

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.

1. PROJECT-MANAGEMENT-RISK FACTORS THEMES

As per the results obtained from the responses of the participants, it has been observed that there are several risks

involved in the Research and Development Center (RDC) projects. These risks were arranged into three main groups:

- Client related risks
- Project related risks
- RDC related risks.

1.1. Client Related Risks

As per the findings, there were five risks within the customer related risk group that

are summarized in Table 1 hereafter.

Table 1: Client Related Risks

Client Related Risks				
#	Risk	Types / Causes	Impact	# Participants Mentioned the Issue
1	Unclear Operational Requirements	<ul style="list-style-type: none"> ▪ Undefined mission requirements ▪ Opposing views ▪ Loose definition of operational requirements 	<ul style="list-style-type: none"> ▪ Options that no one use ▪ Extra cost ▪ Scope creep ▪ Time creep 	3
2	Unclear Technical Specifications	<ul style="list-style-type: none"> ▪ Lack of technical knowledge ▪ Lack of engineers in some operational units ▪ The allure of acquiring the latest technology 	<ul style="list-style-type: none"> ▪ Integration with other subsystems 	2
3	Lack of information	<ul style="list-style-type: none"> ▪ Sensitive information 	<ul style="list-style-type: none"> ▪ Time creep 	1
4	Customer Delays	<ul style="list-style-type: none"> ▪ Approval delays ▪ Payment delays 	<ul style="list-style-type: none"> ▪ Time creep 	3
5	High Customer expectations	<ul style="list-style-type: none"> ▪ Trust issues 	<ul style="list-style-type: none"> ▪ Project cancellation ▪ No new project requests 	2

The client related risks are well recognized in the risk management research literature. Many researchers observed that the fundamental risks occurred in the Research and Development (R&D) projects are related to customers (Mazareanu, 2010; Lehar, 2003).

According to Mar (2016), the risks of unclear operational requirements and unclear technical specification may fall within the area of 'Scope risks', which were of the findings of Luppino, et al. (2014) quantitative research using RFEMA model and scored "High" risk impact in their analyzed R&D project (Luppino, et al., 2014, pp. 75, 79). Also, one of the main technical risk's findings in Antinyan, et al. (2018) in Sweden was that *"unfeasible, unclear or untestable requirements have high likelihood impact causing difficulty to understand and implement these requirements because of unclear syntactic description"* (Antinyan, et al. 2018, pp. 4).

Customers' delays have been addressed in many occasions in the risk management literature. Dillerup, et al. (2018) research findings were that *"milestones starting after order placement cause time delay"* (Dillerup, et al., 2018, pp. 36). Also, Mar (2016)

has categorized this type of risk under 'Approval' risk category.

The risk of the high customer expectations has been recognized by other researchers, as well, confirming the finding of this study. Mar (2016) has listed this risk under 'Stakeholders' risk category as *"stakeholders develop inaccurate expectations"* and 'Communication' risk category as *"users have inaccurate expectations"*. Luppino, et al. (2014, pp. 75, 79) results encompassed that *"customer satisfaction and expectation"* scored *"Extremely"* impact in the two analyzed R&D projects of the research. Moreover, Shin, et al. (2018) conducted quantitative research using Failure Mode & Effect Analysis (FMEA) and Decision-Making Trial and Evaluation (DEMATEL) methods. Their study findings included that failure mode could occur in R&D process due to *"wrong idea"*, and *"customer analysis error"* and therefore can affect the success of R&D projects (Shin, et al., 2018, pp. 8).

1.2. Project Related Risks

As per the findings, there were four risks within the project related risk group that are summarized in Table 2 hereafter.

Table 2: Project Related Risks

Project Related Risks				
#	Risk	Types / Causes	Impact	# Participants Mentioned the Issue
1	Software Issues	<ul style="list-style-type: none"> ▪ Incompatibility issues ▪ Integration issues ▪ Legacy system ▪ Lack of required software 	<ul style="list-style-type: none"> ▪ Extra cost ▪ Scope creep ▪ Time creep ▪ Outsource 	3
2	Hardware Issues	<ul style="list-style-type: none"> ▪ Technology obsolescence ▪ Lack of required hardware 	<ul style="list-style-type: none"> ▪ Extra cost ▪ Scope creep ▪ Time creep 	4
3	Human Resource Issues	<ul style="list-style-type: none"> ▪ Difficulty in the execution 	<ul style="list-style-type: none"> ▪ Time creep ▪ Project cancellation ▪ Extra cost 	5
4	Budget Issues	<ul style="list-style-type: none"> ▪ Misallocation of budget ▪ Difficulty to acquire the required 	<ul style="list-style-type: none"> ▪ Time creep 	1

Through browsing the literature of the risk management, software and hardware issues are among the well identified technical risks of projects (Mar, 2016). A study accomplished by Dandage, et al. (2017) revealed that technical risks' issues such as technological developments, variation in codes

and standards, have been ranked as the second important cause of projects failure. In addition, the design risks have ranked the third important cause of projects failure as they can lead to operational or technical risks (Dandage, et al., 2017). Furthermore, Hijazi, et al. (2014) study recognized

technology change as software risk factor in which *“the project may involve the use of new technologies that has not been used before, which developers may find it difficult to deal with these technologies”* (Hijazi, et al., 2014, pp. 224).

In addition, other researchers corroborated the result of this study that legacy systems pose issues in software development projects. In her study, Mar (2016) has revealed that *“integration with undocumented legacy components and integration with legacy components that are no longer in support”* (Mar, 2016, pp. 4) are among the high-risk factors of ‘Technical’ risk category.

Another finding of the project related risks was the human resource issue. In the context of R&D practice, the lack of the expert human resource can lead to many issues in the R&D lifecycle and cause projects failure. Mar (2016) has listed inability to secure sufficient resources for the project as project risk factor confirming to this research results regarding the hazards of the lack of experienced human capital in R&D projects. Moreover, Shin, et al. (2018) have also recognized insufficient R&D resources as one of the failure causes of R&D projects. Trained

or expert human resources were also an issue that was addressed by the research of Dillerup, et al. (2018). In their study of multiple projects for software developments, they have found out that *“lack of technical qualification will lead to technology competence”* (Dillerup, et al. 2018, pp. 32). This has also been addressed in the Luppino, et al. (2014) study in which due to lack of human resources, ‘installation risk’ scored high impact in one of the two analyzed projects of the research.

Budget is an important aspect of any project. A survey conducted by Standish Group International Inc. shows that only 25–30% projects are completed successfully, and that most of the projects fail due to cost overrun or schedule overrun (Dandage, et al. 2018). In addition, the financial and economic risks such as shortage of funds have been ranked in study as the sixth important cause of projects’ failure (Dandage, et al., 2017). Furthermore, (Hijazi, et al., 2014, pp. 216) study have identified *“Unrealistic Budget”* as risk factor in which has been defined as *“The estimated cost for the project may exceed the available budget, if this was not mitigated successfully,*

the project may be out of fund early in the software development lifecycle, and thus fails". (Hijazi, et al., 2014, pp. 216)

Moreover, Luppino, et al. (2014) placed project cost as having an extreme impact in one of the two analyzed R&D projects of the research. In addition, unrealistic time and cost estimates was one of main risk factors identified at the software development projects of the four analyzed companies of Antinyan, et al. (2018) study. Shin, et al. (2018, pp. 8) findings that "*Financial assessment error*" is one of the failure causes which occur in the R&D process.

1.3. RDC Related Risks

As per the findings, there were three main risks within the project related risk group that are summarized in Table 3 hereafter.

One of risks related to RDC issues was the lack of expertise in managers of RDC units. Mar's (2016) findings point out that lack of expert managers is among the main project risks. In addition, the lack of top management support has been addressed in many risk management researches as main project risk cause (Dandage, et al., 2018). Dillerup, et al. (2018) have recognized the lack of expert

managers as a recruitment risk factor which was categorized under internal capacity group of risks for the German Machinery and Plant Engineering Industry. Another research has recognized lack of expert managers as a type under internally generated risk category and referred the main cause for it to the "*failure of project manager*" (Dandage et al, 2018, pp.155).

Cultural differences risk has been found to be a recurrent challenge in project management risks within the risk management literature. Dandage, et al. (2018) have categorized this type under the category cultural risk and referred the main cause for it to the "*language barrier and differences in cultures*" (Dandage, et al. (2018, pp. 155). Furthermore, in Dandage, et al. (2017) study, they have ranked the cultural risks as the fifth important cause of projects' failure.

According to the participants of this research, the lack of the clear direction risk has led to many issues such as unclear career path and difficulty to project execution, which cause delays in project's schedule and losing expert people in the favor of gaining better job opportunities. Mar (2016) talked about the impact of such risk as

“Resource turnover leads to delays and cost overrun” (Mar 2016, pp. 3). The impact found in the current study of some RDC staff leaving the unit because they do not foresee a clear direction is a staff retention issue. In this regard, Dandage, et al. (2018) revealed that retention of competent staff as key risk causes of managerial risk category. This type of risk impact has been noted within the

profession of risk management, as Hijazi, et al. (2014) have ranked this risk under ‘Team Turnover’ as they stated

“In most organizations, experienced team member are looking for better job vacancies and leave their work if any was found. This factor threatens any project in any of its phases”. (Hijazi, et al., 2014, pp. 230).

Table 3: RDC Related Risks

RDC Related Risks				
#	Risk	Types / Causes	Impact	# Participants Mentioned the Issue
1	Lack of Expert Managers	<ul style="list-style-type: none"> ▪ No clear guidance on roles and responsibilities ▪ Lack of top management support ▪ Juggling on priorities ▪ Difficulty in the execution 	<ul style="list-style-type: none"> ▪ Scope creep ▪ Time creep 	3
2	Cultural Differences	<ul style="list-style-type: none"> ▪ Integration Issues ▪ Miscommunication 	<ul style="list-style-type: none"> ▪ Scope creep ▪ Time creep 	2
3	Lack of Clear	<ul style="list-style-type: none"> ▪ Difficulty in the execution 	<ul style="list-style-type: none"> ▪ Time creep 	4

RDC Related Risks				
#	Risk	Types / Causes	Impact	# Participants Mentioned the Issue
	Direction	<ul style="list-style-type: none"> ▪ Unclear career path ▪ Unclear vision and mission ▪ Lack of top management support 	<ul style="list-style-type: none"> ▪ Extra cost ▪ Loosing People ▪ Juggling on technology focus 	

2. RDCUAEAF RISK MANAGEMENT PRACTICES

Risk management observation is an important part of the RDC risk management practices, aiding project managers to mitigate the impact of risks on the projects. Identifying risks at the early stage of the project, and defining and planning tasks ahead of time can be an effective risk management practice.

Communicating updates among the project team and providing feedback are considered also of the risk management practices that can be highly effective in managing the impact of risks on the research project's execution and delivery.

In order to minimize the impact of risks on the execution and delivery of the projects, there is always a need for following risk management practices, which all the participants of this research had agreed on confirming the literature review as indicated by Luppino, et al. (2014, pp. 74) as well, who stated that

“All of the interviewees agreed that risk management is vital to the success of R&D projects. However, the various risk management methodologies currently adopted within the interviewees’ organizations varied in their maturity and level of formality”.

As per the results obtained from the participants of this study, it has been observed that there are

several risks management methodologies and practices, which can be used and integrated in the RDC projects in order to mitigate or minimize the impact of risks. For instance, it has been mentioned that *AS/NZS ISO 31000:2009 Risk management - Principles and guidelines* can be one of the effective risk management practices in the military R&D projects, since it offers comprehensive guidelines and best practices in risk management area.

This is confirmed in the risk management literature as well. For instance, Olechowski, et al. (2016) empirical evidence from the statistical analysis study suggested that the *ISO 31000* is indeed a promising guideline for the establishment of risk management in the engineering management. Also, the *ISO 31000* principles were found to be a significant factor in better reaching cost, schedule, technical and customer targets, in addition to achieving a more stable project execution. They conclude, as well, that their findings provide evidence of the potential for the principles to form the basis of a project risk management body of knowledge and to have a strong impact on the professionalization of the risk

management function (Olechowski, et al., 2016).

Moreover, various other risk management practices have been observed in the findings, which include educating customers, which offers customers better understanding regarding the research and development process in general and in the armed forces specifically, as well as making them understand the project lifecycle. This has been confirmed in the literature in many occasions, as some researchers suggested integrating customers into the innovation process to reduce the risks of unmet customer needs (Wang, 2010). Also, another researcher favored the participation of customers in the innovation process to achieve the necessary objectives which are as per the customer need (Mikkelsen, 1990).

Furthermore, as per the literature review and the study' findings, there are a lot of available and developed tools, standards, methodologies, practices, and frameworks that can fit for risk management of projects and R&D projects (Luppino, et al., 2014; Shin, et al., 2018), which the Research and Development Center of the UAE Armed Forces (RDCUAEAF) can use and benefit

from. However, a new and expert judgment can always be used also to provide best solution to tackle the risks occurred. Luppino, et al. (2014) findings acknowledged that 77.8 % of the interviewed project managers believed that “*their respective organizations would benefit from a new, more structured risk management methodology for their R&D projects*” (Luppino, et al., 2014, pp. 74).

The authors expanded that the new methodologies should be flexible and can be adapted to accommodate the risks associated with the R&D projects, and must involve relatively simple processes and procedures so that it doesn't carry out additional overhead to the project (Luppino, et al., 2014). Therefore, the management of the RDC organization should consider the recommended practices suggested by the participants of this research, along with other methodologies.

3. UAE Risk Model for R&D Projects

Results and discussion of this study led to the development of a risk model for UAE R&D Project environment. This risk model is illustrated in Figure 1 below.

The three main group risks are as discussed before; client related risks, project related risks, and organization related risks. Each risk includes variables deemed important by participants of this study. These risk groups have a direct impact on the management of project within a research environment. The result impact, direct and indirect leads to three main issues: scope creep, time creep and cost creep. These in turns have an impact on employee attrition rate and project failure or cancellation. This risk model can be used by interested organizations, students and researchers in future quantitative studies to test, update and generalize the model to the wider R&D community.

4. RECOMMENDATIONS AND CONCLUSION

The following set of recommendations if implemented can result in success for the R&D center:

Risk Management

The researchers of UAE R&D center need to plan for their complex projects much prior before the commencement of the actual project. Therefore, will preserve the wastage of resources and capital to a huge extent.

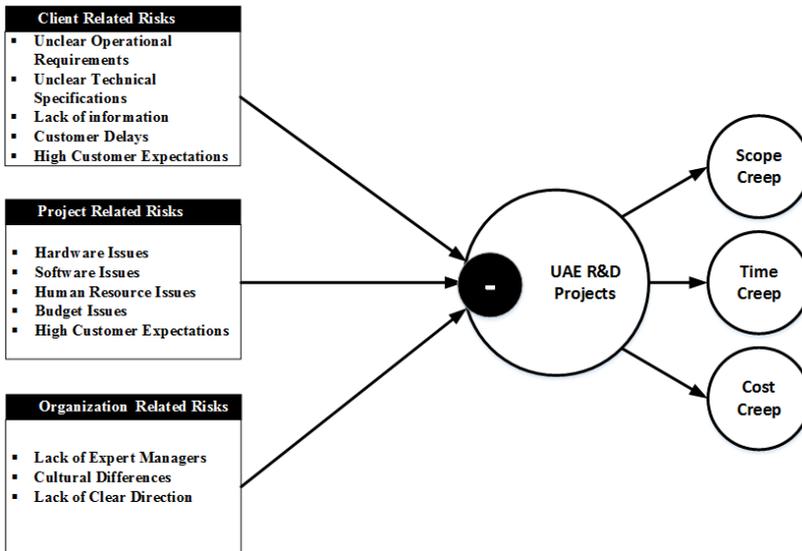


Figure 1: UAE R&D Risk Model.

(Source: Created by the researcher for the purpose of this study)

The UAE Armed forces project management personnel should be trained for the risk management in the complex R&D projects, which should include the techniques as well as the managerial responsibilities which are involved in the interpretation of the risk mitigation, assessments, and management of risks. There should be development and adoption of specific processes, which should include identifying, evaluating, designing, and selecting alternatives of the risks.

The project managers should consider the aspects of human resource, cost, and time to select

the type of matrices. They should develop more improved and expertise tools for risk management. The innovative approaches should be used for the adaptability of the R&D projects and risk management.

R&D Formation

No one can work alone in today's world. As complexity involves in each aspect of the life cycle, the cooperation among all sectors is required. Thus, the RDCUAEAF should involve and cooperate with the related sectors in the development and implementation of the R&D projects, taking in concern a close

control of highly classified research and without jeopardizing the safety of the Armed Forces information and security. Thus, the United Arab Emirates (UAE) government, including the Armed Forces, can cooperate with the academic sector as well as the industrial sector to execute the R&D projects, as each sector has set of capabilities and requirements that can benefit and exchange with the other sector.

Other Strategies

Another possible successful strategy is stimulated by Jordan (2019) who mentioned that organizations should encourage project managers which show potential characteristics such as the following:

- *Broad and deep experience leading projects:* Project managers get experience through managing more projects and involves in different business areas, and thus they rely in their own abilities rather than relying on defined processes.
- *A questioning attitude:* Ambitious project managers who are always looking for other methods to accomplish activities and do not tight themselves by existing approaches have the best chance of encountering innovative approaches. These

project managers are often seen as the ‘troublemakers’ who repeatedly ignore to follow processes they don’t believe in.

- *Exceptional self-belief and self-control:* Project managers who attempt to take innovate difficult decisions in situations where lack of both experience with the approaches being used exist.

Dandage, et al. (2018) have also suggested some project risk management strategies, which have been concluded in consultation with more than 20 project practitioners. These strategies include the following:

- Project should have clear scope, realistic cost and time estimates, and clear communication with the all stakeholders.
- Risk management must be integral part of the organizational culture.
- Risk management structure must be established within the organization.
- Top management support to risk management efforts.
- Risk management cost should be seen as an investment to prevent the forthcoming losses of the risk occurrence in the project.

The cooperation between all the sectors in UAE would result of world-class R&D that links and

leverages the development of capabilities to secure technological foundation, enhance military capabilities, and stimulate economic growth. This will result of a collaborative R&D environment supporting the defense industrial sector growth in UAE, manage and guide R&D national and international cooperation programs that meets stakeholders' requirements, and maximize outcome through effective R&D lifecycle and efficient spending, hence taking the UAE to the next level of prosperity.

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