturity with project objectives and its implementation (Jugdev & Thomas, 2002; Nenni et al., 2014).

The primary aim for maturity models in projects is to use them periodically for maturity assessment, implementation of improvement activities, re-assessment, and analysis of the results, which increase the level of maturity, quality, customer satisfaction, and mitigation of project risk in the organization (Albrecht & Spang, 2016; Project Management Institute, 2013). Based on the literature, maturity models assist project management by:

1. expanding the discussion in the field,

2. identifying that maturity is a result of step-by-step improvements in project implementation,

3. generating core values from quality movements into project management,

4. raise the awareness of the projects capabilities (Johansson et al., 2011; Jugdev & Thomas, 2002).

As the design of PM maturity models and their degree of data availability are different, the outcomes can be compared restrictedly (Albrecht & Spang, 2014). The potential advantages of a high maturity level in project management are taken into account in the recent studies, and the research about the advantages of project management maturity is carried out continuously (Albrecht & Spang, 2014, 2016; Brookes et al., 2014).

2.6 Risk Management and Megaprojects

Project managers regard to control of risk as the most significant goal (Kardes et al., 2013; Sanchez-Cazorla et al., 2016). Two phenomena of uncertainty and risk are included in megaprojects (Kardes et al., 2013). The discussion below amplifies the phenomenon of managing megaproject risks.

Both complex projects and risk issues can greatly affect different sections of an organization (Geraldi & Adlbrecht, 2007; H. Thamhain, 2013; J. Thomas & Mengel, 2008).

Complexity can be easily identified in the literature of academic projects; however, the concept of project risk and managing risks in complex projects are not extracted and focused on yet (Sanchez-Cazorla et al., 2016; Williams, 2017).

There are a number of researchers conducting broader categorization of project complexity, including structural complexity, novelty or innovation, pace, and technology, which all aim at developing some metric to categorize the degree of project difficulty and establishing some beneficial guidelines for analyzing risks in the context of project complexity (H. Thamhain, 2013). Also, in largely complex projects, some other aspects such as processes, technologies, and stakeholders can cause the level of uncertainty and risk in different sections of an enterprise and its partners (Sanchez-Cazorla et al., 2016; H. Thamhain, 2013; H. J. Thamhain, 2004).

Complex projects can have either positive or negative effects, which lead several risks required to be considered during the life cycle of megaprojects, along with the uncertainty as an indigenous part of megaprojects (Sanchez-Cazorla et al., 2016). Moreover, the risk is a substantial element having a cause and probable merits and demerits, which can have a significant impact on the amount of the budget, implementation time, financial variables and the demand during the whole processes of the project (Sanchez-Cazorla et al., 2016; Zhang, 2011).

According to the literature review, many projects are stopped to be implemented due to some factors, including project complexity increasing over time; as well as uncertainty and risk, which are effective specifically in complex projects based on risk management standards

(Atkinson, Crawford, & Ward, 2006; Sanchez-Cazorla et al., 2016; Zhang, 2011). Thus, having identified the complexity within project risk, some attempt to simply evaluate the complexity through questionnaires (Williams, 2017). A similar comprehensive scoring model is provided by the Treasury Board of Canada (2013), but, again, in this model, systematicity is not taken into account. In fact, to overcome the risk factors that make the megaprojects life cycle fail or be postponed, some special management actions need to be taken by implementing models with mitigation measures (Flyvbjerg, 2014; Sanchez-Cazorla et al., 2016; Zhang, 2011). At the minimum, understanding three interrelated sets of variables are important for selecting a suitable method of risk management, which also influence the cost and overall ability to deal with risk, including the level of uncertainty, risk effect on project-based companies, and project complication (H. Thamhain, 2013). To achieve an effective RM in megaprojects, due to the large number of risks, the risks should be recognized even at the beginning before the project work plan is drafted (Sanchez-Cazorla et al., 2016).

The effective study of risk management in megaprojects is especially important, allowing project managers to anticipate risks and delays whilst revising the project planning (Grant et al., 2006; Lehtiranta, 2014). Risk management has a significant impact on megaproject by managing probable high uncertainty in the project (Sanchez-Cazorla et al., 2016).

Since megaprojects as a research area are getting popular thus, it is justifiable to study risk management in megaprojects, due to a host of reasons, including their specific features, the significant effect of risk management in the management of megaprojects, the need to consider all sorts of risks to achieve a comprehensive point of view; the megaprojects growth in number and value, and the significant dissimilarity identified in recent studies on megaprojects, which avoids creating a specific framework and it is totally different from smaller-scale projects (Dimitriou et al., 2013; Esty, 2004; Flyvbjerg, 2014; Kwak, 2003; Lehtiranta, 2014). The bigger the size and the more complex a project is, the more efforts for risk management need to be made (Kwak, 2003).

Risk management is considered a substantial element in megaproject success because risks are far more complex and have a big effect on megaprojects (Sanchez-Cazorla et al., 2016). While there are a large number of literature on risk management in common projects (Marcelino-

Sádaba et al., 2014), there is very few literature focusing on risk management in megaprojects (Sanchez-Cazorla et al., 2016). Thus, it is essential to study large-scale projects, which aid managers in establishing clear infrastructures and allocating a specific budget for megaprojects to deal with the shortcomings in the capital market (Esty, 2004; Sanchez-Cazorla et al., 2016).

Moreover, there is a lack of academic research studying megaprojects due to their difficulty and complexity, which make the number of researches done on megaprojects limited (Sanchez-Cazorla et al., 2016) because it is too difficult to have data collection and access it (Esty, 2004; Lehtiranta, 2014; Sanchez-Cazorla et al., 2016).

2.7 Risk Management and Maturity

There are an increasing number of enterprises getting cognizant of the significant role that risk management plays in the success of **not only projects but also organizations** (D. A. Hillson, 1997). In order to deal with the risks and uncertainties that organizations encounter, it is required to establish an effective framework to recognize and evaluate risk management processes (Heravi & Gholami, 2018; D. A. Hillson, 1997). In this regard, Choudhry and Iqbal (2013), cited in Heravi and Gholami's (2018) study, concluded that there are two main impediments to effective risk management, which are the lack of a formal risk management system and the lack of a mechanism for common risk management by the parties. The standards of best practices entail maturity, which usually indicates high complexity levels and other characteristics (D. A. Hillson, 1997; Yeo & Ren, 2009). Moreover, it is quite helpful for the enterprise to view its risks as a portfolio because it enhances both the senior management's and the board's ability to manage the enterprise risk properly (Farrell & Gallagher, 2015).

As risk management is quite significant in project management maturity models (PMMMs) (Albrecht & Spang, 2016), Albrecht and Spang (2016), in their study, made a great consideration on selected PMMMs that were subjected to qualitative content analysis in order to arrive at a generic understanding of maturity. Then they summarized the results of the qualitative content analysis in listing the clusters of project management maturity based on their frequency of mentioning in the PMMMs. Moreover, the frequency of mentioning the risk management was 12 out of 15 PMM models (Albrecht & Spang, 2016). Therefore, a general risk-focused maturity model would be helpful for organizations that are willing to assess the risk management processes or enhance the current risk approach (D. A. Hillson, 1997; Jia et al., 2013).

Overall, in the companies with higher levels of maturity, as there is a connection between improvements and areas of maturity,

1. Risk management should be implemented;

2. It is necessary to comprehend better the association between risk management and projects (Brookes et al., 2014).

Besner and Hobbs (2013) pointed out in their study that more performing maturity, better-defined projects, and greater application of tools result in better use of risk management.

2.8 Risk Management Maturity models

Over the past decade, there has been an increasing interest in research about maturity models and their application to achieve process assessment in domains (Serpell, Ferrada, Rubio, & Arauzo, 2015).

The maturity models of RM aid organizations in identifying the level of their abilities to perform RM and compare those abilities with a reference framework defined by maturity best practices (D. A. Hillson, 1997; Jia et al., 2011). RM Maturity is evaluated through models, which measure the capability of the risk management process within an organization (Serpell et al., 2015). In addition, these models can effectively illustrate the organization strengths and weaknesses towards RM practice; thus, proper actions can be taken to enhance their RM performances (Jia et al., 2013). In general, the effectiveness of RM processes implementation is measured by project risk management maturity to achieve project goals (Heravi & Gholami, 2018).

There are some models suggested in terms of RM maturity, such as the one initially proposed for the projects by Hillson (1997) (Jia et al., 2011; Serpell et al., 2015). He originally introduced four levels of RM capability for the RMM model, including naive, novice, normalized, and natural, which could be discovered in projects and businesses (Heravi & Gholami, 2018; D. A. Hillson, 1997). Moreover, in each of these levels, not only the implementation of previous levels is attested, but also some aspects are specifically focused per level, such as culture, process, experience and application of risk management (Serpell et al., 2015). He highlighted that different success levels could be achieved as the rest of the implementation of RM (Heravi & Gholami, 2018). As many cannot manage to obtain the desired benefits, they get demotivated (Heravi & Gholami, 2018; D. A. Hillson, 1997; Serpell et al., 2015). According to the Risk Management Maturity (RMM) model elaborated by him in his research, he developed a vivid guideline for companies seeking the development or improvement of their RM approach (D. A. Hillson, 1997). In his model, each RMM level represents the organization state of maturity of its RM processes (Heravi & Gholami, 2018). It also enables firms to discover their real objectives for RM improvement and provide action plans for boosting their RM capability (D. A. Hillson, 1997; Serpell et al., 2015). Moreover, it described that some organizations might go beyond the boundaries between sequential RMM levels, but the association between levels should be distinctive and unambiguous in most cases (D. A. Hillson, 1997).

Hillson's (1997) model has been used as a reference for creating other maturity models suggested by different researchers (Mu et al., 2014; Serpell et al., 2015). One of these models, which is based on Hillson's (1997) model, is suggested by the International Council on Systems Engineering INCOSE (2002), proposing Risk Management Maturity Model, RMMM (Jia et al., 2011; Mu et al., 2014; Serpell et al., 2015). In this model, the original definitions of four maturity levels proposed by Hillson (1997) have been altered, the elements of risk management have been defined within each of the attributes to assess, and eventually, their features based on each of the four maturity levels suggested (Serpell et al., 2015). Further, Yeo and Ren (2004 & 2009) established a Risk Management Capability Maturity Model (RM-CMM), specifically for Complex Product Systems (CoPS) projects. The maturity model proposed includes five levels, where the features were gradually enhanced (Jia et al., 2011).

The initial three levels of maturity were formed to ensure a structured process for managing risks and risk control through proper procedures to operate them; however, the next two levels of maturity (four and five) were developed to make the process of risk management capable of dealing with possible risks (Jia et al., 2011; Serpell et al., 2015). The Risk Management Maturity Model, RM3, suggested by Zou et al. (2010), was established based on the maturity models offered by Hillson (1997), and Ren and Yeo (2004 & 2009). This model characteristics are as follows:

1. It attempts to evaluate the maturity of **industrial projects** which are managed by construction companies in five aspects, including management, risk culture, ability to identify risk, ability to analyze risk, and application of standardized RM processes;

2. All these aspects are assessed in four levels of maturity;

3. The only disadvantage of this model is that it brings only one part of the RM process into focus, and other processes like risk response and risks control are left untouched (Heravi & Gholami, 2018; Serpell et al., 2015).

Gladden (2012), in his research, studied a framework for evaluating risk management capability as a Project Risk Maturity Model (PRMM), which was revealed by Martin Hopkinson in 2011. Hopkin's model validity has been asserted by the assessment of more than 200 risk maturity during 10 years, and based upon his own experience as a risk management consultant; he has elaborated the issues encountered by assessing project risk capability and the use of the Risk Maturity Model (RMM) to the readers (Gladden, 2012; Heravi & Gholami, 2018). His practical RMM model is categorized into two parts, including a contextual introduction to the RMM and a guide to the content of the model provided in detail (followed by six attributes: stakeholders, risk identification, risk analysis, risk responses, project management, and risk management culture) (Gladden, 2012).

Overall, according to ever-increasing recent studies of **RM maturity**, in Table 2.1, as well as the above models, a summary of **RMM** models is given (Elmaallam & Kriouile, 2011; Heravi & Gholami, 2018; Hoseini, Hertogh, & Bosch-Rekveldt, 2019; Jia et al., 2013; Mu et al., 2014;

Serpell et al., 2015). Also, to evaluate the Risk Management Capability (RMC), many studies resulted by companies such as HVR Consulting, Risk and Insurance Management Inc. (RIMI), Risk Management Research Development Program Collaboration (RMRDPC), and International Association for Contract and Commercial Management (IACCM), which all successfully developed RMM models (Mu et al., 2014).

Table 2.1 Summary of key papers on RMM models

Model	Author	Description	Maturity Level
RMM	Hillson, 1997	This model (Risk Management Maturity) is the first approach to generate a framework for assessing the maturity of risk management. But it's too general in the definitions of the levels and characteristics of the attributes measured. The domains include process, experience, culture, and application. The model type is attributes-maturity level matrix.	4 levels
RMMM	Bosler, 2002	The model (Risk Management Maturity Model) type is attributes-maturity level matrix.	4 levels
RMMM	INCOSE, 2002 & Shoults, 2003	It partially completes Hillson's model, but it is still very general. It does not propose an instrument for evaluation. The domains include risk management process activities.	5 levels.
BRMMM/ BRM3	IACCM, 2003	The model (Business Risk Management Maturity Model) type is questionnaire and attributes-maturity level matrix	4 levels
PMI's RMMM	Loosemore et al., 2006	The model type is attributes-maturity level matrix	4 levels
RMCMM	Macgillivray et al., 2007	The model (Risk Management Capability Maturity Model) type is attributes-maturity level matrix	5 levels
A model based on the RMMM	Heijden, 2006 & Wolbers, 2009	It complements the INCOSE model and adds the attribute "Structure" as the fifth attribute to be evaluated in the model. Wolbers proposes a measuring tool based on a questionnaire. However, the instrument is not well calibrated and does not accurately reflect the organization situation.	
RMCMM	Yeo & Ren, 2004 & 2009	This model proposes to evaluate (questionnaire) attributes both at the organizational level and the risk management process. It addresses the concepts of security and robustness that a maturity model should have. But, no procedure is presented for the evaluation of the risk management maturity. Its attributes include culture, RSKM process, experience, and application.	5 levels
CRMMM	Ongel, 2009	The model (Construction Risk Management Maturity Model) type is questionnaire.	4 levels
Model for Risk Management in the Public Services	ALARM, 2009	The model (The Alarm National Performance Model for Risk Management in the Public Services) type is questionnaire and attributes-maturity level matrix	5 levels
RM3 /RMMM	Zou, Chen & Chan, 2010	It is based on attributes for construction companies. It focuses on evaluating (questionnaire) attributes like Management and leadership capabilities about risks, Organizational RM culture, Ability to identify risks, Ability to analyze risks, Development and application of standardized RM process. But, its focus is only on one part of the risk management process and neglects important steps such as the risk response and control.	4 levels
Risk IT	ISACA , 2010	It corresponds to the IT discipline. RISK IT defines three risk domains: risk governance, risk evaluation and risk response. Each domain has a maturity model high level and a detailed maturity model. Its attitudes include raising sensitization and communication, responsibilities and imputability, defining the objectives and the associated measures, politics, standards and procedures, skills and expertise, and tools and automation.	5 levels
PRMM	Hopkinson, 2011	The model (Project Risk Maturity Model) type is questionnaire.	4 levels
RMM	Cienfuegos Spikin, 2013	The model type is questionnaire.	5 levels
RMM for ERM	RIMS, 2015	The model (RMM for Enterprise Risk Management) type is questionnaire.	5 levels
OGC	Office of Government Commerce, 2007	Its attitudes include organizational context, organizational objectives, stakeholder involvement, support structure, supportive culture, rules and responsibilities, early warning indicators, MoR approach, overcoming barriers to MoR, reporting, review cycle, and continual improvement.	5 levels
MMGRSeg	Janice Mayer & Leonardo Lemes Fagundes, 2009	This model (Risk Management Maturity Model In Information Security) was created to evaluate the level of risk management process maturity in information security. It is based on 1) three stages: maturity, immaturity and excellence, 2) 43 objectives of control, 3) a map of control, 4) a tool for assessing the maturity level of the risk management process activities, 5) RACI matrix relative to each risk management process activity, and 6) a dashboard of the risks.	5 levels

According to all these proposals of maturity models, it can be claimed that the implication of a maturity model in an organization can primarily make a good risk-management function within an established culture, an appropriate system and the practice of RM in not only the organization but also for continuous improvement in projects risk management (Serpell et al., 2015). Further, as risks are evaluated by the ways they may affect the attainment of project goals, it is confirmed that there is a sensible close connection between risk management capability maturity and project success (Heravi & Gholami, 2018). It is claimed that organizations inclined to employ a formal approach to risk management should value the essence of risk and the capability maturity, which is required during ongoing learning and improvement (Heravi & Gholami, 2018; Serpell et al., 2015).

2.9 Risk Management Maturity and Megaprojects

During the last decade, risk management has been considered one of the main fields of study in project management, and improper risk management makes a project fail that needs longer time and more budget to be conducted (Gladden, 2012). Moreover, due to lack of maturity in organizations about risk management, the effectiveness of risk mitigation processes cannot be evaluated properly, and eventually, in terms of maturity, it is required to establish a framework for assessing RM processes while comparing its standards against an identified standard (Gladden, 2012; Heravi & Gholami, 2018; Williams, 2017).

Since the complicated tasks correlated with risks are the features of complex projects, there is a rational association between RM maturity and projects success, because RM is measured by its possible impact on project objectives attainment (D. A. Hillson, 1997). Yet, the operation of RM brings about different levels of success, and many people may get demotivated due to being unable to obtain the benefits they are seeking (D. A. Hillson, 1997; Yeo & Ren, 2009).

Despite the fact that risk management has high impact on the success of megaprojects, it remains as one of the least developed research issues (Zwietering, 2015).

Organizations that are willing to operate a formal structured approach to control RM processes are required to consider the implementation itself as a project in which apparent goal setting, success criteria, appropriate planning and resourcing as well as effective monitoring and control should be taken into account (D. A. Hillson, 1997; Yeo & Ren, 2009). It is essential to have a straightforward view of the organization present approach to risk and a description of its objectives (Heravi & Gholami, 2018; D. A. Hillson, 1997; Jia et al., 2013; Yeo & Ren, 2009). The organization must be able to evaluate its current maturity and capability of managing risk based on a set of standards and a framework -which is generally confirmed so that present levels can be impartially assessed and the improvement of maturity can be described as well- and, as a result, the objectives, process as well as progress can be specified, defined and managed (D. A. Hillson, 1997).

According to the previous section of the current chapter (2.8 Risk Management Maturity models), in terms of assessing Risk Management Capability (RMC), there are some studies have been carried out, and in all of them, RM maturity models have been successfully developed (Mu et al., 2014).

After assessing the risk maturity, action plans should be established before starting the next level because, during the appraisal, the organization may confront some drawbacks at each RMM level, which must be managed (along with taking new strategies) to progress successfully to the next level of maturity (Heravi & Gholami, 2018; D. A. Hillson, 1997). Overall, organizations in risk management assessment are regularly faced with several potential scenarios, which in practice, some of these are ignored because they are not identified and valid enough or because of judged low probability (Aven, 2016b).

Studies conducted by researchers such as D. A. Hillson (1997), Yeo and Ren (2009), Zou et al. (2010), and Mu et al. (2014) have illustrated the significant role that the implementation of the formalized Risk Management Maturity approach plays in the evaluation of RM processes, risk culture, and related resources in organizations and projects. Nowadays, on the one side, organizations have realized that inadequate RM can cause a project to fail due to some reasons such as project delays and high cost; on the other side, companies are unable to properly assess the effectiveness of their risk mitigation processes due to lack of a proper assessing system, like maturity approach, for risk management (Heravi & Gholami, 2018).

2.10 Conclusion

This chapter has provided a detailed description and critical overview of the theoretical background of this research project. The review conducted in this chapter has also assisted in identifying the gaps in the literature that this research project aims to bridge. Key discussions of risk management maturity are considered within three elements: maturity, risk management processes, and megaprojects.

CHAPITRE 3

METHODOLOGY

3.1 Introduction

In this chapter, the research methodology is discussed. In the following sections, the research question will be answered concluded from the plan followed, and according to the research objectives, a justified methodology and various concerns in different parts of it will be discussed.

The ‘research onion’ framework (see Figure 3.2) is used to develop and justify all aspects of this research (M. N. K. Saunders, Lewis, & Thornhill, 2019, p. 130). In this research, an inductive approach to theory formation is undertaken. Also, it comprises a number of issues, including research design based upon the specifications of the plan, methodology, strategy, time horizon, data collection, and ethical considerations (Creswell, 2013; M. N. K. Saunders et al., 2019, p. 130). Figure 3.1 presents a summary of different steps undertaken for the research design of the current study, which the author developed.

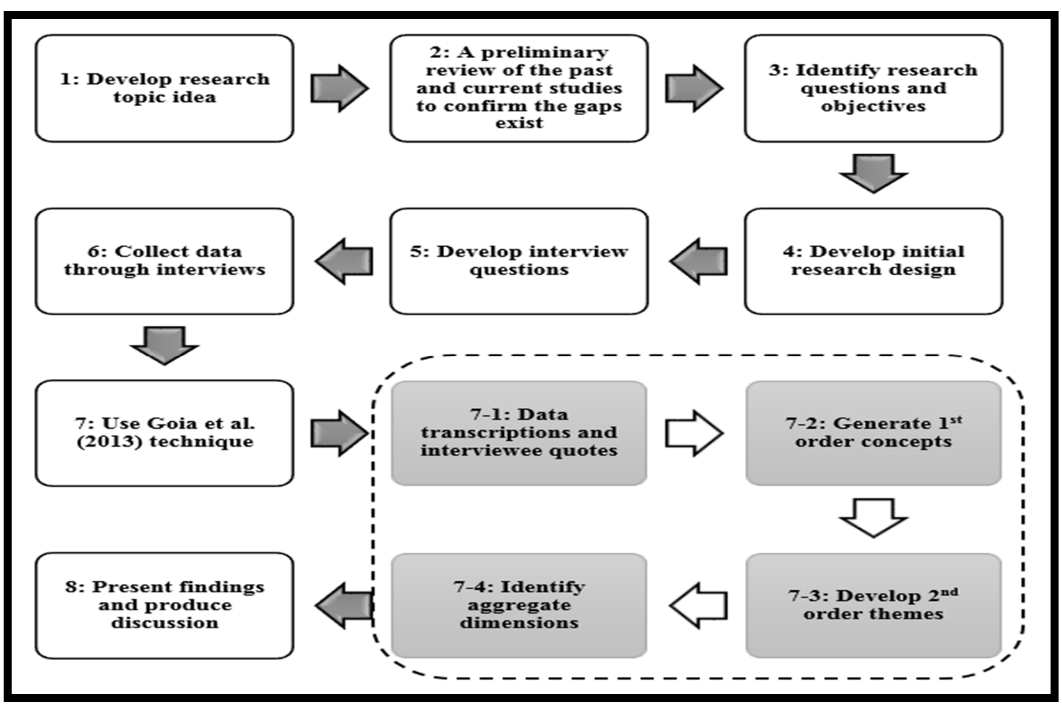

Figure 3.1 Overview of research design, developed by the author

3.2 Research design

3.2.1 Research onion as a model of designing research methodology

Research methodology can be constructed by the theoretical concept of "research onion" which is proposed by M. N. K. Saunders et al. (2019) (see Figure 3.2). In fact, it is a tool that is helpful (Leedy & Ormrod, 2015, p. 26) in developing a constructive methodology, specifically research design based on the following six main layers or stages: research philosophy, approach to theory development, methodological choice, strategy, time horizons, and techniques and procedures (Melnikovas, 2018; M. Saunders, Lewis, & Thornhill, 2009; M. N. K. Saunders et al., 2019).

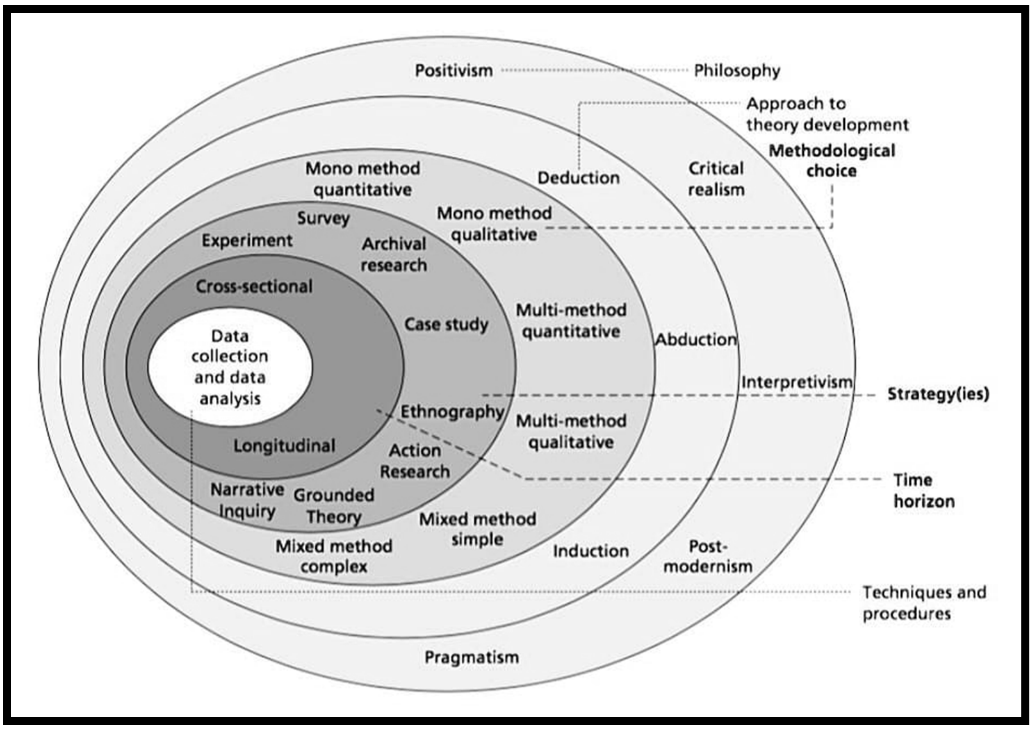

Figure 3.2 The research onion framework
Taken from M. N. K. Saunders et al. (2019, p. 130)

3.3 Research philosophy

Objectivism is regarded as social entities in the real world, which are visible to social actors; for instance, to prove that the study of specific features of organization management is an objective entity, there should be job descriptions for managers to report about their duties in a formal hierarchical order (M. Saunders et al., 2009, p. 110). This view stresses that the principles of the management structures are alike in all organizations, but there might be some differences in the objective features of the management structures (M. Saunders et al., 2009, p. 111).

Objectivism is the ontological position adopted by several business and management studies to logically explore the reasons for organizational problems and make some suggestions adapting to the present structure of the organization management (M. Saunders et al., 2009, p. 120; M. N. K. Saunders et al., 2019, p. 135). In particular, the organizations can be regarded as logical entities where reasonable solutions can be provided for real problems by exploring them rationally, and an evaluation study of a communication strategy can be considered as a practical model of a management research project to assess its effectiveness and make suggestions for higher efficacy (M. Saunders et al., 2009, p. 121).

3.4 Research approach

Current study adopts an inductive approach to qualitative research design. An inductive approach is applied to conduct a new research topic (Leedy & Ormrod, 2015, p. 37; M. Saunders et al., 2009, p. 126). In inductivism, it is suggested that the theory is constructed as a result of data collection based on a "bottom-up" approach by researchers (Creswell, 2013, p. 45). In fact, inductivism is basically regarded as the novelty of the current research problem approved by the literature review (M. Saunders et al., 2009, p. 126,128; M. N. K. Saunders et al., 2019, p. 154). In addition, inductivism makes researchers realize how the social environment is interpreted by interviewees and draw audiences' close attention to whether or not organizations implement and benefit (Leedy & Ormrod, 2015; M. Saunders et al., 2009, p. 126,128; M. N. K. Saunders et al., 2019, p. 154) from risk management maturity models. Thus, the audiences' interpretations cause theory formation rather than source credibility theory by revealing their opinions and experiences (M. N. K. Saunders et al., 2019, p. 154). In inductivism, a logical gap between the conclusion and the observed premises can be justified by the fact that observations based on supporting evidence lead to the conclusion (Ketokivi & Mantere, 2010; M. N. K. Saunders et al., 2019, p. 155). In the inductive approach, research data collection and data analysis explore the theoretical underpinning and offer an in-depth view of the research objectives (Eisenhardt & Graebner, 2007; M. Saunders et al., 2009, p. 126; M. N. K. Saunders et al., 2019, p. 155).

3.5 Research strategy

3.5.1 Grounded theory

Researchers should implement the philosophy, approach, and methods to achieve objectives by applying appropriate research strategy and data collection and data analysis procedures (M. Saunders et al., 2009). Thus, research subject, aim and objectives, current knowledge, research philosophy, resources, and time frame have an impact on research strategy (M. Saunders et al., 2009; A. B. Thomas, 2004). Yet, it is far more significant to go beyond strategy labelling and follow a proper and practical one (M. Saunders et al., 2009). There are various kinds of research strategies, including Experiment, Survey, Archival research, Case study, Ethnography, Grounded Theory, Action Research, and Narrative Inquiry (Dawson, 2002; Leedy & Ormrod, 2015; M. Saunders et al., 2009; M. N. K. Saunders et al., 2019; A. B. Thomas, 2004).

In the methodological choice of the current study, systematic procedures are implemented to inductively formulate a grounded theory strategy (M. Saunders et al., 2009). In this strategy, data collection and data analysis have to be constantly done by researchers (Bryant & Charmaz, 2007). They should apply comparison analysis within the data to establish analytical codes from the data, and record the connections and gaps between the coded categories by using memo writing (J. M. Corbin & Strauss, 1990). In fact, grounded theory has gotten popular in different areas practically instead of makeing theoretical boundaries into practice (Bryant & Charmaz, 2007; M. Saunders et al., 2009). The major distinctions between grounded theory and other strategies are:

1) do simultaneous data collection and analysis in an iterative process;

2) follow continuous comparative analysis within the study;

3) attain “**theoretical saturation**” (the point that incremental learning obtained from the data collection is insignificant; which means collecting more **empirical** data does not add significant

value to the existing data (Creswell & Poth, 2016; D. A. Gioia, Corley, & Hamilton, 2013; Suleiman & Othman, 2021));

4) create inductive concepts and categories through systematic data analysis;

5) apply memos to clarify categories and their relationships;

6) determine core categories according to similarities;

7) establish a grounded theory (Bryant & Charmaz, 2007).

3.6 Time horizon

There is a significant question proposed in planning the research: ‘Is a research like a “snapshot” taken at a specific time or should it be similar to a diary or a series of snapshots uncovering events during a period of time?’ (M. Saunders et al., 2009; M. N. K. Saunders et al., 2019). There are different replies, which rely on the research question (M. N. K. Saunders et al., 2019). Whereas the ‘snapshot’ time horizon is called cross-sectional, the ‘diary’ view is called longitudinal regardless what research strategy or method is in research design (M. Saunders et al., 2009; M. N. K. Saunders et al., 2019). For instance, the study on manufacturing processes in a company during a year is considered as a longitudinal study (M. Saunders et al., 2009). In the current research, since the problem is investigated over a period of time but not at a particular time, it is regarded as a longitudinal study (M. N. K. Saunders et al., 2019).

The change and development in the study is the main merit of longitudinal research (M. Saunders et al., 2009). The researcher can practice controlling variables in evaluating people and events during a period of time if they are not influenced by the research process itself (M. Saunders et al., 2009; M. N. K. Saunders et al., 2019). The initial question in longitudinal studies is ‘Are changes expected during a period of time?’ (M. Saunders et al., 2009).

3.7 Research methodological choice

3.7.1 Qualitative research method

Although both qualitative and quantitative methods can be used to investigate the current research problems, when the problems are hard to be measured by the quantitative approach, the most appropriate method to discover problems with variables would be the qualitative approach which assists researchers to have a deeper understanding (Creswell, 2013) of research problems and objectives. Thus, in megaprojects in the aerospace companies, the effectiveness of implementing RMM models could be identified by direct conversations with the informants and asking interviewees' opinions, experiences, attitudes, and their reasoning about the challenges of executing the risk management maturity models.

In addition, since it is hard to define qualitative research due to the lack of a unique pattern of carrying out this study, it can be simply defined as an approach without quantitative data (Creswell, 2013; Gill & Johnson, n.d., p. 148). Whereas numeric and quantitative data are applied in quantitative methods, non-quantifiable and non-statistical data of phenomena are used in qualitative methods (J. Corbin & Strauss, 2014; Leedy & Ormrod, 2015; M. Saunders et al., 2009). In addition, quantitative research is basically based upon scientific approaches; however, qualitative research is constructed by how the subject, events, and words are interpreted by the interviewees in the context of the study (Creswell, 2013; M. Saunders et al., 2009).

As a qualitative research method is fundamentally subjective, it is helpful for researchers to perform an in-depth analysis of an unknown phenomenon leading to valuable possibilities and opportunities to have a far more clear-cut perception of tangible aspects. For instance, human beings' and informants' worlds, social activities, cultural lives, inner experiences, behaviors, intentions, feelings, desires, beliefs, values as well as their attitudes within the field of study, all allow the researchers to get a descriptive picture of informants' participative activities and more holistic view of the reality (J. Corbin & Strauss, 2014; Leedy & Ormrod, 2015; M. Saunders et al., 2009).

A discussion between individuals within an interview aims at valid and reliable data collection resulting in answering research questions and fulfilling objectives or even formulating them (Kahn & Cannell, 1957). There are different kinds of categorizations for research interviews based on different purposes (Leedy & Ormrod, 2015; M. Saunders et al., 2009). There is a categorization relevant to interviews' formality and structure, including structured interviews; semi-structured interviews; and unstructured or in-depth interviews (M. Saunders et al., 2009). Further categorization is standardized interviews; non-standardized interviews (Healey & Rawlinson, 1994; M. Saunders et al., 2009). Also, there are other categorizations based on Powney and Watts (2018): respondent (participant) interviews and informant interviews.

In this study, a semi-structured interview is used.

Semi-structured interviews are included in non-standardized research interviews in which there should be the capability to **collect data in detail** (M. Saunders et al., 2009). Semi-structured interviews are often regarded as 'qualitative research interviews' (King, 2004). In each research, there are some themes and questions, which may be either added or omitted from interview to interview objectives (that cause flexibility in the interview as one of the advantages of such approach) according to the organizational context aiming at the research topic (King, 2004; M. Saunders et al., 2009). Most non-standardized interviews can be recorded face-to-face, on the phone, online or electronically in audio recording or even note-taking (M. Saunders et al., 2009).

Another point regarding the research methodological choice is **secondary data** which are the primary data interpreted by some individuals in an event not observed (Leedy & Ormrod, 2015). Three different kinds of secondary data, including documentary, survey, and multiple sources, are already collected to be purposefully processed and stored (M. Saunders et al., 2009; M. N. K. Saunders et al., 2019). Multiple-source secondary data can be either documentary or survey secondary data, or a mixture of both (Dawson, 2002; M. Saunders et al., 2009). After combining different data sets, multiple-source data sets are compiled to formulate research question(s) or objectives (M. Saunders et al., 2009). Secondary data collected from different sources on the same geographical basis is named area-based multiple-source data sets (Dawson, 2002; M. Saunders et al., 2009). In such data, quantifiable information and statistics are usually collected, produced, published, and archived by governments for their country and standard economic areas (M.

Saunders et al., 2009; M. N. K. Saunders et al., 2019). These kinds of sources that are commonly applied by Canadian researchers are collected in chapter one in the current study (M. N. K. Saunders et al., 2019).

3.7.2 Interview steps

- **Interviewees selection**

In this study, all the terms, including Key Informant (KI), informant, and interviewee, are considered as interview respondent.

The research adopts a **grounded theory** strategy which requires **independent** key informants, and a sample size of 20-30 key informants is appropriate for studies using the grounded theory approach (Bryant & Charmaz, 2007; Creswell, 2013; Creswell & Poth, 2016; M. N. K. Saunders et al., 2019).

Further, the selection of interviewees was by intensity sampling, which is a kind of purposeful sampling that selects key informants who are experts about a particular experience (Morse, 1994). Thus, to meet the research purposes, the current study collected its data by interviewing professionals involved in megaprojects in aerospace industry, which were developed within the past 10 years (2011-2021). Some of the megaprojects they were involved in are included Airbus-A220, Bombardier C-series, and Bombardier Global-7500, which were at different stages of their lifecycle from initial design to testing and commissioning.

The selected interviewees have primarily worked in managerial positions from various departments of the companies involved in megaprojects of aerospace. For instance, they should be experienced in the megaprojects in the aerospace industry 1. as a middle manager, project manager, or operational manager (current or previous position), or 2. as a project specialist (current position) with the previous managerial experience in daily decision-making. Moreover, they had a minimum five years experience in aerospace industry and megaprojects. Only one interviewee had no managerial experience but has studied in the aerospace field as a Ph.D. student who also has been working on a research project related to the aerospace industry.

Further, due to confidentiality restrictions of interviewees and respecting their privacy following the **ethical consideration** section of the current study, all interviewees' specific data has remained anonymous (also discussed in the 3.9 section).

Selecting interviewees from different megaprojects and distinct managerial positions in the aerospace companies enabled the researcher to identify different opinions between the sectors and across project types, thereby exploring the challenges of implementing RMM models more appropriately to the project management community in megaprojects in the aerospace industry.

- **Interview planning**

After identifying the relevant individuals, the interview questions (see APPENDIX III, p. 123) with the attached information sheet (see APPENDIX II, p. 121) were sent to the interviewee by email, and the researcher scheduled a virtual meeting with per interviewee officially. All the mentioned processes were conducted after receiving each interviewee's authorization. Thus, all interviews were audio-recorded, except nine interviews (the interviewees did not allow the use of the voice-recorder, so the written notes from the interview, approved by them, were used). Moreover, each interview lasted from 30 to 75 minutes and was then transcribed by the researcher.

After the first 10 interviews, the researcher started analyzing the raw data proposed by interviewees (D. A. Gioia et al., 2013) (discussed in the following data analysis section). This process continued until the researcher, as a result, has reached the point to stop the data collection process because collecting more **empirical** data did not add significant value to the existing data (Creswell & Poth, 2016; D. A. Gioia et al., 2013; Suleiman & Othman, 2021). That is one of the main reasons the researcher used the "**theoretical saturation**" term (also discussed in the 3.5.1 section) (Bryant & Charmaz, 2007; Creswell & Poth, 2016). After 16 interviews, the point of "theoretical saturation" was reached in the current study.

Moreover, the interviews were held during non-working hours, between the researcher and one interviewee (per interview) and were undertaken between February and March 2021.

- **Interview questions**

During the interviews, the key informants were first asked to give an overview of the related project/company and their role in it. Further, each semi-structured interview was scheduled in a specific duration, allowing the researcher to ask the first draft of interview questions, which addressed the research objectives. Also, to cross-check the interviewees' answers, different types of questions with the same purpose were developed by the researcher, extracted from extant source credible literature.

The interviewees possessed a broad, comprehensive knowledge of the status of RM systems in their organizations. Apart from asking about the benefits of RM approaches in aerospace companies involved in megaprojects, the interviews were followed by questions about the degree of interviewees' knowledge in implementing the maturity systems. Also, the questions were aimed to reveal the consequences and improvement actions taken to address the barriers of implementing RMM in megaprojects in aerospace companies.

The interviews answers were based on:

1. the internal perspective consisting of the employees' and managers' views as well as the departments needs for implementing RMM;

2. the perspective of a megaproject-based company;

3. an external view consisting of factors related to clients, partners, and sectoral regulations proposed by the government.

The researcher gathered the preliminary interviewees' insights into the RMM implementation challenges in megaprojects in aerospace companies.

After the first five interviews, the researcher reviewed the interview transcripts and analyzed the answers, which resulted in the second (and last) draft of the interview question. Therefore, the rest of the interviews were conducted over the new set of questions (see APPENDIX III, p. 123).

According to Table 3.1, the following interview questions as the last draft of questions have been extracted from extant source credible literature while also comparing with the research objectives.

Table 3.1 Interview questions linked to theory

Research Objectives (RO)	Interview Questions (IQ)	Relevant References
RO1	IQ1: What are the key features of risk management processes and what are the principles of effective application of risk management in your aerospace firm or projects?	(De Bakker et al., 2010; Flyvbjerg, 2006, 2014; Irimia-Diéguez et al., 2014; Kardes et al., 2013; Khameneh et al., 2016; Olechowski et al., 2016; Pollack et al., 2018; Sanchez-Cazorla et al., 2016; Söderlund et al., 2017; Williams, 2017; Yeo & Ren, 2009; Zwikael & Ahn, 2011)
RO1 and RO2	IQ2: What are the successful assessment approaches/models for risk management in your aerospace firm or projects?	(Antunes et al., 2014; Aven, 2016b; de Carvalho et al., 2015; Farrokh & Mansur, 2013; Flyvbjerg, 2006; Gladden, 2012; Görög, 2016; Jia et al., 2013; Kardes et al., 2013; Khameneh et al., 2016; Khoshgoftar & Osman, 2009; Mu et al., 2014; Park et al., 2016; Sanchez-Cazorla et al., 2016; H. Thamhain, 2013; Williams, 2017; R. Yim et al., 2015; Zwietering, 2015; Zwikael & Ahn, 2011)
RO1	IQ3: Does your firm apply an assessment approach/model for risk management based on any particular guideline (what is the guideline and why so)?	(Albrecht & Spang, 2014; Besner & Hobbs, 2013; De Bakker et al., 2010; Heravi & Gholami, 2018; Jia et al., 2013; Kardes et al., 2013; Khameneh et al., 2016; Khoshgoftar & Osman, 2009; Mu et al., 2014; Mullaly, 2014; Olechowski et al., 2016; Sanchez-Cazorla et al., 2016; Spalek, 2015; H. Thamhain, 2013; Williams, 2017)
RO1	IQ4: How often does your firm implement an assessment approach/model use for risk management? Do you implement the assessment model in all areas of your aerospace firm or projects?	(Albrecht & Spang, 2016; Andersen & Jessen, 2003; Antunes et al., 2014; Besner & Hobbs, 2013; de Carvalho et al., 2015; Jia et al., 2013; Johansson et al., 2011; Kardes et al., 2013; Katuu, 2016; Khoshgoftar & Osman, 2009; Rodriguez-Segura et al., 2016; Spalek, 2015; R. Yim et al., 2015)
RO2	IQ5: Do you think your firm can benefit from maturity assessment models for risk management processes, which assess all areas of your aerospace firm or projects (Why so)?	(Albrecht & Spang, 2016; Andersen & Jessen, 2003; Antunes et al., 2014; Besner & Hobbs, 2013; Brookes et al., 2014; Cooke-Davies & Arzymanow, 2003; de Carvalho et al., 2015; Elmaallam & Kriouile, 2011; Farrell & Gallagher, 2015; Farrokh & Mansur, 2013; Flyvbjerg, 2014; Gladden, 2012; Görög, 2016; Heravi & Gholami, 2018; D. A. Hillson, 1997; Jia et al., 2013; Johansson et al., 2011; Kardes et al., 2013; Katuu, 2016; Khoshgoftar & Osman, 2009; Mu et al., 2014; Mullaly, 2014; Nenni et al., 2014; Park et al., 2016; Pasian, 2014; Rodriguez-Segura et al., 2016; Salawu & Abdullah, 2015; Serpell et al., 2015)
RO2	IQ6: What are the key challenges of implementing maturity assessment model for risk management in your aerospace firm or projects?	(Andersen & Jessen, 2003; Farrell & Gallagher, 2015; Flyvbjerg, 2014; Heravi & Gholami, 2018; Jia et al., 2013; Kardes et al., 2013; Park et al., 2016; Söderlund et al., 2017; Yeo & Ren, 2009)
RO2	IQ7: What are the benefits of maturity assessment model for risk management in your aerospace firm or projects? If you have not used this model before, what are the benefits to aerospace firms or projects overall?	(Albrecht & Spang, 2016; Antunes et al., 2014; Besner & Hobbs, 2013; Brookes et al., 2014; Cooke-Davies & Arzymanow, 2003; de Carvalho et al., 2015; Farrell & Gallagher, 2015; Gladden, 2012; Görög, 2016; D. A. Hillson, 1997; Jia et al., 2013; Johansson et al., 2011; Katuu, 2016; Mu et al., 2014; Mullaly, 2014; Nenni et al., 2014; Park et al., 2016; Pasian, 2014; Rodriguez-Segura et al., 2016; Salawu & Abdullah, 2015; Serpell et al., 2015; Spalek, 2015; Yeo & Ren, 2009)
RO1 and RO2	IQ8: Do you think the application of maturity assessment model for risk management can be improved in your aerospace firm or projects? If so, why or how?	(Albrecht & Spang, 2016; Cooke-Davies & Arzymanow, 2003; Farrokh & Mansur, 2013; Heravi & Gholami, 2018; D. A. Hillson, 1997; Jia et al., 2013; Kardes et al., 2013; Nenni et al., 2014; Rodriguez-Segura et al., 2016; Söderlund et al., 2017; Yeo & Ren, 2009)

3.7.3 Criteria for judging the validity of research design

Since a research design is supposed to represent a logical set of statements, we can also judge the validity of any given design according to specific logical tests and various tactics available to deal with those tests (Creswell, 2013; Leedy & Ormrod, 2015; Yin, 2009, 2018). In fact, most of the tactics occur through the data collection, data analysis, or compositional stages of the research (Creswell, 2013; Yin, 2009, 2018).

Four tests have been commonly used to establish the validity of most social science research and methods (Gibbert, Ruigrok, & Wicki, 2008; Yin, 2009, 2018). The four tests are indicated below:

1. Construct validity: identifying correct operational measures for the concepts being studied;

2. Internal validity: seeking to establish a causal relationship, whereby certain conditions are believed to lead to other conditions, as distinguished from spurious relationships,

3. External validity: showing whether and how research findings can be generalized;

4. Reliability: demonstrating that the operations of a study -such as its data collection procedures- can be repeated, with the same results (Creswell, 2013; Yin, 2009, 2018).

Table 3.2 lists the tests and applied tactics, as well as a cross-reference to the phase of research when the tactic was to be used (Creswell, 2013; Leedy & Ormrod, 2015; Yin, 2009, 2018).

Table 3.2 Grounded Theory tactics for Four Design Tests
Taken from (Yin, 2018)

Tests	Grounded Theory tactic	Phase of Grounded Theory research in which tactic is addressed
Construct validity	Use source of evidence	Interview and second resource were used
	Have key informants review draft grounded theory report	Results were shared in key informants
Internal validity	Do pattern matching	Gioia, Corley, & Hamilton (2013) study was followed for pattern matching
	Do explanation building	Detailed explanation and direct code were provided in chapter four
	Use logic models	Gioia et al. (2013) technique was followed
External validity	Use theory in grounded theory studies	Relevant literature for RMMM was reviewed
	Use replication logic in grounded theory	Interviews were conducted to reach the “theoretical saturation” point
Reliability	Use grounded theory protocol	M. N. K. Saunders et al. (2019) layers and Gioia et al. (2013) technique were applied
	Maintain a chain of the evidence:	Based on the Gioia et al. (2013) technique, chain was developed which followed by the research data structure, including first-order concepts, second-order themes, and aggregate dimensions.

3.8 Data analysis: techniques and procedures

This study has been conducted based upon grounded theory and semi-structured interviews as an appropriate data collection method and proper procedures for researchers who plan to explore interviewees' responses, attitudes, opinions, and understanding (Creswell, 2013; M. Saunders et al., 2009) through the barriers of implementing risk management maturity models in aerospace companies involved in megaprojects.

Although qualitative research can be potentially rich in exploratory aspects, there have been some criticisms about its lack of scholarly rigor, including:

1. How can an inductive study be filled with ''qualitative rigor'' along with creativity and potential for creating novel concepts and views as the best studies?

2. How can inductive researchers use systematic conceptual and analytical discipline to make interpretations of data and conclusions reliable, feasible, justifiable and convincible (D. A. Gioia & Pitre, 1990)?

These kinds of ever-concerning questions make qualitative researchers motivated to create novel concepts and theories for inductive research (D. A. Gioia et al., 2013; D. A. Gioia & Pitre, 1990). That is one of the main reasons the researchers have applied the Gioia et al. (2013) technique to conduct and analyze qualitative research over the past 20 years (D. A. Gioia et al., 2013). This technique is based on a systematic procedure in qualitative research to develop new concepts (Suleiman & Othman, 2021).

3.8.1 The Gioia et al. (2013) technique: key definitions

In the current study, the primary purpose of the data analysis by adopting the Gioia et al. (2013) technique is developing a guideline to answer the research question (Suleiman & Othman, 2021). In this regard, the "**data structure**" developed by Gioia et al. (2013) is the most significant part of this technique, which consists of three standard processes of data analysis (D. A. Gioia et al., 2013; Suleiman & Othman, 2021). The data structure graphically illustrates the processes of the data transformation from raw data (key informant quotes) into concepts, themes, and dimensions (Suleiman & Othman, 2021). The main terms of Gioia et al. (2013) technique are as follows:

1- First-order concept: It is a rough representation of different concepts extracted from direct quotes, which means based on raw data provided in the interviews by interviewees, same data gathered in the same group (D. Gioia, 2021; D. A. Gioia et al., 2013; Suleiman & Othman, 2021). First-order concepts are described based on the **informants' experiences** (D. A. Gioia et al., 2013; D. A. Gioia, Schultz, & Corley, 2002). During the initial wave of data analysis, the researcher codes independently to identify first-order concepts (Brown & Gioia, 2002);

2- Second-order theme: Once key concepts, as a result of developing first-orders, are put together, emerging results can rise as in the form of **themes** (D. Gioia, 2021; D. A. Gioia et al., 2013). At this stage, to represent and explain the interviewees' experiences, the focus is on the **theoretical development** of the concepts, which means based on the literature knowledge, reducing the categories developed in the first-order and developing new categories as the second-order theme (Brown & Gioia, 2002; Suleiman & Othman, 2021). Thus, at this level of abstraction, the similar or related concepts become more evident (D. A. Gioia & Pitre, 1990);

3- Aggregate Dimension (AD): Once key themes (as the result of developing second-orders) are put together, particular directions can be developed in the form of **dimensions** (D. Gioia, 2021; D. A. Gioia et al., 2013; Nag & Gioia, 2012). The generated **aggregate dimensions** enabled the researchers to develop a grounded theoretical framework that linked the various concepts which emerged from the data (Nag & Gioia, 2012).

Moreover, Gioia et al. (2013) offered the **Coding Process**, which means the process of summarizing the first-order to the second-order (D. A. Gioia et al., 2013; Suleiman & Othman, 2021). Moreover, "code" refers to any given statement as a first-order concept and a second-order theme (D. A. Gioia et al., 2013).

Gioia et al.'s (2013) technique steps are summarized below. Also, Figure 3.3 was developed by the researcher to illustrate the overview of this technique.

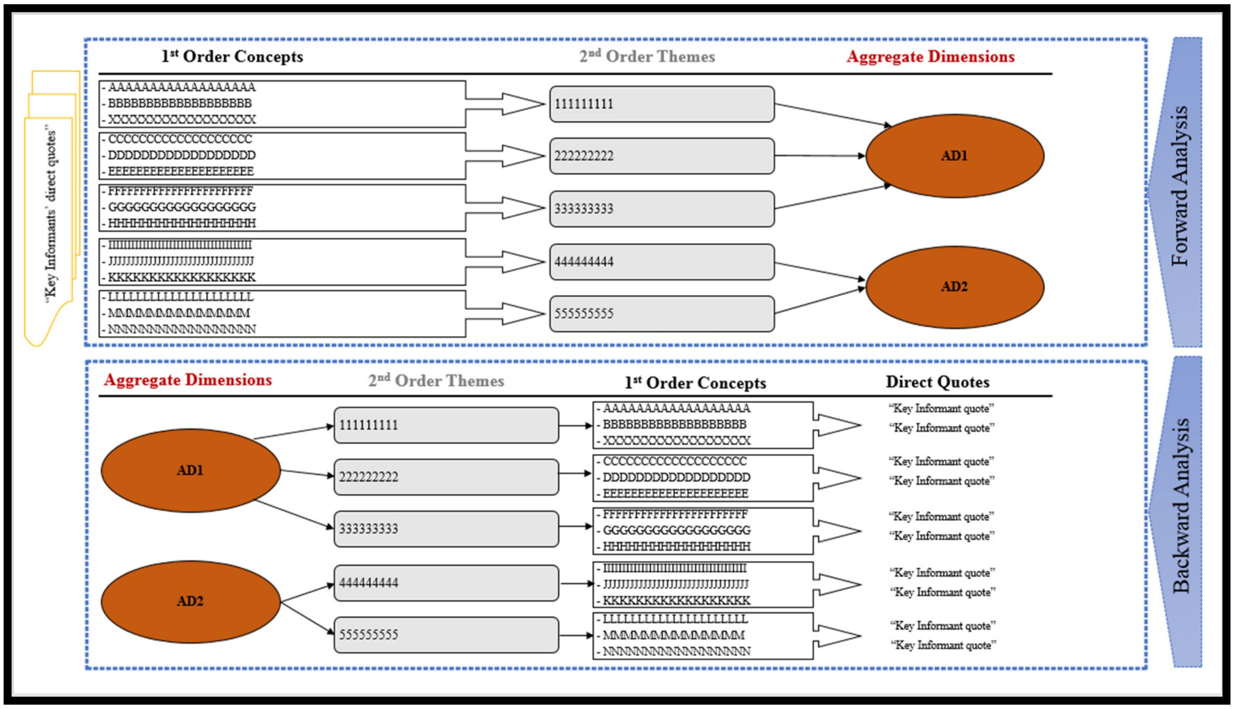

Figure 3. 3 Overview of Gioia et al. (2013) technique, developed by the author

3.8.2 The Gioia et al. (2013) technique: Forward Analysis

- **First step (developing first-order concepts):** A number of informant quotes, codes, and categories were initially uncovered in the research (J. M. Corbin & Strauss, 1990). In the first-order analysis, based on **informant quotes**, the initial 10 interviews generated a draft of 50 to 100 first-order **concepts** (D. A. Gioia et al., 2013).

- **Second step (developing second-order themes):** Initially, the researcher cut down the number of categories based on similarities and differences (J. M. Corbin & Strauss, 1990; D. A. Gioia et al., 2013). The researcher provided categories labels or phrasal descriptors (preferably retaining informant quotes) and arranged them (D. A. Gioia et al., 2013; Suleiman & Othman, 2021). At this phase, the researcher acted as a knowledgeable agent who simultaneously considered multiple levels based on **the literature and theoretical knowledge** (J. M. Corbin & Strauss, 1990; D. A. Gioia et al., 2013). In this regard, **nascent concepts** should be taken into account to ensure there are enough theoretical referents in the literature (Corley & Gioia, 2004; D. A. Gioia et al., 2013). By incorporating interviewees' and researchers' voices into the structure, the connection between the raw data and the novel concepts was presented. Therefore, both qualitative rigor and an insightful account of the findings were ensured (D. A. Gioia et al., 2013) and second-order **themes** were developed.

- **Third step (developing aggregate dimensions):** The final step of creating the **data structure** was developing aggregate dimensions by narrowing down the **themes** (D. A. Gioia et al., 2013).

3.8.3 The Gioia et al. (2013) technique: Backward Analysis

To finalize the **data structure** analyses, researchers invariably must deal with the issue of what if two different researchers concluded to two different sets of first-orders, second-orders, and ADs (D. A. Gioia et al., 2013). In doing so, and to ensure the validity and reliability of results, the researcher of the current study also engaged in a backward process (reverse analysis) (D. Gioia, 2021; D. A. Gioia et al., 2013). That means going backward from aggregate dimensions to second-order themes, then first-order concepts, and direct quotes (see APPENDIX V, Table-A V-1).

Backward step based on the Gioia et al. (2013) technique could be done by the **authors**, while in this study, there was just one author. Thus, to make this backward process as a cross-check of the initiate codes of the data structure, the researcher asked five interviewees (**minimum** 20% of the total number of interviews is approved by Yin (2018), which means 20% of 16 interviews) with a wealth of experiences in the megaprojects in the aerospace industry. Then 15% of the codes were randomly selected (Yin, 2009, 2018), including first-order concepts and second-order themes, and tried to identify each pattern again. Also, when there were low agreements about some codes, the mentioned members revisited the data, engaged in mutual discussions, and developed understandings for arriving at consensual interpretations. That meant they reconciled differing interpretations by developing consensual decision rules about how various terms or phrases should be coded (D. A. Gioia et al., 2013). Eventually, they developed the same quotes through the same ideas. Because first: they had the related knowledge and experience and the same understanding of the field of study; second: the interview questions that they all answered were collected from the same body of literature.

After different levels of iteration in the forward and backward analysis, a total of 46 first-order concepts, 18 second-order themes, and seven aggregate dimensions were developed as the results of the above steps, which all are described in the next chapter and presented through the graphic view in Figure 4.1 (data structure) and Table-A V-1 (see APPENDIX V, Table-A V-1).

3.9 Ethical consideration

Ethical considerations are required **before** and **during** data collection, amid analysis and when reporting findings (Creswell, 2013; Leedy & Ormrod, 2015). **Before** engaging with potential interviewees, the Research Ethics Committee of ETS University (le Comité d'éthique de la recherche de l'ÉTS) verified the **data collection plan** (see APPENDIX IV, Figure-A IV-1). After approval of the Research Ethics Committee, an information sheet (followed the Ethics Committee rules) elaborating participation potential risks and processes were given to anonymous and voluntary interviewees to get informed consent (for the consent form, see APPENDIX II, p. 121). Thus, the interviewees were allowed to withdraw at any time. After the interviews, both the collected data and the consent forms were safely stored. Since saving time was quite significant to make the interviewees more willing to participate in the research, the agreement was done by either audio call, video call, or email. The interview processes could be done depending on where and how interviewees would be more comfortable with the interviews (at non-working hours) at ETS University or anywhere else like a public or common area.

The interviews were recorded (based on interviewees' approval); the results were typed and saved on a password-protected university computer file. The provided data are accessible to the researcher and the supervisor of current project research and will be unavailable after the defence. All the interview documents have been stored separately, and the report included the interviewees' names and identification numbers to protect their identities. The researcher has been committed to remain honest and unbiased throughout the data analysis and reported the findings.

3.10 Conclusion

The research methodology of the current study followed the “research onion” proposed by M. N. K. Saunders et al. (2019) as a model of designing research methodology (see Figure 3.2). Compared with the research onion framework, Figure 3.4 demonstrates the full layout of the **research design** adopted for this study based on the framework in Figure 3.2.

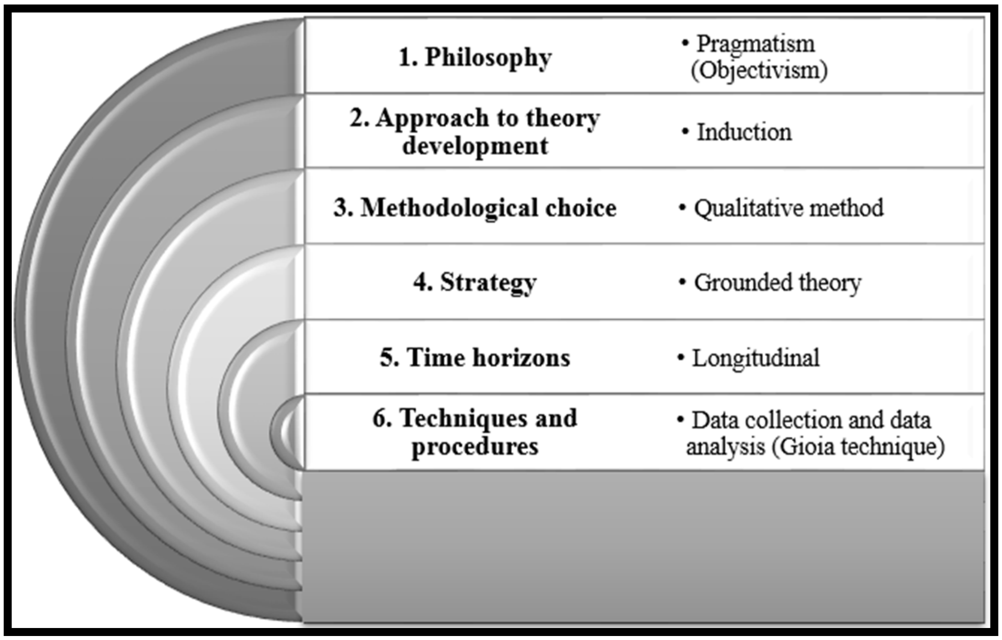

Figure 3.4 Research design layout

Following the research design layout (Figure 3.4), for the **data analysis**, the researcher applied the Gioia et al. (2013) technique, which is a widely adopted technique for coding qualitative data, particularly within business and management studies.

The technique enabled the researcher to go back and forth between **real-life data** (i.e., direct quotes) and **theoretical development** (i.e., relevant literature). It also helped the researcher to extract valuable insights from direct quotes, which were obtained from key informants. Going back and forth in such a manner enabled the research to address theoretical issues that had practical implications and develop value-adding discussions. Figure 4.1 (data structure) and Table-A V-1 (see APPENDIX V, Table-A V-1), concluded from forward and backward analysis (added in next chapter with a detailed description), clearly demonstrated the journey of extracting valuable insights from direct quotes. Through this back and ford transitions on “data structure” terms, and after 16 interviews (discussed in previous sections), the **final number** of 46 first-order concepts, 18 second-order themes, and seven aggregate dimensions were reached. These numbers resulted from conferring with five selected interviewees that were highly experienced in the megaprojects in the aerospace industry; thus, the result of data analysis is not just a lucky representation of data.

Moreover, the research results were exclusive to the megaprojects in the aerospace industry because 1) as mentioned before, key features of the megaprojects, in general, those in other sectors and those in the aerospace in particular, were described in detail in the literature chapter, 2) to have a practical view of the aerospace sector in Canada, critical features of this industry and the challenges, were also added in research context chapter, and 3) KIs were particularly those that were exclusively involved in megaprojects of the aerospace industry. Identifying key informants in such manners was a vital element in the selection criteria for the interviews. Although, a certain degree of overlap between megaprojects in the aerospace and megaprojects elsewhere was unavoidable. Despite this, the results of data analysis (chapter four) and the discussion (chapter five) highlighted the importance of implementing risk management maturity in megaprojects in aerospace companies more completely.

Finally, as a result of using this technique, the result of data collection can benefit from the latest updates of the relevant scientific literature.

CHAPITRE 4

FINDINGS

4.1 Introduction

This chapter presents the research findings. It follows the proposed course of action outlined in chapter three that described the process and purpose of the qualitative research design in detail (see Figure 3.1). It transforms the **received raw data** into more meaningful and relevant information. The researcher demonstrates that qualitative data collection and analysis can be executed with scholarly rigor. An analysis, evaluation, and interpretation of the collected data against the objectives of the study are also undertaken. They present the needs of implementing the RMM model in **megaprojects in aerospace companies**, grounded in the collected data. Therefore, the chapter consists of the findings, analysis, and interpretation of the collected data.

Based on the prior literature, the megaprojects, specifically those in the aerospace industry, to improve the efficiency of their current RM approach, are better to implement controlling and assessment systems for RM, such as RM maturity models. Thus, better controlling risk management processes help to produce safer products as one of the main megaprojects objectives. The current study determines whether such development is accompanied by **some solutions and a decrease/ removal in the barriers** that megaprojects in aerospace firms would face during the implementation of the RMM approach.

In this regard, conducting interviews with some **professionals of the megaprojects** in aerospace industry contributes to better understanding the barriers and solutions of RMM implementation. Interviewees across **different** organizational **positions** involved **in megaprojects** (**with managerial experience**) provided insights into the impact of those barriers while comparing them with some basic characteristics of maturity models proposed in the literature (e.g., impact on all the company projects, follow a comprehensive assessment approach through different scoring levels while covering all employees in different positions involved in a project).

According to the back and forth analyses of the Gioia et al. (2013) technique, a detailed assessment of interviews data analysis commences with developing a static representation of the key themes derived from the data for the next step of data analysis. In fact, the researcher was able to capture a more comprehensive view of the key challenges, and potential opportunities (that firms within megaprojects in aerospace face when applying RMM approaches) resulted in the seven key aggregate dimensions, 18 second-orders, and 46 first-orders through developing:

1. Figure 4.1, which illustrated **data structure** through the transition **from first-order concepts** (gathered from direct quotes) to second-order themes, and **Aggregate Dimensions**;

2. Table-A V-1 (see APPENDIX V, Table-A V-1), which provided an overview through the backward transition **from Aggregate Dimensions** to second-order themes, first-order concepts, and **direct quotes**. Also, the summary of Table-A V-1, as a quick review, is illustrated in Table 4.1.

Eventually, the detailed **description** of data analysis per aggregate dimensions, second and first orders is provided below in the current chapter based on the **interviewees' answers**. While a comprehensive **comparison** between **ADs** and **literature**, which shows the research **added values**, is proposed in the next chapter (discussion) and the last chapter (as theoretical and managerial implementation).

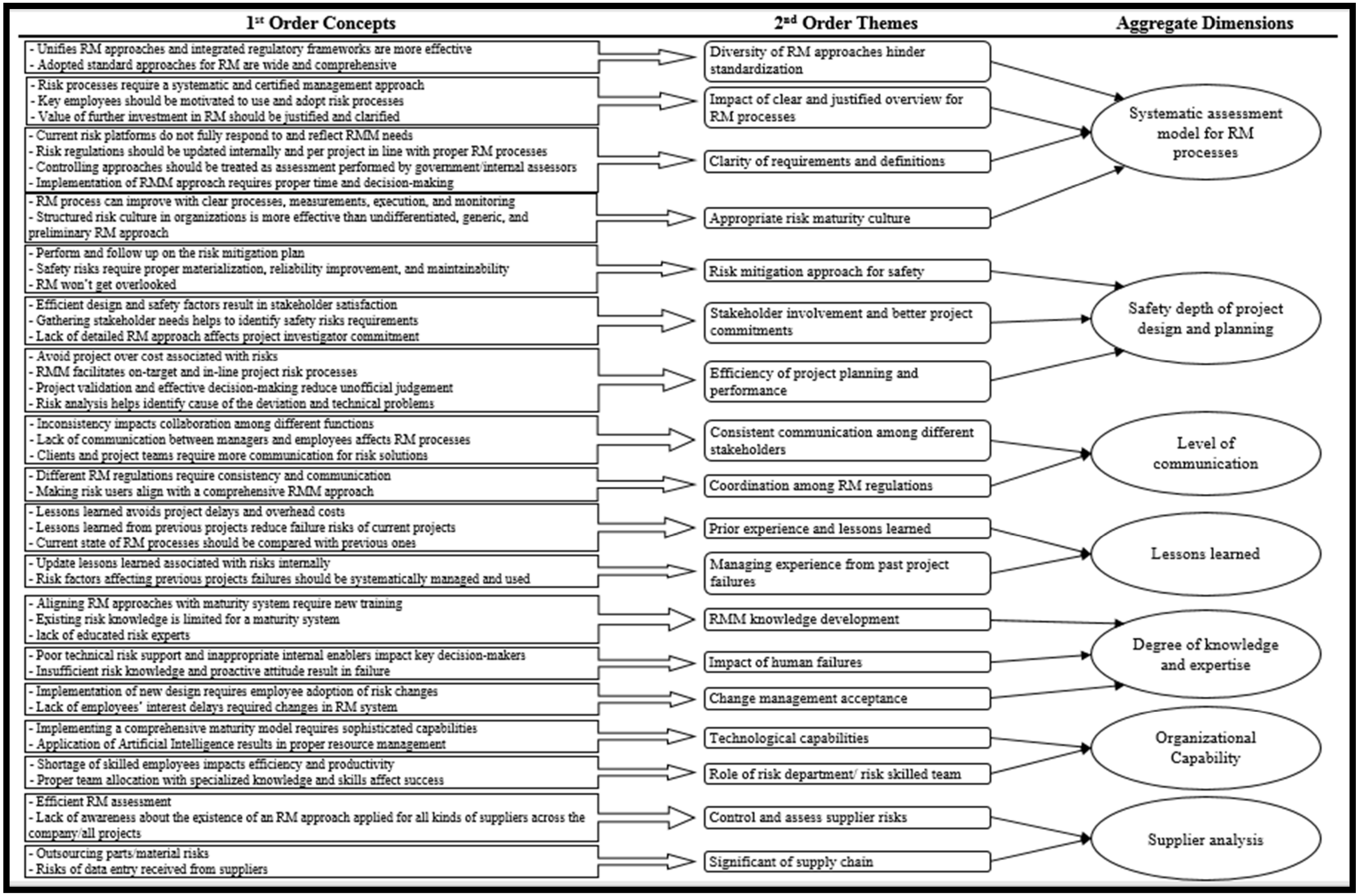

Figure 4.1 Data Structure

Table 4.1 Summary of Aggregate Dimensions, second-order themes, first-order concepts, direct quotes, and Key Informants' (KI) IDs

Aggregate Dimensions	Second-order themes	First-order concepts	Direct quotes	KI
1. Systematic assessment model for RM processes	1. Diversity of RM approaches hinder standardization	1. Unified RM approaches and integrated regulatory frameworks are more effective	*"It's better to analyze, execute; risks and benefit from integration of regulatory frameworks"*	16
		2. Adopted standard approaches for RM are wide and comprehensive	*"For megaprojects, in Aerospace or the other megaprojects, we lack a user-friendly risk management method ... commercially and technically"*	10
	2. Impact of clear and justified overview for RM processes	3. Risk processes require a systematic and certified management approach	*"Everywhere I worked, I never saw any systematic approach to assess risk processes, so they don't follow the processes"*	15
		4. Key employees should be motivated to use and adopt risk processes	*"For risk management generally, engineer hates to hear about it, that's how it's always perceive within the organization"*	15
		5. Value of further investment in RM should be justified and clarified	*"Organizations do not trace back the extra cost to the risk management that is the weakness"*	10
	3. Clarity of requirements and definitions	6. Current risk platforms do not fully respond to and reflect RMM needs	*"Existing risk platforms only meet part of the requirements of maturity models, according to internal systems"*	11
		7. Risk regulations should be updated internally and per project in line with proper RM processes	*"By regularly reviewing and updating the risk processes, we ensure to have meaningful risk management assessment"*	2
		8. Controlling approaches should be treated as assessment performed by government/internal assessors	*"They can find out how in line their current risk management practices are with the risk maturity indicators. Also help to assess the current effectiveness of a group or a project and supports figuring out what are our options".*	1
		9. Implementation of RMM approach requires proper time and decision-making	*"One of the challenges in big programs is that there are so many layers of management, so decision-making is really hard and multi-dimensional"*	12
	4. Appropriate risk maturity culture	10. RM processes can improve with clear processes, measurements, execution, and monitoring	*"Defining the objective of the risk assessment by looking at important factors to measure the risks, can provide a platform where risks are registered, tracked, updated, and concluded"*	2
		11. Structured risk culture in organizations is more effective than undifferentiated, generic, and preliminary RM approach	*"Companies know they need a specific place for risk. So, establishment of risk based culture is needed. Also, there is lack of enough related knowledge".*	11

4.2 Systematic assessment model for RM processes (AD1)

Besides being interested in assessing the risk management processes, a primary reason firms turn to apply one assessment model, followed by the maturity approach, is the wide range of project activities and requirements in megaprojects such as aerospace, which could be covered by the maturity model characteristics. Also, megaprojects complexity, need to adopt more regulations and standards, provide more resources to reach the project goals and finally meet the government regulations required for aerospace manufacturing companies. The interviewees in this study agreed that all these requirements, specifically about risk management, could be managed and controlled under one comprehensive and systematic assessment model for RM processes aligning with government regulations and project needs. The following four factors (**four second-orders**) were determined within the dimension.

- **Diversity of RM approaches hinder standardization (second-order No.1)**

Various key informants (50%) perceived that following the **unified RM approaches and integrated regulatory frameworks are more effective (first-order No.1)** for companies with megaprojects in the aerospace industry.

> Per my own experience, we did not have any specific department to manage all the risks. Or, even one system that covers all the risk processes across departments. Each department and discipline managed their own risk, and they reported that to the work package management when the risk went higher. (KI14, involved in Bombardier Global-7500 project, in response to interview question No.8)

Moreover, several interviewees (50%) emphasized that one of the challenges in managing the risks is that currently **adopted standard approaches for RM are wide and comprehensive (first-order No.2).** "The risk management currently is implemented based on some comprehensive approaches which are mostly proposed by governmental organizations (including Transport Canada-TC to manufacturing aerospace companies) for producing the safer products" (KI11, involved in Airbus-A220 project, in response to interview question No.3).

- **Impact of clear and justified overview for RM processes (second-order No.2)**

Three factors (three first-orders) had been derived from key informants' accounts in this term. Most interviewees (70%) firstly valued that **risk processes require a systematic and certified management approach (first-order No.3).** Interesting perspectives have been raised regarding RM appraisal. Indeed, with a few exceptions, interviewees agreed that they did not see and hear if there was a formulated system to assess the risk processes. Unless some companies follow their customized platform for risk processes, they were doubtful if there was an appraisal approach to control RM processes. Thus, based on interviewees' data analysis, as aerospace manufacturing companies produce the essential components of the aircraft, a comprehensive risk management approach can be beneficial. "The other point is that they (TC auditors or internal PMO auditors) check if the risks we identified were real or not. They don't check if we go exactly based on the risk management processes" (KI14, involved in Bombardier Global-7500 project, in response to interview question No.5).

Furthermore, a fundamental determinant was perceived as **key employees should be motivated to use and adopt risk processes (first-order No.4).** Almost 31% of interviewees mentioned that too much technical workload and lack of clear understanding of risk processes are some issues that influence the project team's interest in preparing risk reports. "When it comes to risk management generally, engineer hates to hear about it. They just do not like it, nobody wants to touch it, and nobody wants to deal with it, so that is how it's always perceived within the organization" (KI15, involved in Bombardier C-series project, in response to interview question No.1).

Lastly, it has also been asserted by interviewees (25%) that the **value of further investment in RM should be justified and clarified (first-order No.5)**. Monitoring the managerial processes such as RM, especially in aerospace firms with megaprojects, help them to determine the extra cost of those specific processes. "RMM approaches help to know where they are standing, to compare their current state to where they want and need to be and to discuss the value and cost of further investment in risk management" (KI1, in response to interview question No.8).

- **Clarity of requirements and definitions (second-order No.3)**

Most interviewees (70%) raised that **current risk platforms do not fully respond to and reflect RMM needs (first-order No.6)**. Establishing and executing a maturity model need some basics as maturity characteristics. Some of them include measurement and assessment approach, ranking criteria, assigning the right people to coordinate information and make the proper decision, establishing user's guidelines to help employees to understand how the assessment model works, and providing a comprehensive platform for executing such an assessment system over organization/projects. In addition, key informants agreed that the ideal RM approach is to have cross-project/department risk management validation or evaluation. "One of the challenges among different aerospace companies is a conflict of interest to apply maturity models and getting ranked. Another issue is assigning a right place/position in the organizational chart responsible for implementing the maturity model" (KI11, in response to interview question No.6).

Further, the data analysis derived from key informants (50%) covered two types of "updating" regarding the risks theme at the level of the project. First, the one applied by the government (not companies) on their risks regulations proposed to aerospace firms. That is, in general, per risk event (such as a change in the project plan), not frequently per specific time. The second kind of updating applied by the project team is related to risk updates per project, daily, weekly, or monthly. Interviewees also mentioned that they are not sure about updating the processes of risk management per project; however, it has been much applicable and already applied in other industries, including civil and construction. Lastly, they have all agreed that reviewing and updating the risk processes help to have an effective and practical RM assessment. Thus, as determined, the factor "**risk regulations should be updated internally and per project in**

line with the proper RM processes" (first-order No.7) is conceptualized, as another requirement and the definition need to clarify for implementing the RMM model. "Every time something major happens for an airplane, the regulations get updated by government. Based on the event importance, they get updated, not frequently per a specific time" (KI14, involved in Bombardier Global-7500 project, in response to interview question No.1).

The aspect of **"controlling approaches should be treated as assessment performed by government/internal assessors" (first-order No.8)** was also concluded from interviews data analysis. One of the fundamental characteristics of maturity models is that they follow the assessment approach, not audit. While different key informants (50%) mentioned that they follow global recommended practices, including risk management practices, and their company does internal audits based on its own customized risk practices that they defined at the beginning of the program/project. Even the TC risk regulations assigned per program to companies need to be approved by the TC auditors. Moreover, interviewees emphasized that they do risk assessment per project, but they are unsure if they assess the RM processes. Furthermore, they stated that one of the benefits of assessment toolkits such as maturity is that they help to determine how in line their current risk management practices are with the RM maturity indicators. Also, it helps to assess the current effectiveness of a group or a project.

> If there is any assessment approach, I am not aware of. I don't know that. But, I am sure about the audit. During the audit process, our internal auditors in our company review, control, and categorize the findings based on the criticality of the findings. So, some findings are critical and need to be fixed right away, and some are major that we did a certain amount of time that they should be fixed. Some are minors or a minor observation that is just for improvement. So, it is a kind of audit. (KI12, involved in Airbus-A220 project, in response to interview question No.3)

Consequently, several interviewees (44%) were aware that **implementation of RMM approach requires proper time and decision-making (first-order No.9)**. That means in megaprojects such as aerospace, there are so many different processes for different aspects, and that comes up with many papers works, reports that need to be generated and published, so many KPIs to report for, etc. Thus, the professional engineers and managers have to spend almost 70%-90% of their time doing all the paperwork and reporting relevant to different regulations, including risk management, while they can focus more on the technical part of their job. Another challenge was that due to the megaprojects complexity, there are too many management layers, making the decision-making complicated and time-consuming. “Also, PMO division in aerospace companies needs to assign more time to provide and then run a proper risk management system or new controlling system. So, in my opinion, that is how it should be the approach” (KI15, involved in Bombardier C-series project, in response to interview question No.8).

- **Appropriate Risk maturity culture (second-order No.4)**

Different interviewees (50%) mentioned that **RM processes can improve with clear processes, measurements, execution, and monitoring (first-order No.10)**. Indeed, claiming such evidence is an essential aspect concluded from a well-defined RMM. Furthermore, setting such a platform where risks are registered helps to have a clear picture of assessing the RM processes. “Main benefits of RMM application in aerospace firms with large projects would establish metrics and define processes which help to monitor and improve risks effectively” (KI16, in response to interview question No.1).

Moreover, interviewees’ reviews enhanced the perception that **structured risk culture in organizations is more effective than undifferentiated, generic, and preliminary RM approaches (first-order No.11).** Some (55%) clearly emphasized that controlling checklists are very general and not applicable to a specific discipline anymore. When managers tend to make one sheet applicable to everything, it will not work and will not be applicable. Thus, it caused low effectiveness. Some others were not sure if there was any controlling toolkit specific to risk processes. “I don’t know the detail if there is any assessment approach for RM, but I think even if there is a risk management, should be very preliminary” (KI7, in response to interview question No.3).

4.3 Safety depth of project design and planning (AD2)

Respecting the rules and regulations of government (including TC: Transport Canada, TSB: Transport Safety Board, etc.) and different guidelines of the aerospace industry (including SMS: Safety Management System, IATA: The International Air Transport Association, ARP: Aerospace Recommended Practice, etc.), imposed to aerospace companies, all manuals emphasize on safety aspects. Indeed, interviewees highly valued that safety is necessary for producing aircraft in aerospace manufacturing companies.

- **Risk mitigation approach for safety (second-order No.5)**

As interviewees (25%) valued, **perform and follow up on the risk mitigation plan (first-order No.12)** is another benefit of RMM implementation. "Depending on the project, each can benefit from RMM. As it helps to define meaningful mitigation plans and actions, regularly update the action list, implement and follow up on the mitigation plan to ensure the risks are not materialized, and if they are, there is a proper plan in place to reduce the damage due to that risk" (KI2, in response to interview question No.2).

Moreover, some interviewees (25%) as senior project managers perceived that **safety risks require proper materialization, reliability improvement, and maintainability (first-order No.13).** They believed that the effective application of RMM causes quality increase, availability, increased flight safety, and flight reliability.

> One of the important thing I think is the consequence if the risk materializes. Therefore on safety. Second, the schedule: the aircraft design and manufacturing are very competitive on the schedule. Third would be the domino effect of that design if it materialized on other design. (KI14, involved in Bombardier Global-7500 project, in response to interview question No.1)

Several reasons also were given for preferring the RMM over current approaches to ensure that **RM will not get overlooked (first-order No.14).** The perceived reliability of interviews data

(13%) highlighted that; however, RM is an essential knowledge area for aerospace companies, it is very often overlooked. Therefore, RMM helps the project team step truly to identify risks.

> If I want to say the benefits of RMM: in aerospace, safety is so important. On the other hand, this is a very high-value product, so it is very expensive. And there are so many like resources and so much money behind a product like an Airplane. So, controlling risk management in terms of first the technical risks, because of the safety, and second, the scheduled wise risks, is very important to be able to maintain companies and industries like that. So, it is like a must. It is not just a benefit; it is a must to my understanding. (KI12, involved in Airbus-A220 project, in response to interview question No.7)

- **Stakeholder involvement and better project commitments (second-order No.6)**

"Efficient design and safety factors result in stakeholder satisfaction" (first-order No.15), concluded as another factor of interviewees' data analysis. They (44%) acknowledged that aerospace firms need to manage even the minimum risks following the governmental guidelines. Some risks, such as customer satisfaction, are at a low level, while others are extremely remote risks and can kill many people because of a plane crash, for instance. These risks are called catastrophic events. The design should be safe even for the one billion events. Closely connected to such comments is "effectiveness of RM approaches helps to make intelligent decisions to provide reasonable assurance, optimized performance, and desired levels of value delivered to stakeholders" (KI1, in response to interview question No.2).

Further, according to data suggested by some other interviewees (38%), **gathering stakeholder needs helps to identify safety risks requirements (first-order No.16)**. Implementing an appropriate RM system causes better 1- client identification, 2- gathering stakeholder requirements, 3- establish vision and strategy, and 4- better analysis of the market feedback.

> To be honest with you, the benefit of a good RM platform, as I explained to you before, could be, for instance, when we identify the risk; first, we go to the platform. So like, based on all the information we received from suppliers, I mean the latest information that is flown down from them, we

> put all those data into our Risk Events. We call it a risk event. So, when we identify a risk, we create an event in our risk platform, we explain there all the data we have received from the supplier, and the result and the impact of those risks on the next delivery or next KPIs. (KI3, in response to interview question No.6)

Interestingly, an opposing perspective also emerged. Once an effective RM approach affects stakeholder needs analysis, the **lack of a detailed RM approach affects project investigator commitment (first-order No.17).** The interviews data (19%) created the perception that RMM resulted in competition in the market by building client trust. "Sometimes lack of risk management in one department will affect others massively. Especially when we deal with megaprojects, our delays or errors will affect other stakeholders in the project. Therefore, there are clauses like delivery delay penalties liquidated damage in major project contracts" (KI10, in response to interview question No.2).

- **Efficiency of project planning and performance (second-order No.7)**

Interviewees considered the repeated usage of the RMM system, influencing positively on project performance, which also resulted in producing a safer product. Most of them (65%) believe that if the aerospace companies apply the RMM approach, it helps them to **avoid project over cost associated with risks (first-order No.18),** which impact project performance.

> The principles of effective RM implementation would be identifying risks early in project planning and continually identifying them throughout the project lifecycle. Also, it helps to do in-depth analysis on each risk and apply them to specific tasks to determine their positive or negative consequences on the overall project scope, schedule or budget. (KI5, in response to interview question No.2)

Further, **RMM facilitates on-target and in-line project risk processes (first-order No.19)**. Several key informants (44%) believe this factor, which confirms they have a positive opinion about the RMM application. That said, aerospace firms would benefit from knowing where they stand in the RM planning theme. "The RMM benefits are efficient consumption of resources (any kind) as well as in-time delivery of the safe and effective product to customers within the agreed time frame. But of course, there are always risk margins involved as well" (KI4, in response to interview question No.2).

Moreover, **project validation and effective decision-making reduce unofficial judgement (first-order No.20)**. Bringing up topics like this can cause another acknowledgment, which some interviewees (25%) perceived. Although they perceived that one of the challenges of RMM systems is their complexity, which makes it hard to have a user-friendly usage, conversely they valued it helps to make equal decisions among different divisions because currently, the risk decision-makings of each department are not equal. "RMM helps information flows more fluidly, it reduces the blaming game and finger-pointing at each other and project will be implemented successfully" (KI10, in response to interview question No.7).

Finally, the interviewees knew the risk analysis differences between the current risk platforms and RMM systems. From their perspective (50% of interviewees), one of the benefits of the RMM models is to have a chance to control and assess if all the RM processes for risks analysis are appropriately implemented or not. Thus, they valued the **risk analysis** was done by RMM also **helps to identify cause of the deviation and technical problems (first-order No.21)** correctly. In contrast, the current RM system is just a platform to use risk management processes. Overall, RMM helps to determine a proper risk plan and reduce its damages. That means RM appraisal, and considering the defect items, help to determine who was responsible for that event and how to solve the defects through some processes. For instance, the responsible team first asks all the customers to stop using the parts that might negatively impact (based on negative risks) product safety. Then the technical team uses quality improvement techniques to identify the root cause of the deviation. After identifying and measuring the risks, implementing corrective measures as required, and following proper reviews, the production of that part will continue again. All the mentioned notes help better project performance and create a clear picture of the final product safety. "Absolutely for megaprojects, RM assessment is essential. If a risk is not managed regardless of the size of the project, we will be exposed, and it happens very often, and in order to correct the damage, it costs us much money" (KI10, in response to interview question No.5).

4.4 Level of communication (AD3)

Key informants found the lack of communication as another substantial obstacle to implement a maturity approach. Because currently, there is no constant communication among different involved parties, including managers, team members, departments, and clients, which contrasts with the maturity model characteristic that needs to make links among them for a better comprehensive assessment. In other words, proper communication primarily improves risk data exchange with external parties.

- **Consistent communication among different stakeholders (second-order No.8)**

The interviewees (38%) revealed that **inconsistency impacts collaboration among different functions (first-order No.22).** Especially in terms of RM assessment for the megaproject, it must be managed via all the departments. "Coherence and taking the ownership and passing the project from one department to another is often the weak point in our projects. A project manager with an eye on the big picture needs to communicate the information between departments and follow the plan in multiple departments simultaneously" (KI10, in response to interview question No.3).

Moreover, key informants (31%) viewed **lack of communication between managers and employees affects RM processes (first-order No.23).** It can be perceived that, for instance, department managers need to communicate with the senior managers on how to apply RM processes. Otherwise, the employees will not get familiar with the processes of RM, so they cannot make an accurate risk report. Employees are one of the project stakeholders.

> Improvement needed: People seem to be too busy doing their job in a silo that is a risk itself. Management of the organization needs to believe in it.

> Management needs to provide the tools, training, and review and empower the people who act every day to manage the risks, and the organization should also encourage risk management. (KI10, in response to interview question No.8)

Further, the factor **“clients and project teams require more communication for risk solutions” (first-order No.24)**, resulting in another sign of consistent communications, perceived by some other interviewees (31%). In addition, clients and suppliers as stakeholders need to be contacted and communicated by managers so the project team can receive their information regularly to update the risk platforms. “The risk assessment should be applied to the entire involved parties and should be communicated well between the suppliers, customer and final consumers” (KI7, in response to interview question No.2).

- **Coordination among RM regulations (second-order No.9)**

Several interviewees (44%) mentioned that as the government or companies impose many RM regulations and standards on the project team, one of the inputs of executing a proper RMM system is consistency among the current risk approaches. That would not be possible unless by coordination and communicating. Indeed one of the challenges of using RMM is that **different RM regulations require consistency and communication (first-order No.25),** which need to be made by top managers. “There is currently no standardized risk model for assessing RM used across the organization. There are multiple iterations of risk matrixes used to assess risk, not risk management processes. Different company divisions use different styles and templates” (KI5, in response to interview question No.3).

Another factor regarding communication mentioned by interviewees (19%) is **making risk users align with a comprehensive RMM approach (first-order No.26)**. That means before and after applying the RMM system, there is a need to make all related parties in line with the RMM system. It helps a more effective execution of RMM. “I believe that assessment approach should include all departments some have more impact on the risks some less. But, a lack of risk management in one department will affect others massively. Especially when dealing with megaprojects” (KI10, in response to interview question No.2).

4.5 Lessons learned (AD4)

On the one hand, in organizations with megaprojects (dealing with a complex and wide range of processes), recording lessons learned help them to prevent some failures in the future and even replicate past success in their projects. Because lessons learned clearly, specify the pros and cons of the projects. On the other hand, RMM processes are a frequently updating process that would help to better identify project risk failures (such as time and cost risk), which impact providing better lessons learned. Thus, performing lessons learned from the beginning of the new project can save valuable time, avoid over cost, and provide opportunities for RM improvement during the project lifecycle. However, different risks with different impacts on the project will be identified per new project.

- **Prior experience and lessons learned (second-order No.10)**

Based on the different interviewees' data analysis (38%), one of the significant benefits of similar projects is understanding how their improper management caused the cost and time issues. Thus, using **lessons learned avoids project delays and overhead costs (first-order No.27)** while it currently does not exist in most aerospace companies. "We need the RM assessment to be compared and evaluated cross-project/cross-department to ensure benefiting from the lessons learned of the previous/parallel projects. In other words, not inventing the wheels from scratch and taking advantage of costs that an organization already paid for the previous RM assessments" (KI2, in response to interview question No.9).

Comparing the current project with previous projects of similar nature helps to identify the parallel risks and makes a clear statement of failures in managing the risk processes. Prior experience can lower the risk of failure and repeating errors. In this regard, some key informants (38%) emphasized that the **lessons learned from previous projects reduce failure risks of current projects (first-order No.28).**

> For example, the risk management in my area working on the schedule is not very good, which means that we are not using the lessons learned from the previous similar projects to reduce the risks of the current projects. Sometimes it happens that we make the same mistakes, and we're still facing the same level of risks in this project, not in this project, but it happens in most of the projects. (KI12, involved in Airbus-A220 project, in response to interview question No.8)

At the same time, some other interviewees (25%) emphasized that the **current state of RM processes should be compared with previous ones (first-order No.29)** for a better improvement of RM. "Learning from each project will show the risks very clearly, there are not millions of risks, there are going to be some identified and limited number of known risks that need to be managed" (KI10, in response to interview question No.8).

- **Managing experience from past project failures (second-order No.11)**

Almost 25% of key informants concluded that applying an RMM approach per megaproject in aerospace company helps to **update lessons learned associated with risks internally (first-order No.30).**

> Overall, the RM approaches/regulations proposed by the government get an update by them when they plan to upgrade a product with the same model, an airplane crash, etc. So updating RM regulations is not a frequent process based on the specific periods or systematic assessing approach. It is an external decision proposed by the government to companies if a significant and essential event needs consideration. (KI11, in response to interview question No.8)

Further, data analysis (of 25% of interviewees) resulted that **risk factors affecting previous projects failures should be systematically managed and used (first-order No.31).** In this regard, the comprehensive management approach of an RMM system could help to better manage lessons learned related to the risks.

> So for me, the part of the risk management I think is important is that if you hold post-mortem meetings and join conclusions, you can apply to future programs. But, they don't do that. Therefore such a maturity model in risk management can definitely help to apply the **post mortem** (lessons learned). (KI15, involved in Bombardier C-series project, in response to interview question No.5)

4.6 Degree of knowledge and expertise (AD5)

The next overarching dimension is the degree of knowledge and skill about risk management, which is determined in the following three second-orders. Overall, most interviewees, at least in principle, believed that risk knowledge and experience benefit the project team. While currently in aerospace megaprojects, they face limited risk knowledge because of insufficient training and in-depth knowledge applied to current and new employees. This claim also impacts implementing RM maturity systems.

- **RMM knowledge development (second-order No.12)**

Most of the interviewees (63%) strictly emphasized that even about the current risk approach applied in their firms (which is much simpler than maturity models characteristics), employees do not train enough regarding the risk processes and how they need to work with them. There is no protocol to help them in this regard. Therefore, as the maturity models are more comprehensive with respecting many items that they need to be aware of, it clearly resulted from interviews data analysis that **aligning RM approaches with maturity system require new training (first-order No.32).** "For new employees, they do not have a clue about what are the risk management processes, and they learn them by themselves during working and by doing it wrong! Not based on any procedure or guideline" (KI14, involved in Bombardier Global-7500 project, in response to interview question No.6).

Further, implementing a maturity model has some requirements. While, based on what most interviewees (63%) indicated, for instance, the **existing risk knowledge is limited for a**

maturity system (first-order No.33). They argued that as there are no assessment systems for risk processes, they have no clue what the appraisal needs are in their company and are not practiced to deal with this kind of model. “There is currently no maturity assessment implemented. However, if one was implemented, yes, I believe there would be a benefit. A key benefit would be a mutual understanding across the project or program of where we stand in the risk management spectrum and set a standard goal and template” (KI5, in response to interview question No.8).

Finally, almost 50% of key informants emphasized the **lack of educated risk experts (first-order No.34)** as another challenge for developing the RMM knowledge in their aerospace companies. They believed that for implementing an RMM system, people in aerospace firms still need to be certified and educated, especially about risk knowledge areas. “The challenges are human factors due to lack of experience and understanding the big picture. Also, the knowledge and expertise of the employees are not the same” (KI10, in response to interview question No.6).

- **Impact of human failures (second-order No.13)**

“Poor technical risk support and inappropriate internal enablers impact key decision-makers” (first-order No.35). This factor was also concluded from interviews analysis. For some interviewees (38%), the level of technical knowledge profoundly impacts the final decision and response to the risk event. They believed that even large aerospace companies do not assign proper people to make the right decision in this term. In order to have successful risk management, there should be a balance between the knowledge of the department/people who wants to manage the risks and the technical risk reports proposed by professional engineers. As they mentioned, mostly the person responsible for closing a risk event (top manager) at the end does not know what the technical engineer talks about in the final technical report. Therefore, it puts pressure on both of them and the top manager cannot close that event or close it wrongly. “The world of a program manager who makes the checklist for checking the design is disconnected from the world of an engineer who does the technical design. It means mostly the people who make the checklists have no clue about the design" (KI14, involved in Bombardier Global-7500 project, in response to interview question No.6).

Another factor through interviews analysis resulted that **insufficient risk knowledge and proactive attitude result in failure (first-order No.36)**. Indeed, some interviewees (38%) reported that improper RM knowledge would demonstrate the employees' failures while identifying risks after product design and flight tests. However, if they first identified risks truly, the number of risks during flight tests will be decreased. "Lack of time and understanding of risk value are the two greatest challenges" (KI5, in response to interview question No.7).

- **Change management acceptance (second-order No.14)**

An emerging theme within implementing RM appropriately is accepting risk changes while implementing the RM processes, including risk response. During interviewing, even those few interviewees (19%) who initially argued that they did not have enough information about RMM agreed that **implementation of new design requires employee adoption of risk changes (first-order No.37).** In this regard, RMM helps them to implement and control RM properly, resulting in better adoption of risk changes**.**

> I faced risk management issues when working on the schedules for different projects. One of the challenges I faced, for example, was about the design change process of part of the aircraft, like sectional landing. So when we have a design change, it should have sub schedule with new risks, and that schedule was combined with aircraft schedule delivery, and in that aspect, there are some changes in risks for the aircraft delivery, and any kinds of preparation and organize, so, we have to put some like margins in the schedule. (KI12, involved in Airbus-A220 project, in response to interview question No.1)

Further, regarding change management, most managers see the push back from employees to implement some new systems such as RMM that cause changes in the current RM approach. Because, for instance, the lack of resources caused them to push the employee and load them with too many works about risk events and risk system. That is so challenging for employees.

Almost 31% of interviewees claimed that **lack of employees' interest delays the required changes in RM system (first-order No.38)**.

> So about the challenges, the first thing I would see is that when it comes to risk management, people don't wanna hear about it. They think it is a waste of time. I think there is a need for more education that needs to have it first. So people get educated to get to know why risk management is good and what its benefits are. Once people learn about it, then they accept the changes. (KI15, involved in Bombardier C-series project, in response to interview question No.6)

4.7 Organizational Capability (AD6)

Organizational capability is the unique combination of processes, technologies, and human abilities created internally and differentiating a company. In other words, the organizational capability is the company ability to manage the above elements. There are many requirements for executing an RMM platform, including required resources, different types of activities assessment, ranking approach, and a robust platform where risks are managed properly.

- **Technological capabilities (second-order No.15)**

There are many requirements for executing an RMM platform, including different users who need to be accessed by, a ranking approach, resources, and a robust platform where risks are appropriately managed from risk registered to update and respond them. Several interviewees (44%) clearly stated that **implementing a comprehensive maturity model requires sophisticated capabilities (first-order No.39).** They mentioned, for instance, that technological complexity mainly involves the challenges in facilitating collaboration with other parties or disciplines and the complexity stemming from the diversity and uniqueness of projects. One of the primarily required capabilities is a proper IT infrastructure.

> If you ask me: by the way, we're gonna implicate a new risk platform (maturity one), and you will spend one hour a day to put information updates there, I would never be able to do my job. That's why one of the challenges, I think, is resources, including the labor, and the budget for improving the current platform and having enough labor who are

> responsible for updating the risk events; that's one thing. (KI3, in response to interview question No.7)

Some key informants (31%) also noted that if the RMM platform is presented with new digital technologies such as AI, it further enhances proper resource allocation in risk management. That claim resulted in another factor that **application of Artificial Intelligence results in proper resource management (first-order No.40).** "I would see like many many hours of activities can be performed by machine. I would definitely see the tremendous opportunities for like bringing AI and use AI to save time and even streamline implication of risk analysis and risk assessment systems in our company" (KI3, in response to interview question No.9).

o Role of risk department/ risk skilled team (second-order No.16)

Last but not least, two other elements (first-orders) derived from interviews data analysis are as follows. The first one demonstrated that lack of proper staff would cause low efficiency and productivity of the RMM system. Overall, such a claim (by 31% of interviewees) resulted that the **shortage of skilled employees impacts efficiency and productivity (first-order No.41).**

> We have so many different processes for different aspects, and that come up with a lot of paperwork, a lot of reports that you need to generate and publish, and so many key performance indicators (KPIs) that you need to report for. So that like for me as a professional engineer that I would like to do the design job, the analyses of the technical information, and all that, I spend like, I don't know, sometimes 90%, sometimes 70% of my time doing all the paperwork and all these reporting which is relevant to different kind of ARP processes. (KI12, involved in Airbus-A220 project, in response to interview question No.6)

The last factor in this section, argued by interviewees, is that **proper team allocation with specialized knowledge and skills affects success (first-order No.42).** Different key informants (50%) believed that separating the risk management team from the technical team would be beneficial because employees are concerned about their own day-to-day activities. While the RM team can make all the paperwork and reporting, so there would be a valid RM analysis done by a skilled team.

> Second thing, in my opinion, you need a dedicated department for this, within the organization that they generally don't have it as part of project management. You're gonna need specifically dedicated department who take care of this who always keeps itself up to date whether within the industry or the economy. (KI15, involved in Bombardier C-series project, in response to interview question No.8)

4.8 Supplier Analysis (AD7)

Aerospace companies, especially those with megaprojects, need to develop a mechanism for analyzing the suppliers' risks through which key equipment suppliers and internal decision-makers can benefit from the accurate and updated information over the distribution channels. Through this platform, they will ensure that related internal stakeholders can collect and analyze required data from diverse sources and multiple suppliers. Further, since some roles, such as procurement managers, play a crucial role in initiating managing and supporting product development, they need to choose appropriate distribution sources with high-quality materials as one of the inputs of the product design process. In other words, managers must ensure that day-to-day operations reflect the overall internal measures of their success. They moreover need to make sure of proper information within the complex network of suppliers in aerospace megaprojects. That helps to share risks and problems within the suppliers and procurement team more appropriately.

- **Control and assess supplier risks (second-order No.17)**

Some key informants (19%) agreed that to control part of the supply chain risks in aerospace companies involved in megaprojects, they need a comprehensive analysis of suppliers' risks for all projects. They emphasized that to stop flow problems within the distribution channels and misalignment between the supply and demand; they need an **efficient RM assessment (first-order No.43)** to control the suppliers' risks all over the involved parties.

> We have a feature for RM in the company that I think is customized for our company. As the procurement team, we are in charge of identifying the risks and sending the information of the risks to that platform. We have several meetings

> with our suppliers, and every procurement specialist has the portfolio suppliers responsible for. Thus during the week, we work on the planning that arises, which means depending on the risk level that we identify, we might decide to extend the risks assessment to like three months while some of my other colleagues used to do it in eight weeks. So once we update our risk event, the entire supply chain team would have visibility over the latest updates on the progress we made on that specific risk. Then, they assess and prioritize the risks based on their impact on overall business goals. So you see how much the supplier risks are important for the business. So yes, we assess risks but not RM. (KI3, in response to interview question No.3)

Some interviewees (13%) also viewed the **lack of awareness about the existence of an RM approach applied for all kinds of suppliers across the company/all projects (first-order No.44).** Thus, they acknowledged that an RM assessment approach is needed, and a maturity assessment approach, which covers all suppliers' risks over the projects and company risk processes, is highly recommended. Therefore, decision-makers can control suppliers' risks much better by being aware of different risks across the supply chain process for product manufacturing. "We have a customized RM platform for the operation part. I work in the operation side of the business; I'm not working in the engineering side. We have many projects now, but I don't know what risk approach or RM assessment system they have. What I'm telling you right now is based on the risk of the operation side" (KI3, in response to interview question No.4).

- **Significant of supply chain (second-order No.18)**

While the supply chain concept is thriving in the current business environment, the interviewees (13%) also linked its significance with employing the RM assessment, which increases interaction with equipment suppliers and facilitates receiving high-quality materials by decreasing the **outsourcing parts/material risks (first-order No.45).**

> One of the most prominent key features from the quality and technical standpoint we have in aerospace is that we have very strong measures in place. For instance, there are two types of quality deviations, one is when the quality deviation is identified after we receive the parts, and the other is when the supplier identifies the quality deviation before they ship the parts to us. Each has a different approach to mitigating any risks associated with the type of deviation. So, we have a very

> strong trace and tracking system in place to understand that all the parts have to be serialized or even some of our suppliers have to serialize the parts. (KI3, in response to interview question No.1)

Finally yet importantly, in aerospace companies with megaprojects, one of the crucial inputs before starting the product design is the accuracy and sensitivity of information required for simulation and designing a product. In this term, the interviewees (19%) also claimed a high dependency between the accuracy of receiving data from a wide range of suppliers and accurate managing risks, which increase efficiency in product design. Thus company, within the supply chain process, requires it to manage and unify data inflow from multiple diverse sources (e.g., a complex network of equipment suppliers present in foreign countries), which concluded the low **risks of data entry received from suppliers (first-order No.46).**

> We receive all the information that we need to identify the risks twice a day. You know aerospace has a very fast-paced supply chain. We use like Kanban and Inventory approach, which pushes much pressure on the supply chain. That's why we do risk practices twice a day, once at 4 am and the other at midnight. Twice a day, we collect the latest data and put them in the SAP, and then again, they provide you with the second data based on the updates of the first four hours of the day. So, the management team would have the ability over any progress push out or push in, and based on that, they can define the new decision the business requires for risks. (KI3, in response to interview question No.5)

4.9 Conclusions

This chapter presented the core finding of this research following seven key aggregate dimensions from second-order themes, first-order concepts, and direct quotes. It illustrates that the data analysis was conducted in a rigorous manner; its process was detailed. Thus, as an overall view of this chapter, the below prioritizes the works done by the researcher:

1. Figure 4.1 (data structure) and Table-A V-1 (Summary of Aggregate Dimensions, second-order themes, first-order concepts, direct quotes, and Key Informants' IDs), (see APPENDIX V, Table-A V-1), were developed by the researcher specifically based on the Gioia et al. (2013) technique to ensure high research quality;

2. The researcher also proposed a detailed description of the data analysis process based on **interviewees' quotes** from sections 4.2 to 4.8. Meanwhile, the researcher tried to illustrate two different quotes (with the same objective) per first-order to better validate data analysis. That means the quotes mentioned in the current chapter are mostly different from the quotes in the Table-A V-1 (see APPENDIX V, Table-A V-1);

3- While the researcher in the current chapter **only** focused on detailed **direct quotes** proposed by interviewees, in the **next chapter** (discussion) researcher demonstrated how the objective of developing the data structure and ADs is to add **new knowledge** and **phenomenon** to the **literature**, which in the current study is applicable for **most** ADs. That means most ADs are **new** in the **related** literature to the current **research topic**, as challenges and opportunities by **implementing RMM in megaprojects of the aerospace industry**. Moreover, in this study, the results as AD are about **identifying challenges**. They are not about exploring the process. Thus, there is no need to prioritize the ADs in a process-based journey.

CHAPITRE 5

DISCUSSION

5.1 Introduction

In the current chapter, second section 5.2, as discussion, contributes to close the crucial gaps on studying the proper attention to implementing the risk management maturity models, particularly for megaprojects in the aerospace industry. This section also confirms that the research aim and objectives were met, and the research question was answered (by comparing the research findings with the related literature). The answers proposed through seven main dimensions provide empirical findings regarding: **what are the challenges that organizations with megaprojects in the aerospace industry face to execute an RMM approach**.

The existing study identified the need to explore potential solutions to implementing the risk management maturity approach. It expands our understanding of the limitations and challenges that megaprojects in the aerospace face in this regard due to their complex manufacturing process and particular requirements to produce safer products. As a result, this research categorized the diversity of challenges into seven main dimensions. Although these dimensions were determined by interviewees across different companies, they were proposed by the management levels predominantly as well. Thus, managers as final decision-makers of RMM play a significant role in investigating the organizational improvements required for RMM execution and use. The result of data analysis and the extant literature reviewed in chapter two also highlighted that the success of implementing the RMM is bounded mainly by all project members and the decision-maker teams. Analyzing results of in-depth and semi-structured interviews reiterated the need to implement a systematic assessment model for RM processes that followed the main characteristics of maturity models proposed in the literature (including their impact on different projects and their appraisal approaches for employees using different scoring levels).

5.2 Assessment model for RM processes

First, although the maturity concept is often associated with larger companies (Spalek, 2014), in a mature organization, the processes will execute clearly and consistently to make an efficient contribution towards the project goals (Siebelink, Voordijk, Endedijk, & Adriaanse, 2021; Team, 2010). To that end, key informants emphasized that in megaprojects in the aerospace industry, the company cannot easily switch to a maturity approach for RM processes due to the complexity of processes toward production goals. Because one challenge is about project teams who are fully occupied operationally, and time limitation hinders them from using development tools (even if they are interested in taking on these responsibilities). Moreover, as final decision-makers, risk managers play critical roles in facilitating RMM implementation. Second, on the one hand, several standard risk regulations are imposed by the government on the aerospace companies (per project), and on the other hand, each company has its own unique RM approach. Thus, the RMM development defines specific processes and unifies all/most of these approaches in one standard system (covering both government and the company RM requirements). Organizations with complex projects should provide a framework of standard best practices to implement and enhance their risk management approach (D. A. Hillson, 1997; Yeo & Ren, 2009). Third, making a clear and justified overview for RM processes and clarifying the RM maturity requirements help employees' motivation and competence in implementing an RMM system. Forth, to make a proper environment for applying the RMM system, the organization must provide an appropriate risk maturity culture regarding the interviewees' belief. For instance, the employee's top managers can help to create such a culture by demonstrating the benefits of several maturity models. These models result in several improvements in some dimensions, including time/cost/quality, Return On Investment (ROI), customer satisfaction, minimization of project risks, and decreasing barriers against change management (Albrecht & Spang, 2014).

Eventually, prior literature also highlighted **risk culture** and **systematic assessment model for RM processes** as key aspects of some risk management maturity models such as RMM proposed by D. A. Hillson (1997), RMCMM by Yeo and Ren (2009), RM3 by Zou et al. (2010), and PRMM by Martin Hopkinson (2011) (Elmaallam & Kriouile, 2011; Gladden, 2012; Heravi & Gholami, 2018; D. A. Hillson, 1997; Hoseini et al., 2019; Jia et al., 2013; Mu et al., 2014; Serpell et al., 2015).

5.3 Safety depth of projects

Meanwhile, concerning megaprojects goals in the aerospace industry, the significance of aircraft safety was frequently highlighted by interviewees. They also perceived that one of the main aspects, which highly affect product safety, was the impact of the proper RM system. Interviewees also emphasized risk mitigation and stakeholder involvement as two other crucial terms that affect the final product safety. In fact, the appraisal of successful A&D megaprojects depends on significant criteria, including stakeholder satisfaction, achieving a successful design, level of technological development, controlling and managerial processes, and the robust management tools for risk management (Rodriguez-Segura et al., 2016). Also, for proper risk mitigation, companies were willing to execute a structured RM system or enhance their current risk management approach to justify the objectives and processes clearly, making proper planning and efficient controlling approach for risks (D. A. Hillson, 1997).

As far as the impact of maturity models, better implementation of maturity models in the companies leads to better performance (Görög, 2016). In other words, one of the benefits that organizations have obtained from using particular maturity models is continually improving the performance of all projects undertaken by an organization (Farrokh & Mansur, 2013; Khoshgoftar & Osman, 2009). Indeed, RM capability maturity has the potential to directly impact project success (Heravi & Gholami, 2018; Serpell et al., 2015; Yeo & Ren, 2009). Additionally, firms have realized that improper risk management causes project failures such as project delays and high costs (Heravi & Gholami, 2018). Overall, to improve the company RM performance, further design and development of a maturity model that can capture the strengths and weaknesses of the firms towards future RM practices effectively is required (Jia et al., 2013). Also, based on the prior literature, risk management maturity models such as OGC proposed by the Office of Government Commerce (2007) highlighted **early warning indicators** and **continual improvement** as their key aspects (Elmaallam & Kriouile, 2011; Heravi & Gholami, 2018; Hoseini et al., 2019; Jia et al., 2013; Mu et al., 2014; Serpell et al., 2015). Benefiting such models could be helpful to **identify the failure risks, causes of some deviation, technical problems,** and project failures.

5.4 Importance of communication

One of the differences between the typical project and megaproject such as aerospace is the higher number of involved stakeholders (Flyvbjerg, 2014; Zhai et al., 2009). In fact, a key challenge arising from interviews was the lack of communication among different departments involved in the projects, particularly those between managers and employees, and between clients and the project team. In aerospace industries, applying regulated processes for evaluating the stakeholders' involvement and clients monitor should be considered to achieve project success (Rodriguez-Segura et al., 2016). Key informants repeatedly noted that management coordination needs to be improved for implementing RMM. Holt, Armenakis, Feild, and Harris (2007) also discussed that managers' lack of commitment and support hinders the achievements of executing the maturity model in a company. In fact, companies should set and prepare the conditions that employees can link with each other, share their thoughts, and involve in an effective process (Siebelink et al., 2021).

Key informants explained that the level of communication determines the limited coordination among different RM regulations and approaches in the company. They also argued that even if related standards and regulations were available, the inconsistent coordination and lack of clarification of use cause another challenge to perform any controlling systems. In this regard, both risks and performance of the projects are under project managers' responsibility, which highly impacts the final risk decision and their project approach (Brookes et al., 2014; Görög, 2016; Siebelink et al., 2021). Finally, **communication** and the significance of **stakeholders** are also highlighted as two key aspects of some risk maturity models such as Risk-IT proposed by ISACA (2010) and OGC by the Office of Government Commerce (2007) (Elmaallam & Kriouile, 2011; Heravi & Gholami, 2018; Hoseini et al., 2019; Jia et al., 2013; Mu et al., 2014; Serpell et al., 2015).

5.5 Vital effects of lessons learned

Meanwhile, transferring past failures and experiences from previous projects to another has led to the creation of a phenomenon among industry experts known as *lessons learned*. If the project team takes the lessons learned from one project and applies that knowledge and experience to another project, they could progress effectively (Siebelink et al., 2021). The need to learn from past projects and prepare for future risks has long been highlighted in the extant literature (D. A. Hillson, 1997). Doing so, for maturity models, can transform the company skills and experiences into effective plans and databases (de Carvalho et al., 2015).

5.6 Knowledge, expertise, and training

Several interviewees have attributed that employees' insufficient experiences and risk knowledge hinder applying and developing a controlling system like RMM. These issues cause some challenges for their managers as implementation and use of such a system usually make extra responsibilities for personnel, leading to discouragement and time pressure. In this regard, interviewees also claimed that lack of proper training is a significant reason for limited skilled employees, which hinders them from accepting change and adopting a controlling system. To implement a structured system for RM through the maturity capabilities, organizations require continual learning and improvement (Heravi & Gholami, 2018; Serpell et al., 2015). Although data analysis also highlighted that lack of training for employees prevents companies from improving the RM approach. Overall, if workforces do not understand the benefits of such tools, there would be human failures, which contrasts with the project success and management objectives. Because megaprojects by nature meet new risks over time, which cause some failures and delays during the project life cycle, and to reduce the risk factors, managerial action needs to be taken to implement a proper controlling system that helps project success (Flyvbjerg, 2014; Sanchez-Cazorla et al., 2016). Also, to reduce these new risks in complex projects, decision-makers' plans need to be changed (Kardes et al., 2013). The data analysis of the interviews also stressed the importance of decision-maker support to encourage employees for change acceptance. Moreover, a maturity model is a necessary tool to help companies perform changes and improve processes by systematically assessing them (Jia et al., 2011; Mullaly, 2014). Overall, **knowledge, experience and training** are also illustrated in prior literature as main aspects of some risk management maturity models. For instance, Risk-IT proposed by ISACA (2010) highlighted **responsibilities, skills and expertise** aspects**,** RMM by D. A. Hillson (1997) emphasized the **experience** aspect, and RM3 by Zou et al. (2010) demonstrated **management and leadership capabilities** aspects (Elmaallam & Kriouile, 2011; Heravi & Gholami, 2018; D. A. Hillson, 1997; Hoseini et al., 2019; Jia et al., 2013; Mu et al., 2014; Serpell et al., 2015).

5.7 Significance of capabilities

Almost all informants referred to a lack of organizational resources from skilled workforces to technological capabilities. The comparative analysis of the barriers to implementing RMM revealed some interesting findings related to the technological concept. Although the interviewees in this study, from various aerospace firms, agreed that the current platforms for risk management processes support the basic needs of identifying and mitigating risks, implementing the maturity approach, due to its comprehensive nature, the high definition and adoption of information technology infrastructure are needed. These tools and platforms need to establish and implement with the permission of higher managers who have proper risk knowledge. In this regard, success factors for technological capabilities highly depends on being in line with employee work practices (Taylor & Levitt, 2007), while they should not cause extra work and demand for personnel (Siebelink et al., 2021). That is why the lack of sufficient employees noted by interviewees can be seen as another challenge. Executing a beneficial RMM system requires sophisticated capabilities and enough skilled resources. Interviewees highly recommended it. Also, additional resources are required to apply the RMM approach and structurally work on it. Therefore, to make an efficient final decision about risk reports, the company needs to establish a specific department or a skilled team with proper risk knowledge and experience to implement and run such a controlling system (Ernst, 2002; Rodriguez-Segura et al., 2016). Some risk management maturity models in prior studies highlighted the **significance of organizational capabilities**, including 1. Risk-IT established by ISACA (2010) illustrated **tools and automation** aspect, and 2. RMM suggested by D. A. Hillson (1997), RMCMM by Yeo and Ren (2009), and RM3 by Zou et al. (2010), showed **the related resources in organizations to implement the risk maturity** as one of the main aspects of their models (Elmaallam & Kriouile, 2011; Heravi & Gholami, 2018; D. A. Hillson, 1997; Hoseini et al., 2019; Jia et al., 2013; Mu et al., 2014; Serpell et al., 2015).

5.8 Better supplier analysis

Analyzing the benefits of RMM implementation also concluded to analyze better supplier's risk over the supply chain distributions channels, which was highlighted by highly experienced interviewees with managerial positions in this field. Because control and assessing suppliers' risks from multiple diverse sources result in low risks of received information/materials from equipment suppliers. Such a maturity concept needs a comprehensive implementation in the organization and informing all the related parties. However, some key informants emphasized they do not know (lack of awareness) if the existing RM approach in their company applied for all kinds of suppliers across the organization/all projects. That is why the more maturity of processes in a project-based organization also causes the more development of the supply chain orientation of the organization to align its processes with project goals (Siebelink et al., 2021; Team, 2010). While to this date, the lack of an adequate measurement approach for risks over the complex network of equipment suppliers and partners causes decision-makers troubles

(Aven, 2016b; Heckmann, Comes, & Nickel, 2015). Overall, previous studies highlighted the **stakeholder** analysis as the main aspect of some risk management maturity models, including PRMM revealed by Martin Hopkinson (2011) and OGC proposed by the Office of Government Commerce (2007) (Elmaallam & Kriouile, 2011; Gladden, 2012; Heravi & Gholami, 2018; Hoseini et al., 2019; Jia et al., 2013; Mu et al., 2014; Serpell et al., 2015).

CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

The current study shed new light on those barriers that hinder the RMM execution and use. The barriers were concluded from the different departments representatives, which provided a broad organizational perspective on those improvements experienced by the risk decision-makers, mainly from the top management level down to the project management level in megaprojects in the aerospace industry. Although the results are valid in the mentioned context and were provided from valuable references (related scientific literature), they were impacted by several limitations, which must be considered. In addition, several opportunities and directions for future research were proposed as follows.

Further, the **added value** (or contribution) for this study is that the researcher tried to address the proposed gap in the literature. The relevant literature fails to explore the impact of implementing RM maturity models, particularly those in aerospace megaprojects. In other words, in the literature, mostly the significance of maturity models in megaprojects or the significance of maturity model for risk management is highly claimed by researchers. In contrast, the reason why the aerospace companies involved in megaprojects do not apply RMM existed as a gap in the literature. Numerous calls for future studies have been identified in the scientific literature to explore and identify different barriers to executing the risk management maturity models in megaprojects in the aerospace industry. This research contributes to this vital gap while responding to the highlighted ongoing calls.

First, the section on theoretical justification (in the introduction chapter) explains the importance of the thesis topic and the important value that it adds to the relevant scientific literature.

Second, the section on research contribution explains the existing literature gap and how this study contributes to this gap (i.e. Added value).

Third, the Venn diagram presented at the beginning of chapter two, literature, shows 1) risk management literature is a well-established and extensive knowledge area, and 2) the critical importance of the proposed gap that this research is addressing (i.e. Added value).

Finally, the current chapter presents the study conclusions, structured as follows: the first part (6.1) is the introduction. Further, the theoretical implications of the findings and managerial implications are investigated in sections 6.2 and 6.3. In this regard, while chapter one offers a review of the latest challenges, opportunities, and key players involved in megaprojects in Canadian aerospace, chapter two reviews the **scientific literature** extensively and in much more detail. Doing so enables the thesis to have **practical** and **theoretical justifications** (introduction chapter). More importantly, it will also enable the research to offer **theoretical** and **managerial implications** in the current chapter. Finally, section 6.4 illustrates the research limitations and suggested opportunities for future studies

6.2 Theoretical implications

The main aim of the theoretical implication section is to highlight which body of the relevant literature this research contributes to. After explaining the contribution of this research to the relevant body of the literature, i.e., risk management maturity and megaprojects literature, it would be helpful to highlight the contribution of each **aggregate dimension** (research results) to the **relevant literature** as well.

The existing study contributes to the growing debates in the **RMM** literature. It extends our understanding of the key challenges for assessing **RM** processes as **measured** by project **RMM**. While **RM** processes and the effectiveness of their implementations across different projects have been documented properly (Gladden, 2012; Heravi & Gholami, 2018; Mu et al., 2014; Serpell et al., 2015); insights into exploring the implementing **assessment** journey in risk management processes remain fragmented (Görög, 2016; Sanchez-Cazorla et al., 2016; Spalek, 2015). Moreover, exploring key challenges that risk managers in **assessing RM** processes face is overlooked (Heravi & Gholami, 2018; Serpell et al., 2015). This study explores these challenges in detail by answering the research question: What are the challenges and solutions that impact the implementation of risk management maturity models in megaprojects in the Canadian aerospace industry?

Prior literature has largely focused on the importance of **risk management** processes and the effectiveness of different RM standards whilst highlighting key differences and similarities at the same time (Sanchez-Cazorla et al., 2016; Yoon, Tamer, & Hastak, 2015). These include, but are not limited to, RM planning, risk identification, risk analysis and assessment, risk response, risk monitoring, and RM reporting (Jia et al., 2013; Project Management Institute, 2017a; Serpell et al., 2015). Different studies then highlighted that the general **effectiveness of RM** processes and their implementation are often **measured** by project **risk management maturity** (Heravi & Gholami, 2018). However, prior literature hardly discusses the challenges and potential opportunities that emerge for implementing the **assessment approach of risk management** processes (such as maturity models) (Serpell et al., 2015). Extant risk management literature assumes that the **effectiveness** and emerging challenges of **RM** processes can be **measured** and explored **after** implementing these processes (Gladden, 2012; Mu et al., 2014; Zou et al., 2010). This underlying perception has emerged from RM literature where successful projects are heavily based on experience-based evidence and knowledge of best practices, which are primarily gained from past projects (Görög, 2016). Despite the importance of learning from experience-based evidence (Görög, 2016; Serpell et al., 2015); **RM assessing** approaches like the **maturity** approach, require careful understanding of potential executing challenges **prior to the implementation** of assessment techniques, and according to the unique features and objectives of each RM process itself.

The extensive data collection and analysis, as a result of in-depth and semi-structured interviews performed in this project, also highlighted the diversity of requirements and objectives about the RMM implementation. Indeed, multiple challenges emerged about implementing these approaches, which require careful consideration prior to embarking on the assessment journey. These added multiple layers of complexity to the assessment of the RM process, particularly in megaprojects like aerospace. Nonetheless, these challenges if identified and explored appropriately and in advance, can also be viewed as opportunities, which increase the chances of successful implementing the assessment approaches of RM processes.

First, the assessment of RM processes is a comprehensive procedure that requires technical knowledge, clear requirements, and well-defined objectives. Doing so will enable project and risk managers to design and develop a systematic assessment model for the risk management process, which will prevent unforeseen circumstances from emerging and delaying project progress (Görög, 2016; D. A. Hillson, 1997). Notwithstanding the requirements of assessment models and the conditions of the risk management processes, assessment models should be implemented continuously and offer persistent evaluations (Khoshgoftar & Osman, 2009). Consequently, this will enable the assessment models for risk management processes to be aligned with the latest standards and successful measurements (Brookes et al., 2014). **Second**, the depth of the project design and planning process can add an extra layer of complication to assess risk management processes. Appropriate project design requires direct involvement and commitment of stakeholders to assure the safety and efficiency of the process (Rodriguez-Segura et al., 2016; H. Thamhain, 2013). Indeed, stakeholders' interests based on project design and specification can minimize the risk and facilitate the overall safety of the process (H. Thamhain, 2013). Furthermore, an efficient planning procedure can minimize risk and facilitate maintainability. This is of particular importance for risk management processes in megaprojects as it enables risk managers to anticipate potential and unprecedented risks and delays (Grant et al., 2006; Lehtiranta, 2014).

Third, considering the comprehensive requirements and activities involved in assessing the risk management processes, different members with various degrees of knowledge and expertise will be involved in the process. As a result, consistent communication across different members involved in the assessment of RM processes remains vital. In fact, project teams and clients involved in the process can utilize RM assessment solutions and smooth the effectiveness of the assessment model through constant communication and collaboration (D. A. Hillson, 1997). Indeed, collaboration across implementing RM assessment models has not only been applied in project risk management but across different themes within RM literature, including those for RM maturity models in megaprojects (Farrokh & Mansur, 2013; Jia et al., 2011). **Fourth**, managing evidence-based experience, particularly those gained from past projects, can avoid project delays, overhead costs, and risks of current projects. The significance of lessons, which were learned from the success and failure of past projects, widely known as Lesson Learned across industry experts and practitioners, can offer risk managers an advantage while designing and developing an assessment model for the risk management processes (Serpell et al., 2015; Siebelink et al., 2021). In that respect, RM processes are ongoing practices requiring substantial efforts to manage prior experiences and lessons learned from past projects (Serpell et al., 2015). Doing so will enable risk managers to identify the most appropriate techniques to implement and benefit from lessons learned in previous projects.

Fifth, the degree of knowledge and expertise can affect the success and failure of assessment models for the risk management processes. Project risk management is assessed by considering different knowledge areas in detail to make the assessment model more practical and easier to achieve (Spalek, 2015). In fact, the overall knowledge and expertise of an organization, including those of its employees, can facilitate the adoption of new processes, specific plans, and the latest standards (D. A. Hillson, 1997). Sixth, organizational capabilities and the extent to which firm resources can be dynamic utilize the implementing assessment models. Despite its short-term effect, organizational capabilities can also improve the overall success and effectiveness of the RM processes enabling the organization to meet new standard requirements in the long term (Khoshgoftar & Osman, 2009). However, proper risk management and adaptation of resources require identifying the most appropriate framework for the RM assessment (Heravi & Gholami, 2018; Yeo & Ren, 2009). **Seventh**, while the supply chain concept is thriving in the fast-growing environment of aerospace companies involved in megaprojects, which are facing a wide range of suppliers, employing a comprehensive RMM model, would help to perform a better analysis of supplier's risks. Because it significantly impacts receiving parts/materials/information with lower risk but with more quality and accuracy. The risk concept is addressed in all fields, including supply chain management (Aven, 2016b; Pournader, Kach, & Talluri, 2020) and the risk management in supply chain area has quite recently developed from an emerging topic into a growing research field (Aven, 2016b; Fahimnia, Tang, Davarzani, & Sarkis, 2015; Pournader et al., 2020). However, supply chain risk management suffers from the lack of a proper and precise measurement for RM processes, which follows the characteristics of a modern supply chain with more solid and dynamic networks (Aven, 2016b; Heckmann et al., 2015; Pournader et al., 2020). Being relatively mature in a project environment can improve the supply chain orientation of organizations to align their demands and their suppliers/partners with their maturity processes in order to reach project goals and expectations (Siebelink et al., 2021; Team, 2010).

To summarize, the below table (Table 6.1) demonstrates the summary of **theoretical relevance** to the seven aggregate dimensions. These offer **new insight** into the **related literature**. While they may be known as a term in megaprojects, RM systems, or maturity models, there is still limited understanding of the barriers to implementing the **RMM model** in megaprojects in the aerospace industry.

Table 5.1 Summary of theoretical relevance to the seven aggregate dimensions

Research results		Theoretical Relevance
1- Systematic assessment model for RM processes	➡	(Albrecht & Spang, 2014; Brookes et al., 2014; D. A. Hillson, 1997; Gladden, 2012; Görög, 2016; Heravi & Gholami, 2018; Jia et al., 2013; Khoshgoftar & Osman, 2009; Mu et al., 2014; Sanchez-Cazorla et al., 2016; Serpell et al., 2015; Siebelink et al., 2021; Spalek, 2014; Team, 2010; Yeo & Ren, 2009; Yoon et al., 2015; Zou et al., 2010)
2- Safety depth of project design and planning	➡	(D. A. Hillson, 1997; Farrokh & Mansur, 2013; Görög, 2016; Grant et al., 2006; Lehtiranta, 2014; H. Thamhain, 2013; Heravi & Gholami, 2018; Jia et al., 2013; Khoshgoftar & Osman, 2009; Rodriguez-Segura et al., 2016; Serpell et al., 2015; Yeo & Ren, 2009)
3- Level of communication	➡	(Brookes et al., 2014; D. A. Hillson, 1997; Farrokh & Mansur, 2013; Flyvbjerg, 2014; Görög, 2016; Holt et al., 2007; Jia et al., 2011; Rodriguez-Segura et al., 2016; Siebelink et al., 2021; Zhai et al., 2009)
4- Lessons learned	➡	(D. A. Hillson, 1997; de Carvalho et al., 2015; Serpell et al., 2015; Siebelink et al., 2021)
5- Degree of knowledge and expertise	➡	(D. A. Hillson, 1997; Flyvbjerg, 2014; Heravi & Gholami, 2018; Jia et al., 2011; Kardes et al., 2013; Mullaly, 2014; Sanchez-Cazorla et al., 2016; Serpell et al., 2015; Spalek, 2015)
6- Organizational Capability	➡	(Ernst, 2002; Heravi & Gholami, 2018; Khoshgoftar & Osman, 2009; Rodriguez-Segura et al., 2016; Siebelink et al., 2021; Taylor & Levitt, 2007; Yeo & Ren, 2009)
7- Supplier analysis	➡	(Aven, 2016b; Fahimnia et al., 2015; Heckmann et al., 2015; Pournader et al., 2020; Siebelink et al., 2021; Team, 2010)

6.3 Managerial implications

As shown in chapter one (research context), both global and Canadian organizations in the aerospace industry have recently faced a wide variety of challenges. To address these problems, this study aims to understand the improvements and requirements further to implement the RMM system by considering industrial statistical reports (which allowed a broad view of current barriers) and then comparing it with the previous literature and current study results. The result of the current study has general recommendations for managers.

First, there is a need to understand the value of implementing the RMM system in practice, particularly in aerospace companies. This study provides insights on where to focus RMM implementation measures and how to improve the current state of RM approach to RM maturity at aerospace companies involved in megaprojects in Canada. Prior studies have focused on comparing different RMM models, providing an overview of maturity models or developing a new RMM model, regardless of the impact of RMM executing specifically in the megaprojects in the aerospace industry. However, they failed to identify certain requirements, including challenges and solutions, for implementing such models and the barriers that prevent aerospace organizations from applying them. Overall, the type of barriers that firms in the aerospace industry may face and how to remove the obstructions in this path remain unknown. Unlike prior studies, the current research 1) suggests an in-depth understanding of how these barriers can manifest themselves across aerospace companies involved in megaprojects and 2) determines the actions to overcome these barriers.

Second, practitioners can utilize the result of this study to obtain practical insights and the actuality of the RMM approach whilst reflecting on how RMM execution might be beneficial in their field. As a result, this research provides some valuable understanding that managers can use to remove or change these specific barriers.

Third, besides collecting data from different aerospace companies with megaprojects, the researcher has conducted chiefly interviews with professionals in the field who experienced both specialist and manager positions (now or before) to gain more insights into practical barriers and perceptions from the industry. These insights focus on specific issues, which guide aerospace decision-makers in solving them. Interviewees postulated that before embarking on RMM implementation, companies must first provide their readiness to implement such transition (change RM approach to RMM). Doing so will allow them to understand and make foundations a prerequisite for the successful implementation of RMM. Therefore, the results of data analysis highlighted seven main criteria (Aggregate Dimensions) as barriers to RMM implementation and covered the interviewees' perceptions. Indeed, interviewees reported that they were more inclined if their firms executed one systematic assessment model for RM processes, which covered all the related risk regulations and platforms proposed by other parties to them per project. Implementing a comprehensive assessment approach for RM in an aerospace company leads the project to reach one of its crucial goals: aircraft safety. Moreover, interviewees emphasized basic needs to implement the RMM, including increasing the degree of risk knowledge, proper communications with stakeholders, applying lessons learned and executing a robust technological infrastructure like AI as an organizational capability.

Fourth, to improve the current state of controlling the RM processes in aerospace companies in Canada, the decision-makers need to introduce congruent and holistic processes for risk data collection, and unification and diffusion of risk knowledge within the industry. Through these processes, they will ensure that their aerospace companies can collect and analyze risk data from diverse sources and multiple stakeholders, including equipment suppliers, partners, etc.

Fifth, since managers, as key decision-makers, play a crucial role in changing/improving the organizational control structures about RM, they need to manage, communicate, and support people in implementing the RMM system. In other words, managers must ensure that the everyday RM operations reflect their overall RM control strategy. Appropriate risk identification processes could help to establish mitigation strategies that reduce the possible adverse effect of these risks for megaproject management (Sanchez-Cazorla et al., 2016). These controlling processes can also be embedded and continuously improved to contribute to a competitive advantage in the market.

Sixth, managers need to relate the RM outcomes of the company to the key regulators of the RM approach. The existing interrelationships between the mentioned approaches could make it possible to formulate a more purposeful and effective controlling system for RM processes.

Seventh, the maturity models for assessing RM could support the aerospace companies with megaprojects in identifying those phases of their project cycle that have primary importance from the point of view of their further RM development.

Finally, the key outcomes of this study, alongside its main managerial implications, were compared to key business reports created by industrial and governmental bodies. Table 6.2

clearly illustrates that the seven aggregate dimensions from the data analysis, were also aligned with industry challenges and visions mentioned in chapter one. For instance, the perception of creating a high-tech platform for RM controlling and the significance of risk management was emphasized in the current research result and empirical studies in chapter one.

Table 5.2 Summary of comparison between the results of this research and common practices from the established business reports

Research results		**Aerospace Practical Challenges**	
		Global	**Canada**
1- Systematic assessment model for RM processes	→	(Airbus, 2019; Raconteur-1, 2017, 2018; Raconteur-2, 2018; Raconteur, 2019)	(Aerospace Review by the Government of Canada, 2012; AIAC-1, 2015; AIAC, 2019; Bombardier, 2019)
2- Safety depth of project design and planning	→	(Raconteur-1, 2018)	(AERO, 2018; Aerospace Review by the Government of Canada, 2012; AIAC, 2018; Investincanada-AIAC, 2018)
3- Level of communication	→	(Raconteur-1, 2017; Raconteur, 2016)	(AERO, 2018; Aerospace Review by the Government of Canada, 2012; AIAC, 2018)
4- Lessons learned	→	(Boeing, 2021)	(Aerospace Review by the Government of Canada, 2012)
5- Degree of knowledge and expertise	→	(Raconteur-1, 2017; Raconteur-2, 2018; Raconteur-3, 2018; Raconteur, 2015, 2019)	(Aerospace Review by the Government of Canada, 2012)
6- Organizational Capability	→	(Raconteur-1, 2017; Raconteur-2, 2017; Raconteur, 2019)	(AERO, 2018; Aerospace Review by the Government of Canada, 2012; AIAC, 2018; CanadaParliament, 2013; McKinsey&Company, 2018)
7- Supplier analysis	→	(Boeing, 2021; Deloitte, 2020, 2021)	(AIAC, 2018)

6.4 Research limitation and recommendation for future study

First, identifying the most suitable individuals, particularly those at the managerial level with extensive industry experience, proved to be crucial to this study. Such identification needs a broader network and close connections. As a result, future studies can detect valid databases as a bank of companies in different industries to approach and connect with.

The second was senior managers' understanding of the latest development of the field and its extant literature, particularly those in megaprojects in aerospace companies. Although the researcher highly appreciated the interviewees' open and critical attitudes, their perspectives were limited to the managerial level. As a result, conducting interviews with employees other than managers could help to generate proper suggestions for implementing RMM. Also, these kinds of positions are more available to reach. Many respondents from the same companies, mostly junior level of the respondent, may not provide them with the whole visibility at the megaproject level. Thus, future studies can recruit interviewees from different organizational levels, not just those of senior managers.

Given the similarities of RMM practices across aerospace and construction industries as both are involved in megaprojects, future research could explore barriers to implementing RMM for **megaprojects** in the **constructions** companies. Further, prior literature also highlighted the significance of RM performance in **insurance** companies, which can be determined by future research through exploring the challenges of implementing RMM in such companies.

Future research can broaden the context of this study and benefit from additional statistical evidence by employing larger samples representing the vast diversity of organizations, disciplines, and country-specific conditions in the aerospace industry. As quantitative validation would add significant power to these findings, it is recommended that future research should apply a mix of qualitative and quantitative techniques as well.

This study identified and classified its results based on theoretical evidence and empirical perspectives. Future research can provide more comprehensive insights to develop **actionable guidance** on how to resolve the barriers presented in this study.

Finally, current research highlighted barriers in controlling the risk management within the aerospace industry from 2010 onwards, plus what is expected by the government as an aerospace vision. Future research can leverage these findings in investigating the future progress of implementing assessment systems for RM and identifying new barriers that may arise. For instance, the notion of integration between business partners across all projects in aerospace companies can be further studied. The current study results can form a foundation on which a shared understanding of RMM implication barriers can be built. It is hoped that the current study can inspire future work on developing precise methods for adopting and implementing the RMM system.

APPENDIX I

2019 GLOBAL A&D INDUSTRY OUTLOOK

Country/region	A&D industry trends and outlook
China	• Over the next 20 years, China could require 7,690 new commercial aircraft worth US$1.2 trillion.[11] • The country is the second-largest defense-spending nation after the United States;[12] however, China's military expenditure to GDP percentage is much lower than that of the United States. • China's 2018 defense budget grew 8.1 percent year over year to US$175 billion, which is the largest increase in the past three years.[13] • The country's defense expenditure is projected to grow in the range of 9–10 percent in the near future.[14]
France	• France plans to boost its defense spending by 40 percent over the next six years as it aims to meet the NATO target of "2 percent of GDP" spent on defense by 2025.[15] • The defense ministry is targeting to increase defense spending of approximately US$2 billion per year between 2019–22 and US$3.5 billion each year during the 2023–25 period.[16] • The 2019 defense budget is expected to be around US$42.2 billion, up 5 percent year over year.[17] • Military spending in France is projected to increase by 5 percent per year until 2022.[18]
India	• By 2025, India is expected to become the "third largest" aviation market and supply about 478 million passengers by 2036.[19] • There could be a demand for more than 2,000 new aircraft in India over the next two decades, which would be dominated by single-aisle aircraft.[20] • The 2018–19 defense budget for the country stood at US$43.8 billion, a 7.7 percent increase from the 2017–18 budget.[21]
Japan	• Japan's passenger traffic growth over the next 20 years is expected to be sluggish at about 3.2 percent, much below the Asia Pacific passenger growth of 5.3 percent.[22] • The country's domestic market is dominated by two major Japanese airlines, but their market share has decreased over the past decade.[23] • However, the recent surge in low-cost carriers (LCCs) is likely to drive commercial aircraft demand in the future.[24] • Japanese airlines are primarily aiming to increase traffic from the high-growth Asia Pacific region by collaboration with other airlines.[25] • Japan's defense budget for 2018–19 was up by 2.1 percent to US$47.6 billion, marking an all-time high and the seventh straight annual increase; however, it remained below 1 percent of GDP.[26]
Middle East	• Over the 2018–37 period, passenger traffic in the Middle East is forecast to grow at 5.2 percent, creating demand for 2,990 new aircraft valued at US$660 billion.[27] • In the Middle East, wide-body aircraft are likely to comprise more than 40 percent of the total aircraft demand over the next two decades, as the region primarily accounts for high-volume, ultra-long-haul flights.[28] • Seven out of the top ten countries with the highest military expenditure as a percentage of GDP are in the Middle East: Oman, Saudi Arabia, Kuwait, Jordan, Israel, Lebanon, and Bahrain.[29] • Though the pace of growth in defense spending by the two key countries in terms of defense expenditure in the region—the UAE and Saudi Arabia—has slowed, their defense expenditure is significant, and the region is expected to see mid-single-digit growth annually over the next decade.
United Kingdom	• The United Kingdom's defense budget of about US$52 billion (£40 billion) is near 2 percent of GDP.[30] • This budget could increase as a recent defense committee report recommended increasing the budget to 3 percent of GDP or US$78 billion (£60 billion) to strengthen the country's armed forces, including anti-submarine warfare to counter possible threats from Russia.[31] • As Brexit nears, there is uncertainty around its impact on the UK A&D industry—it may lead to disruption in supply chains and create new trade barriers as the country would renegotiate trade agreements with the European Union and other major trading nations.

Figure-A I-1 2019 global A&D industry outlook

APPENDIX II

INFORMATION SHEET

Le génie pour l'industrie

Research project Title:	Exploring the challenges of implementing risk management maturity models for megaprojects: a study of the aerospace industry in Canada
Lead Researcher:	Professor Yvan Beauregard (dissertation superviser), Département de Génie Mécanique
Student:	Haniyeh Homayounfard, MSc. in Engineering Project Management, Département de Génie Mécanique

The inherent complexity of Risk Management (RM) processes in **megaprojects** across sectors can be a major challenge with potential to result in project failure and impairment. There is also a need for measurable and effective progressive approaches to RM processes, which deal with unique characteristics of **complex and megaprojects**. In particular, lack of proper attention to the assessment approach of all RM processes, particularly for megaprojects, remains a vital issue that has yet to be addressed within the extant literature.

Therefore, this research aims to explore the challenges of implementing the RM maturity scenarios, particularly for organizations involved in megaprojects in the Canadian aerospace industry. It looks into identifying key barriers and potential solutions that need to be considered for the effective execution of RM maturity in aerospace megaprojects.

The current project has two main objectives:

- To understand and explore the effectiveness of RMM models in megaprojects in the Canadian aerospace industry.
- To identify challenges and solutions for implementing RMM models in megaprojects in the Canadian aerospace industry.

Participation

You are invited to participate in this research project. After you read this document and agree to participate in the project, we will ask you to attend an interview with a member of the research team, **or** answer the interview questions that will be sent by email.

You will be asked questions about exploring and identifying a set of key techniques, which are widely used within the implementing of risk management maturity model in megaproject. The interview (if needed) will take approximately 45-60 minutes.

The interview (if needed) will be audiotape for transcription purposes upon participant's approval.

Your participation is voluntary, meaning you may decline if you wish. You can cease participating at any time during the interview, **or** answering the questions without interviewing, by informing the member of the research team. You will not have to provide any reason to justify your decision. After the interview, you can still withdraw from the project as long as the researcher has the match key that links your identity to your answers.

Privacy
The data collected for this project will be anonymous and confidential to the extent permitted by law. This information will be kept by the lead researcher on the project at ETS (École de Technologie Supérieure) secure server for 6 months. The data will only be used to advance knowledge in the field.
The data may be published in reports, articles, be the subject of scientific discussion or used for teaching purposes. However, it will not be possible to identify you in any of these cases.

Ethical Considerations
The ÉTS Research Ethics Committee has authorized this research project. If you have questions about your rights as a participant in the research project, please contact the coordinator of the Research Ethics Committee at **514- 396-8800 extension 7807**.

Contact person
If you have questions about the project or your role in it, please contact:
Homayounfard, Haniyeh, Researcher, haniyeh.homayounfard.1@ens.etsmtl.ca

APPENDIX III

INTERVIEW QUESTIONS

Section 1: Interview Information

1. Interviewee information:
Full name:
Job title:
Company name or aerospace megaproject name:
Email Address:
Date:

2. Interview type:
Video call: YES__ NO__
Audio Cal: YES__ NO__

3. Questions notes:
Note1: Prior to answering the below questions, please double check the `**information sheet**` (email attachment) which includes the brief description of project targets and interview ethical consideration
Note2: Please answer each question in response to **your aerospace firm** or **aerospace megaproject** whether you are currently involved in or not.

Section 2: Interview Questions

Question1: What are the key features of risk management processes and what are the principles of effective application of risk management in **your** aerospace firm or projects?
Your response:

Question2: What are the successful assessment approachs/models for risk management in **your** aerospace firm or projects? (e.g., 1- a model to measure risk management for **all** organizational departments or **all** project processes including a risk management maturity model, or national and international standards such as ISO, 2- a model to measure risk management for **some** of the organizational departments or project processes, for instance many project-based companies have developed their own policies, procedures, and management tools for dealing with risks, or 3- other specific assessment approaches for risk management in your point of view).
Your response:

Question3: Does **your** firm apply an assessment approach/model for risk management based on any particular guideline (what is the guideline and why so)?
Your response:

Question4: How often does **your** firm implement an assessment approach/model use for risk management? Do you implement the assessment model in **all** areas of **your** aerospace firm or projects? (e.g., all organizational departments or all project processes).
Your response:

Question5: Do you think **your** firm can benefit from **maturity** assessment models for risk management processes, which assess **all** areas of **your** aerospace firm or projects (Why so)? (e.g., all organizational departments or all project processes).
Your response:

Question6: What are the key **challenges** of implementing **maturity** assessment model for risk management in **your** aerospace firm or projects?
Your response:

Question7: What are the **benefits** of **maturity** assessment model for risk management in **your** aerospace firm or projects? If you haven't used this model before, what are the benefits to aerospace **firms or projects overall**?
Your response:

Question8: Do you think the application of **maturity** assessment model for risk management can be improved in **your** aerospace firm or projects? If so, why or how?
Your response:

APPENDIX IV

AUTHORIZATION TO PROCEED BY RESEARCH ETHICS COMMITTEE OF ETS UNIVERSITY

ÉTS
Le génie pour l'industrie

Comité d'éthique de la recherche
École de technologie supérieure

27 février 2020

Titre du projet :	**Modeling the risk management maturity (RM2) assessment**
Responsable ÉTS :	**Yvan Beauregard, Professeur au département de génie mécanique**
Étudiant :	**Haniyeh Homayounfard, Étudiante à la maîtrise**
Référence :	**H20200204** — *Demande :* **Nouvelle**

AUTORISATION DE PROCÉDER

Monsieur Beauregard,

Le projet de recherche mentionné en rubrique a été soumis le 26 février 2020 pour évaluation par le Comité d'éthique de la recherche de l'ÉTS (CÉR). La présente lettre est pour vous informer que nous avons procédé à l'évaluation du dossier en comité délégué.

Liste des documents soumis :

- Formulaire de présentation allégé
- Questionnaire d'entrevue

Le dossier présenté répond aux exigences éthiques établies par le CÉR de l'ÉTS pour les projets de recherche évalués selon la procédure d'autorisation. J'ai donc le plaisir de vous informer que votre projet a été autorisé et que vous pouvez procéder au recrutement des participants.

En acceptant cette autorisation de procéder, vous vous engagez à :

- Observer une conduite responsable tout au long de vos travaux de recherche;
- Informer dès que possible le CÉR de tout changement apporté au projet;
- Respecter les conditions de confidentialité et de protection des renseignements et des données, telles qu'énoncées dans le dossier et validés par le CÉR.

Veuillez agréer, Monsieur Beauregard, l'expression de mes sentiments les meilleurs.

Mathias Glaus, Ing., Ph.D.
Président, Comité d'éthique de la recherche

cc : Charles Despins, Doyen de la recherche par intérim
Laurence Marck, Coordonnatrice du CÉR

p.1/1

Figure-A IV-1 Authorization to proceed by Research Ethics Committee

APPENDIX V

SUMMARY OF AGGREGATE DIMENSIONS, SECOND-ORDER THEMES, FIRST-ORDER CONCEPTS, DIRECT QUOTES, AND KEY INFORMANTS' IDS

Table-A V-1 Summary of Aggregate Dimensions, second-order themes, first-order concepts, direct quotes, and KIs' IDs

Aggregate Dimensions	Second-order themes	First-order concepts	Direct quotes	KI
1. Systematic assessment model for RM processes	1. Diversity of RM approaches hinder standardization	1. Unified RM approaches and integrated regulatory frameworks are more effective	*"It's better to analyze, execute; risks and benefit from integration of regulatory frameworks"*	16
		2. Adopted standard approaches for RM are wide and comprehensive	*"For megaprojects, in Aerospace or the other megaprojects, we lack a user-friendly risk management method … commercially and technically"*	10
	2. Impact of clear and justified overview for RM processes	3. Risk processes require a systematic and certified management approach	*"Everywhere I worked, I never saw any systematic approach to assess risk processes, so they don't follow the processes"*	15
		4. Key employees should be motivated to use and adopt risk processes	*"For risk management generally, engineer hates to hear about it, that's how it's always perceive within the organization"*	15
		5. Value of further investment in RM should be justified and clarified	*"Organizations do not trace back the extra cost to the risk management that is the weakness"*	10
	3. Clarity of requirements and definitions	6. Current risk platforms do not fully respond to and reflect RMM needs	*"Existing risk platforms only meet part of the requirements of maturity models, according to internal systems"*	11
		7. Risk regulations should be updated internally and per project in line with proper RM processes	*"By regularly reviewing and updating the risk processes, we ensure to have meaningful risk management assessment"*	2
		8. Controlling approaches should be treated as assessment performed by government/internal assessors	*"They can find out how in line their current risk management practices are with the risk maturity indicators. Also help to assess the current effectiveness of a group or a project and supports figuring out what are our options".*	1
		9. Implementation of RMM approach requires proper time and decision-making	*"One of the challenges in big programs is that there are so many layers of management, so decision-making is really hard and multi-dimensional"*	12
	4. Appropriate risk maturity culture	10. RM processes can improve with clear processes, measurements, execution, and monitoring	*"Defining the objective of the risk assessment by looking at important factors to measure the risks, can provide a platform where risks are registered, tracked, updated, and concluded"*	2
		11. Structured risk culture in organizations is more effective than undifferentiated, generic, and preliminary RM approach	*"Companies know they need a specific place for risk. So, establishment of risk based culture is needed. Also, there is lack of enough related knowledge".*	11

Aggregate Dimensions	Second-order themes	First-order concepts	Direct quotes	KI
2. Safety depth of project design and planning	5. Risk mitigation approach for safety	12. Perform and follow up on the risk mitigation plan	*"Root Cause Failure Analysis is needed to see and solve the risk that was not managed properly. Better risk mitigation plan is needed in that respect"*	10
		13. Safety risks require proper materialization, reliability improvement, and maintainability	*"Effective application of RMM cause reliability improvement, quality increase availability, maintainability, and increase flight reliability"*	11
		14. RM won't get overlooked	*"Risk management is very important and very often overlooked and RMM helps everybody ways in the risk identification"*	10
	6. Stakeholder involvement and better project commitments	15. Efficient design and safety factors result in stakeholder satisfaction	*"RMM helps Customer satisfaction improvement and decrease client order delays"*	11
		16. Gathering stakeholder needs helps to identify safety risks requirements	*"Better identify customers; establish vision, strategy; gather customer requirements; market feedback analysis"*	16
		17. Lack of detailed RM approach affects project investigator commitment	*"RMM causes minimize wasting resources, meeting deadlines, keep the competency in the market and build trust of clients"*	4
	7. Efficiency of project planning and performance	18. Avoid project over cost associated with risks	*"Some of RMM benefits for example are to avoid project over costing, project being delayed, technical roadblocks"*	2
		19. RMM facilitates on-target and in-line project risk processes	*"Some of RMM benefits I believe are the fact that the company would benefit from knowing where they stand in the risk management planning spectrum"*.	5
		20. Project validation and effective decision-making reduce unofficial judgement	*"Increase safety (Safety rise), Quality increase and Reputational of benefits are effective and essential"*	11
		21. Risk analysis helps to identify cause of the deviation and technical problems	*"RM systems help to moderate the risk by using all the potential deviation parts in house. Then, we will ask all the customers to stop using the parts"*	3
3. Level of communication	8. Consistent communication among different stakeholders	22. Inconsistency impacts collaboration among different functions	*"We need RM assessment systems across all projects, because it facilitates projects integration across various business units, partners, or product lines"*	16
		23. Lack of communication between managers and employees affects RM processes	*"In terms of the communications, one way is that the manager of that department, communicate with my top manager to how apply risk processes. Right now, the risk management team is very small with limited activities"*	12
		24. Clients and project teams require more communication for risk solutions	*"Stakeholders take ownership, they look for solution, help and communication to become part of the risk solutions"*	10
	9. Coordination among RM regulations	25. Different RM regulations require consistency and communication	*"One challenge of using RM approach is consistency of using risk management toolkits by employees in different department"*	16
		26. Making risk users align with a comprehensive RMM approach	*"Assessment approach should include all departments as sometimes lack of risk management in one department will affect others massively"*	10

Aggregate Dimensions	Second-order themes	First-order concepts	Direct quotes	KI
4. Lessons learned	10. Prior experience and lessons learned	27. Lessons learned avoid project delays and overhead costs	*"If you can benefit from lessons learned, whether within your company or not, then definitely it's going to help to avoid a lot of problem like having delay in the program or too much cost at the end and so far"*	15
		28. Lessons learned from previous projects reduce failure risks of current projects	*"Sometimes it happens that we do the same mistakes and we're still facing the same level of risks in this project, and this project and all time"*	12
		29. Current state of RM processes should be compared with previous ones	*"Learning from each and previous projects, there are going to be some identified and limited number of known risks that need to be managed"*	10
	11. Managing experience from past project failures	30. Update lessons learned associated with risks internally	*"Updating RM regulations is not a frequent process based on the specific periods or systematic assessing approach. It is an external decision proposed by the government to companies"*	11
		31. Risk factors affecting previous projects failures should be systematically managed and used	*"The part of the risk management I think that is important is that if you hold post-mortem meetings and you join conclusion out of them, you can apply to the future programs"*	15
5. Degree of knowledge and expertise	12. RMM knowledge development	32. Aligning RM approaches with maturity system require new training	*"One of the challenges of current risk approach in my company is that we have to make risk reports with no specific procedure for them"*	1
		33. Existing risk knowledge is limited for a maturity system	*"There isn't any assessment system for risk processes internally. The recycle approach is a wide approach that risk management is one of its steps"*	11
		34. lack of educated risk experts	*"For improvement, I think people must be certified and get educated"*	15
	13. Impact of human failures	35. Poor technical risk support and inappropriate internal enablers impact key decision-makers	*"Knowing the nature of the project, there is no right person to decide, don't know how to assess"*	1
		36. Insufficient risk knowledge and proactive attitude result in failure	*"As employee have not enough knowledge about the Risk, at the end, all their faults in identifying risk, will be seen in the flight test and its failure"*	14
	14. Change management acceptance	37. Implementation of new design requires employee adoption of risk changes	*"When we have design changed it should have sub schedule with new risks and that schedule will be combined with aircraft scheduled delivery"*	12
		38. lack of employees' interest delays the required changes in RM system	*"With regards to the change management, if you have enough resource, you won't see much of push back from your employees for implementation new RM system"*	3

Aggregate Dimensions	Second-order themes	First-order concepts	Direct quotes	KI
6. Organizational capability	15. Technological capabilities	39. Implementing a comprehensive maturity model requires sophisticated capabilities	*"Provide a platform where risks are registered, tracked, updated, and concluded to allocate times and update all the risks information"*	2
		40. Application of Artificial Intelligence results in proper resource management	*"I believe new digital technologies such as AI and machine learning can be utilized to enhance conventional risk management models"*	16
	16. Role of risk department/ risk skilled team	41. Shortage of skilled employees impacts efficiency and productivity	*"The challenge is Lack of knowledge and vison as well as limited number of real experts in this field"*	7
		42. Proper team allocation with specialized knowledge and skills affect success	*"Because our risk outlet didn't have any external place, we go to TC to see if we can sell our design based on its risk or not. Which means if TC accept this design for certification or not"*	14
7. Supplier analysis	17. Control and assess supplier risks	43. Efficient RM assessment	*"The key principles of RM is to apply the risk management appraisal to all the involved parties, including; human resources, partners, tools, parts and materials and process, qualification tests, procedures, etc."*	7
		44. Lack of awareness about the existence of an RM approach applied for all kinds of suppliers across the company/all projects	*"We have a customized RM platform for the operation part. I work in the operation side of the business; I'm not working in the engineering side. We have many projects now, but I don't know what risk approach or risk assessment activity they have. What I'm telling you right now is based on the risk of the operation side"*	3
	18. Significant of supply chain	45. Outsourcing parts/material risks	*"As I told you, for the operation part, there is a platform for risk management in my company. We also have outsourced partners, including some partners from out of the country. Because they use a cheaper resource, they put some reports together, sending us like every morning 4 am Canadian time to all the supply chain team such as the management level, executive level and so on"*	3
		46. Risks of data entry received from suppliers	*"In aerospace megaprojects, the important thing for the project contactor before starting the design of a product for an aircraft project is that the contractor first asks for high efficiency and safety factors then focuses on low cost for sure. For that, we need definitely do the risk management processes as accurately as possible. So the accuracy and sensitivity of information required for simulation and designing a product have an important impact on designing. That means more accurate receiving data, more accurate managing risk with high efficiency. So when we didn't receive the required data, we had to mention it in our monthly report to increase the system efficiency".*	6

LIST OF BIBLIOGRAPHICAL REFERENCES

Acharyya, M. (2008). In measuring the benefits of enterprise risk management in insurance: An integration of economic value added and balanced score card approaches. *ERM Monograph*, 1–25.

AERO. (2012). *Profile of the Aerospace industry*. Canada. Retrieved from https://www.aeromontreal.ca

AERO. (2016). *Seizing new heights, 10th anniversary, activity report*. Canada. Retrieved from https://www.aeromontreal.ca

AERO. (2017). *Workforce and the next generation of talents key growth drivers of the aerospace industry, activity report*. Retrieved from https://www.aeromontreal.ca

AERO. (2018). *Aero Montreal: industry 4.0 skill sets for aerospace*. Retrieved from https://www.aeromontreal.ca

AERO. (2019). *Sustainable mobility at the heart of aerospace innovation, activity*. Retrieved from https://www.aeromontreal.ca

AERO. (2020). *Aero Montreal: Québec's aerospace cluster*. Retrieved from https://www.aeromontreal.ca

Aerospace Review by the Government of Canada. (2012). *Beyond the Horizon: Canada's Interests and Future in AEROSPACE*. Retrieved from http://aerospacereview.ca/eic/site/060.nsf/eng/home

AIAC-1. (2015). *Guide to Canada's aerospace industry, 2015-2016*. Retrieved from https://aiac.ca

AIAC-2. (2015). *Aerospace*. Retrieved from https://aiac.ca

AIAC. (2014). *Leadership in Aerospace*. Retrieved from https://aiac.ca

AIAC. (2018). *Charting a new course, Canada as a global aerospace champion, vision 2025*. Retrieved from https://aiac.ca

AIAC. (2019). *Beyond our imagination: 2019-2020 guide to Canada's aerospace industry"*. Retrieved from https://aiac.ca/guide

AIAC. (2021). *2021 GUIDE TO CANADA'S AEROSPACE INDUSTRY*. Retrieved from https://aiac.ca/guide

Airbus. (2012). *Global market forecast 2012-2030*. Retrieved from https://www.airbus.com

Airbus. (2018). *Airbus aircraft 2018 average list prices*. Retrieved from https://www.airbus.com

Airbus. (2019). *Airbus Annual Report 2019*. Retrieved from https://www.airbus.com

Albrecht, J. C., & Spang, K. (2014). Linking the benefits of project management maturity to project complexity: Insights from a multiple case study. *International Journal of Managing Projects in Business*.

Albrecht, J. C., & Spang, K. (2016). Disassembling and reassembling project management maturity. *Project Management Journal*, *47*(5), 18–35.

Andersen, E. S., & Jessen, S. A. (2003). Project maturity in organisations. *International Journal of Project Management*, *21*(6), 457–461.

Antunes, P., Carreira, P., & da Silva, M. M. (2014). Towards an energy management maturity model. *Energy Policy*, *73*, 803–814.

Atkinson, R., Crawford, L., & Ward, S. (2006). Fundamental uncertainties in projects and the scope of project management. *International Journal of Project Management*, *24*(8), 687–698.

Attewell, R. G. (2012). Statistics: an essential tool for model citizens. In *Uncertainty and Risk* (pp. 99–108). Routledge.

Aven, T. (2016a). Ignoring scenarios in risk assessments: Understanding the issue and improving current practice. *Reliability Engineering & System Safety*, *145*, 215–220.

Aven, T. (2016b). Risk assessment and risk management: Review of recent advances on their foundation. *European Journal of Operational Research*, *253*(1), 1–13.

Baccarini, D. (1996). The concept of project complexity—a review. *International Journal of Project Management*, *14*(4), 201–204.

Becker, J., Niehaves, B., Poeppelbuss, J., & Simons, A. (2010). *Maturity models in IS research*.

Besner, C., & Hobbs, B. (2008). Discriminating contexts and project management best practices on innovative and noninnovative projects. *Project Management Journal*, *39*(1_suppl), S123–S134.

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

Bing, L., Akintoye, A., Edwards, P. J., & Hardcastle, C. (2005). The allocation of risk in PPP/PFI construction projects in the UK. *International Journal of Project Management*, *23*(1), 25–35.

Bishel, A., & Hermans, A. (2020). Aerospace and Defense: Taking Flight. *PMI, PM Network, 34(1), 33.*

Boeing. (2020). *Commercial market outlook 2020–2039*. Retrieved from https://www.boeing.com

Boeing. (2021). *The Boeing company 2020 annual report: global aerospace resilience and resolve*. Retrieved from https://www.boeing.com

Bombardier. (2019). *ONWARD, 2019 Activity Report*. Retrieved from https://www.bombardier.com

Bombardier. (2021). *Bombardier reports full year 2020 financial results, provides 2021 guidance and outlines actions to drive profitability and productivity*. Retrieved from https://www.bombardier.com

Brookes, N., Butler, M., Dey, P., & Clark, R. (2014). The use of maturity models in improving project management performance: An empirical investigation. *International Journal of Managing Projects in Business*.

Brown, M. E., & Gioia, D. A. (2002). Making things click: Distributive leadership in an online division of an offline organization. *The Leadership Quarterly*, *13*(4), 397–419.

Bryant, A., & Charmaz, K. (2007). *The Sage handbook of grounded theory*. Sage.

CanadaParliament. (2013). *The Canadian Aerospace Industry and the Role of the Federal Government*. Retrieved from https://publications.gc.ca/

Choudhry, R. M., & Iqbal, K. (2013). Identification of risk management system in construction industry in Pakistan. *Journal of Management in Engineering*, *29*(1), 42–49.

Clegg, S. R., Pitsis, T. S., Rura-Polley, T., & Marosszeky, M. (2002). Governmentality matters: designing an alliance culture of inter-organizational collaboration for managing projects. *Organization Studies*, *23*(3), 317–337.

Cooke-Davies, T. J., & Arzymanow, A. (2003). The maturity of project management in different industries: An investigation into variations between project management models. *International Journal of Project Management*, *21*(6), 471–478.

Cooke-Davies, T. J., & FAPM, F. (2004). Measurement of organizational maturity. *Innovations-Project Management Research*, 211–228.

Cooper, D. F., Grey, S., Raymond, G., & Walker, P. (2021). *Project risk management guidelines: Managing risk in large projects and complex procurements*. John Wiley & Sons, Inc.

Corbin, J. M., & Strauss, A. (1990). Grounded theory research: Procedures, canons, and evaluative criteria. *Qualitative Sociology*, *13*(1), 3–21.

Corbin, J., & Strauss, A. (2014). *Basics of qualitative research: Techniques and procedures for developing grounded theory*. Sage publications.

Corley, K. G., & Gioia, D. A. (2004). Identity ambiguity and change in the wake of a corporate spin-off. *Administrative Science Quarterly*, *49*(2), 173–208.

Creswell, J. W. (2013). *Qualitative Inquiry and Research Design: choosing among five approaches* (3rd ed.). SAGE Publications.

Creswell, J. W., & Poth, C. N. (2016). *Qualitative inquiry and research design: Choosing among five approaches*. Sage publications.

Crosby, P. B., & Free, Q. I. (1979). The art of making quality certain. *New York: New American Library*, *17*, 174–183.

Davenport, T. H. (2005). The coming commoditization of processes. *Harvard Business Review*, *83*(6), 100–108.

Dawson, D. C. (2002). *A practical research methods*. How to Books limited.

de Bakker, K., Boonstra, A., & Wortmann, H. (2012). Risk managements' communicative effects influencing IT project success. *International Journal of Project Management*, *30*(4), 444–457.

De Bakker, K., Boonstra, A., & Wortmann, H. (2010). Does risk management contribute to IT project success? A meta-analysis of empirical evidence. *International Journal of Project Management*, *28*(5), 493–503.

De Bruin, T., Rosemann, M., Freeze, R., & Kaulkarni, U. (2005). Understanding the main phases of developing a maturity assessment model. *Australasian Conference on Information Systems (ACIS)*, 8–19. Australasian Chapter of the Association for Information Systems.

de Carvalho, M. M., Patah, L. A., & de Souza Bido, D. (2015). Project management and its effects on project success: Cross-country and cross-industry comparisons. *International Journal of Project Management*, *33*(7), 1509–1522.

De Palma, A., Picard, N., & Andrieu, L. (2012). Risk in transport investments. *Networks and Spatial Economics*, *12*(2), 187–204.

De Rezende, L. B., Blackwell, P., & Pessanha Gonçalves, M. D. (2018). Research focuses, trends, and major findings on project complexity: A bibliometric network analysis of 50 years of project complexity research. *Project Management Journal*, *49*(1), 42–56.

de Souza, T. F., & Gomes, C. F. S. (2015). Assessment of maturity in project management: a bibliometric study of main models. *Procedia Computer Science*, *55*, 92–101.

de Vries, H., & Margaret, J. (2003). The development of a model to assess the strategic management capability of small-and medium-size businesses. *Journal of American Academy of Business, Cambridge*, *3*(1–2), 85.

Deloitte-AIAC-1. (2010). *Profile of the Canadian Aerospace Industry: Analysis of the 2009 AIAC Annual Survey*. Retrieved from https://aiac.ca

Deloitte-AIAC-2. (2010). *Global aerospace market outlook and forecast*. Retrieved from https://aiac.ca

Deloitte. (2016). *Program management in aerospace and defense*. Retrieved from https://www2.deloitte.com

Deloitte. (2018). *2019 global aerospace and defense industry outlook*. Retrieved from https://www2.deloitte.com

Deloitte. (2019). *2020 global aerospace and defense industry outlook*. Retrieved from https://www2.deloitte.com

Deloitte. (2020). *2020 aerospace and defense industry outlook*. Retrieved from https://www2.deloitte.com

Deloitte. (2021). *2021 aerospace and defense industry outlook*. Retrieved from https://www2.deloitte.com

Dietrich, P., & Lehtonen, P. (2005). Successful management of strategic intentions through multiple projects–Reflections from empirical study. *International Journal of Project Management*, *23*(5), 386–391.

Dimitriou, H. T., Ward, E. J., & Wright, P. G. (2013). Mega transport projects—Beyond the 'iron triangle': Findings from the OMEGA research programme. *Progress in Planning*, *86*, 1–43.

Duffield, S., & Whitty, S. J. (2015). Developing a systemic lessons learned knowledge model for organisational learning through projects. *International Journal of Project Management*, *33*(2), 311–324.

Dunović, I. B., Radujković, M., & Vukomanović, M. (2013). Risk register development and implementation for construction projects. *Gradjevinar*, *65*(1), 23–35.

Eisenhardt, K. M., & Graebner, M. E. (2007). Theory building from cases: Opportunities and challenges. *Academy of Management Journal*, *50*(1), 25–32.

Elmaallam, M., & Kriouile, A. (2011). Towards a model of maturity for is risk management. *International Journal of Computer Science & Information Technology*, *3*(4), 171–188.

Ernst, H. (2002). Success factors of new product development: a review of the empirical literature. *International Journal of Management Reviews*, *4*(1), 1–40.

Esty, B. C. (2004). Why study large projects? An introduction to research on project finance. *European Financial Management*, *10*(2), 213–224.

Eweje, J., Turner, R., & Müller, R. (2012). Maximizing strategic value from megaprojects: The influence of information-feed on decision-making by the project manager. *International Journal of Project Management*, *30*(6), 639–651.

Fahimnia, B., Tang, C. S., Davarzani, H., & Sarkis, J. (2015). Quantitative models for managing supply chain risks: A review. *European Journal of Operational Research*, *247*(1), 1–15.

Farrell, M., & Gallagher, R. (2015). The valuation implications of enterprise risk management maturity. *Journal of Risk and Insurance*, *82*(3), 625–657.

Farrokh, J., & Mansur, A. K. (2013). Project management maturity models and organizational project management maturity model (OPM3®): a critical morphological evaluation. *Project Management*, *2*(7), 23–33.

Flyvbjerg, B. (2006). From Nobel Prize to project management: Getting risks right. *Project Management Journal*, *37*(3), 5–15.

Flyvbjerg, B. (2007). Megaproject policy and planning: Problems, causes, cures. *Summary of Dissertation for Higher Doctorate in Science,(Dr. Scient.), Aalborg: Aalborg University*.

Flyvbjerg, B. (2014). What you should know about megaprojects and why: An overview. *Project Management Journal*, *45*(2), 6–19.

Fortune, J., & White, D. (2006). Framing of project critical success factors by a systems model. *International Journal of Project Management*, *24*(1), 53–65.

Gao, T., Lechler, T. G., & PMP, P.-R. (2013). *Silver Lining of Project Uncertainties*. Project Management Institute.

Gellert, P. K., & Lynch, B. D. (2003). Mega-projects as displacements. *International Social Science Journal*, *55*(175), 15–25.

Geraldi, J. G., & Adlbrecht, G. (2007). On faith, fact, and interaction in projects. *Project Management Journal*, *38*(1), 32–43.

Gibbert, M., Ruigrok, W., & Wicki, B. (2008). What passes as a rigorous case study? *Strategic Management Journal*, *29*(13), 1465–1474.

Gill, J., & Johnson, P. (n.d.). *Clark. M.(2010) Research Methods for Managers*. SAGE Publications, Washington DC.

Gioia, D. (2021). A systematic methodology for doing qualitative research. *The Journal of Applied Behavioral Science*, *57*(1), 20–29.

Gioia, D. A., Corley, K. G., & Hamilton, A. L. (2013). Seeking qualitative rigor in inductive research: Notes on the Gioia methodology. *Organizational Research Methods*, *16*(1), 15–31.

Gioia, D. A., & Pitre, E. (1990). Multiparadigm perspectives on theory building. *Academy of Management Review*, *15*(4), 584–602.

Gioia, D. A., Schultz, M., & Corley, K. G. (2002). On celebrating the organizational identity metaphor: A rejoinder to Cornelissen. *British Journal of Management*, *13*(3), 269–275.

Gladden, R. (2012). *Book Review: The Project Risk Maturity Model: Measuring and Improving Risk Management Capability*. SAGE Publications Sage CA: Los Angeles, CA.

Görög, M. (2016). A broader approach to organisational project management maturity assessment. *International Journal of Project Management*, *34*(8), 1658–1669.

Grant, K. P., Cashman, W. M., & Christensen, D. S. (2006). Delivering projects on time. *Research-Technology Management*, *49*(6), 52–58.

Guangshe, J., Li, C., Jianguo, C., Shuisen, Z., & Jin, W. (2008). Application of organizational project management maturity model (OPM3) to construction in China: An empirical study. *2008 International Conference on Information Management, Innovation Management and Industrial Engineering*, *2*, 56–62. IEEE.

Harter, D. E., Krishnan, M. S., & Slaughter, S. A. (2000). Effects of process maturity on quality, cycle time, and effort in software product development. *Management Science*, *46*(4), 451–466.

Healey, M. J., & Rawlinson, M. B. (1994). Interviewing techniques in business and management research. *Principles and Practice in Business and Management Research*, *12345*.

Heckmann, I., Comes, T., & Nickel, S. (2015). A critical review on supply chain risk–Definition, measure and modeling. *Omega*, *52*, 119–132.

Heravi, G., & Gholami, A. (2018). The influence of project risk management maturity and organizational learning on the success of power plant construction projects. *Project Management Journal*, *49*(5), 22–37.

Hillson, D. (2003). Assessing organisational project management capability. *Journal of Facilities Management*.

Hillson, D. A. (1997). Towards a risk maturity model. *The International Journal of Project & Business Risk Management*, *1*(1), 35–45.

Hogan, T. J. (2008). The adaptive leadership maturity model. *Organization Development Journal*, *26*(1).

Holt, D. T., Armenakis, A. A., Feild, H. S., & Harris, S. G. (2007). Readiness for organizational change: The systematic development of a scale. *The Journal of Applied Behavioral Science*, *43*(2), 232–255.

Hoseini, E., Hertogh, M., & Bosch-Rekveldt, M. (2019). Developing a generic risk maturity model (GRMM) for evaluating risk management in construction projects. *Journal of Risk Research*, 1–20.

Howell, D., Windahl, C., & Seidel, R. (2010). A project contingency framework based on uncertainty and its consequences. *International Journal of Project Management*, *28*(3), 256–264.

Ibbs, C. W., & Kwak, Y. H. (2000). Assessing project management maturity. *Project Management Journal*, *31*(1), 32–43.

Investincanada-AIAC. (2018). *Canada's competitive advantages, aerospace sector*. Retrieved from investincanada.com

Irimia-Diéguez, A. I., Sanchez-Cazorla, A., & Alfalla-Luque, R. (2014). Risk management in megaprojects. *Procedia-Social and Behavioral Sciences*, *119*, 407–416.

ISED-AIAC. (2019). *State of Canada's aerospace industry, 2019 report*. Retrieved from https://www.ic.gc.ca/eic/site/ad-ad.nsf/eng/h_ad03964.html

Jaafari, A. (2003). Project management in the age of complexity and change. *Project Management Journal*, *34*(4), 47–57.

Jeffrey Thieme, R., Michael Song, X., & Shin, G. (2003). Project management characteristics and new product survival. *Journal of Product Innovation Management*, *20*(2), 104–119.

Jia, G., Chen, Y., Xue, X., Chen, J., Cao, J., & Tang, K. (2011). Program management organization maturity integrated model for mega construction programs in China. *International Journal of Project Management*, *29*(7), 834–845.

Jia, G., Ni, X., Chen, Z., Hong, B., Chen, Y., Yang, F., & Lin, C. (2013). Measuring the maturity of risk management in large-scale construction projects. *Automation in Construction*, *34*, 56–66.

Johansson, C., Hicks, B., Larsson, A. C., & Bertoni, M. (2011). Knowledge maturity as a means to support decision making during product-service systems development projects in the aerospace sector. *Project Management Journal*, *42*(2), 32–50.

Jugdev, K. (2004). Through the looking glass: Examining theory development in project management with the resource-based view lens. *Project Management Journal*, *35*(3), 15–26.

Jugdev, K., & Thomas, J. (2002). 2002 student paper award winner: Project management maturity models: The silver bullets of competitive advantage? *Project Management Journal*, *33*(4), 4–14.

Kahn, R. L., & Cannell, C. F. (1957). *The dynamics of interviewing; theory, technique, and cases.*

Kardes, I., Ozturk, A., Cavusgil, S. T., & Cavusgil, E. (2013). Managing global megaprojects: Complexity and risk management. *International Business Review*, *22*(6), 905–917.

Katuu, S. (2016). Assessing the functionality of the enterprise content management maturity model. *Records Management Journal*.

Ketokivi, M., & Mantere, S. (2010). Two strategies for inductive reasoning in organizational research. *Academy of Management Review*, *35*(2), 315–333.

Khameneh, A.-H., Taheri, A., & Ershadi, M. (2016). Offering a framework for evaluating the performance of project risk management system. *Procedia-Social and Behavioral Sciences*, *226*, 82–90.

Khoshgoftar, M., & Osman, O. (2009). Comparison of maturity models. *2009 2nd IEEE International Conference on Computer Science and Information Technology*, 297–301. IEEE.

Khosravi, S., Afshari, H., Ghorbanali, A., Borzabadi, M., & Valipour, M. (2011). Improving project management competency by using an OPM3 approach. *International Proceedings of Economics Development & Research*, *2*.

King, N. (2004). *Using interviews in qualitative research*. Sage.

Kleffner, A. E., Lee, R. B., & McGannon, B. (2003). The effect of corporate governance on the use of enterprise risk management: Evidence from Canada. *Risk Management and Insurance Review*, *6*(1), 53–73.

Kleindorfer, P. R., & Saad, G. H. (2005). Managing disruption risks in supply chains. *Production and Operations Management*, *14*(1), 53–68.

Koltveit, B. J., Karlsen, J. T., & Gronhaug, K. (2005). Exploiting opportunities in uncertainty during the early project phase. *IEEE Engineering Management Review*, *33*(1), 26.

Koppenjan, J. F. M. (2005). The formation of public-private partnerships: lessons from nine transport infrastructure projects in the Netherlands. *Public Administration*, *83*(1), 135–157.

Kutsch, E., & Hall, M. (2009). The rational choice of not applying project risk management in information technology projects. *Project Management Journal*, *40*(3), 72–81.

Kwak, Y. H. (2003). Perceptions and practices of project risk management: Aggregating 300 project manager years. *Proceedings of 2003 PMI® Global Congress-North America*.

Kwak, Y. H., & Ibbs, C. W. (2002). Project management process maturity (PM) 2 model. *Journal of Management in Engineering*, *18*(3), 150–155.

Leedy, P. D., & Ormrod, J. E. (2015). Practical research: Planning and design, global edition. *England: Pearson Education Limited*.

Lehtiranta, L. (2014). Risk perceptions and approaches in multi-organizations: A research review 2000–2012. *International Journal of Project Management*, *32*(4), 640–653.

Loch, C. H., Solt, M. E., & Bailey, E. M. (2008). Diagnosing unforeseeable uncertainty in a new venture. *Journal of Product Innovation Management*, *25*(1), 28–46.

Marcelino-Sádaba, S., Pérez-Ezcurdia, A., Lazcano, A. M. E., & Villanueva, P. (2014). Project risk management methodology for small firms. *International Journal of Project Management*, *32*(2), 327–340.

Maytorena, E., Winch, G. M., Freeman, J., & Kiely, T. (2007). The influence of experience and information search styles on project risk identification performance. *IEEE Transactions on Engineering Management*, *54*(2), 315–326.

McClory, S., Read, M., & Labib, A. (2017). Conceptualising the lessons-learned process in project management: Towards a triple-loop learning framework. *International Journal of Project Management*, *35*(7), 1322–1335.

McKinsey&Company. (2018). *AI looks north: bridging Canada's corporate artificial intelligence gap*. Retrieved from www.mckinsey.com

Melnikovas, A. (2018). Towards an explicit research methodology: Adapting research onion model for futures studies. *Journal of Futures Studies*, *23*(2), 29–44.

Mettler, T., & Rohner, P. (2009). Situational maturity models as instrumental artifacts for organizational design. *Proceedings of the 4th International Conference on Design Science Research in Information Systems and Technology*, 1–9.

Milosevic, D., & Patanakul, P. (2005). Standardized project management may increase development projects success. *International Journal of Project Management*, *23*(3), 181–192.

Mojtahedi, S. M. H., Mousavi, S. M., & Aminian, A. (2008). Fuzzy group decision making: A case using FTOPSIS in mega project risk identification and analysis concurrently. *2008 IEEE International Conference on Industrial Engineering and Engineering Management*, 1769–1773. IEEE.

Morse, J. M. (1994). *Designing funded qualitative research.*

Mu, S., Cheng, H., Chohr, M., & Peng, W. (2014). Assessing risk management capability of contractors in subway projects in mainland China. *International Journal of Project Management*, *32*(3), 452–460.

Mullaly, M. (2006). Longitudinal analysis of project management maturity. *Project Management Journal*, *37*(3), 62–73.

Mullaly, M. (2014). If maturity is the answer, then exactly what was the question? *International Journal of Managing Projects in Business*.

Nag, R., & Gioia, D. A. (2012). From common to uncommon knowledge: Foundations of firm-specific use of knowledge as a resource. *Academy of Management Journal*, *55*(2), 421–457.

Nenni, M. E., Arnone, V., Boccardelli, P., & Napolitano, I. (2014). How to increase the value of the project management maturity model as a business-oriented framework. *International Journal of Engineering Business Management*, *6*, 8.

Ogunlana, S. O. (2010). Beyond the 'iron triangle': Stakeholder perception of key performance indicators (KPIs) for large-scale public sector development projects. *International Journal of Project Management*, *28*(3), 228–236.

Olechowski, A., Oehmen, J., Seering, W., & Ben-Daya, M. (2016). The professionalization of risk management: What role can the ISO 31000 risk management principles play? *International Journal of Project Management*, *34*(8), 1568–1578.

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.

Park, J., Park, B., Cha, Y., & Hyun, C. (2016). Risk factors assessment considering change degree for mega-projects. *Procedia-Social and Behavioral Sciences*, *218*, 50–55.

Pasian, B. (2014). Extending the concept and modularization of project management maturity with adaptable, human and customer factors. *International Journal of Managing Projects in Business*.

Patil, R., Grantham, K., & Steele, D. (2012). Business risk in early design: A business risk assessment approach. *Engineering Management Journal*, *24*(1), 35–46.

Pellegrinelli, S. (1997). Programme management: organising project-based change. *International Journal of Project Management*, *15*(3), 141–149.

Pereira, R., & Da Silva, M. M. (2011). A maturity model for implementing ITIL V3 in practice. *2011 IEEE 15th International Enterprise Distributed Object Computing Conference Workshops*, 259–268. IEEE.

Peterson, A. S. (2000). The impact of PM maturity on integrated PM processes. *Proceedings Symposium 2000 Connections*.

Pollack, J., Biesenthal, C., Sankaran, S., & Clegg, S. (2018). Classics in megaproject management: A structured analysis of three major works. *International Journal of Project Management*, *36*(2), 372–384.

Pournader, M., Kach, A., & Talluri, S. (2020). A review of the existing and emerging topics in the supply chain risk management literature. *Decision Sciences*, *51*(4), 867–919.

Powney, J., & Watts, M. (2018). *Interviewing in educational research*. Routledge.

Project Management Institute. (2013). *Organizational Project Management Maturity Model (OPM3)* (3th ed.). Project Management Institute.

Project Management Institute. (2017a). *A guide to the Project Management Body of Knowledge (PMBOK guide)* (6th ed.). Project Management Institute.

Project Management Institute. (2017b). *The Standard for Program Management* (4th ed.). Project Management Institute.

Raconteur-1. (2017). *Project management*. Retrieved from https://www.raconteur.net/

Raconteur-1. (2018). *Future of manufacturing*. Retrieved from https://www.raconteur.net/

Raconteur-2. (2017). *Product lifecycle management*. Retrieved from https://www.raconteur.net/

Raconteur-2. (2018). *Risk Culture*. Retrieved from https://www.raconteur.net/

Raconteur-3. (2018). *Industry 4.0*. Retrieved from https://www.raconteur.net/

Raconteur. (2015). *Project management*. Retrieved from https://www.raconteur.net/

Raconteur. (2016). *Project management*. Retrieved from https://www.raconteur.net/

Raconteur. (2019). *Business risk*. Retrieved from https://www.raconteur.net/

Raz, T., & Michael, E. (2001). Use and benefits of tools for project risk management. *International Journal of Project Management*, *19*(1), 9–17.

Raz, T., Shenhar, A. J., & Dvir, D. (2002). Risk management, project success, and technological uncertainty. *R&d Management*, *32*(2), 101–109.

Rodriguez-Segura, E., Ortiz-Marcos, I., Romero, J. J., & Tafur-Segura, J. (2016). Critical success factors in large projects in the aerospace and defense sectors. *Journal of Business Research*, *69*(11), 5419–5425.

Royer, P. S. (2000). Risk management: The undiscovered dimension of project management. *Project Management Journal*, *31*(1), 6–13.

Safety management systems in aviation. (2020). Retrieved from Transport Canada website: https://tc.canada.ca/

Salawu, R. A., & Abdullah, F. (2015). Assessing Risk Management Maturity of Construction Organisations on Infrastructural Project Delivery in Nigeria. *Procedia - Social and Behavioral Sciences*, *172*(2006), 643–650. https://doi.org/10.1016/j.sbspro.2015.01.414

Sanchez-Cazorla, A., Alfalla-Luque, R., & Irimia-Dieguez, A. I. (2016). Risk identification in megaprojects as a crucial phase of risk management: A literature review. *Project Management Journal*, *47*(6), 75–93.

Saunders, F. C., Gale, A. W., & Sherry, A. H. (2016). Mapping the multi-faceted: Determinants of uncertainty in safety-critical projects. *International Journal of Project Management*, *34*(6), 1057–1070.

Saunders, M., Lewis, P., & Thornhill, A. (2009). *Research methods for business students*. Pearson education.

Saunders, M. N. K., Lewis, P., & Thornhill, A. (2019). *Research methods for business students* (8th ed.). Pearson education.

Serpell, A., Ferrada, X., Rubio, L., & Arauzo, S. (2015). Evaluating risk management practices in construction organizations. *Procedia-Social and Behavioral Sciences*, *194*, 201–210.

Siebelink, S., Voordijk, H., Endedijk, M., & Adriaanse, A. (2021). Understanding barriers to BIM implementation: Their impact across organizational levels in relation to BIM maturity. *Frontiers of Engineering Management*, *8*(2), 236–257.

Simon, A., Schoeman, P., & Sohal, A. S. (2010). Prioritised best practices in a ratified consulting services maturity model for ERP consulting. *Journal of Enterprise Information Management*.

Söderlund, J., Sankaran, S., & Biesenthal, C. (2017). *The past and present of megaprojects*. SAGE Publications Sage CA: Los Angeles, CA.

Spalek, S. (2014). Assessing project management maturity in the area of knowledge management in select companies. *Spalek S."Assessing Project Management Maturity in the Area of Knowledge Management in Select Companies". International Journal of Economics, Finance and Management Sciences*, *2*(2), 164–170.

Spalek, S. (2015). Establishing a Conceptual Model for Assessing Project Management Maturity in Industrial Companies. *International Journal of Industrial Engineering*, *22*(2).

Srivannaboon, S., & Milosevic, D. Z. (2006). A two-way influence between business strategy and project management. *International Journal of Project Management*, *24*(6), 493–505.

Suleiman, N., & Othman, Z. (2021). Forensic accounting investigation of public sector corruption in Nigeria: The Gioia Methodology. *The Qualitative Report*, *26*(3), 1021–1032.

Tan, K. C. (2001). A framework of supply chain management literature. *European Journal of Purchasing & Supply Management*, *7*(1), 39–48.

Tan, K. C., Lyman, S. B., & Wisner, J. D. (2002). Supply chain management: a strategic perspective. *International Journal of Operations & Production Management*.

Taylor, J. E., & Levitt, R. (2007). Innovation alignment and project network dynamics: An integrative model for change. *Project Management Journal*, *38*(3), 22–35.

Team, C. P. (2010). *CMMI for services, version 1.3*.

Thamhain, H. (2013). Managing risks in complex projects. *Project Management Journal*, *44*(2), 20–35.

Thamhain, H. J. (2004). Team leadership effectiveness in technology-based project environments. *Project Management Journal*, *35*(4), 35–46.

Thomas, A. B. (2004). *Research skills for management studies*. Routledge.

Thomas, J., & Mengel, T. (2008). Preparing project managers to deal with complexity–Advanced project management education. *International Journal of Project Management*, *26*(3), 304–315.

Torres, L. C. (2014). A contingency view on the effect of project management maturity on perceived performance. *Skema Business School*.

Van Looy, A., De Backer, M., & Poels, G. (2011). Defining business process maturity. A journey towards excellence. *Total Quality Management & Business Excellence*, *22*(11), 1119–1137.

Van Marrewijk, A., Clegg, S. R., Pitsis, T. S., & Veenswijk, M. (2008). Managing public–private megaprojects: Paradoxes, complexity, and project design. *International Journal of Project Management*, *26*(6), 591–600.

van Marrewijk, A. H. (2015). *Inside mega-projects. Understanding cultural practices in project management*. Liber & Copenhagen Business School Press.

Vidal, L.-A., Marle, F., & Bocquet, J.-C. (2011). Measuring project complexity using the Analytic Hierarchy Process. *International Journal of Project Management*, *29*(6), 718–727.

Williams, T. (2017). The nature of risk in complex projects. *Project Management Journal*, *48*(4), 55–66.

Wu, D., & Olson, D. L. (2008). Supply chain risk, simulation, and vendor selection. *International Journal of Production Economics*, *114*(2), 646–655.

Yeo, K. T., & Ren, Y. (2009). Risk management capability maturity model for complex product systems (CoPS) projects. *Systems Engineering*, *12*(4), 275–294.

Yim, R., Castaneda, J., Doolen, T., Tumer, I., & Malak, R. (2015). A study of the impact of project classification on project risk indicators. *International Journal of Project Management*, *33*(4), 863–876.

Yim, R. L., Castaneda, J. M., Doolen, T. L., Tumer, I. Y., & Malak, R. (2015). Exploring the relationship between rework projects and risk indicators. *Project Management Journal*, *46*(4), 63–75.

Yin, R. K. (2009). *Case study research: Design and methods* (Vol. 5). sage.

Yin, R. K. (2018). *Case study research and applications*. Sage.

Yoon, Y., Tamer, Z., & Hastak, M. (2015). Protocol to enhance profitability by managing risks in construction projects. *Journal of Management in Engineering*, *31*(5), 4014090.

Zhai, L., Xin, Y., & Cheng, C. (2009). Understanding the value of project management from a stakeholder's perspective: Case study of mega-project management. *Project Management Journal*, *40*(1), 99–109.

Zhang, H. (2011). Two schools of risk analysis: A review of past research on project risk. *Project Management Journal*, *42*(4), 5–18.

Zou, P. X. W., Chen, Y., & Chan, T.-Y. (2010). Understanding and improving your risk management capability: Assessment model for construction organizations. *Journal of Construction Engineering and Management*, *136*(8), 854–863.

Zwietering, M. H. (2015). Risk assessment and risk management for safe foods: Assessment needs inclusion of variability and uncertainty, management needs discrete decisions. *International Journal of Food Microbiology*, *213*, 118–123.

Zwikael, O., & Ahn, M. (2011). The effectiveness of risk management: an analysis of project risk planning across industries and countries. *Risk Analysis: An International Journal*, *31*(1), 25–37.

Zwikael, O., & Globerson, S. (2004). Evaluating the quality of project planning: a model and field results. *International Journal of Production Research*, *42*(8), 1545–1556.

Zwikael, O., & Sadeh, A. (2007). Planning effort as an effective risk management tool. *Journal of Operations Management*, *25*(4), 755–767.