Mitigating the Risk Management challenges in Global Software Development

MCS

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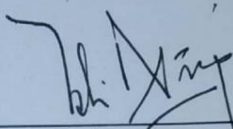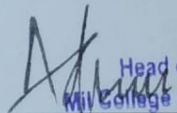Registration Number

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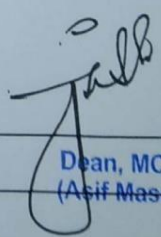Supervisor

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A thesis submitted to the faculty of Department of Computer Software Engineering, Military College of Signals, National University of Science and Technology (NUST), Rawalpindi in partial fulfillment for the degree of MS in Computer Software Engineering

(August, 2023)

THESIS ACCEPTANCE CERTIFICATE

Certified that final copy of MS Thesis written by **Ms. Maria Javed**, Registration No. **00000363965**, of **Military College of Signals** has been vetted by undersigned, found complete in all respects as per NUST Statutes/Regulations/MS Policy, is free of plagiarism, errors, and mistakes and is accepted as partial fulfillment for award of MS degree. It is further certified that necessary amendments as pointed out by GEC members and local evaluators of the scholar have also been incorporated in the said thesis.

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Declaration

I certify that this research work titled "*Mitigating the risk management challenges in Global Software Development*" is my own work. The work has not been presented elsewhere for assessment. The material that has been used from other sources, it has been properly acknowledged / referred.

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Dedication

This Thesis is dedicated to my beloved Parents, siblings, friends, and fellows, who have all been my endless source of love, encouragement, and strength. Your unwavering beliefs in my abilities, countless sacrifices, and relentless support have been the foundation upon which I built my academic pursuits. Without their love and support, this research work would not have been possible.

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I am thankful to all my family, particularly my parents, for they have always been my pillar of utmost strength and assistance. All this is an outcome of their love and prayers. I owe this degree of mine to my father, who was the ultimate source of motivation for me to pursue the bigger and better opportunities offered by life. I also want to extend my gratitude to my mother for always taking care of my needs and schedule and always blessing me with lots of prayers.

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Abstract

Global Software Global Software Development (GSD) has become increasingly popular as organizations look for ways to reduce costs, tap into global talent, and accelerate product development. However, managing software development across geographically dispersed teams poses unique challenges that can negatively impact project success. One of the biggest challenges in GSD is risk management, where the inability to identify and mitigate risks can lead to project delays, cost overruns, and quality issues. To mitigate these challenges, software organizations need to adopt a comprehensive risk management approach that addresses various aspects of GSD projects. In this research a risk management framework has been proposed by integrating several agile practices and seven risk management principles. The seven risk management principles help identify and manage risks at earlier stages, while the agile practices help improve communication and collaboration among team members. Incorporating seven risk management principles and various agile practices into one single framework or conceptual model known as RMMM (Risk Mitigation, Monitoring, and Management plan), GSD teams can effectively manage risks, minimize their impact, and ensure successful project delivery. The proposed model encompasses the identification, analysis, and mitigation of potential risks, emphasizing clear communication protocols, realistic project timelines, appropriate technology tool selection, and team members' requisite skills and expertise. Through rigorous research and validation from industry experts specializing in GSD, the RMMM model has proven to be highly effective in enhancing risk management in this context. The validated Risk Management Framework for Global Software Development (GSD) boasts a 66.7% comprehensiveness rate. Over 75% of experts are confident in its implementation, and more than 55% find it feasible and applicable to GSD, showcasing its potential to enhance project outcomes in complex distributed contexts.

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List of Abbreviation

GSD -------------------- Global Software Development

RMMM -------------------- Risk Mitigation Monitoring and Management

SDLC -------------------- Software Development Life Cycle

SEI -------------------- Software Engineering Institute

IP -------------------- Intellectual Property

HRM -------------------- Human Resource Management

CMMI -------------------- Capability Maturity Model Integration

ISM -------------------- Interpretive Structural Modelling

SLR -------------------- Systematic Literature Review

ISO -------------------- International Organization for Standardization

CHAPTER 1

INTRODUCTION

1.1. Overview

Global Software Development is an innovative approach to software engineering that combines skilled professionals from diverse locations worldwide. It offers cost-effective solutions, access to a global talent pool, and leveraging cutting-edge ideas. GSD empowers businesses to overcome barriers, fostering efficient communication, collaboration, and creativity, leading to increased productivity and faster time-to-market [1]. Risk management plays a significant role in GSD projects because risk management is a critical process in software development that involves identifying, assessing, and mitigating potential risks and issues that may arise during the entire SDLC.

Fig.1.1 shows basic framework of risk management in software industry.

Figure 1.1 Basic risk management framework used in software industry (Michael Buckbee, 2021)

However, it faces significant challenges when it comes to risk management because there is a lack of an appropriate framework for risk management that considers GSD issues mainly poor collaboration, cultural diversity, staff turnover, and time zone differences. Different techniques have been put forward addressing these concerns, but recent research have shown thatresearch is still not up to the mark in this field and risk management should be regarded as an important and major consideration while

operating in the domain of GSD [2][3][4].

The main objective and motivation behind this research are to develop a customized risk management framework that will aid the software industry aiming to do offshore development or operate in different co-locations. The proposed model will utilize several agile practices, as agile practices in software development emphasize iterative and incremental development, fostering collaboration, adaptability, and continuous improvement, enabling teams to respond promptly to changes and deliver high-quality software. The seven risk management principles developed by SEI will also prove to be a major contribution because they emphasize maintaining a global perspective, encouraging open communication among distributed stakeholders, and integrating risk considerations throughout the software development process, ensuring proactive risk identification and effective risk mitigation. As a result, enhanced and effective risk management will be carried out as part of the RMMM plan, helping the industries in more efficient ways and increasing their performance and productivity.

The proposed model will be validated by the targeted industry experts, to know the applicability of the model, helping the experts in the analysis of their own risk management framework and improving it wherever necessary.

 Followed steps of this thesis are summarized in these below mentioned points.

- Discovering major challenges that are generally faced by the GSD teams.

- Filtering out the challenges specifically related to risk management and then explaining them in related work.

- Presenting the explored challenges and their mitigation strategies in a tabular

form.

- Development of proposed model, explaining each phase and getting the model validation from 25-30 software industry experts operating in the domain of GSD.

- Lastly, drawing analysis and conclusions from the gathered data validated by industry experts and predicting future directions.

1.2. Motivation

Global Software Development is becoming increasingly popular in today's globalized world driven by the need for organizations to access a broader talent pool where teams spread across different geographical locations, time zones, and cultures. With this distributed nature of work, there are significant risks involved in terms of communication, coordination, collaboration, cultural differences, time zone differences, technology, project management, legal and regulatory [1- 4]. Also risk management is a critical aspect of project management, and GSD introduces additional risks that must be managed. These challenges increase the risk of project failure if they are not effectively managed. Hence, it is crucial to adopt effective risk management strategies to mitigate these risks.

By exploring how to mitigate risk management challenges in GSD, this thesis research can contribute to the development of best practices for managing risk in a globally distributed software development environment. Earlier, there is an abundance of literature on software project management and risk management, much of this research is focused on co-located teams. Research that examines the unique challenges of risk management in GSD along with a conceptual model/framework is limited.

The 7 risk management principles provide a comprehensive framework for managing risks, including identification, assessment, treatment, and monitoring. These principles can be applied

to the context of GSD to identify and manage risks effectively. Agile practices are widely adopted in software development, particularly in the context of GSD, to enhance flexibility, collaboration, and adaptability.

 By integrating Agile practices with risk management principles, identifying, and assessing potential risks, developing and implementing mitigation strategies, and monitoring and controlling risks throughout the project, GSD teams can improve communication, build trust, and deliver high-quality software products on time and within budget. It can also help to improve the effectiveness of GSD teams, enhance project outcomes, and increase the competitiveness of organizations operating in this space.

1.3. Problem Statement

Global Software Development has gained widespread traction, revolutionizing how software projects are executed. While GSD offers numerous advantages such as access to a diverse talent pool and cost-effective operations, it also introduces a host of novel and intricate challenges in risk management. The inherent nature of GSD, with teams dispersed across different regions and time zones, brings forth a myriad of risk factors that demand meticulous attention and innovative solutions.

The primary challenges arise from the potential communication breakdowns, cultural disparities, and varying time zones prevalent in GSD settings. These obstacles engender an environment where risks can manifest and escalate quickly, jeopardizing project timelines, budgets, and overall success. Even with the widespread adoption of agile practices, which emphasize adaptability and collaboration, risk management in GSD remains an overarching obstacle, necessitating a more profound exploration of potential solutions.

To address the challenges of GSD, it is crucial to integrate risk management principles and agile practices. A comprehensive conceptual model must proactively identify and assess risks, devise dynamic mitigation strategies, foster open communication, and facilitate continuous monitoring

and learning. This model should also handle cultural differences, legal compliance, and fluctuations in skilled resources. By adopting this innovative approach, organizations can confidently undertake GSD projects, minimize risk exposure, and increase the likelihood of successful outcomes.

1.4. Research Objectives

The fundamental tenets for this research thesis are summarized in the following broad range of objectives:

- **RO1:** To determine the risk management challenges encountered throughout the entire SDLC and their mitigation strategies to reduce the identified risk management challenges in Global Software Development.

- **RO2:** To present a mapping between identified risk management challenges and mitigation strategies.

- **RO3:** To propose a conceptual model based on 7 risk management principles alongside several agile practices to handle risk management challenges effectively.

- **RO4:** To get validation of the conceptual model from industry experts and drawing conclusions from it.

1.5. Relevance to National Needs

- Early identification of risks can save a lot of time, cost and even repute of the companies operating with the aim of developing Global Software Development projects.

- Pakistan is a country prone to various natural disasters, which can disrupt software development projects. Effective risk management can help these companies to anticipate and mitigate these risks, ensuring that their projects are not impacted by such events globally.

- By applying the 7 risk management principles and integrating agile practices, Pakistani software development companies developing GSD projects can better manage risks and improve the success rate.

1.6. Area of Application

Application of this research will aid these industries in minimizing potential risks, enhancing project outcomes, and promoting successful collaboration in the ever-evolving landscape of Global Software Development:

- Software development projects that involve distributed teams or offshore development.

- Global businesses that have operations in different countries and regions.

- Cross-cultural team management.

- Supply Chain Management, where it can prove to be resilient and can withstand disruptions.

- Disaster management, especially in countries like Pakistan, which are prone to natural disasters.

1.7. Advantages

The following set of advantages have been discovered through the diligent implementation of a thorough survey and the subsequent in-depth research done. These benefits highlight the important contributions made by this study to the world of technology, demonstrating its ability to stimulate development and innovation within the field.

- By combining the seven risk management principles with agile concepts, effective risk management may help guarantee that GSD projects are finished on schedule, within budget, and to the required quality standards. By adopting effective risk management strategies, project teams can improve communication and collaboration among team members, which is critical for the success of GSD projects.

- Identifying and addressing potential issues before they become significant problems, project teams can avoid costly rework, delays, or failures.

- By adopting effective risk management strategies, GSD projects can become more resilient to unexpected events, such as natural disasters or disruptions to the supply chain. This can help ensure that projects are completed despite adverse circumstances.

- Demonstrating a proactive approach to risk management, project teams can increase stakeholder trust and support, which can lead to increased investment and opportunities.

1.8. Thesis Organization

The research work has been organized and distributed in the following chapters enlisted below. Also Fig. 1.3, represents the layout of this thesis which is described in detail in this section.

- **Chapter 1**: A brief introduction is given in this chapter. Problem statement followed by research objectives, relevance to national need, area of application and its advantages are elaborated.

- **Chapter 2**: This chapter describes related works carried out by first defining the major risk management challenges faced by GSD teams and at the end listing all the challenges and discovered mitigation strategies in a tabular form.

- **Chapter 3**: This chapter explains the proposed model in detail. It is covering the major research objectives of this research by explaining all three phases of proposed model in detail and presenting mapping between mitigation strategies with agile practices and seven risk management principles.

- **Chapter 4**: This Chapters presents how the validation of proposed model is carried out by the industry experts, what methodology is followed and how the results will be collected.

- **Chapter 5**: This chapter presents the results of the thesis study, analysis, objective achieved by proposed model and the shortcomings that were noticed during the process.

- **Chapter 6**: This Chapter sums up the research with conclusions drawn and discusses the future aspects of the research.
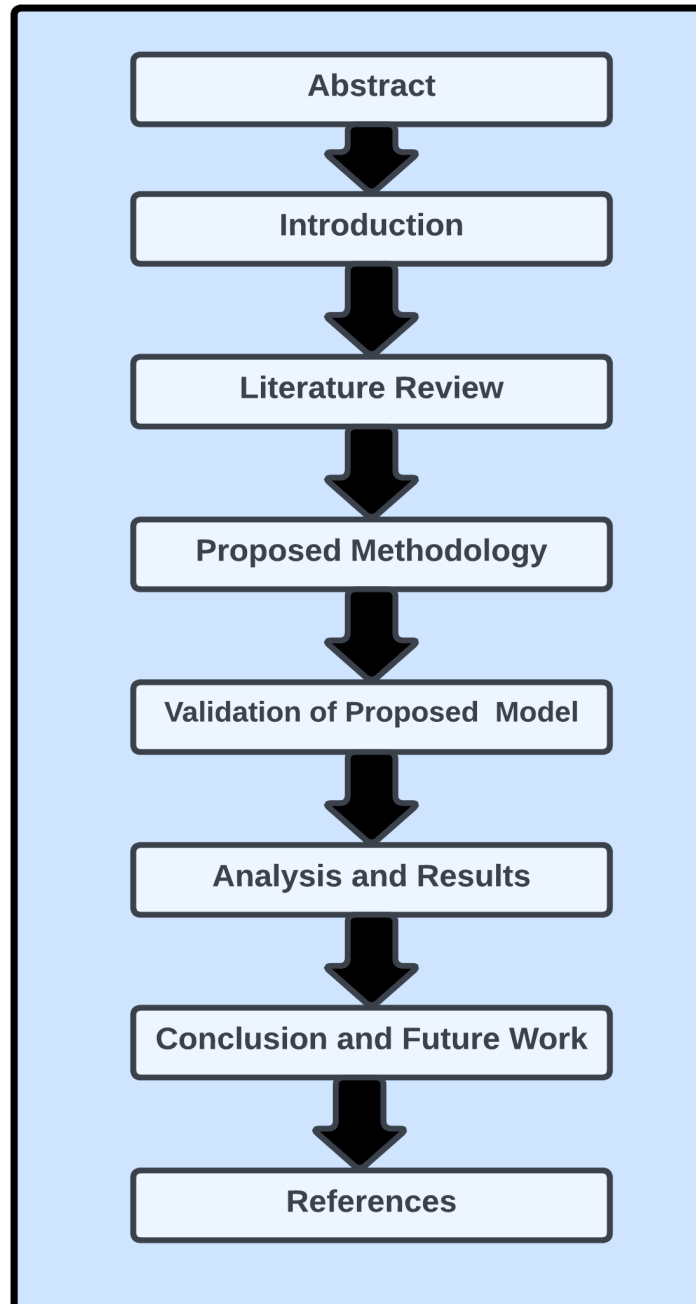

Figure 1. 2: Organization of the thesis

CHAPTER 2

LITERATURE REVIEW

2.1. Introduction

In this chapter, some of the most significant challenges that the global software development teams encounter during the risk management process are discussed. The many existing mitigations and processes/methods, their applicability, and functions, as well as a thorough examination of what has already been done and what needs to be considered, are all presented in depth. At the conclusion, a table listing all challenges identified and mitigation measures are provided.

2.2. Related Work

The concept of "Global Software Development" has its roots in the early days of software engineering and the emergence of distributed computing. While it is difficult to attribute the exact origin of the term to a single individual, it can be traced back to the late 1980s and early 1990s .Since then it is gaining immense popularity with each passing day due to its cost saving benefits, highly skilled workers and better development ideas .However it possess significant challenges in the field of managing risks that may arise as a result of poor communication, collaboration, cultural diversity, staff turnover, time zone differences and many other issues related to quality and technology, most importantly due to lack of a proper framework for risk management including the aspects of GSD. Although many strategies have been used but they have not been proven to be the ultimate mitigation strategies. The efficient management of risks is crucial for the success of GSD projects. There is need to identify the key risk factors and propose effective strategies, customized frameworks, and tools that can enhance risk mitigation in GSD projects. Understanding and addressing these challenges is essential for organizations to leverage the benefits of GSD while minimizing potential risks and ensuring successful project outcomes.

GSD and its major challenges specifically related to risk management have been discussed by Qureshi et al., 2021; Saleem et al., 2019; Wan Husin et al, 2019; Bass et al., 2018

respectively in [1, 4] .These articles provide a comprehensive analysis of risk management challenges as well as some general challenges related to GSD by categorizing them into different groups i.e. individual, team and organizational level. The most significant issues discussed by them includes communication, coordination, collaboration, cultural differences, technology and staff retention challenges. They have also discussed some of the mitigation strategies including a risk management framework that may be comprising of risk management process with clear roles and responsibilities for identifying, analyzing, mitigating, and monitoring risks, and addressing communication breakdowns, cultural differences, and technological challenges, also a communication and coordination plan, evaluating effectiveness through case studies and data analysis are suggested. Also, for enhancing employee retention, factors such as job satisfaction, organizational commitment, and social support should be considered, and organizations should evaluate the advantages and disadvantages of in-house offshoring and offshore outsourcing models based on their priorities and available resources.

Communication, collaboration, and coordination are considered as some of the main problems faced by GSD teams, hence effecting the overall risk management system of the development because different teams are located at different places, within different time zones and having cultural differences. Pakistan is a country that faces a lot of challenges related to it. Janjua *et al*. in [5] discussed the effects of communication issues on GSD projects in Pakistan's IT industry. A survey was conducted involving people from all over the Pakistan who were involved in GSD. Language barriers, limited face-to-face communication, and time zone differences were identified as the most significant communication issues prevalent in GSD projects in Pakistan, substantially impacting the project outcomes, leading to delays, compromised quality, and increased costs. Alongside these challenges several strategies were also presented for project managers, such as

enhancing language skills, utilizing video conferencing tools, and establishing effective communication protocols. The mitigations also underscored the significance of cultural awareness and sensitivity in GSD projects.

A solution has been provided by Morrison-Smith *et al.* in [6], but the research is still in demand of understanding the importance of and developing strategies to address the challenges in order to promote successful collaboration and achieve project goals. The authors begin by defining virtual teams as teams that work across geographic and/or temporal boundaries and use communication technologies to collaborate. They identified several challenges and barriers that can affect the success of virtual teams. These include communication difficulties, lack of trust and cohesion, cultural and linguistic differences, time zone differences, and differences in work styles and practices. Additionally, the authors note that virtual teams can face unique challenges related to technology, such as technical issues and difficulties in using collaboration tools. The mitigation strategies defined include building trust through regular communication and social interaction, providing clear guidelines and expectations for communication and collaboration, using technology tools effectively, and adapting to cultural and linguistic differences for the challenges and barriers faced by virtual teams.

In GSD, teams face risk management challenges because of the continuous changing requirements [7]. These challenges include communication barriers, cultural differences, geographical distance, and differing software development processes and tools. A survey of practitioners in the field was also presented along with the results. The survey results indicate that the most effective mitigation strategies for overcoming the challenges of reusing requirements in large-scale distributed agile software development include effective communication, collaboration, and knowledge sharing among team members. The use of agile development methodologies and tools, such as user stories and agile boards, also

emerged as important mitigation strategies. It also underscores the importance of establishing clear roles and responsibilities within teams engaged in large-scale distributed agile software development projects. Results indicate that a clear understanding of who is responsible for specific tasks can significantly aid in mitigating the challenges of reusing requirements. Furthermore, the authors emphasize the role of organizational culture in fostering collaboration, knowledge sharing, and continuous improvement, which are crucial in overcoming the challenges of reusing requirements in these projects.

 Some more success factors related to requirement implementation and thus resulting in effective risk management were presented in [8]. These factors need to be carefully considered when planning and executing GSD projects. These factors were presented in a group of 6 categories. The six categories of success factors identified by the authors are: organizational, team-related, project-related, communication-related, process-related, and technology-related factors. Organizational factors include the maturity of the organization's software development process, the organization's culture, and the organization's commitment to GSD. Team-related factors include team cohesion, trust, and communication among team members. Project-related factors include project scope, project complexity, and project management practices. Communication-related factors include communication technologies and channels used by team members and the quality of communication. Process-related factors include the process maturity level, process standardization, and the degree of process tailoring. Technology-related factors include the use of tools and technology to support requirements implementation in GSD projects.

Software architecting also plays an important role in the success of GSD projects. The authors discuss the challenges faced by software architects in the context of GSD, including communication challenges, cultural differences, and time zone differences [9]. These potential challenges can result in poor risk management. To overcome these challenges a set

of best practices were also presented. Use of collaborative tools that can help overcome communication challenges and facilitate collaboration among team members. Tools such as video conferencing, chat, and document sharing can be used to improve communication and enable better collaboration. Adoption of agile methodologies that can help software architects to manage changing requirements and facilitate collaboration among team members. Agile practices such as continuous integration, frequent releases, and backlog prioritization can help improve the quality of software architecture. Clear responsibilities should be defined for each team member to ensure that everyone understands their role in the software architecture process. This can help reduce confusion and improve communication among team members. Cultural differences can impact communication and collaboration in GSD projects. Software architects should be aware of these differences and be sensitive to them to ensure effective communication and collaboration. Standardized architectural patterns can help improve the quality of software architecture and ensure that it meets the requirements of stakeholders. These patterns can be reused across different projects, making it easier to maintain and evolve software architecture over time. These practices can help improve communication, collaboration, and the quality of software architecture, ensuring that software meets the requirements of stakeholders.

A solution primarily focusing on applying Capability Maturity Model Integration (CMMI) to GSD projects was presented in [10], CMMI can offer significant benefits, but it also presents unique challenges that need to be addressed. The presented challenges such as communication barriers, cultural differences, and time zone differences are somewhat closely related to all the risk management challenges mentioned earlier in this section. The paper highlights the importance of understanding the relationship between GSD and CMMI, and it emphasizes the need for project managers to carefully consider these challenges and benefits when implementing CMMI in GSD projects. Although the impact of CMMI on

GSD project outcomes is influenced by several factors, such as project size, project complexity, and organizational culture, CMMI has a positive impact on project outcomes, such as quality, cost, and time to market. By selecting the appropriate CMMI-based process model and addressing critical factors project managers can improve project outcomes, enhance process control, increase efficiency, and achieve better software process improvement in GSD projects.

Partnership formation among GSD teams plays significant role in the risk management because GSD projects are primarily based on partnership among different stakeholders. In [11,12], the importance of partnership formation in software outsourcing and the need to address the barriers such as trust issues, cultural differences, and communication issues that hinder successful collaborations is discussed. The authors provide insights and strategies to overcome these barriers, emphasizing effective communication, cultural awareness, and shared goals. The interpretive structural modeling (ISM) approach is also discussed as a tool for analyzing the relationships between barriers to partnership formation in software outsourcing. It addresses the growing trend of software outsourcing and the challenges that arise due to cultural differences, communication issues, and differences in goals and expectations. The ISM approach is used to develop a hierarchical model of the barriers and identify the most significant ones. The paper suggests strategies such as cross-cultural training, effective communication practices, and goal setting to address these barriers. It emphasizes the value of the ISM approach in identifying and addressing barriers in outsourcing partnerships.

The importance of effective leadership, communication, collaboration, and cultural sensitivity in the success of distributed projects is discussed in the context of student projects, the authors highlight the impact of time zone differences, communication barriers, and technical difficulties on team resilience. They conducted a study involving 30 student

teams and found that effective leadership, clear communication, and task coordination were crucial factors in promoting team resilience. The authors recommend that educators and project managers prioritize these dimensions to support resilient teams in distributed student projects [13].

Similarly, the article [14] delves into the challenges encountered by multicultural teams developing a global software user interface. The authors discuss the importance of understanding cultural differences and designing culturally sensitive interfaces. The case study presented involves a team dispersed across different countries and time zones. The authors identify language barriers, cultural differences, and technical issues as the main challenges faced by the team. They stress the significance of regular communication, collaboration tools, and fostering trust and openness within the team to overcome these challenges. The recommendations provided in the paper serve as a guide for developing global software user interfaces by multicultural teams.

Collaboration, coordination along with learning the effectiveness of team wisdom has been discussed in [15-19]. In today's complicated and globally interconnected environment, shared leadership and collaborative software development are essential. Successful collaborative software development relies on good communication, code reviews, version control, and task management. Similar to this, effective coordination of shared leadership in virtual teams depends on clear communication, coordination procedures, cultural sensitivity, technical tools, and trust. Collaboration in GSD projects has particular difficulties due to language limitations, cultural differences, and time zone variances. These obstacles can be addressed, though, with the correct coordination techniques, such as consistent status meetings, collaborative software, and effective project management. Team members should also receive training and assistance, and cultural variations should be considered. Team wisdom, characterized by knowledge sharing, collaborative problem-solving, reflective

learning, and trust, plays a significant role in project performance. Building team wisdom enhances the team's ability to solve complex problems and make sound decisions, leading to better project outcomes.

Emphasize have been paid to understand and address different risks to enhance the effectiveness and efficiency of GSD projects. In [20] a SLR study was conducted to identify the risks associated with GSD projects that utilize the agile methodology. The authors emphasize the flexibility, iterative nature, and collaborative aspects of agile methodology that make it suitable for GSD. However, they also acknowledge the presence of risks in this approach such as communication barriers, cultural differences, time zone differences, and technical challenges. Strategies for mitigating these risks are also discussed, including the use of appropriate communication tools, training for team members, and agile practices that promote collaboration and feedback. Similarly [21] aims to identify the factors that impact the adaptation of agile methodology in GSD and provide insights into its effective implementation. The review reveals positive outcomes of agile implementation in GSD, including improved team collaboration, faster project delivery, and better software quality. However, challenges such as the need for more planning and preparation time, flexibility in agile approaches, and enhanced coordination and communication are also identified.

A comparison was drawn between traditional and agile approach to project management in [22]. Traditional project management, characterized by a sequential and structured approach and agile project management, which is more flexible and iterative. Specific approach to risk management was further examined in both scenarios. In traditional project management, a formal process involving risk identification, assessment, prioritization, and the development of a risk management plan is typically followed. On the other hand, agile project management takes a collaborative approach, where team members work together to identify and address risks throughout the project's lifecycle. The article emphasizes that both

methodologies recognize the importance of risk management but adopt different strategies. Traditional project management focuses on risk minimization, while agile project management emphasizes the identification and mitigation of risks as they arise.

Lean methodology is often considered as a complimentary approach to agile methodology [23]. This article provides valuable insights for organizations that are considering transitioning from a plan-driven approach to a lean approach. The authors emphasize the importance of understanding the organization's context and culture, identifying, and implementing lean practices that are aligned with the organization's goals, and continuously monitoring and adapting the practices to achieve the desired outcomes. Traditional plan-driven approach as a rigid and hierarchical process where requirements are defined upfront, and development follows a strict plan. On the other hand, a lean approach is more flexible and emphasizes continuous improvement, customer satisfaction, and waste reduction. The paper highlights several challenges that organizations may face during the transition, such as resistance to change, lack of knowledge and skills, and cultural differences. To overcome these challenges, the authors suggest a practice-centric approach, which focuses on identifying and implementing lean practices that are aligned with the organization's context and culture.

Significance of risk management in Scrum software development projects was discussed in [24, 25]. Risk management in Scrum projects is challenging because of the fast-paced nature of the methodology and the constant changes that occur during the development process. The authors provide several examples of risks that can occur in Scrum projects, such as requirements changes, team turnover, and technical challenges. To mitigate these risks, the authors suggest several risk management strategies or framework that can be applied in Scrum projects. These strategies include continuous risk assessment, early risk identification, risk prioritization, risk response planning, risk monitoring and control and

risk mitigation planning. The authors also suggest that risk management should be an integral part of the Scrum framework and that it should be included in the project backlog. A framework for identifying the hard and soft skills required for success in Scrum GSD teams was discussed in [26]. By adopting a holistic approach to skill development, organizations can improve their software development practices and achieve better outcomes in Scrum GSD projects. The framework consists of three categories: technical skills, communication skills, and cultural awareness. The technical skills required for success in Scrum GSD teams include knowledge of programming languages, software development tools, and development methodologies. Team members should have a deep understanding of the Scrum methodology and its associated practices. The communication skills required for success in Scrum GSD teams include active listening, effective feedback, and conflict resolution. Team members should be able to communicate clearly and effectively and should be able to adapt their communication style to different cultural contexts. The cultural awareness required for success in Scrum GSD teams includes an understanding of cultural differences, values, and beliefs. Team members should be able to work effectively with people from different cultures and should be sensitive to cultural nuances.

Implementing agile in the context of GSD offers a variety of benefits. Majority of the studies focus on the benefits of using agile methods in GSD projects, such as increased productivity, improved quality, and better collaboration among team members [27, 28]. Researchers highlighted that most of the studies proposed specific techniques and tools for implementing agile methods in GSD projects, such as daily stand-up meetings, user stories, and test-driven development. The authors also highlight the importance of communication, collaboration, and cultural awareness in risk management in Agile GSD projects. They suggest that project managers should establish effective communication channels, build trust and relationships

among team members, and develop a shared understanding of project goals and objectives. The SWOT analysis provides a useful tool for identifying the challenges and opportunities of scaling agile methods in GSD [29]. By understanding these factors, organizations can develop strategies to overcome the challenges and leverage the opportunities of scaling agile methods in a global context. The SWOT analysis proposed by the authors consists of four components: strengths, weaknesses, opportunities, and threats. The strengths of scaling agile methods in GSD include increased customer satisfaction, improved product quality, and faster time-to-market. The weaknesses of scaling agile methods in this context include cultural barriers, communication challenges, and the need for a highly skilled workforce. The opportunities of scaling agile methods in GSD include improved collaboration, increased innovation, and reduced costs. The threats of scaling agile methods in this context include resistance to change, lack of management support, and difficulty in managing distributed teams.

The challenges and strategies specific to projects based on open-source software, enterprise projects, and the software development life cycle in general have been discussed in [30-33]. Inadequate risk identification and analysis, poor communication and collaboration among stakeholders, and a lack of formal risk management processes are the root causes of these challenges. To address the identified challenges, the project team implemented process improvement initiatives. These initiatives included developing a risk management plan, establishing a risk management team, adopting a risk management software tool, adopting best practices, establishing formal support agreements, and providing risk management training to project stakeholders. A theme has also been discussed it includes the need for a systematic and integrated approach to risk management, early risk identification and analysis, the role of risk management in software process improvement, challenges of risk management in agile development environments, and the importance of effective risk

communication and collaboration. The identified critical success factors using ISO 31000:2018 standard include top management commitment and support, integration of risk management into organizational processes, communication and collaboration among stakeholders, effective risk assessment, and a focus on continuous improvement.

The Seven Principles of Risk Management (Pressman, 2014) are particularly relevant in the context of GSD because they provide a comprehensive framework for effectively managing software development project risks in a global environment. These principles include maintaining a global perspective, taking a forward-looking view, encouraging open communication, integrating risk management, emphasizing a continuous process, shared product vision and encouraging teamwork [34]. By following these principles, software development teams can effectively identify and address potential risks, resulting in more successful projects and satisfied stakeholders. The principles are practical and straightforward, and the SEI provides additional resources to help organizations implement them effectively.

Managing software products in a global context poses various challenges. These challenges include language and cultural barriers, time zone differences, and regulatory compliance issues. [35-38] emphasizes the significance of understanding local markets by adapting software products to local markets is also emphasized as an important aspect. Understanding the unique needs and preferences of target markets, including local languages, currencies, and regulations, is vital for the success of software products in global contexts. Cultures, and regulations, effective communication, adapting software to local contexts, rigorous testing, and quality assurance because testing and quality assurance are highlighted as essential steps in GSD. Rigorous testing is necessary to ensure that the software functions correctly in different cultural and regulatory contexts. Building strong partnerships by building strong relationships with global partners and suppliers is another key factor in successful GSD.

Effective partnerships can help overcome language barriers and cultural differences, leading to smoother collaboration. Considering critical success factors and cost attributes by providing an integrative framework to identify the software cost attributes of software project management in GSD. This framework considers project characteristics, team characteristics, process characteristics, communication, cultural factors, and environmental factors as important cost attributes in GSD. By addressing these aspects, software development projects in a global context can overcome challenges and achieve better outcomes.

Effective project risk management plays a crucial role in creating value for organizations by improving project outcomes, enhancing stakeholder satisfaction, and enabling better decision-making [39]. It goes beyond merely avoiding or mitigating risks and involves identifying opportunities that can benefit the organization. Taking a proactive approach to risk management allows organizations to identify potential risks and opportunities, taking appropriate actions to create value. To achieve this, organizations should adopt a holistic approach to project risk management, encompassing the identification, assessment, response, and monitoring of risks throughout the project's lifecycle. Leadership also plays a vital role in fostering a risk-aware culture and promoting effective risk management practices.

The challenges and best practices for achieving success in GSD have been focused in [40]. Researchers proposed best practices by emphasizing that GSD requires using a combination of synchronous and asynchronous communication methods, such as video conferencing, email, and instant messaging, also establishing a common language for communication to reduce language barriers. Then strong project management using agile methodologies, which emphasize collaboration, flexibility, and rapid feedback, use of project management tools to track progress, identify risks, and manage dependencies, a strong team culture

promoting diversity, encouraging team members to share their perspectives, giving them opportunities for training and development to enhance their skills and promote career growth and fostering a sense of shared ownership for the project's success, and the effective use of technology tools for version control, code reviews, and automated testing to improve software quality and reduce development time, cloud-based tools to enable collaboration and access to resources from anywhere in the world.

2.3. Major Risk Management Challenges Faced by Global Software Development Teams

This section aims to provide an overview of the main concerns associated with risk management in GSD that require attention and emphasizes the need for effective risk management by GSD teams to ensure smooth project execution and favorable outcomes. These challenges are presented with references in tabular form at the end of this chapter.

- **Communication Challenges**

Communication challenges are prevalent within GSD teams due to a variety of factors, including language barriers, cultural differences, and the absence of face-to-face interaction. These challenges can impede effective communication, leading to miscommunication and misunderstandings that can adversely affect project outcomes.

  o **Language Barriers**

  It poses a significant hurdle in GSD teams where members may have varying levels of proficiency in a common language. Communication becomes intricate when team members are unable to express themselves clearly or comprehend instructions accurately. Differences in language fluency can lead to misunderstandings, incorrect interpretations, and misaligned expectations. It requires additional effort to overcome these language barriers and ensure that messages are conveyed accurately and comprehensively.

o **Cultural Differences**

It further complicates communication within GSD teams. Each team member may come from diverse cultural backgrounds, which influence their communication styles, norms, and expectations. These disparities can manifest in several ways, such as differing attitudes towards hierarchy, directness in communication, or the perception of deadlines. Misinterpretations and conflicts can arise when these cultural nuances are not recognized or adequately addressed. Cultural sensitivity and awareness are vital in promoting effective communication and fostering a collaborative environment.

o **Lack of Face-to-Face Interaction**

It poses another challenge. Non-verbal cues, such as facial expressions, body language, and tone of voice, play a crucial role in conveying meaning and building rapport. In virtual communication, these visual and auditory cues are often limited or absent, making it harder to gauge intent and emotions accurately. Without these cues, messages can be misinterpreted, leading to confusion and potential breakdowns in communication.

- **Coordination and Collaboration Challenges:**

Geographical distance, differences in work cultures, and lack of trust between team members can pose challenges in coordinating and collaborating effectively, impacting project progress and outcomes.

o **Geographical Distance**

GSD often involves teams located in different geographical locations, sometimes across multiple time zones. This dispersion can make it difficult to coordinate and align project activities, leading to delays, miscommunication, and increased risks.

o **Differences in Work Cultures**

The presence of different cultural norms and practices within a team can have a significant impact on team dynamics and understanding. This can result in conflicts and challenges when it comes to aligning work approaches and expectations. The diverse work cultures, practices, and expectations among team members can create coordination challenges, leading to delays, conflicting approaches, and ultimately reduced productivity. It is crucial for GSD teams to recognize and address these cultural differences in order to foster effective collaboration and ensure a harmonious working environment.

o **Lack of Trust Between Team Members**

Establishing trust and fostering cohesion among team members in GSD (GSD) projects can be challenging, and these difficulties can have a significant impact on collaboration, knowledge sharing, and decision-making processes. In GSD, team members often have limited familiarity and face-to-face interaction with one another, which can lead to trust issues. The absence of direct personal interactions can hinder the development of trust and mutual understanding among team members. Consequently, trust issues can negatively affect communication, collaboration, and decision-making within the team. Team members may hesitate to share knowledge, express their opinions, or take risks due to the lack of trust. This can impede effective collaboration and hinder the overall success of the project.

- **Quality Assurance Challenges:**

Working across different time zones and non-identical testing environments can result in delays in communication, decision-making, and problem-solving, which may affect project timelines productivity and quality. It also includes challenges related to communication, coordination and collaboration and are already in upper section.

o **Time Zone Differences**

Working with teams across different time zones can lead to delays in communication, decision-making, and problem-solving. This can affect project timelines and the ability to address quality issues in a timely manner.

o **Non-Identical Testing Environments**

GSD often involves teams using different hardware, software configurations, and network setups. These variations can make it challenging to maintain consistent testing environments, leading to discrepancies in testing results and potential quality issues.

- **Security and Privacy Risks**

Global Software Development presents various security and privacy risks that must be handled as part of risk management. These risks can arise due to various factors such as distributed teams, cultural differences, legal frameworks, sensitive data online, utilizing third-party tools and services and technological challenges. Some of the key security and privacy risks in GSD include:

o **Exchange of Sensitive Information and Data Breaches**

When development teams are distributed across different geographical locations, data exchange and storage become crucial. Inadequate data protection measures, insecure communication channels, and weak access controls can lead to data breaches, resulting in unauthorized access to sensitive information.

o **Intellectual Property (IP) Theft**

Global Software Development involves sharing proprietary code and design documents among different teams. This increases the risk of IP theft, where sensitive information or trade secrets may be misused or leaked to competitors or unauthorized entities.

o **Lack of Regulatory Compliance**

Different countries have different regulations regarding data privacy and security. Adhering to diverse regulatory frameworks can be challenging, especially when global development teams handle data from multiple jurisdictions. Failure to comply with relevant laws can result in legal penalties and damage to the organization's reputation.

o **Insider Threats**

Distributed teams may include contractors, third-party vendors, or temporary staff who have access to sensitive data and systems. Insufficient vetting and monitoring of these individuals can lead to insider threats, where unauthorized individuals misuse their access privileges or intentionally cause harm to the organization.

o **Use of Third-Party Tools and Services**

Global software development teams heavily depend on external tools and services, which can introduce security vulnerabilities and privacy concerns as part of supply chain risks. These teams often encounter technical challenges associated with collaboration tools, software infrastructure, and network connectivity, leading to disruptions in communication and project progress. By relying on external tools and services, GSD teams expose themselves to potential security risks and privacy breaches. The use of third-party tools may compromise the confidentiality, integrity, and availability of project data. Furthermore, challenges related to collaboration tools, software infrastructure, and network connectivity can hinder effective communication and coordination among team members, causing delays and impacting the overall progress of the project.

o **Infrastructure and Network Vulnerabilities**

Distributed development teams rely on network infrastructure and communication

channels for collaboration. Inadequate security measures, unsecured Wi-Fi networks, or unpatched software can expose the infrastructure to vulnerabilities, making it susceptible to attacks like eavesdropping, man-in-the-middle attacks, or data interception.

- **Knowledge Management Challenges**

Knowledge management poses significant risk management challenges in GSD projects. GSD teams often face the following knowledge management challenges:

- o **Shared Understanding of Project Goals and Objectives**

  GSD teams, being geographically dispersed, find it challenging to establish a common understanding of project goals, objectives, and requirements. Differences in language, culture, and work practices can hinder effective knowledge sharing and alignment. The lack of shared understanding increases the risk of misinterpretation, rework, and delays. Implementing collaborative platforms, clear communication channels, and documentation standards can help mitigate these risks.

- o **Lack of Knowledge Transfer and Collaboration**

  GSD projects require effective knowledge transfer between team members, which can be impeded by physical separation and time zone differences. This hampers knowledge sharing, collaboration, and the dissemination of important project insights, lessons learned, and best practices. It can lead to suboptimal solutions, repeated mistakes, and knowledge silos.

- o **Absence of a Common Understanding of Technical Aspects**

  GSD teams often consist of members with diverse technical backgrounds and expertise. Misalignment and varying interpretations of technical aspects can result in misunderstandings, incompatible solutions, and rework.

o **Documentation and Knowledge Repository Management**

Managing project documentation and knowledge in GSD is vital. Diverse practices, formats, and access among team members can create challenges. Inconsistent documentation results in misunderstandings, knowledge gaps, and retrieval issues.

- **Human Resource Management Challenges**

Human Resource Management (HRM) poses a significant risk management challenge in GSD projects. Managing human resources across different cultures, backgrounds, and geographical locations can be complex and challenging. Following are some key risk management challenges related to HRM in GSD:

   o **Cultural and Communication Differences**

GSD teams consist of members from diverse cultural backgrounds can lead to differences in communication styles, work practices, and expectations. Misunderstandings and misinterpretations due to cultural differences can result in delays, conflicts, and reduced productivity.

   o **Recruitment and Selection**

Recruiting and selecting the right individuals for GSD teams can be challenging. Ensuring that team members possess the necessary technical skills, adaptability, and cross-cultural competencies is crucial. Inadequate recruitment and selection processes can lead to a mismatch of skills and cultural fit, resulting in project delays and suboptimal performance.

   o **Onboarding and Training**

Integrating new team members into GSD projects requires effective onboarding and training programs. Inadequate onboarding can lead to a lack of understanding of project goals, expectations, and work processes, increasing the risk of errors, miscommunication, and low team morale.

o **Team Dynamics and Conflict Resolution**

GSD teams face challenges in building cohesive and collaborative team dynamics. Conflicts and disagreements can arise due to different work cultures, time zone differences, and communication barriers.

o **Performance Management**

Evaluating and managing the performance of remote team members can be complex in GSD projects. Lack of direct supervision, differing performance expectations, and challenges in monitoring individual contributions can affect performance assessment.

2.4. Mitigation Strategies Discovered Against Each Discovered Challenge

This section aims to provide an explanation of the mitigation strategies discovered against critical challenges associated with risk management in GSD.These mitigations are presented with references in tabular form at the end of this chapter.

- **Language Barriers**

o **Enhance Language Skills:** Provide language training programs to improve communication skills, ensuring team members can effectively express ideas and understand each other.

o **Regular Communication:** Frequent communication through written and verbal channels helps to bridge language gaps and clarify misunderstandings.

o **Effective Partnership:** Foster collaboration between developers fluent in different languages, enabling them to work together on various components of the software.

o **Establishing a Common Language:** Select a widely-used common language, such as English, for documentation, communication, and coding.

- **Cultural Differences**

  o **Effective Partnership:** Encourage team members to understand and respect diverse cultures, leading to more efficient collaboration.

  o **Effective Communication:** Promote cross-cultural sensitivity to ensure clear communication across cultural backgrounds.

  o **Collaboration and Knowledge Sharing:** Encourage sharing of cultural insights and practices, enriching the team's understanding.

  o **Coordination Techniques:** Implement communication protocols that cater to different cultural preferences and time zones.

  o **Cultural Awareness Programs:** Conduct training sessions to enhance awareness and understanding of cultural differences.

  o **Culturally Sensitive Interfaces:** Design software interfaces that accommodate various cultural norms and preferences.

  o **Agile Practices:** Apply agile methodologies to adapt to diverse cultural needs and foster adaptive development.

- **Lack of Face-to-Face Interaction**

  o **Video Conferencing:** Leverage video conferencing tools to simulate face-to-face interactions and build rapport among remote team members.

  o **Regular Social Interactions:** Encourage informal virtual gatherings or online team-building activities to create a sense of camaraderie.

  o **Collaborative Tools:** Use collaboration platforms for real-time interaction, allowing team members to work together seamlessly.

  o **Document Sharing:** Share documents online to ensure everyone has access to necessary information.

- **Trust and Openness:** Build trust by emphasizing transparency and open communication in virtual interactions.

- **Geographical Distance**

  o **Effective Communication:** Emphasize timely and clear communication to bridge geographic gaps.

  o **Technical Tools:** Utilize video conferencing, instant messaging, and project management tools to maintain connectivity and collaboration.

- **Differences in Work Cultures**

  o **Cultural Awareness Sessions:** Regularly educate team members about cultural nuances to prevent misunderstandings.

  o **Roles and Responsibilities:** Clearly define roles within a globally distributed team to avoid confusion and overlapping responsibilities.

  o **Collaborative Tools:** Employ tools that enable seamless collaboration across cultures, time zones, and work practices.

  o **Trust and Openness:** Cultivate trust by facilitating open dialogue and fostering understanding of different work cultures.

  o **Project Management:** Utilize project management techniques that accommodate different work styles and preferences.

  o **Agile Practices:** Apply agile methodologies to adapt quickly to diverse cultural and work style variations.

- **Lack of Trust between Team Members**

  o **Effective Communication:** Regular and transparent communication is key to building trust among team members who may never meet face-to-face.

- **Team Cohesion:** Foster a sense of unity and shared purpose, emphasizing that everyone's contribution is essential to project success.

- **Knowledge Sharing:** Encourage sharing of insights, lessons learned, and best practices to demonstrate goodwill and promote collaboration.

- **Collaborative Problem-Solving:** Encourage team members to tackle challenges collaboratively, reinforcing the idea that they're all in it together.

- **Reflective Learning:** Create opportunities for team members to reflect on their experiences and learn from each other, promoting trust and mutual respect.

- **Time Zone Differences**

  - **Communication Protocols:** Establish clear communication protocols that address time zone differences, such as scheduled meetings that accommodate all time zones.

  - **Appropriate Tools:** Use tools that allow asynchronous communication, like chat and shared documents, to minimize time zone challenges.

- **Non-Identical Testing Environments**

  - **Technology Tools:** Implement version control systems to manage code changes and track modifications across different environments.

  - **Code Reviews and Automated Testing:** Regular code reviews and automated testing help maintain consistent quality and functionality across environments.

  - **Rigorous Testing:** Perform thorough testing to identify and address any inconsistencies or discrepancies arising from different testing environments.

  - **Test-Driven Development:** Embrace test-driven development to ensure code correctness and uniformity in various testing contexts.

Table 2. 1: Communication Challenges in Global Software Development

Studies	Challenges	Mitigation Strategies	Studies
5,6,14,15-19, 35-38,40	Language barriers	• Enhance language skills. • Regular communication • Effective partnership • Establishing a common language	5,14,35-38,40
1,2,3,4,7,9,10,1 1,12,14, 15-19,20,23, 35-38	Cultural differences	• Effective partnership • Effective communication • Collaboration and knowledge sharing • Use of correct coordination techniques Cultural awareness programs • Designing culturally sensitive interfaces • Use of agile practices	7,9,11,12,14,2 0,26,35-38
5	Lack of face-to-face interaction	• Utilizing video conferencing tools and establishing effective communication protocols • Regular social interactions • Use of collaborative tools • Document sharing • Fostering trust and openness within the team	5,6,9,14

Studies	Challenges	Mitigation Strategies	Studies
1,2,3,4,5,7,13,15-19,21	Geographical distance	• Effective communication • Use of technical tools	7,5,21
1,2,3,4,5,8,13,15-19,21	Differences in work cultures	• Regular cultural awareness and sensitivity sessions • Establishing clear roles and responsibilities within teams • Use of collaborative tools • Fostering trust and openness within the team • Effective project management • Use of agile practices	5,7,9,11,12,14, 15-19,20,26,35-38
6	Lack of trust between team members	• Trust building through effective communication and collaboration. • Effective team cohesion Knowledge sharing • Collaborative problem-solving • Reflective learning	6,8,11,12,14,15-19,27,28

Studies	Challenges	Mitigation Strategies	Studies
1,2,3,4,5,6,11, 10,13,20,35-38	Time zone differences	• Establishing effective communication protocols and use of appropriate tools	5,6,9,10,20,35 -38
35-38,40	Non-identical testing environments	• Effective use of technology tools for version control • Code reviews and automated testing • Rigorous testing • Test-driven development using agile	27,28,35- 38,40

Table 2. 4: Security and Privacy Challenges in Global Software Development

Studies	Challenges	Mitigation Strategies	Studies
26,6	Exchange of sensitive information and Data Breaches	• Regular communication with clear guidelines and penalties	6
6,7	Intellectual Property (IP) Theft	• Project management tools to track progress, identify risks, and manage dependencies	40
35-38	Lack of Regulatory Compliance	• Rigorous testing • Building strong partnership based on proper regulations	35-38
40	Insider Threats	• Educate employees about any possible risks and consequences related to it.	-
1,2,3,4,6,7,8,1 4,20,40	Use of third-party tools and services	• Effective use of technology tools (Tools such as video conferencing, chat, and document sharing) for version control	6,8,9,14,20,4 0

		• Code reviews and automated testing	
		• Cloud-based tools to enable collaboration	
40,6	Infrastructure and Network Vulnerabilities	• Project management tools to track progress. • Identify risks and manage dependencies. • Rigorous testing	35-38,40

Table 2. 5: Knowledge Management Challenges in Global Software Development

Studies	Challenges	Mitigation Strategies	Studies
11,12,27,28	Shared Understanding of Project Goals and Objectives	• Fostering a sense of shared ownership for the project's success • Establish effective communication channels. • Build trust and relationships among team members. • Shared product vision and encouraging teamwork	27,28,34,40
7,15-19,23	Lack of Knowledge Transfer and Collaboration	• Fostering collaboration and collaborative problem-solving • Knowledge sharing and continuous improvement Reflective learning and trust building	7,15-19
11,12,27,28,34	Absence of a Common Understanding of Technical Aspects	• Shared product vision and encouraging teamwork	27,28,34

Studies	Challenges	Mitigation Strategies	Studies
9	Documentation and Knowledge Repository Management	• Cloud-based tools to enable collaboration and effectively storing data	40

Table 2. 6: Human Resource Challenges in Global Software Development

Studies	Challenges	Mitigation Strategies	Studies
1,2,3,4,5,6,8-12	Recruitment and Selection	• Establishing clear roles and responsibilities within teams	7,9,13
11,12,15-19,20,21, 30-33,40	Onboarding and Training	• Regular training and assistance	15-19,40
8,9,13,26	Team Dynamics and Conflict Resolution	• Active listening and effective feedback • Conflict resolution	26,34
1,2,3,4,7,23,26,39	Performance Management	• Effective feedback • Use of Agile practices	27,28,34
1,2,3,4,24,25	Employee Engagement and Retention	• Encouraging team members to share their perspectives. • Opportunities for training and development to enhance team member˝s skills and increase job satisfaction. • Organizational commitment, promoting career growth and give social support.	1-4,40

2.5. Summary

This chapter covered the fundamentals of GSD, how software development is managed in global context, the potential risks it faces, and the possible mitigation strategies. Challenges to risk management in general and in GSD were presented. Many other challenges are also mentioned that may or may not be a direct part of the risk management, but they were contributing towards it. This section also discussed existing mitigation strategies with their merits as well as demerits. At the end of related work, the identified risk management difficulties in GSD and the typical mitigation techniques are shown in a tabular format. The conceptual model and the suggested work will be presented in Chapter 3.

CHAPTER 3

PROPOSED METHODOLOGY

3.1. Introduction

In this chapter, the conceptual model for risk management in GSD based on agile practices and seven risk management principles has been described. A detailed description of entities and their communication flow is given for better understanding of risk management. The proposed conceptual model with all phases discussed in detail is presented. The research includes the following contributions:

- A customized risk management framework for GSD teams is presented in this chapter. The framework is customized with employing the generic seven risk management principles and the agile practices specifically supporting these principles against the identified challenges.

- The framework is analysis for its performance by IT domain experts for carrying out effective risk management in the field of GSD or the companies intended for offshore development.

3.2. Overview of Proposed Model

Global Software Development projects have gained prominence in today's interconnected world, bringing with them unique challenges and risks that traditional development teams seldom encounter. Managing these risks requires a dedicated framework that addresses the complexities of distributed teams, cultural differences, and geographical distances. In this study, a risk management framework for GSD has been developed. This framework consists of three phases. First phase consists of the risk management challenges faced by the GSD teams, second phase consists of the best possible mitigation strategies incorporated with 7 risk management principles and several agile practices. The third phase will be incorporating all these mitigation strategies into GSD sites as a part of their RMMM to help improve their risk management. Many different strategies have been used earlier but they are not fully benefitting the entire risk management in different projects of organizations. However, this proposed model will be more effective as

compared to others because it is incorporating the agile practices in accordance with the 7 risk management principles. Fig 3.1 depicts the entire proposed model for mitigation of risk management in Global Software Development.
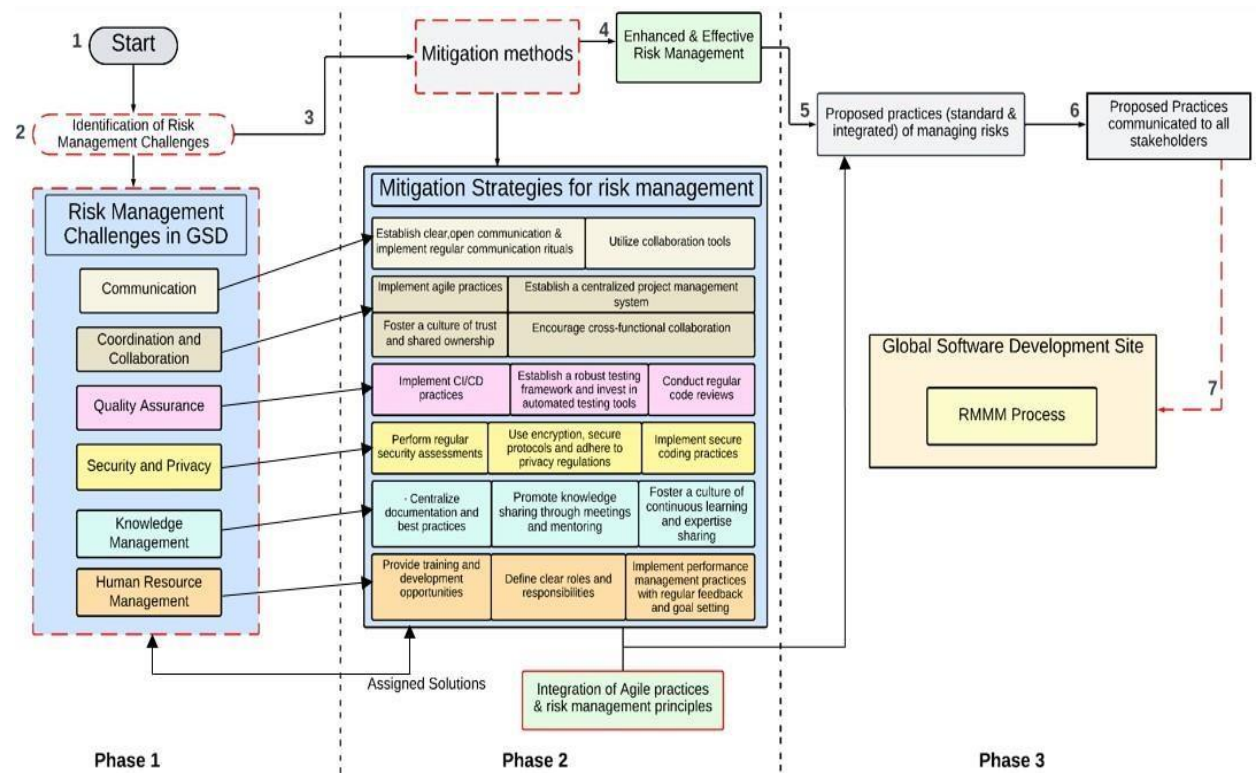

Figure 3. 1: Suggested proposed model for risk management in GSD

3.3. Proposed model Description

This model description presents a comprehensive Risk Management Framework designed specifically for GSD teams. The framework comprises three distinct phases aimed at identifying, mitigating, and managing risks in GSD projects. The first phase explores the challenges that GSD teams encounter in the context of risk management. The second phase proposes mitigation strategies based on agile practices and seven risk management principles. Lastly, the third phase amalgamates these mitigations with standard approaches to create a unified Risk Mitigation, Monitoring, and Management plan to be deployed across GSD sites. Following are the comprehensive depiction of each phase:

- **Phase 1:**

The first phase of the Risk Management Framework for GSD focuses on identifying the primary challenges that GSD teams encounter while managing risks in their projects. These challenges encompass various aspects of the GSD environment and have the potential to impact project success significantly. By understanding and addressing these challenges, GSD teams can establish a robust foundation for effective risk management throughout the project lifecycle.

- **Phase 2:**

In the second phase of the Risk Management Framework for GSD, this research delve into the proactive approach to risk management by proposing a set of mitigation strategies supported by agile practices and seven fundamental risk management principles. These strategies and principles are designed to enhance risk identification, assessment, and mitigation in GSD projects, ensuring better project outcomes and increased adaptability to changing circumstances.

- **Agile based mitigation strategies:**

The following Agile-based mitigation strategies contribute to efficient risk management in the GSD context:

- **Iterative Development:** An iterative development approach promotes early communication and collaboration among team members, enabling early risk identification and resolution, thereby reducing future issues.

- **Regular Feedback and Review:** Frequent feedback and reviews facilitate ongoing risk assessment and provide opportunities to adjust mitigation strategies as the project progresses. By reflecting on previous iterations and identifying areas for improvement, teams can proactively address potential risks and prevent similar issues from arising in the future.

o **Continuous Integration and Deployment:** Implementing continuous integration and deployment practices enables rapid risk identification and resolution, enhancing software quality and reducing overall risk exposure. Agile practices prioritize flexibility and adaptability, allowing teams to respond quickly to changing requirements, unforeseen challenges, and potential risks. This can help mitigate risks by enabling teams to adjust their plans and strategies in real-time based on new information or changing circumstances.

o **Cross-Functional Collaboration:** Encouraging cross-functional collaboration between distributed teams promotes knowledge sharing, risk awareness, and collective ownership of risk management activities. Agile practices promote transparency and visibility into the development process, enabling all team members to have a clear understanding of the project status, progress, and potential risks. This can help prevent misunderstandings, miscommunications, and other issues that can lead to risks in GSD.

- **Seven risk management principles by SEI based mitigation strategies:**

The Seven Principles of Risk Management are particularly relevant in the context of GSD because they provide a comprehensive framework for effectively managing software development project risks in a global environment. By following these principles, software development teams can ensure that they are identifying and addressing potential risks effectively, leading to successful project outcomes and satisfied stakeholders. These principles can help in the context of GSD in the following ways:

o **Maintain a Global Perspective:** Global Software Development involves collaborating with teams and stakeholders across different geographies, cultures, and time zones. By maintaining a global perspective, software development teams can ensure that software risks are viewed within the larger context of the system and business problem that it is intended to solve. This helps to ensure that the overall system is working efficiently, and

any risks are addressed comprehensively.

- **Take a Forward-Looking View:** In GSD, changes in software and other factors can be particularly challenging due to different regulatory environments, cultural norms, and technical infrastructures. By taking a forward-looking view, teams can anticipate potential risks that may arise due to changes in software or other factors and develop contingency plans to manage them more effectively.

- **Encourage Open Communication:** Effective communication is essential in GSD to ensure that all stakeholders are on the same page regarding risks and potential solutions. Encouraging open communication and active participation from all stakeholders helps to identify and address potential risks quickly.

- **Integrate Risk Management:** Risk management must be integrated into the software development process from the beginning. By considering risks throughout the development process, teams can identify potential issues that may arise due to differences in technology, culture, or geography and take steps to manage them more effectively.

- **Emphasize a Continuous Process:** Continuous risk management is essential in GSD due to the ever-changing landscape of software development. Teams must remain vigilant throughout the software development process, modifying identified risks as more information becomes available and adding new risks as they become apparent.

- **Develop a Shared Product Vision:** Developing a shared product vision is particularly important in GSD. By ensuring that all stakeholders share the same vision of the software, it's more likely that better risk identification and assessment will occur, leading to a more successful project outcome.

- **Encourage Teamwork:** Global Software Development involves collaboration between teams and stakeholders across different locations, cultures, and time zones. Encouraging

teamwork ensures that all stakeholders' talents, skills, and knowledge are pooled, leading to better risk identification and more effective solutions.

- **Combining Agile practices and seven risk management principles**

The combination of agile practices and risk management principles plays a crucial role in collectively contributing to the success of GSD projects.

- o **Efficient Risk Identification and Assessment:** Agile practices promote iterative development and regular feedback, enabling teams to identify and assess risks early in the project lifecycle. By combining this with the risk management principle of maintaining a global perspective, teams can consider risks in the context of the broader system and business problem, ensuring a comprehensive risk assessment.

- o **Proactive Risk Mitigation:** Taking a forward-looking view and establishing contingency plans aligns with Agile's adaptive nature. By continuously monitoring and addressing risks throughout the project, teams can be proactive in mitigating potential issues, reducing the impact of risks as they arise.

- o **Open Communication and Collaboration:** Agile methodologies emphasize open communication and collaboration within cross-functional teams. When combined with the risk management principle of encouraging open communication, GSD teams foster an environment where all stakeholders feel comfortable voicing potential risks and concerns, leading to more effective risk identification.

- o **Continuous Improvement:** The risk management principle of emphasizing a continuous process aligns with Agile iterative approach. GSD teams continuously learn from past experiences and adapt their risk management strategies, accordingly, improving risk identification and mitigation throughout the project.

- o **Collective Ownership of Risk Management:** The risk management principle of encouraging teamwork aligns with Agile emphasis on cross-functional collaboration. By pooling the talents and knowledge of all stakeholders, GSD teams take a collective approach to risk management, ensuring that everyone is involved in identifying and addressing potential risks.

- o **Resilience to Changing Circumstances:** The combined approach of agile practices and risk management principles equips GSD teams with the ability to adapt swiftly to changing circumstances. This adaptability is essential in the dynamic GSD environment, where factors like time zone differences and cultural nuances can impact project progress.

- o **Enhanced Software Quality:** Agile practices, such as continuous integration and deployment, and the risk management principle of maintaining a shared product vision, contribute to improved software quality. By aligning their efforts and understanding the shared vision, GSD teams can deliver software that better meets customer expectations and minimizes risks related to product quality.

By combining Agile practices and these seven risk management principles into their project processes, GSD teams can build a resilient risk management approach, ultimately leading to more successful GSD project outcomes. The principles promote a forward-looking, integrated, and collaborative risk management approach, ensuring that risks are identified early, addressed effectively, and continuously monitored and adapted to achieve project success. This not only allows for more efficient risk identification and assessment but also empowers teams to adapt swiftly to changing circumstances and deliver successful GSD projects.

- **Phase 3:**

In this final phase of the Risk Management Framework for GSD, this research bring together the Agile-based mitigation strategies, the seven risk management principles, and standard risk

management approaches to create a comprehensive Risk Mitigation Plan. This plan is designed to address the specific risk challenges faced by GSD teams and provide a structured approach to mitigate, monitor, and manage risks throughout the project lifecycle. The plan is intended to be communicated to all stakeholders and deployed across GSD sites as part of their risk management strategy. The overall flow of all three phases is depicted in figure 3.2.
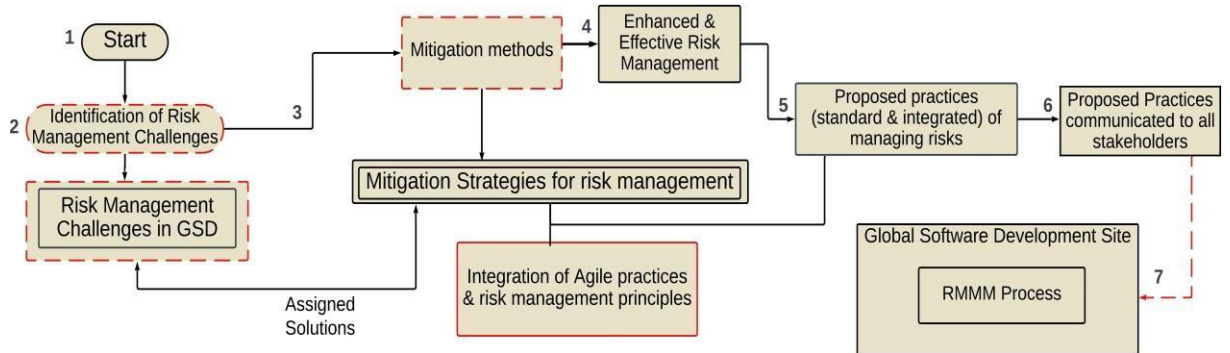

Figure 3. 2: Workflow of model phases for risk management in GSD

3.4. Justification of Proposed Model

The justification for selecting this model lies in its holistic approach to risk management in Global Software Development. The model explicitly identifies and addresses the unique challenges faced by GSD teams, including communication barriers, coordination complexities, cultural differences, and security risks. By acknowledging these challenges, the framework provides tailored solutions to enhance risk management in the context of distributed software development. It emphasizes a proactive approach to risk management by integrating Agile-based mitigation strategies and risk management principles. This forward-looking perspective enables GSD teams to identify potential risks early, develop contingency plans, and adapt to changing circumstances, mitigating the impact of risks on project outcomes.

The three-phase structure of the framework culminates in the creation of a comprehensive Risk Mitigation Plan. This plan incorporates agile practices, risk management principles, and standard risk management approaches, offering a well-rounded and practical strategy for managing risks

throughout the project lifecycle. The integration of agile practices in the model aligns with the modern software development paradigm, which emphasizes iterative development, customer feedback, and continuous improvement. By incorporating agile practices, the framework becomes more relevant and adaptable for GSD teams already employing agile methodologies.

The model promotes collaboration and collective ownership of risk management activities. Encouraging open communication and teamwork enables all stakeholders and team members to contribute to risk identification and mitigation, fostering a sense of shared responsibility for project success. It acknowledges the importance of customizing risk management strategies for the GSD context. By considering factors like geographical dispersion, cultural diversity, and time zone differences, the model ensures that risk management efforts are relevant and effective in distributed development environments. It emphasizes a culture of continuous improvement through regular feedback and lessons learned sessions. This focus on learning from past experiences empowers GSD teams to refine their risk management practices, enhancing the overall project outcomes over time.

The proposed framework provides practical guidelines and actionable steps for GSD teams to implement effective risk management. By offering a structured and well-defined approach, the model is accessible and feasible for organizations seeking to improve their risk management capabilities in GSD projects.

3.5. Summary

In this chapter, a comprehensive Risk Management Framework for GSD is presented that addresses unique challenges faced by distributed teams and enhances project outcomes. An overview of the model, a detailed framework diagram, and explanations of its three phases is also explained. Additionally, a workflow diagram illustrates its execution in a GSD project. The chapter concludes with a justification of the model's selection, highlighting its ability to foster proactive risk management and adaptability in the GSD context.

CHAPTER 4

VALIDATION OF PROPOSED MODEL

4.1. Introduction

In this chapter, the validation of the proposed Risk Management Framework for GSD seeks to assess its practicality, relevance, and effectiveness in addressing the challenges encountered by distributed development teams. To ensure a robust validation process, this study will engage 25-30 industry experts who possess substantial experience in managing risks in GSD environments. Specifically targeting professionals involved in offshore development projects or those whose offices are located in multiple countries will provide with diverse perspectives on the model's applicability and adaptability in real-world scenarios.

4.2. Methodology

The validation methodology will employ a structured questionnaire. The questionnaire is a structured data collection tool that will be utilized to validate the proposed Risk Management Framework for GSD. It will be designed on the Google Forms platform, offering a user-friendly and efficient means of gathering feedback from industry experts. The questionnaire will consist of a combination of multiple-choice questions (MCQs) and open-ended questions, ensuring a comprehensive assessment of the model's effectiveness, applicability, and alignment with GSD challenges. The questions will cover various dimensions of the proposed framework, ranging from the participant"s current risk management practices to their perceptions of the model's components and recommendations for improvement. By adopting a questionnaire-based approach, this study aims to collect valuable insights from a diverse group of experts located in different regions, allowing us to strengthen the validation process and refine the model based on their feedback. The methodology includes the following key steps:

- **Questionnaire Design:** The questionnaire will be thoughtfully crafted with a mix of multiple-choice questions (MCQs) and open-ended questions. The MCQs will gather introductory information about the participants, their current risk management practices, and their experiences with GSD projects.

- **Selection of Participants:** Industry experts with expertise in GSD projects will be identified and invited to participate in the validation. The participants will receive a link to the Google Forms questionnaire.

- **Data Collection:** Participants will complete the questionnaire via Google Forms, providing their feedback on the model's effectiveness, practicality, and alignment with GSD challenges. The Google Forms platform allows for ease of data collection and automated organization of responses.

- **Data Analysis:** The responses collected through Google Forms will be analyzed quantitatively for the MCQs and qualitatively for the open-ended questions. This analysis will identify common themes, patterns, and recommendations provided by the industry experts.

4.3. Questionnaire Content

The questionnaire will cover various dimensions of the proposed Risk Management Framework:

- **Introductory Questions:** Participants will be asked to provide basic information about their role, experience in GSD, and their organization's size and industry.

- **Current Risk Management Practices:** Participants will be asked about the risk management framework they are currently using, the challenges they face in risk management, and their level of satisfaction with their current approach.

- **Evaluation of Model Components:** Participants will be prompted to evaluate each phase of the proposed framework through MCQs, providing feedback on the effectiveness and applicability of Agile-based strategies, risk management principles, and the comprehensive Risk Mitigation Plan.

- **Applicability to GSD Environment:** Participants will be encouraged to share specific examples of how the model's components align with the unique characteristics of GSD projects, such as geographical dispersion and cultural diversity.

- **Recommendations for Improvement:** Participants will have the opportunity to suggest any modifications or enhancements that could further strengthen the model's effectiveness and adaptability in GSD projects through open-ended questions.

4.4. Summary

In this chapter, the validation process of the proposed risk management framework has been discussed. The validation will be done using google forms questionnaire because the convenience and flexibility offered by Google Forms make it an ideal tool for collecting data, valuable insights and feedback from industry experts located in different regions. The results of this validation will be analyzed to refine and enhance the framework, ensuring its relevance, practicality, and effectiveness in managing risks in distributed software development environments in chapter 5 and the validation form is attached as Annex „A".

CHAPTER 5

RESULTS AND ANALYSIS

5.1. Introduction

This chapter presents the validated results of the proposed model, offering a detailed exploration of its effectiveness in mitigating risk management challenges within GSD. Additionally, the chapter conducts a comprehensive comparison between the proposed model and existing industry frameworks, highlighting the model's innovative contributions to addressing the unique complexities of GSD environments. Through analysis, the chapter underscores the model's potential to reshape risk management practices in distributed software development. At the end of this chapter comparison with existing frameworks and distinctive points of the proposed model supported by agile practices and SEI"s seven risk management principles are presented in tabular form.

5.2. Analysis

The comprehensive questionnaire responses collected from a diverse group of industry experts shed light on the effectiveness, alignment, and applicability of the proposed Risk Management Framework for GSD projects. By evaluating the expert"s perspectives across various domains, this research gained valuable insights into how the framework addresses the challenges inherent in managing risks within distributed and culturally diverse teams, while also examining its adaptability to different project scales and complexities. In this analysis, we delve into the key findings and draw a comparison between the proposed framework and existing risk management standards such as ISO 31000, COSO ERM, NIST ERM, CAS ERM, and COBIT ERM. This comparison highlights the framework's unique strengths, including its integration of agile practices along with risk management principles, and underscores its potential to significantly enhance risk management practices in GSD environments. Moreover, the analysis also explores the framework's alignment with contemporary project management methodologies, contributing to the ongoing discourse on optimizing risk management strategies within the realm of GSD. The following section-wise analysis provides a detailed exploration of these aspects:

- **Validation and Satisfaction:** Industry experts with diverse backgrounds and experience levels across domains such as game development, AI, IT, healthcare, banking, and finance have provided validation for the proposed framework. Their medium level of satisfaction with current risk management approaches indicates a need for improvements, which the proposed framework aims to address.

- **Challenges in GSD Risk Management:** The industry experts have identified coordination, collaboration, communication, knowledge management, security, privacy, quality assurance, and human resource management as significant challenges in managing risks in GSD. These findings highlight the complexity of risk management in distributed and diverse teams.
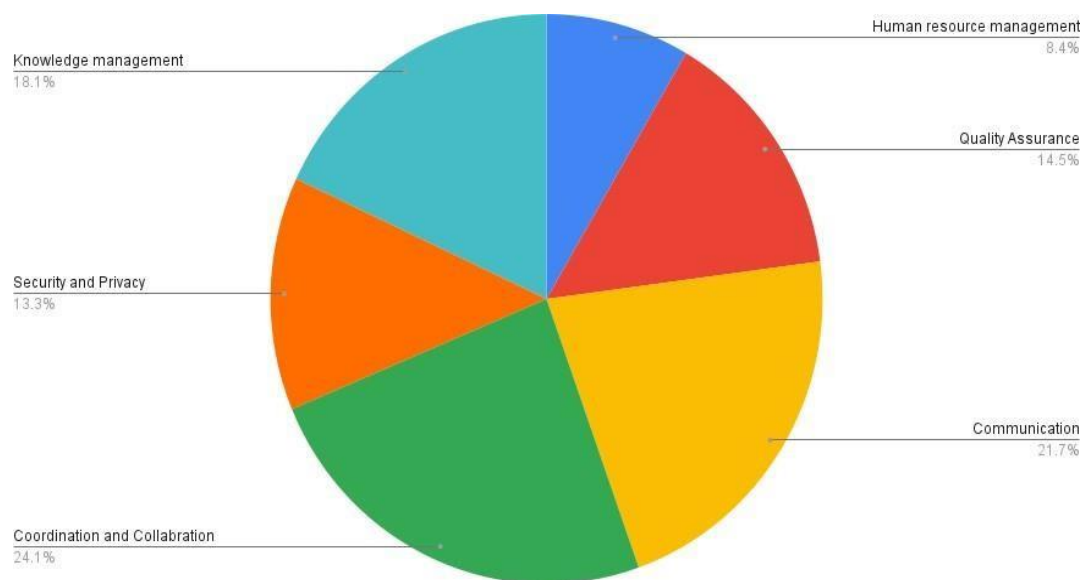

Figure 5.1: Identified GSD risk management Challenges by industry experts.

- **Existing Frameworks:** The experts are using existing risk management frameworks, including ISO 31000, COSO ERM, NIST ERM, CAS ERM, and COBIT ERM. The experts have positively acknowledged the strengths of proposed framework. This alignment enhances the credibility and relevance of the proposed framework.
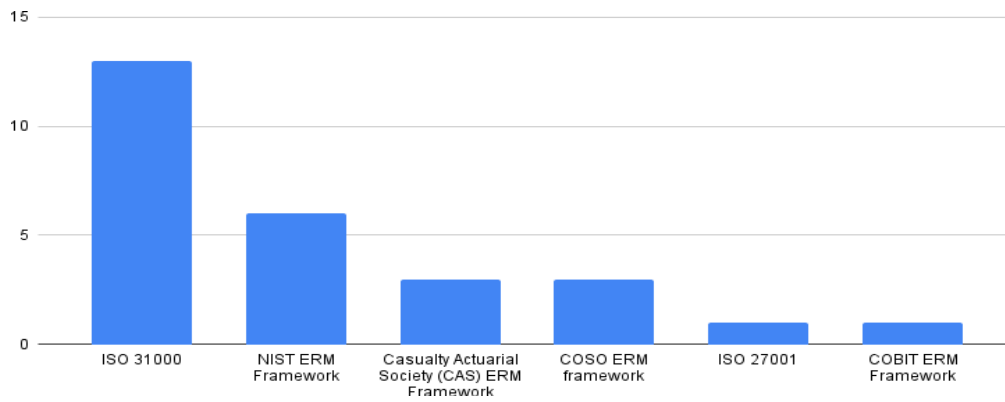
Figure 5.2: Existing risk management frameworks used by industry experts.

- **Agile-Based Mitigation Strategies:** The experts' overwhelming agreement (96%) on the high effectiveness of Agile-based mitigation strategies for GSD risk management underscores the importance of incorporating agile practices in risk management practices.

- **Crucial Agile Practices:** The identified crucial Agile practices for GSD risk management include regular feedback and review, continuous integration and deployment, and to a lesser extent, iterative development and cross-functional collaboration.
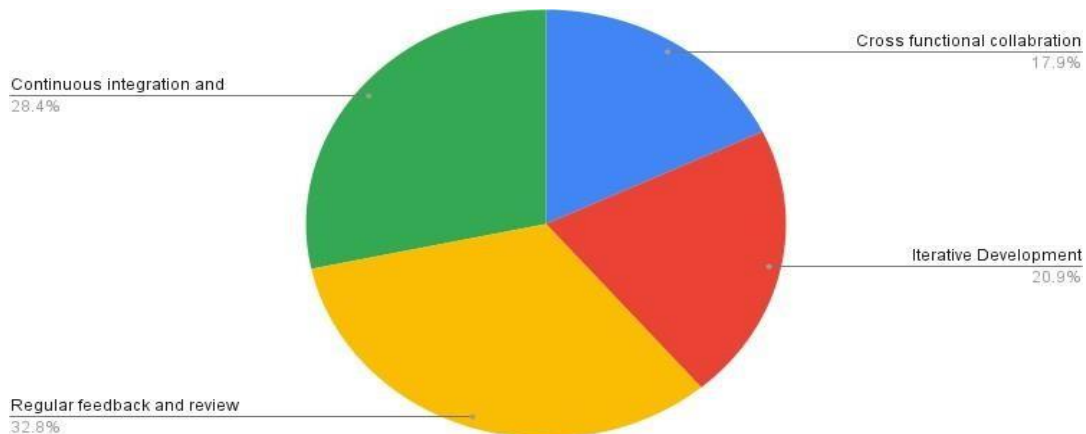

Figure 5.3: Crucial agile practices for GSD risk management

- **Crucial Risk Management Principles:** The experts consider "Integrate Risk Management" as the most crucial risk management principle for effective GSD risk management, followed by "Encourage Open Communication" and "Maintain a Global Perspective."
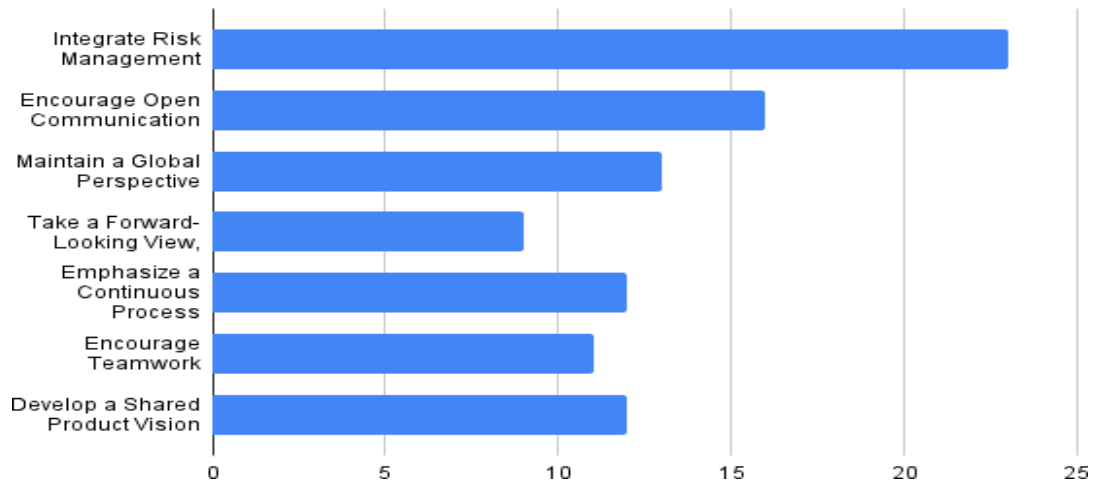

Figure 5.4: Crucial risk management principles by SEI identified by experts in terms of GSD.

- **Comprehensive Risk Mitigation Plan:** A majority of the experts (66.7%) find the Risk Mitigation Plan presented in Phase 3 to be very comprehensive, indicating its ability to address various risk challenges effectively.
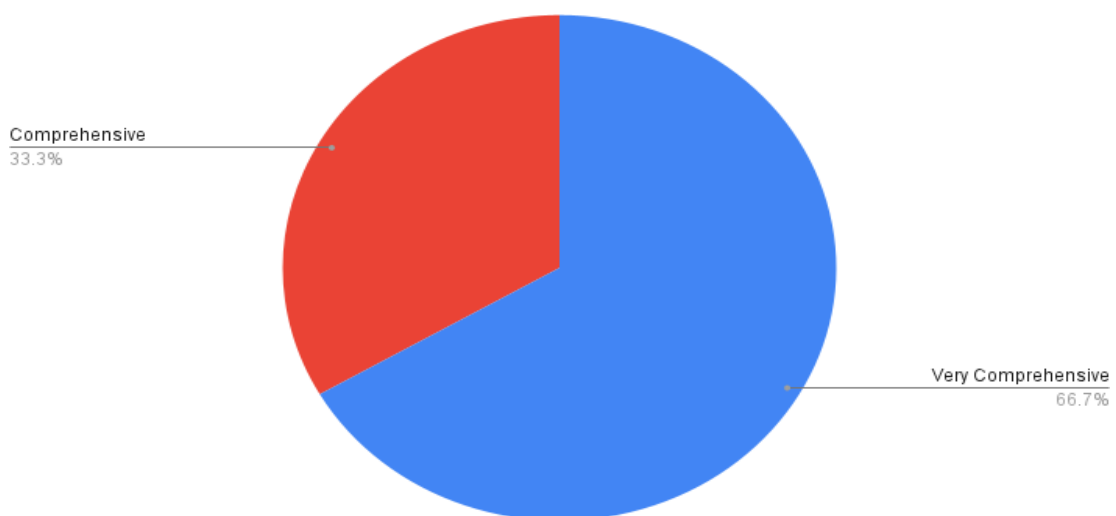

Figure 5.5: Comprehensiveness of risk mitigation plan

- **Confidence in Implementation:** A significant proportion of experts express high confidence in implementing the proposed framework in their organizations' GSD projects, showcasing the experts' belief in its practicality.

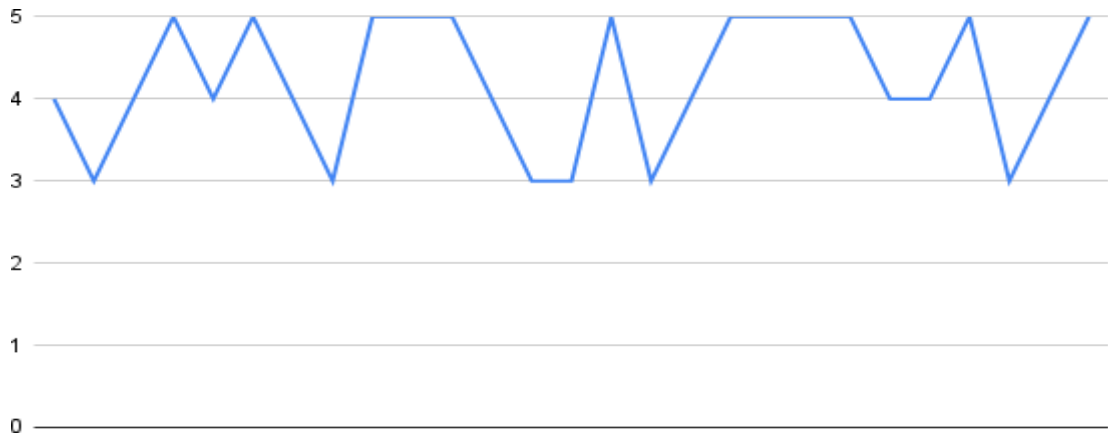*Figure 5.6: Expert's confidence level in implementing proposed framework.*

- **Strengths of the Proposed Framework:** The strengths of the proposed framework as highlighted by the experts include its integration of agile practices, effective risk mitigation using RMMM, communication management, and its ability to predict and address risks.
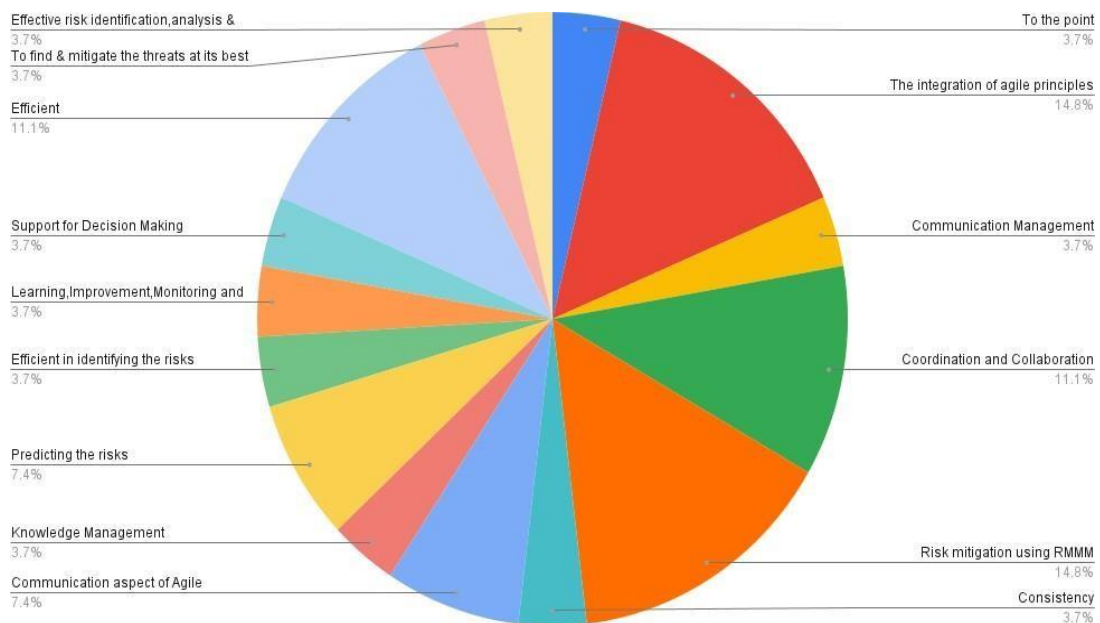

Figure 5.7: Strengths of proposed framework identified by experts.

- **Feasibility and Applicability:** The experts do not express any major concerns or reservations about the feasibility or applicability of the proposed framework in various GSD contexts. The framework is seen as feasible and potentially applicable across different scenarios.

It is feasible owing to its relatively lesser perplexity.
3.7%
Can be applicable & work effectively
3.7%
It is feasible and applicable for small scaled intelligent systems
3.7%
No,It seems practical
3.7%
Feasible if model's conformance is cost effective and provides results
3.7%
Can be applicable in almost all scenarios.
3.7%
It's feasible in most of the scenarios
3.7%
No, It will be an appropriate approach.
3.7%
No concerns or reservations about the model's feasibility or
3.7%
No, it seems practical.
11.1%
No
55.6%

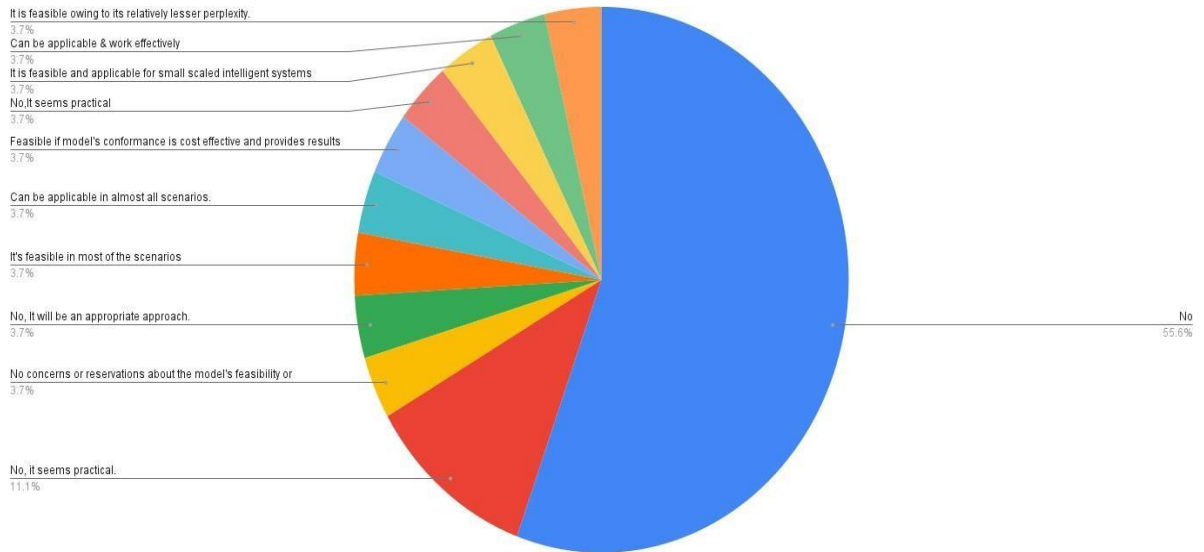*Figure 5.8: Feasibility and applicability of framework in GSD risk management*

- **Improved Project Outcomes:** All experts unanimously believe that adopting the proposed Risk Management Framework could lead to improved project outcomes in GSD environments, emphasizing its potential benefits most importantly proactively identifying risks.
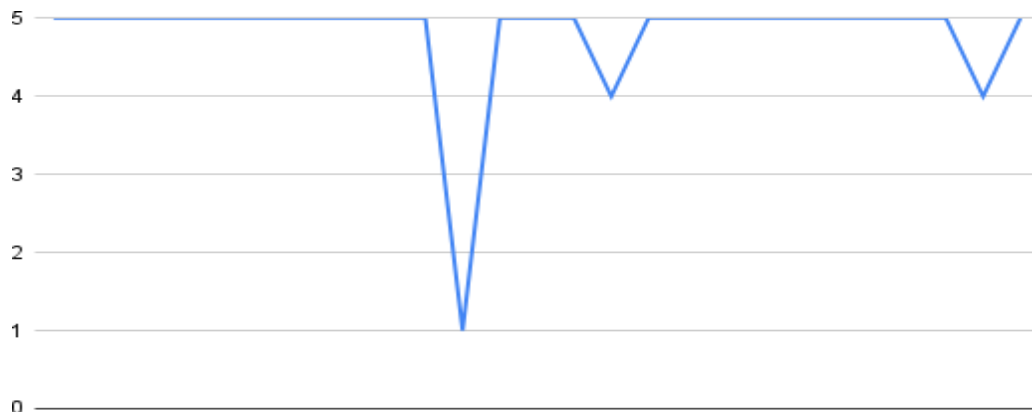

Figure 5.9: Improved project outcomes by proactive risk identification

- **Usability and Practicality:** The clarity of the proposed model is highly appreciated by the experts. The suggestions for enhancing usability include integration with project management tools, real-time risk monitoring, and machine learning for risk prediction.

5.3. Comparison of Results with existing frameworks

The proposed Risk Management Framework aligns with existing standards such as ISO 31000, COSO ERM, NIST ERM, CAS ERM, and COBIT ERM, its distinctive strength lies in its integration of Agile methodologies. This integration enables the framework to effectively address the challenges of coordination, collaboration, and rapid risk evolution inherent in GSD projects. By amalgamating traditional risk management principles with Agile practices, the proposed framework offers a comprehensive, adaptable, and contextually relevant approach to risk management in the dynamic landscape of GSD. Comparing the results with existing risk management frameworks, several key points can be observed:

- **ISO 31000:** The proposed Risk Management Framework exhibits a notable alignment with ISO 31000, a widely recognized standard for risk management. Both frameworks emphasize the importance of risk identification, assessment, treatment, and ongoing monitoring. However, the proposed framework extends beyond the traditional risk management approach by integrating agile practices. While ISO 31000 provides a solid foundation for risk management, the proposed framework's incorporation of agile methodologies adds a dynamic and adaptive dimension. This dynamic approach allows for real-time adjustments and iterative risk management strategies in response to changing GSD project conditions, contributing to enhanced risk mitigation and project outcomes.

- **COSO ERM Framework:** The COSO ERM Framework emphasizes a holistic approach to enterprise risk management, aligning with the comprehensive nature of the proposed framework. Both frameworks acknowledge the significance of open communication and

collaboration in effective risk management. Nevertheless, the proposed framework distinguishes itself by directly addressing coordination and collaboration challenges, which are particularly pronounced in GSD settings. By integrating agile practices like regular feedback and continuous integration, the proposed framework not only fosters open communication but also streamlines collaboration among dispersed teams. This alignment of principles supports a more practical and contextually relevant risk management approach in GSD projects.

- **NIST ERM Framework:** The proposed framework shares similarities with the NIST ERM Framework in terms of risk assessment, response, and monitoring. Both frameworks advocate for a systematic and iterative risk management process. However, the proposed framework introduces a novel dimension by emphasizing Agile-based mitigation strategies. This infusion of Agile methodologies bolsters the framework's ability to respond promptly to emerging risks and adjust mitigation efforts in real-time. In GSD projects, where risks can evolve rapidly due to geographical dispersion, the proposed framework's agile integration becomes a powerful tool for staying ahead of potential threats.

- **CAS ERM Framework:** The CAS ERM Framework's focus on risk modeling and quantitative analysis resonates with the proposed framework's emphasis on predicting and assessing risks. While the CAS framework primarily caters to the insurance and actuarial sectors, the proposed framework offers broader applicability by accommodating various domains, including game development, healthcare, and finance. Additionally, the proposed framework augments its risk prediction capabilities by integrating agile practices that facilitate iterative risk assessment and mitigation. This combination of risk modeling and agile methodologies enhances the framework's adaptability and responsiveness in the context of GSD projects.

- **COBIT ERM Framework:** The COBIT ERM Framework aligns with the proposed framework in terms of risk identification, assessment, and response. Both frameworks

underscore the importance of effective governance and risk management practices. However, the proposed framework differentiates itself through its agile integration, which empowers organizations to swiftly respond to emerging risks and capitalize on opportunities. This integration is particularly valuable in GSD projects, where the challenge of coordination and communication across diverse teams is prominent. The proposed framework's emphasis on agile principles contributes to a more agile and flexible risk management approach, enhancing its usability and practicality in dynamic GSD environments.

Table 5. 1: Comparison of existing frameworks with proposed model

Existing Framework	Alignment with Proposed Framework	Distinctive Strengths of Proposed Framework
ISO 31000	✓	• Integration of Agile methodologies and SEI's seven risk management principles for dynamic and comprehensive risk management.
COSO ERM Framework	✓	• Directly addresses coordination and collaboration challenges in GSD projects. Integration of SEI principles enhances holistic risk management.
NIST ERM Framework	✓	• Emphasis on Agile-based mitigation strategies for rapid response to emerging risks. Integration of SEI principles enhances risk assessment.
CAS ERM Framework	✓	• Accommodation of various domains and integration of risk modeling with agile practices. SEI principles contribute to accurate risk prediction.
COBIT ERM Framework	✓	• Agile integration for flexible risk management. SEI principles enhance governance and risk response.

5.4. Summary

This chapter has successfully showcased the validated results of the proposed model's effectiveness in mitigating risk management challenges within the realm of GSD. Through a robust analysis of data, the model's practical value in enhancing risk identification, assessment, and mitigation in GSD projects has been underscored. Moreover, the comparative evaluation against existing industry frameworks has highlighted the innovative contributions and distinct advantages of the proposed model. The validated Risk Management Framework for GSD boasts a 66.7% comprehensiveness rate. Over 75% of experts are confident in its implementation, and more than 55% find it feasible and applicable to GSD, showcasing its potential to enhance project outcomes in complex distributed contexts.

CHAPTER 6

CONCLUSION AND FUTURE WORK

6.1. Conclusion and Objective Achieved

In conclusion, this research has successfully introduced a robust and proactive Risk Management Framework tailored to the unique challenges of GSD projects. By incorporating insights from industry experts across domains such as game development, AI, IT, healthcare, medical billing, banking, and finance, the framework's effectiveness has been affirmed. The primary objectives of this research have been achieved with resounding success. The integration of agile practices, SEI's risk management principles, and the endorsement from industry professionals further solidify the framework's position as a valuable tool for effective risk management in GSD scenarios. The validation and endorsement by experienced professionals underscore its practicality and relevance. By addressing the coordination, communication, and knowledge management challenges inherent in GSD, the framework provides a structured yet adaptable solution that holds the potential to significantly enhance risk management processes. Its successful alignment with the demands of GSD, characterized by geographical dispersion and cultural diversity, positions it as a valuable resource for practitioners seeking to navigate the complexities of GSD. The proposed Risk Management Framework represents a significant contribution to the realm of risk management in GSD. By empowering organizations to take a proactive stance in identifying and mitigating risks, the framework lays the foundation for improved project outcomes, fostering success and confidence in risk management practices across a spectrum of industries and global contexts.

6.2. Limitations

While the proposed Risk Management Framework offers proactive risk management, it is important to acknowledge potential limitations. As with any framework, its effectiveness may vary based on project scale and complexity. Moreover, while the responses of industry experts provide valuable insights, further research could encompass explicit integration with advanced technologies such as machine learning and AI to learn its potential in predictive risk analysis and

adaptive risk mitigation. Exploring these technological enhancements could further refine the framework's capabilities and address more complex risk scenarios.

6.3. Future Work

The inclusion of proactive risk management within the framework serves as a steppingstone toward promising future horizons. Integrating machine learning and AI algorithms could elevate the framework's proactive capabilities to new heights, enabling real-time risk prediction, swift decision-making, and data-driven risk mitigation strategies. This integration would empower GSD teams to respond dynamically to evolving risk landscapes, thereby enhancing the framework's practicality and effectiveness. Additionally, ongoing collaboration with industry practitioners, academia, and technology experts could yield continuous insights for refining and expanding the framework's functionalities. As the GSD landscape evolves, so should the framework, adapting to emerging challenges and harnessing cutting-edge technologies to ensure its enduring relevance.

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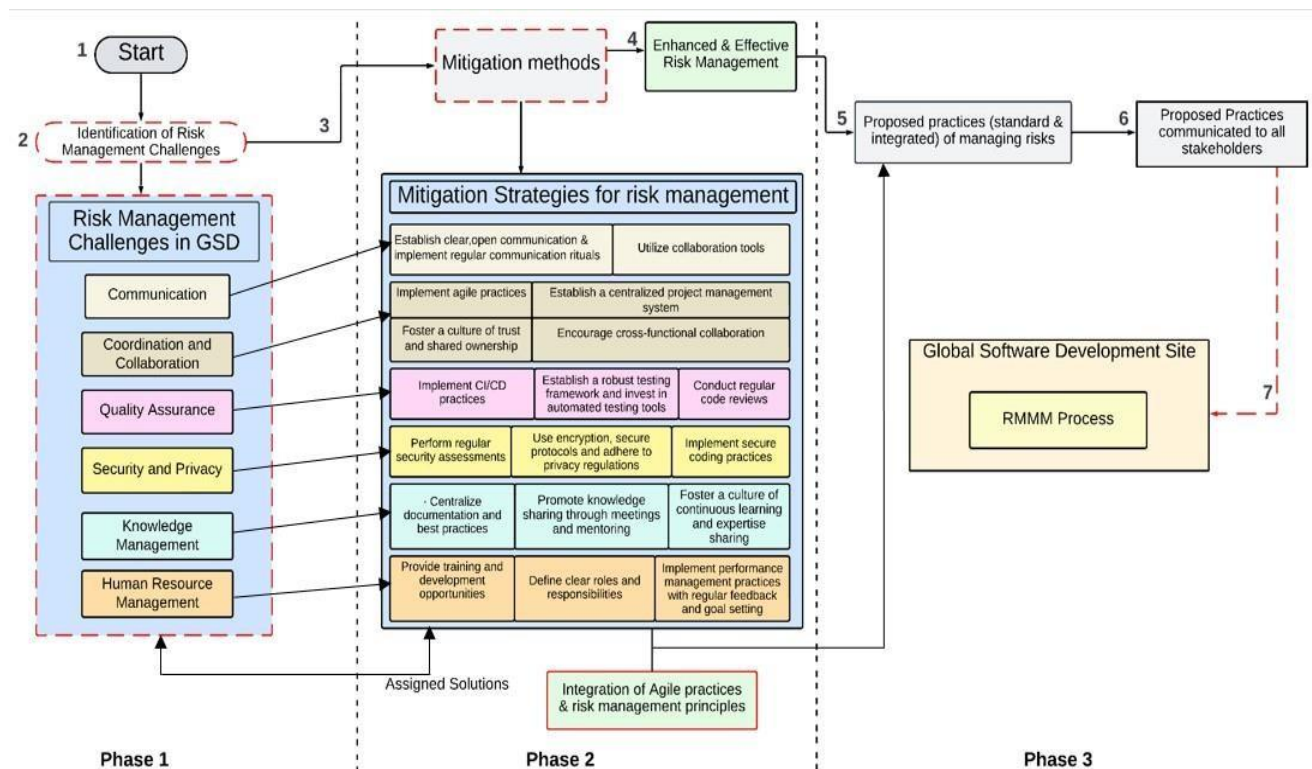
Annex A
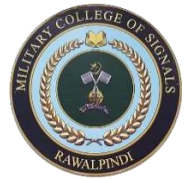
"Mitigating the risk management challenges in Global Software Development"- Proposed model.

Section   1

Questionnaire

I am seeking validation for my research on the topic "Mitigating the risk management challenges in Global Software Development". I have developed a proposed model and would greatly appreciate your expertise in evaluating its effectiveness. Your expert opinions, experiences, and recommendations related to risk management in GSD are crucial for enhancing the credibility and practicality of my research. The collected data will be used for academic purposes only. Your privacy and participation will be confidential.

MSSE Thesis -Proposed Model Validation

"Mitigating the risk management challenges in Global Software Development"- Proposed model

Section 2
Part 1 - Introductory questions and demographics

1. What is your current role in software development projects?

   _____

2. How many years of experience do you have in managing software development projects, particularly in a global or distributed setting?

   _____

3. Which industry does your organization operate?

   _____

4. Is your organization involved in offshore development projects or does it have offices located in multiple countries?

   _____

5. Which geographical region are you primarily based in?

   _____

6. What is the estimated size of your organization (number of employees)?

   _____

Part 2 - Current Risk Management Practices

7. What risk management framework or approach does your organization currently use in software development projects?

   - ISO 31000

   - COSO ERM framework

   - NIST ERM Framework

   - Casualty Actuarial Society (CAS) ERM Framework

   - COBIT ERM Framework

- Other:

8. How satisfied are you with your organization's current risk management practices in GSD projects?

- 1 - Not Satisfied

- 2 – Slightly satisfied

- 3 – Neither satisfied nor dissatisfied

- 4 - Satisfied

- 5 - Highly Satisfied

9. What are the main challenges you face in managing risks in distributed software development projects?

- Communication

- Coordination and Collaboration

- Quality Assurance

- Security and Privacy

- Knowledge management

- Human resource management

- Other: _____

Part 3 - **Evaluation of Model Components**

Part 3 - Phase 1 - **Challenges in Global Software Development's Risk Management**

10. Have the challenges mentioned in Phase 1 of the proposed model accurately represented the common issues you encounter in GSD risk management?

- Yes

- No

- Other:

Part 3 - Phase 2 - **Agile-Based Mitigation Strategies and Risk Management Principles**

11. How effective do you think Agile-based mitigation strategies can be in managing risks in GSD

projects?

- 1 - Not Effective

- 2 – Slightly effective

- 3 – Neutral

- 4 - Effective

- 5 - Highly Effective

12. What do you think the seven risk management principles by SEI are relevant and applicable in the context of GSD?

- Yes

- No

- Other:

13. Which of the following agile practices do you find most crucial for effective GSD risk management?

- Iterative Development

- Regular Feedback and Review

- Continuous Integration and Deployment

- Cross-Functional Collaboration

14. Which of the seven risk management principles do you find most crucial for effective GSD risk management?

- Maintain a Global Perspective

- Take a Forward-Looking View

- Encourage Open Communication

- Integrate Risk Management

- Emphasize a Continuous Process

- Develop a Shared Product Vision

- Encourage Teamwork

Part 3 - Phase 3 - Comprehensive Risk Mitigation Plan

15. How comprehensive do you consider the Risk Mitigation Plan presented in Phase 3?

- 1 - Not comprehensive

- 2 – Slightly comprehensive

- 3 - Neutral

- 4 - Comprehensive

- 5 - Highly comprehensive

16. Do you think the Risk Mitigation Plan adequately addresses the specific challenges of GSD projects?

- Yes

- No

17. What additional elements would you recommend adding to the Risk Mitigation Plan to enhance its effectiveness?

Part 4 - Applicability to GSD Environment

18. How well do you think the proposed framework aligns with the unique characteristics (i.e geographical dispersion and cultural diversity) of GSD projects?

- 1 - Poor

- 2 - Moderate

- 3 - Good

- 4 - Very Good

- 5 – Excellent

19. Can you provide specific examples of how the model's components can be practically applied in real-world GSD scenarios?

Part 5 - **Effectiveness in Risk Mitigation**

20. To what extent do you believe the proposed Risk Management Framework can proactively identify risks in GSD projects?

    - 1 - Limited

    - 2 - Low

    - 3 - Moderate

    - 4 - Slightly High

    - 5 - High

21. How well do you think the model's components can help mitigate identified risks effectively in GSD projects?

    - 1 - Unlikely

    - 2 – More likely than not

    - 3 - Likely

    - 4 – Very likely

    - 5 - Certainly

Part 6 - **Recommendations for Improvement**

22. Are there any aspects of the proposed model that you find unclear or ambiguous?

    - Yes

    - No

    - Other:

23. What specific improvements would you suggest for enhancing the model's usability and practicality in GSD projects?

    _____

Part 7 - **General Feedback**

24. Do you believe that adopting the proposed Risk Management Framework could lead to improved project outcomes in GSD environments?

    - Yes

    - No

25. How confident are you in implementing the proposed framework in your organization's GSD projects?

    - 1 - Not Confident

    - 2 – Little confident

    - 3 - Confident

    - 4 – Fairly confident

    - 5 - Highly Confident

26. In your opinion, what are the main strengths of the proposed Risk Management Framework for GSD?

    _____

27. Do you have any concerns or reservations about the model's feasibility or applicability in certain GSD contexts?

    _____

28. Is there any additional feedback or comments you would like to provide regarding the proposed model?

    _____