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MANAGEMENT OF RISK IN DELIVERING COMPLEX RESEARCH AND DEVELOPMENT PROJECTS

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ABSTRACT:
Risk management continues to be a major feature of the project management of large construction, engineering, technological, and research and development projects in an attempt to reduce uncertainties and to achieve project success. There are uncertainties and risks at every stage of R&D projects through the product lifecycle. Therefore, management of the risks is an important challenge for the R&D project managers, and the close linking of project risk management with the success of the project is acknowledged across the world.
Thus, the focus of this study is on the management of risk in delivering complex research and development projects within the United Arab Emirates Armed Forces. Even though the management of risks related to the military environments has been studied for several years, studies on the risks pertaining to research and development of the military environments are still comparatively low and almost negligible in the UAE. This gives value to such type of study for filling in the literature.
This chapter discuss the theoretical background of the subject at hand. It highlights the perspective of project management and risk management, in addition to reviews of the related literature.
Key Words: Armed Forces, R&D, Complex Project, Risk Management

THEORETICAL PERSPECTIVE

Project

Since the starting of the new age of modern world, many definitions and perspectives have defined project and its activities. One of these definitions is established by (Berkun, 2005) which defined a project as “a carefully defined set of activities that use resources such as money, people, materials, energy, space, provisions, and communication to meet the predefined objectives”. PMI (2017), on the other hand, has expanded the definition and defined project as “a temporary endeavor undertaken to create a unique product, service, or result. The temporary nature of projects indicates that a project has a definite beginning and end. Projects can also have social, economic, and environmental impacts that far outlive the projects themselves”.

Some of the projects are different from other even though on a fundamental level all the projects are different in nature as they have their own objectives. In the current modern world, projects have been conveyed from its simple form to include, relationship, communication, and integration with many organizations. Such of these include joint ventures, collaborative research, intergovernmental projects, and partnerships (AXELOS, 2017).

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Complex Project

Complex project differ from traditional projects of it's large in scope, cost, and size or includes structural, technical, directional, or temporal complexities. Queensland University of Technology (QUT), Brisbane Australia has defined complex projects as those that (Caietti, 2017)

- Are characterized by uncertainty, ambiguity, dynamic interfaces, and significant political or external influences; and/or
- Usually run over a period which exceeds the technology cycle time of the technologies involved; and/or
- Can be defined by effect, but not by solution.

The complex project is massive in cost, scope, size and can involve technical, temporal, structural or directional complexities (Gladden, 2008). Some of the experts and professionals think that the research and development projects are constantly complex because of the planning related to the R&D, which is usually unclear and is full of uncertainties (Brink, 2017). Usually, in a complex R&D project, various phases are present, and these phases can overlap on each other several times increasing the complexity further.

In addition to high complexity, these projects involve cultural implications and communication with various members and suppliers from different culture, in addition to stakeholders and customers with each having different perception about the project (Brink, 2017).

Complex Systems and Project Complexity

A complex project typically comprises several different and overlapping phases, includes cultural implications and interactions with several suppliers and team from various cultures, and has many stakeholders with number of customers or end users each with different perceptions and plans for the project (Kerzner & Belack, 2010). Complexity of the project is still highly argued within both professional and academic worlds, and some projects don't react to best practice of project management (Remington, 2011). The challenges for these type of complex projects include the successful delivery of the outcomes in the short term in addition to ensuring that outcomes are sustainable and provide business and community benefits in the long term (Remington, 2011). Evidence from research and practice point out that leadership for these complex projects differs considerably from leadership for simple and more stable projects (Remington, 2011).

PROJECT MANAGEMENT

Project management is the discipline of organizing and managing resources in such a manner that the project covers all the familiar elements and complete within predefined objectives under all the predefined constraints (Cavaleri and Reed, 2008). The important thing about project management is that it is a convenient methodology that adapts to any size of project or program. The tools and methodology that are used are similar in all projects (Newell, 2005). Project management typically includes the planning, delegating, monitoring and control of all aspects of the project, and the motivation of those involved, to achieve the project objectives within the expected performance targets for time, cost, quality, scope, benefits and risks (AXELOS, 2017). Hence, the project management objectives are to manage cost, timescale, quality, scope, benefits, and risks (AXELOS, 2017).

Five phases of the project management

As per the Project Management Institute guide (PMI, 2017), every project goes through five phases under the project management. These five phases of project management are the following:

Project initiation

This is the beginning of the project, and the objective of this stage is to characterize the

project at a wide level (Mir and Pinnington, 2014). This stage normally starts with a business case. This is the point at which the project manager examines whether the project is achievable and if it should to be attempted.

Project planning

It is one of the most crucial phases in the project management. In this phase, the project manager defines the scope and budget of the project (Essling, 2014). In this phase, the project manager along with the project team develop the work breakdown structure. Also, the project manager develops the communication plan which is very important for the success of any project, in addition to define SMART (Specific, Measurable, Attainable, Relevant and Timely) goals and describes them in front of the project team (Moore, 2017).

Project execution and implementation

In this phase, the initial expectations of the project after completion are decided. It comprises of several frequent meetings involving topics such as status reports, improvement updates, execution reports, and various others. The first meeting, as a rule, indicates the beginning of the project execution stage, where every member involved in the project is made aware of their obligations (Cicmil and Gaggiotti, 2018).

Project monitoring

Project monitoring is important because it helps project managers in identifying the key improvement areas which prevent any damage to the whole project. Without project monitoring, no project manager can ensure the validity, reliability, and accuracy of the plans, methods, and resources used in the project. This is tangled in with estimating project progression and execution and guaranteeing that everything is happening lines up with the task administration design. Administrators with responsibility will utilize key performance indicators (KPIs) to decide whether the project is on track (Orangescrum, 2018).

Project closure

Project closure is also one of the most critical parts of the project management. In this stage, the project managers take the projects towards the ending. This stage shows the completion of the project. Once a venture is finished, the project management holds meetings in order to assess what went well in the project and distinguish venture failures (Orangescrum, 2018). This is particularly useful to comprehend lessons realized so changes can be made for future ventures.

Project Management Plan

Project management plan (PMP) is the most important activity in any kind of project. The PMP is developed to create the source of information which will work as the standard and the guideline for how the project would be planned, implemented, monitored and controlled (PTR Development, 2006). Hence, from authorization to completion, a project goes through a whole lifecycle where several elements are introduced, which defines the objectives of the project, planning related to the steps required for achieving those objectives, controlling and monitoring of the processes, execution of the work, and finishing the whole project (Ahern, Byrne and Leavy, 2015).

The PMP requires essential knowledge of critical areas and composed of the plans and documents generated by the various processes. Those items are the subsidiary plans and components of the PMP, which includes the management of project's integration, scope, time, cost, quality, human resource, communications, risk, procurement, and stakeholders. Each of these areas contains processes and offer detailed information in managing projects (Orangescrum, 2018).

The PMP is not designed at once. The PMP is progressively elaborated that implies that it is refined, revisited, developed, and updated (Mikkelsen, 1990). The PMP assimilates all the knowledge area into a single unified structure,

hence it requires integration after all the components are created. The PMP has several components which consist of subsidiary plans and baselines (Leach, 1999). These components typically include:

- Baselines for the schedule, cost, and scope
- Management plans for schedule, scope, cost, human resources, quality, risk, procurement, and communication
- Requirement management plan
- Configuration management plan
- Change management plan
- Process improvement.

RISK MANAGEMENT

Risks and R&D

Risk can be referred to as an uncertain event or condition that if it occurs has a positive or negative impact on project objectives (PMI, 2017). Many practitioners and researchers in project management consider risk to be more related to adverse effects on project performance (Wang, 2010). Risk management is the efficient way in dealing with the recognizable proof, appraisal, assessment, and positioning of the related risks. Proofs have shown that numerous successful firms understand the advantages that risk management offers to enhance success and project management (Carbone and Tippett, 2004).

There are several organizations have come to comprehend that to get by in the regularly expanding, globalized and competitive marketplace, implementing technological innovations forms an important strategic objective (Teller, 2013). This means Research and Development (R&D) ventures are the source of performance improvement (Bedeian, Ferris and Kacmar, 1992) and strategy (Mikkola, 2001) for the organizations (Hosseini et al., 2016; Wang, Lin and Huang, 2010). Be that as it may, the execution of the technological innovations with the aid of R&D ventures isn't without its difficulties. These undertakings are overflowing with uncertainties and risks at each stage of the product lifecycle (Gassmann and Han, 2004). Therefore, dealing with the risks is a critical test for the R&D project managers (Moehrle and Walter, 2008). Moreover, the close relationship between the project's success and project risk management is broadly recognized. This gives importance to the focal part of viably managing risks for increasing the success rates of the R&D ventures.

Uncertainties within the R&D venture originate from an extensive variety of sources that can possibly antagonistically influence the success of a project (Sicotte and Bourgault, 2008). Large number of these sources show that adverse effect develops from the risks involved in the project. Not dealing with the risks related with such sources of uncertainties in the R&D ventures have verifiably brought about lower success rates (Van Zyl, Du Preez and Schutte, 2012). To enhance the success rates of the projects, the project managers must make use of particular strategies and methods that will enable them to distinguish and deal with these uncertainties as adequately as could be expected under the circumstances.

Risk Management Plan

Almost all projects involve some type of uncertainties and risks. Project management planning only helps in reducing the chances of risks involved in the project. In traditional projects, risk management and proper project management mean that the project will finish without facing any significant challenges (Wang, Lin and Huang, 2010). On the other hand, a complex project is more prone to risks occurrence even after planning of risk management and planning of project management.

Risk Management Plan (RMP) is one of the important plans of project management knowledge areas. It is a key business process within both the private and public sector around the world (Turner, 2006). RMP identifies the procedures used to manage risks

throughout the project in addition to documenting the approach to risk identification and analysis, how risks will be tracked throughout the project lifecycle, and how mitigation and contingency plans are developed and implemented. Sound and effective implementation of risk management is part of best business practice at a corporate and strategic level as well as a means of improving operational activities (Australian Standard HB 436, 2013). Risk management includes the processes concerned with conducting risk management planning, identification, analysis, responses, and monitoring and control on project in addition to the update of these processes (PMI, 2017). Furthermore, the risk management process should be an integral part of management, embedded in the culture and practices, and tailored to the business processes of the organization (ISO 31000:2009, Zwikael and Ahn, 2010). It should not be implemented eventually but should form eventually.

It is, therefore, necessary that the risk management comprises the processes that are involved either directly or indirectly with the planning of risk management, analysis, monitoring, controlling, identification, and response regarding the risk. These processes should also be continuously updated to get the most out of these processes. Effective implementation of the risk management planning also helps in reducing the use of additional resources, which the organization could use otherwise in different projects or areas necessary (Sax and Andersen, 2018).

R&D

R&D Definition

Research and Development (R&D) refers to the activities undertaken by entities to create new / improve existing products or services or processes. The term R&D covers three types of activities: basic research, applied research, and experimental development (OECD, 2015).

- Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view

- Applied research is original investigation undertaken in order to acquire new knowledge which is aimed towards a specific practical objective

- Experimental development is systematic work, drawing on knowledge gained from research and practical experience and producing additional knowledge, which is directed to produce new products or processes or to improve existing products or processes.

Research and Development are different from other major activities involved in the operation (Scandizzo, 2001). It is not an activity or process that can be planned or progressed with an aim to reach at a designated time, as R&D does not produce immediate profits. However, this activity is emphasized by focusing on the long-term profits. Thus, some professionals believe that R&D projects are always complex since planning and heading of R&D are unclear and revolve around uncertainties (Kerzner & Belack, 2010).

R&D Structures

Typically, research and development departments comprise of entire employed staff towards achieving the single goal where the entire department is working on the R&D and offer collaborative effort for innovation (Sicotte and Bourgault, 2008). However, it is necessary to estimate the risk-adjustment return on the activities involved in the R&D as it is a risky process and involves risk to the capital invested. R&D has no immediate profits and the return on investment is also not clear and hence the more invested in the R&D activities, the more is the risk (Bath, 2005).

Research and development has two types of structures, which are used by any country, company or business as per the requirement (Moehrle and Walter, 2008).

■ The first structure of the research and development comprises staff members where only those engineers are involved who develop new products (Moehrle and Walter, 2008). In this process, the involvement of research is extensive and requires a lot of patience for bringing something new to the market to gain an advantage over the competition.

■ The second R&D structure involves people, researchers, and scientists from different departments or from different sectors of R&D. Those staff members are tasked with applying their research and skills in industrial, scientific, or technical fields. These members of the R&D have the necessary knowledge and work experience regarding the working environment and its objectives. They can either be involved in various activities for various reasons. A reason to do so is to improve an existing product or to make some innovative improvement over an existing product. They are also tasked with the advancement of the future products.

Risk Management in the R&D project

In line with its nature, R&D is a procedure which is filled with uncertainties, and with uncertainties comes hazard (Doctor, Newton and Pearson, 2001). New product development (NPD) and Research & Development ventures are impacted by various components (Balachandra and Friar, 1997). The levels and kinds of real risks in R&D ventures are impacted significantly by those variables. The aggregate effect of the vulnerabilities related with these components could be interpreted as the primary explanation for the generally low success percentages of such undertakings. Practically speaking, it is the insufficient administration of the risks and uncertainties which lead to ineffective project performance. Apparently, those could be mitigated through the application of highly effectual risk management strategies (Keizer, Vos and Halman, 2005).

Research and development ventures in firms are among the most basic and useful interfaces (Mousavi et al., 2011). Be that as it may, R&D ventures experience the unpleasant effects of the unfavorable impact of an extensive variety of risks. Uncertainties increases with the involvement of additional components, which can offer innovation to the organization and lack of information regarding them.

The risk management and the project management are related in such a way that increases in one means increase in other and vice versa. Thus, risk management is rapidly gaining recognition as fundamental to proactive and responsible project management as R&D projects introduce unique challenges to project management generally and to risk management specifically (Wageman, 2010). The risks related to the R&D projects are more in private sector as compared to the public sector as the former has to think of the risks involved for business as well on failure (Graetz and Franks, 2015).

Managing risks of R&D environments have been studied for many years. Risk management is one of the approaches that have been widely applied in practice (Wang, 2010). In the literature of R&D risk management, several studies have found that applying risk management techniques to innovative R&D projects can improve their success rates to a considerable extent (Wageman, 2010; Wang, 2010; Hoon Kwak and Dixon, 2008). Some researchers performed empirical studies and reported that risk management practice can lead to success of higher risk projects (Wageman, 2010; Wang, 2010).

Besides, an examination surveyed the risk management methods utilized by different R&D firms around the globe trying to distinguish best practices that can be implemented in the R&D of the public sector. Their investigation found that part of these systems is more usable to particular kinds of industries in comparison to other industries. The outcomes were later affirmed in a research study. The current risk management systems are focused to the industry needs, and

accordingly, they have been observed to be deficient in adequately dealing with the risks related with the R&D ventures. Thus, several researches have been directed trying to recognize particular risk management practices which work for the R&D ventures (Strain and Preece, 1999).

One such study could distinguish practices, for example, employment of the risk experts along with the utilization of certain analytical tools in relation to risk-based decisions to be productive for the R&D projects (Malhotra, 2015; Leblanc, 2010). A few studies have explored the drivers of and barriers to the successful R&D project risk management with an inclination towards organization environment along with the leadership style. A study inspected risk management in the R&D ventures utilizing a procedure. Nevertheless, the study distinguished an arrangement of particular tools and techniques which can be used for managing risks in the R&D projects in an effective manner, including templates and checklists. The study additionally proposed employing the risk experts for facilitating the key risk management process. In any scenario, examinations have shown that potential irregularities remains due to the involvement of assessments that have contrasting view, which happen due to the information from different specialists (Malhotra, 2015; Leblanc, 2010).

Additionally, researchers who are engaged in the activities of gaining new knowledge, approaches or practices required in the project management field are also among those who have participated in the researching field of R&D management. Of those researchers who are involved, some have also developed methodologies regarding the risk management, which are effective in improving the success rate in complex research and development projects (Abdul-Rahman, Mohd-Rahim, and Chen, 2012; Mikkelsen, 1990). Others suggested that managers should adopt different quantitative approaches for different levels of uncertainties in addition to using qualitative tools and relay on judgment and experience as uncertainty increases (Alessandri, 2004).

Furthermore, early detection of complex challenges in the R&D projects' risks required a systematic approach, which is present because of the continuous efforts of the researchers in this field. This systematic approach helps the organization either public or private in achieving a high success rate in complex R&D projects. Nevertheless, this is not the only methodology available for risk management; various other proposed approaches are present such as knowledge management systems and collaboration tools, which help in capturing the experience of the researcher while reducing the risks associated with the R&D projects (Abdul-Rahman, Mohd-Rahim, and Chen, 2012).

In relation to the measurement of the success of R&D ventures, there have been various ongoing studies to recognize particular risk management tools and strategies that can be utilized by NPD and R&D project managers to oversee uncertainties all the more successfully (Mazareanu, 2010; Lehar, 2003). A study led various case studies to discover the sorts of risks that are generally found in the NPD and R&D projects. They recognized two fundamental sorts of risks: first is, "unambiguous risks" (that are risks related with customer marketing and acceptance); and second is, "equivocal risks", that happen when there is a distinction of conclusion in relation to the project management and the organization (Mazareanu, 2010; Lehar, 2003).

In light of this, they set forward a rundown of prescribed activities that the R&D project managers can embrace to aid the better management and identification of the crucial project risks. They proposed that project managers must consider ambiguous risks seriously since they can possibly undermine the project success (Mazareanu, 2010; Lehar, 2003). An academic literature review likewise distinguished two fundamental kinds of risks in

the R&D ventures (Malhotra, 2015). The risks were classified as external and internal. Risks that are known begin from the organizational, technological and operational parts of the project were observed to be internal while the risks that stem from the supplier and the market angles were observed to be external.

Some of the researchers, on the other hand, favored the participation of customers in the innovation process to achieve the necessary objectives which are as per the customer need, since involvement of the customer will reduce the risks as the process will flow as per the requirement of the customer without any major speculations (Mikkelsen, 1990). Because of the ineffectiveness of the existing risk management methodologies to manage uncertainties in NPD and R&D projects, a few researchers have created completely new and innovative risk management frameworks (Wageman, 2010; Wang, 2010). Once the underlying risks get distinguished, contingency strategies and plans must be created to be applied.

As long as there is a need to do some innovation or new products, there is a need for research and development. Also, as long as there are research and development projects, there will always remain a constant risk factors involved with it because of its inefficiency to produce results in a short time and uncertainty regarding the investment (Lehar, 2003). Nevertheless, to mitigate the risks involved in the sophisticated research and development projects, risk management is utilized, which do not actually eliminate the risks involved in these R&D projects but reduces them by managing them effectively.

Therefore, these approaches help in mitigating the risks involved directly with the complex R&D projects by offering risk frameworks, which help in analyzing the risks related to the technological projects. In addition to that, it also offers methodologies, which quantify the technical performance risks so that the identified risks observed throughout the projects can be controlled without facing any significant challenges (Mikkelsen, 1990).

Military R&D

There is not much literature available that discusses the organizational risks involved in the applications related to the armed forces. The literature related to the research and development projects in the military is rarer as compared to the information on civilian organizations. A reason for the low number of literature and studies related to these environments is the nature of the defense sector.

The defense sector in any country is the most confidential and mysterious for ordinary people in addition to its secrecy related to the operations and operational activities. It is the same reason which has encouraged various researchers to start their research in this field to get more information and idea about the secret operations and activities involved in this field. Keat (2012), for instance, developed a theoretical framework for defense R&D investments under uncertainty. Another case is the program started in the United States of America known as the National Institute of Standards and Technology Advanced Technology Program (NIST ATP), which offers sponsoring proposals related to the high-risk in the research and development projects of the military (Scott, 1996).

ELEMENTS INVOLVED IN PROJECTS' RISK MANAGEMENT

Risk management is an important action for the projects and thus it is important to have a minimum number of certain risk management activities that must be performed efficiently. There are various risk analyzes that can be adjusted to a specific issue to help recognize potential risks. All of them have qualities and shortcomings relying upon the application.

Risk Elements

Risks can be good thing as it generates opportunities especially in R&D. Risk is mainly

related to the potential harm of the key assets. These types of assets are observed to be environment, reputation, information, production, materials, and human health and life. Potential losses of assets mean the existence of an uncertainty related to the severity scale and whether the loss will be becoming a reality or not. In the everyday life, the terms uncertainty and risk are utilized randomly. As per a study, the differences between the terms are stated as uncertainty involves both potential positive outcomes (opportunities) and potential losses (threats) (Smith and O'Connor, 1972).

The direct causes of such losses can be used of wrong equipment, wrong/lack of maintenance, errors on the part of operator, and the wrong equipment is utilized. Most often, the latent sources are poor training or poor maintenance culture, violation of procedures or lack of procedures, and insufficiencies in the requirements (Smith and O'Connor, 1972). There are direct causes which are easiest to fix and control. On the other hand, the latent causes are observed to be more complex because of the fact that the relationship of cause and effect cannot be always straightforward (Smith and O'Connor, 1972).

Such losses can occur all of a sudden or there could be certain delay after the initiating event has happened (Smith and O'Connor, 1972). Also, it can happen that the losses lay latent inside the system. As the losses are not observed to occur just after the occurrence of the initiating event, there are certain complications associated with the registration of events and system controls. If losses have happened, they are required to be analyzed to determine both the latent and direct causes in order to make sure that the losses do not reappear.

There has been a trend in the industries to blame the individuals which become the triggering factor (cause) of the event, instead of the latent causes (Smith and O'Connor, 1972). The proactive actions must be introduced for reducing the latent causes that will be more efficient in the long run that "blaming" an individual. The workers must not be blamed, instead there should be a more open discussion related to locating the correct causes of some incident so that the work environment becomes more positive.

Risk Quantification

Quantification of risk in the product development is becoming a highly appealing area of interest. The Risk Management Frameworks (RMF) have turned out to be immensely popular among the Research and Development programs because of the fact that they offer firm approaches for the quantification of risks and construction of the comprehensive mitigation plans. In addition, RMF is able to explain the efficient and effective responses for mitigating risks. There is Concurrent Engineering that is a business approach which links all of the functional areas of a firm like manufacturing, finance, and marketing with the designing process, and in which is encouraged by the RMF analysis model (Investopedia, 2018).

Failure Mode and Effect Analysis (FMEA)

Failure Mode and Effect Analysis or FMEA is amongst the most commonly utilized techniques to reduce the risks related to the NPD projects. It plans to recognize and organize the prospective failure modes before the failures happen and assess the impacts of such failures on the important production process. The FMEA strategy extends the customary risk evaluation process through inclusion of the detection factor in relation to the project risks along with the impact and likelihood factors. The detection factor reveals the ability of an organization to identify an item's fault before it is sent by the manufacturer (Gladden, 2008). Add Figure of FMEA

While FMEA is utilized to decrease the risks related to the technical aspects of the planning and design processes of the product development, the RFMEA is utilized to evaluate

and investigate risks, mainly within the project setting (Gladden, 2008). The contrast between the two procedures is in the meaning of the important detection technique. In case of FMEA, the detection aspect is appointed a higher value if the organization has no technique for recognizing that an item failure will happen and a lower value on the off chance that they are able to identify the fault. In case of RFMEA, detection aspect is observed to be the measure of the capacity to predict a specific risk event so that there is adequate time for planning for the event (Gladden, 2008).

The FMEA technique appear to be acknowledged as successful methodologies within the academic literature, However, their viability in the R&D setting has stayed tricky. The academic literature review reveals that there is an absence of research on these techniques for the R&D ventures (Gladden, 2008). Indeed, even the researchers of the accessible case studies have noticed that the result generalization ends up viable simply after the procedure have been reproduced in different settings and for several cases (Gladden, 2008).

CONCLUSION

Implementing technological innovations forms an important strategic objective of today's organizations. R&D ventures are the source of performance improvements and strategy for these organizations. However, these undertakings are overflowing with uncertainties and risks at each stage of the product lifecycle. Therefore, dealing with the risks is a critical test for the R&D projects. The close relationship between the project's success and project risk management is broadly recognized. This gives importance to the focal part of viably managing risks for increasing the success rates of the R&D ventures.

REFERENCES

1. Abdul-Rahman, H., Mohd-Rahim, F. and Chen, W. (2012). Reducing failures in software development projects: effectiveness of risk mitigation strategies. Journal of Risk Research, 15(4), pp.417-433.
2. Ahern, T., Byrne, P. and Leavy, B. (2015). Developing complex-project capability through dynamic organizational learning. International Journal of Managing Projects in Business, 8(4), pp.732-754.
3. Alessandri, T., Ford, D., Lander, D., Leggio, K. and Taylor, M. (2004). Managing risk and uncertainty in complex capital projects. The Quarterly Review of Economics and Finance, 44(5), pp.751-767.
4. AXELOS 2017, Managing Successful Projects with PRINCE2® 2017 Edition, The Stationery Office Ltd, UK.
5. Balachandra, R. and Friar, J. (1997). Factors for success in R&D projects and new product innovation: a contextual framework. IEEE Transactions on Engineering Management, 44(3), pp.276-287.
6. Bath, M. (2005). Unleash the military super power. Power Engineer, 19(3), p.26.
7. Bedeian, A., Ferris, G. and Kacmar, K. (1992). Age, tenure, and job satisfaction: A tale of two perspectives. Journal of Vocational Behavior, 40(1), pp.33-48.
8. Berkun, S. (2008). The art of project management. ACM SIGSOFT Software Engineering Notes, 33(5), p.29.
9. Brink, T. (2017). Managing uncertainty for sustainability of complex projects. International Journal of Managing Projects in Business, 10(2), pp.315-329.
10. Caietti, Naomi (2017), Master the Complexity of Your Projects, https://www.projectmanagement.com/articles/381180/Master-the-Complexity-of-Your-Projects.
11. Carbone, T. and Tippett, D. (2004). Project Risk Management Using the Project Risk FMEA. Engineering Management Journal, 16(4), pp.28-35.
12. Cavaleri, S. and Reed, F. (2008). Leading dynamically complex projects.

International Journal of Managing Projects in Business, 1(1), pp.71-87.

13. Cicmil, S. and Gaggiotti, H. (2018). Responsible forms of project management education: Theoretical plurality and reflective pedagogies. International Journal of Project Management, 36(1), pp.208-218.
14. de Hek, P. (2002). Endogenous Technological Change under Uncertainty. SSRN Electronic Journal.
15. Doctor, R., Newton, D. and Pearson, A. (2001). Managing uncertainty in research and development. Technovation, 21(2), pp.79-90.
16. Essling, C. (2014). Uncertainty, Flexibility, and Market Entry. SSRN Electronic Journal.
17. Gassmann, O. and Han, Z. (2004). Motivations and barriers of foreign R&D activities in China. R and D Management, 34(4), pp.423-437.
18. Gladden, R. (2008). Book Review: Tools for Complex ProjectsTools for Complex Projects by RemingtonKaye and PollackJulien. Project Management Journal, 39(3), pp.126-126.
19. Graetz, G. and Franks, D. (2015). Conceptualising social risk and business risk associated with private sector development projects. Journal of Risk Research, 19(5), pp.581-601.
20. Hayes, J. (2016). Approaches to Risk Management in Research and Development: An Analysis of Public / Private Partnerships in Ireland. [ebook] Dublin Business School, p.9. Available at: https://esource.dbs.ie/bitstream/handle/10788/3281/mba_hayes_j_2016.pdf.pdf?sequence=1&isAllowed=y [Accessed 7 Jul. 2018].
21. Hoon Kwak, Y. and Dixon, C. (2008). Risk management framework for pharmaceutical research and development projects. International Journal of Managing Projects in Business, 1(4), pp.552-565.
22. Hosseini, M., Chileshe, N., Zuo, J. and Baroudi, B. (2016). The status quo of innovations within the construction industry: a conceptual model. International Journal of Project Organisation and Management, 8(3), p.217.
23. Investopedia, 2018, https://www.investopedia.com.
24. ISO 31000:2009, Risk management - Principles and guidelines, International Standards, Geneva, Switzerland.
25. Keat, A 2012, An Enhanced Evaluation Framework for Defense R&D Investments under Uncertainty, National University of Singapore, Singapore.
26. Keizer, J., Vos, J. and Halman, J. (2005). Risks in new product development: devising a reference tool. R and D Management, 35(3), pp.297-309.
27. Kerzner, H & Belack, C 2010, Managing Complex Projects, John Wiley & Sons, NJ, USA.
28. Leach, L. (1999). Critical Chain Project Management Improves Project Performance. Project Management Journal, 30(2), pp.39-51.
29. Lehar, A. (2003). Measuring Systemic Risk: A Risk Management Approach. SSRN Electronic Journal.
30. Li, S. (2009). Risk Management for Overseas Development Projects. International Business Research, 2(3).
31. Malhotra, Y. (2015). Toward Integrated Enterprise Risk Management, Model Risk Management & Cyber-Finance Risk Management: Bridging Networks, Systems and Controls Frameworks. SSRN Electronic Journal.
32. Mazareanu, V. (2010). Risk Management and Analysis: Risk Assessment (Qualitative and Quantitative). SSRN Electronic Journal.
33. Mikkelsen, H. (1990). Quality of project work and project management. International Journal of Project Management, 8(3), pp.138-143.
34. Mikkola, J. (2001). Portfolio management of R&D projects: implications for innovation management. Technovation, 21(7), pp.423-435.

35. Mir, F. and Pinnington, A. (2014). Exploring the value of project management: Linking Project Management Performance and Project Success. International Journal of Project Management, 32(2), pp.202-217

36. Moehrle, M. G., and Walter, L. (2008). Risk and uncertainty in R&D management. R&D Management, 38(5), 449–451.

37. Mojtahedi, S., Mousavi, S. and Makui, A. (2010). Project risk identification and assessment simultaneously using multi-attribute group decision making technique. Safety Science, 48(4), pp.499-507.

38. Moore, J. (2017). Setting SMART objectives. Headteacher Update, 2017(6), pp.14-14.

39. Mousavi, S., Tavakkoli-Moghaddam, R., Azaron, A., Mojtahedi, S. and Hashemi, H. (2011). Risk assessment for highway projects using jackknife technique. Expert Systems with Applications, 38(5), pp.5514-5524.

40. Newell, M 2005, Preparing for the Project Management Professional (PMP) Certification Exam, 3rd Edition, AMACOM, New York, NY, USA.

41. OECD (2015), "Concepts and definitions for identifying R&D", in Frascati Manual 2015: Guidelines for Collecting and Reporting Data on Research and Experimental Development, OECD Publishing, Paris.

42. Orangescrum (2018). Execution in Project Management | Orangescrum Project Management Tutorial. [online] Orangescrum. Available at: https://www.orangescrum.com/tutorial/introduction-to-project-management/execution-in-project-management [Accessed 29 Oct. 2018].

43. PMI 2017, A Guide to the Project Management Body of Knowledge (PMBOK® Guide), 6th Edition, Project Management Institute, USA.

44. PTR Development Staff 2006, PMP in Depth: Project Management Professional Study Guide for PMP and CAPM Exams, Course Technology, Incorporated, Boston, MA, USA.

45. Remington, K & Pollack, J 2007, Tools for Complex Projects, Gower Publishing Limited, Surrey, England.

46. Remington, Kaye., 2011, Leading Complex Projects, Taylor and Francis, ProQuest Ebook Central.

47. Sax, J. and Andersen, T. (2018). Making Risk Management Strategic: Integrating Enterprise Risk Management with Strategic Planning. European Management Review.

48. Scandizzo, S. (2001). Intellectual Property Rights and International RandD Competition. IMF Working Papers, 01(81), p.1.

49. Scott, W. (1996). Book Review: Soldiers, Society, and National Security. Armed Forces & Society, 23(1), pp.113-115.

50. Sicotte, H. and Bourgault, M. (2008). Dimensions of uncertainty and their moderating effect on new product development project performance. R&D Management, 38(5), pp.468-479.

51. Smith, H. and O'Connor, R. (1972). Force and Diplomacy: Essays Military and Diplomatic. Military Affairs, 36(4), p.151.

52. Strain, J. and Preece, D. (1999). Project management and the integration of human factors in military system procurement. International Journal of Project Management, 17(5), pp.283-292.

53. Teller, J. (2013). Portfolio Risk Management and Its Contribution to Project Portfolio Success: An Investigation of Organization, Process, and Culture. Project Management Journal, 44(2), pp.36-51.

54. Turner, J. (2006). Towards a theory of project management: The nature of the project governance and project management. International Journal of Project Management, 24(2), pp.93-95.

55. Van Zyl, H., Du Preez, N. and Schutte, C. (2012). Utilizing formal innovation models to support and guide industry innovation

projects. The South African Journal of Industrial Engineering, 18(2).

56. Wageman, S 2010, Risk Management on Research and Development Projects, AACE International Transactions, NM, USA.

57. Wang, J 2010, A performance-oriented risk management framework for innovative R&D projects, Taiwan.

58. Wang, J. and Yang, C. (2012). Flexibility planning for managing R&D projects under risk. International Journal of Production Economics, 135(2), pp.823-831.

59. Wang, J., Lin, W. and Huang, Y. (2010). A performance-oriented risk management framework for innovative R&D projects. Technovation, 30(11-12), pp.601-611.

60. Zwikael, O. and Ahn, M. (2010). The Effectiveness of Risk Management: An Analysis of Project Risk Planning Across Industries and Countries. Risk Analysis, 31(1), pp.25-37.