ISSN (Online) 2456 -1304

International Journal of Science, Engineering and Management (IJSEM)

Volume 12, Issue 10, October 2025

Systematic Management of Technical Risks in Defence Science & Technology Projects

[1] Prem Y Borse, [2] Nilesh Ware

[1] Armament Research & Development Establishment (ARDE), Pune, India
Research Scholar, Defence Institute of Advanced Technology, Pune, India
[2] Defence Institute of Advanced Technology, Pune, India
* Corresponding Author's Email: [1] pyborse.arde@gov.in, [2] nilesh.ware@diat.ac.in

***Abstract*— Technical risks arise due to various reasons but mostly due to use of unproven or complex technology or from changes in technology during project development. Identification and mitigation of technical risks is very important for Science and Technology (S&T) type of projects as these risks may hamper the success of the project. S&T projects are one out of six defence R&D projects that are undertaken to accomplish certain objectives. Defence R&D project needs proper project planning and resources to succeed. Projects need to be managed effectively to ensure that they are completed on-time and within cost. Standard project management involves five stages namely; initiation, planning, execution, monitoring & control and closure.**

The objectives of this paper are to study the risk management plan and propose systematic methodology for identification of technical risks. To achieve these two objectives, literature review is done to understand existing methods for identification of technical risks and existing management plan for these risks. A new approach to identify technical risk by utilizing DFMEA methodology is adapted and various stages in the management plan are spelled out.

***Keywords*— Defence R&D, Risk Management Plan, S&T project, Technical risk.**

I. INTRODUCTION

R&D projects are undertaken to enhance country's products, processes & services and therefore these projects are directly proportional to country's technological growth. R&D projects that are implied to increase country's technological dominance in warfare situations are called as defence R&D projects. Defence R&D project are important to boast of technological advancement and dominance in military field and are required to get modernized technology in country. However, uncertainty and complexity hamper the progress of defence R&D projects and therefore these projects are prone to delays and cost escalations.

In the Indian defence context, defence R&D projects are categorized into five types namely, Science & Technology (S&T), Technology Demonstration (TD), Mission Mode (MM), Infrastructure (IF) and Product Support (PS) projects [3, 16, 7] and risks are categorized into three types namely, technical, procurement and test & evaluation risks [7] as illustrated in figure 1.

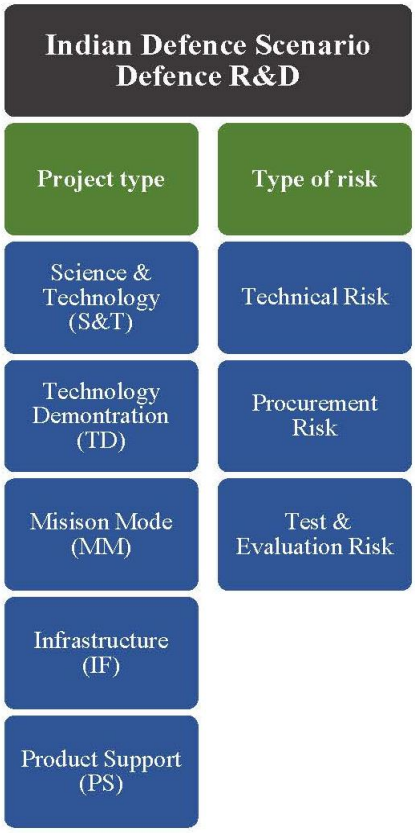

Fig 1. Defence R&D project types and risk types

Technical risks arise due to various reasons but mostly the sources of technical risks could be technical requirements, performance demands and premature technology [11]. Technical risks are crucial and the sources

ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)

Vol 10, Issue 2, February 2023

of technical risks are from the use of unproven or complex technology and from changes in technology during project development [15]. In addition to above mentioned sources of technical risks, Procedure for Project Formulation and Management, PPFM-2016 has proposed two additional sources from where technical risks originate in R&D project; i) changes in design requirements, ii) limitations of manufacturing processes [7]. PPFM-2016 is a revised version of PPFM-2006 which provided guidelines on procedures to be adopted for project formulation and management [7, 13]. Other sources of technical risk are scope change, technology selection, implementation methodology selection, equipment and material risk and engineering & design change [8]. These sources of technical risks arising from various reasons are illustrated in figure 2.

Technological uncertainties are inherently present in S&T projects in the form of technical risks, which may result in S&T project failure [6]. A substantive work had been carried out by these authors earlier where it was proved that technical risks are high in S&T project compared to TD & MM projects [4].

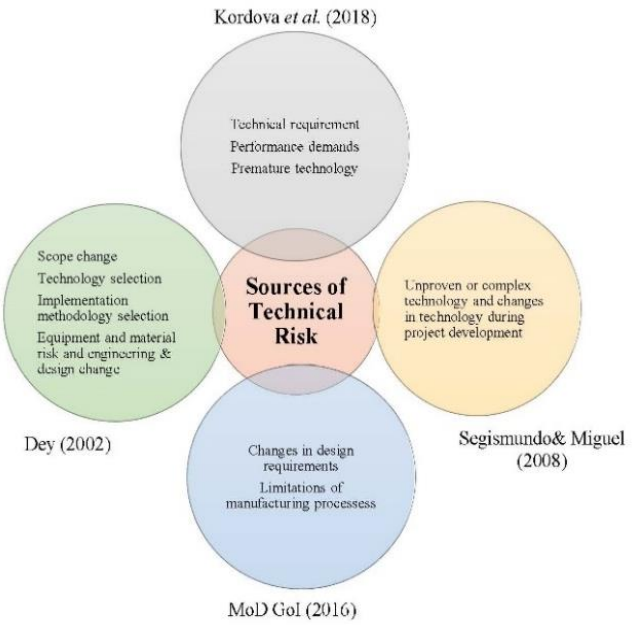

Fig 2. Various sources of Technical risk

In a defence R&D project, two types of risks are impactful, one that can be predicted in advance and the other which can't be predicted in advance [12]. However, the second type of risk has major impact on the outcome of the project. Technical risks, as per its definition are generated during integration of major technologies and therefore technical risks are difficult to predict in advance and hence create major impact on project objectives, namely scope, quality, cost and schedule. Impact of technical risk could result in component failure which ultimately can lead towards failure of the system [9] and therefore, it is important to identify technical risk.

II. RISK MANAGEMENT PLAN FOR TECHNICAL RISKS

Standard risk management plan for any type of risk includes five steps i.e. identification, assessment, prioritization, mitigation and tracking and monitoring as shown in figure 3. Risk management plan for technical risk typically follows the same pattern. It is important to adopt best risk management practices, which eventually results in improvement in the project performance [10]. The purpose of risk management is to reduce the impact of uncertainties on project outcome. All the five steps in risk management, as shown in figure 3 are important however, identification of risk becomes crucial as it is only after proper identification of risks, the other four stages become viable. Many authors have reviewed the process of risk management in R&D projects. Alshehhi *et al.* have studied risk management in complex R&D projects in UAE armed forces [2]. Wageman reviewed R&D risk using sequential and reiterative process of planning, identifying, categorizing, analyzing, prioritizing, response development and monitoring and controlling, which is a standard process of risk management [17]. Another study is by O'Neill *et al.*, who have enumerated risk management plan for risks in R&D projects [14].

III. NEW METHODOLOGY FOR TECHNICAL RISK MANAGEMENT PLAN

The Project Management Body of Knowledge (PMBoK) guide provides standard tools and techniques for identification of risks, which obviously means identification of technical risks too. According to PMBoK, documentation review; information gathering techniques such as brainstorming, Delphi technique, interviewing, root cause identification and SWOT (Strength, Weakness, Opportunity and Threats) analysis; checklist analysis; assumption analysis; diagramming techniques such as cause & effect diagram, system or process flow chart, and influence diagrams are few tools and techniques that are used for identification of risks [1]. Another novel method proposed by these authors for identification of technical risks is by using DFMEA [5]. In this method DFMEA is conducted during the design phase of the product. As the product/system is at the design stage, designers tend to understand the failure modes by considering functional aspects of the product/system and hence they conduct

ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)

Vol 10, Issue 2, February 2023

Design Failure Mode and Effect Analysis (DFMEA), a form of Failure Mode and Effect Analysis (FMEA) right at the conceptual stage of the design. DFMEA is an opportunity for designers to understand various risks during the design phase itself. When the failure modes are identified, causes of the failure modes are identified during DFMEA process. All the causes identified during DFMEA process are nothing but technical risks. Since failure modes are identified considering the function characteristics of the system/product, these failure modes are therefore concerned with technical aspect of the system/product. As the failure modes are concerned with technical aspects, causes for these failure modes therefore are related to technical aspects only.

The complete risk management plan for technical risk includes five stages starting from identification to tracking & monitoring as explained in figure 3. In the proposed new method, identification of technical risk is done by conducting DFMEA in which all the causes are considered as technical risks. However, input for other steps in risk management plan can also be taken from the DFMEA. As the causes are identified as technical risks, recommended corrective actions for these causes are considered as mitigation plan for these risks. Similarly, occurrence number given in DFMEA for these causes can be easily translated to probability of occurrence number in the risk management plan. Detection number in DFMEA is translated to impact on objectives. This model is shown in figure 4.

Fig 3. Risk management plan – five step process

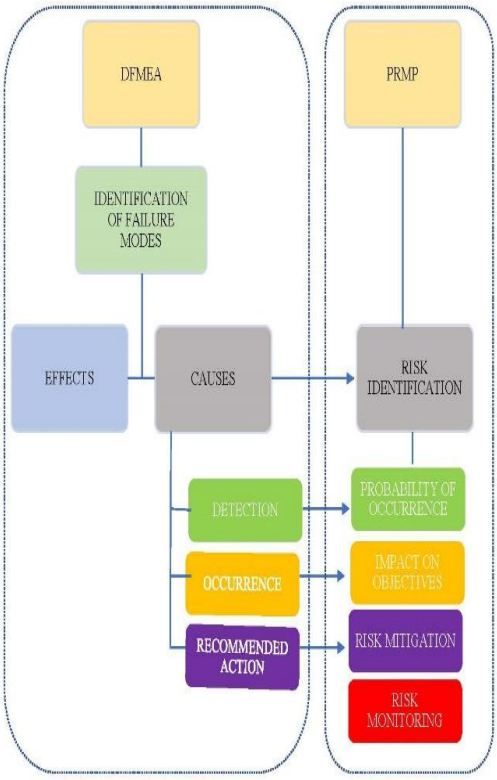

Fig 4. Integral model of DFMEA and PRMP

IV. CONCLUSION

Adapting to the new method of identification of technical risk through DFMEA and considering various output from DFMEA as input to risk management plan can save considerable time for the project manager in completing the risk management plan for technical risk. Besides project manager is in complete control of his technical risk as he need not have to refer multiple templates and at the same time, single team is responsible for conduct of DFMEA and risk management plan, which simplify the responsibility matrix. Project managers have a challenging task for them in terms of completing the project on-time, within cost, and with desired quality. These challenges put pressure on project manager and they have to rely on the designers for provision of reliable design which can meet customer's requirements. Project managers have to ensure that they meet the requirements of delivering project within cost and desired quality and therefore they adopt tools that can help eliminate various risks in the projects. Risk Management Plan serves the purpose of identification of various risks at the beginning of the project and helping project manager take appropriate actions at right time. If technical risks are identified and mitigation plan is spelled out at the beginning of the project, chances of delivering products/systems on

time and within cost increase manifolds.

REFERENCES:

[1] A Guide to the Project Management Body of Knowledge (PMBoK Guide), Newton Square, PA 19073-3299, USA, 2004.

[2] B. Alshehhi, D. Thorpe, S. Goh and S. Alkaabi, "Management of Risk in Delivering Complex Research and Development Projects: a Case of Research & Development Centre of the United Aram Emirates Armed Forces, Archives of Business Research", vol. 6, no. 11, pp. 48-154, 2018. doi: 10.14738/abr.
611.5648.

[3] R. Bedi., India's MoD Advancing 'Mission Mode Projects', Jane's Defence Weekly, Jane's by IHS Markit, March 2018.

[4] P. Borse and N. Ware, "Control of Technical Risks in Defence Science & Technology Projects" [Submitted for publication]. Technology Management Group, Armament Research & Development Establishment, India (2024).

[5] P. Borse and N. Ware, "Integrated Model for Identification & Mitigation of Technical Risk in Defence S&T Projects using Project Risk Management Plan (PRMP) and DFMEA" [Submitted for publication]. Technology Management Group, Armament Research & Development Establishment, India (2025).

[6] P. Crama, B. D. Reyck, Z. Degraeve and R. Leus, "Managing Technological Risk in R&D Project Planning: optimal Timing and Parallelization of R&D Activities", SSRN Electronic Journal, 2005. doi: 10.2139/ssrn.873584

[7] Defence Research and Development Organization, Procedure for Project Formulation and Management, PPFM-2016, MoD, GoI-2016, 2016.

[8] P. Dey, "Project Risk Management: A Combined Analytic Hierarchy Process and Decision Tree Approach. Cost Engineering", vol. 44, no. 3, pp. 13-26, 2002.

[9] C. Hsiao, R. Malak, I. Tumer and T. Doolen, "Empirical Findings about Risk and Risk Mitigating Actions from a Legacy Archive of a Large Design Organization", Procedia Computer Science, vol 16, pp. 844-852, 2013.

[10] R. Junior and M. Carvalho, "Understanding the Impact of Project Risk Management on Project Performance: an Empirical Study", Journal of Technology Management & Innovation, vol. 8, pp. 64-78, 2013.

[11] K. Kordova, E. Katz and M. Frank, "Managing development projects-The partnership between project managers and system engineers", System Engineering, vol. 22, no. 3, pp. 227-242, 2018.

[12] S. Kordova and S. Fridkin, "Risk Management for Defence SoS in a Complex Dynamic Environment", Sustainability, vol. 13, no.4, pp. 1789, 2021.

[13] T. Mohindra, and M. Srivastava, "Comparative Analysis of Project Management Frameworks and Proposition for Project Driven Organizations", PM World Journal, vol. 8, no. 8, pp. 1-15, 2019.

[14] J. O'Neill, N. Thakur and A. Duus, "Technical Risk Assessment: a Practitioner's Guide", Defence System Analysis Division, Defence Science and Technology Organization, DSTO-GD-0493, 2007.

[15] A. Segismundo and P. A. C. Miguel, "Failure Mode and Effect Analysis (FMEA) in the Context of Risk Management in New Product Development: A case study in an automotive company", International Journal of Quality and Reliability Management, vol. 25, no. 9, pp. 899-912, 2008.

[16] Union Government (Defence Services) Army, Ordnance Factories and Defence Public Sector Undertakings, Report No. 44. Report of the Comptroller and Auditor General of India. Chapter VI: Defence Research and Development Organisation, 2015.

[17] S. Wageman, "Risk Management on Research and Development Projects", In AACE International Transactions, Morgantown, RI71-RI76 2004.