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Enhanced AZ-Model for Requirement Change Management in the Context of Global Software Development

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Software organizations are increasingly embracing the advantages of Global Software Development (GSD), such as access to highly skilled developers and reduced development costs. However, the implementation of Requirement Change Management (RCM) activities in GSD is often hindered by a lack of communication and coordination among project stakeholders, as well as an insufficient focus on traceability and monitoring of RCM activities. To overcome these issues, we have enhanced and improved an existing RCM framework to mitigate the identified challenges and to develop a quality product while achieving customer satisfaction and business objectives. To evaluate the effectiveness of the proposed Enhanced AZ-Model, we sought feedback from the industrial experts and performed a statistical analysis of the collected data. The Enhanced AZ-Model was further validated by performing simulations of the model. The empirical and simulation results indicate that the Enhanced AZ-model efficiently and effectively manage the demanded changes according to the budget and time constraints.

KEYWORDS
Requirement Change Management(RCM), Global Software Development (GSD), Requirement Engineering

1 | INTRODUCTION

The term "global software development" (GSD) refers to the process of creating software projects with development teams dispersed across several locales [1]. Projects in the GSD are produced across regional borders, which separates the practitioners physically [2]. The project managers find it challenging to coordinate and interact with the teams efficiently because of the dispersed team locations and various time zones. As a result, while carrying out the GSD initiatives, the project management activities, in particular controlling the modifications, become more challenging [3]. It is important to note that GSD is often used and acknowledged as a strategy for obtaining several advantages, including decreased development time and expense as well as access to the top international development teams [4]. To create software projects with the fewest resources, lowest spending, and shortest timelines possible, the businesses are moving the development toward the GSD environments. For small or large software projects, the team leads or project managers find it difficult to manage change requests linked to requirements from various geographic locations. Figure 1 presents the overview of the GSD paradigm.

Due to continuous development support and accessibility to highly experienced workers worldwide, the GSD strategy has recently received significant attention from the industry and the researchers [5]. Several software companies have switched to a globally dispersed arrangement for their development environments [6], which is essential for the successful and timely completion of the project. According to a poll by the Standish Group, around 20 percent of software clients outsource their software development activities to vendor nations, underscoring the importance of GSD's influence on the sector [7].

Nonetheless, the requirement management process in the GSD is more complicated and high-risk. Clients frequently ask for adjustments to be made throughout the development lifecycle. After examining the risks and the effects of the proposed changes on the finished product, cost, and schedule, these adjustments are implemented. The challenges of requirement change management (RCM) processes have been investigated by several researchers. McGee et al. [8] and Pierce et al. [9] have stated that the main challenge is in discovering and resolving discrepancies between stated needs and expectations. Meanwhile, Nurmuliani et al. [10] argued that recognizing the necessity for the adjustments in the first place is a vital step in managing the changes that are required. The needs may change as a result of the uncertainty surrounding initially acquired criteria and a lack of client participation [11]. Consumers' criteria might not always be easy for them to articulate, which can lead to substandard products and financial losses for GSD enterprises. Chrissis et al. [12] recommend that for establishing how volatile the needs are, the history of the necessary revisions should be recorded. When implementing RCM activities in GSD enterprises, requirements must be recorded and requirement traceability must be maintained due to the requirements volatility and frequent requests for revisions.

To manage the RCM process and deal with frequent challenges like coordinating several stakeholder parties across time zones, carrying out change requests, and resolving communication problems, several frameworks have been presented. To tackle RCM challenges in GSD environments, Akbar et al. [13] designed a model equipped with instructions for relevant projects. Nevertheless, certain obstacles including traceability, process improvement and training of GSD practitioners were not discussed. Kamal et al. [14] suggested an Agile RCM model comprising 20 success elements to overcome issues concerning the GSD. Saim et al. [15] offered a conceptual model that tackled communication and coordination issues, yet did not address the implementation of RCM processes. Akbar et al. [16] proposed an AZ-Model which aimed to facilitate Requirement Change Management in GSD organizations. The purpose of the AZ-Model is to make it possible for stakeholders to examine risks and modification requests while also presenting detailed requirements. The development of the globally required adjustments takes place during the implementation phase. Although this model has some advantages, it only covers three phases and does not actively address issues with coordination

and communication. On the other hand, by choosing the right approach for each change request, the model's implementation phase can be improved. Yet, current approaches for this purpose are still unable to handle change requests while enhancing the GSD businesses' operational effectiveness and financial success. Thus, a more thorough RCM model is required to enable GSD practitioners to successfully manage and adapt changes in line with consumer and business goals.

To address the aforementioned problems, we presented and enhanced the AZ model by introducing the Enhanced AZ model, which enables GSD practitioners to carry out RCM activities and includes the necessary adjustments in accordance with customer expectations and business goals. We have created a model that GSD firms can use to better manage RCM efforts and enhance processes by adding certain innovations to the current framework. To determine the upgraded model's viability, a two-way validation will be conducted, using simulation-based use cases and industrial expert validation.

It is necessary to create an RCM model that enables GSD practitioners to carry out RCM operations to include required modifications in accordance with customer needs and business objectives in order to address the aforementioned problems with the aforementioned models.

To address the goals of this research study, we have developed the following research questions (RQs).

- RQ-1: What practices are reported in the literature related to RCM in GSD?
- RQ-2: How can we develop an effective framework for RCM activities in the domain of GSD?
- RQ-3: How can we validate that the Enhanced AZ-Model is effective enough to assess and improve the RCM activities of GSD organizations?

The rest of the paper is organized as follows: Section 2 consists of research motivation. The related work is explained in Section 3. Section 4 describes the research methodology. Section 5 explains the validation processes of the proposed study. The proposed solution is explained in Section 6. Section 7 explains the results and discussion whereas conclusion and directions for future work are discussed in Section 8 .

2 | RESEARCH MOTIVATION

The analysis of existing literature indicated that a limited search had been conducted to propose a framework that helps GSD practitioners to mitigate RCM challenges in the GSD context. Furthermore, Ramzan et al.[17] and Khan et al.[18] stated that little research had been done to address RCM practices in the GSD context. As observed, 8 out of 10 software companies working in the GSD environment face many challenges due to a lack of planning and the unavailability of RCM standards and models. In GSD, practitioners work across geographic boundaries, creating communication and coordination issues, making change management more difficult because RCM is a collaborative process[19]. Most existing research studies focus on collocated (single-site) RCM activities. However, it is critical to address the change management issues in the domain of GSD[17].

Throughout the phases of requirement collecting, software installation, and maintenance, RCM is renowned for managing requested changes. Similar to requirement engineering, RCM is a technique for dealing with shifting needs during system development. Many factors, such as customer requirements, corporate policy, and governmental regulations, might lead to changes in requirements. The requirements change management (RCM) process is challenging at single sites (collocated environments) and becomes even more complicated in global software development (GSD) environments[20]. Several studies[21,22,6,23,24] have been proposed to identify challenges and success factors for re-

quirement change management in the GSD paradigm.

Similarly, some studies [13,14,15,16] have proposed frameworks to execute Requirement Change Management (RCM) activities in a GSD environment. The difficulties of RCM activities in the setting of GSD cannot be lessened by the existing studies. It is important to note that we have examined the state-of-the-art RCM models in the context of GSD rigorously. According to evidence, communication and coordination, requirement traceability, and tracking and monitoring of RCM operations are issues that are not mitigated by RCM models. Thus, a framework that enables the efficient implementation of RCM operations and creates desired changes within the constraints of cost and time is required.

3 | RELATED WORK

This section represents the previously proposed models and frameworks that have focused on managing and implementing RCM activities in the context of GSD. Several key RCM issues have been recognized, as well as success characteristics that have been exploited to create best practices for RCM activities. By examining the previously suggested studies, some significant drawbacks have been found.

Akbar et al. [13] proposed a readiness model for requirements change management in global software development that provides a set of best practices to execute RCM activities in a GSD organization. The model consists of five levels, and at each station, the organizations can evaluate their process models against each group. However, the proposed model does not highlight the challenges of requirement tracking and monitoring of RCM activities. Furthermore, the proposed framework is ineffective in mitigating all RCM challenges in the context of GSD. Kamal et al. [14] proposed an agile requirement change management readiness model (ARCMRM) in the context of GSD, which is based on identifying success factors and the area of implementation and providing best practices for ARCM in the GSD paradigm. However, the proposed model's scope is limited to Agile methods. Moreover, the proposed model does not highlight the challenge of documentation and tracking project artifacts while managing demanded changes. Qureshi et al. [15] proposed a conceptual model for requirement change management in the GSD domain. Using the existing state of the art, the suggested model has identified 75 main communication and coordination issues and sub-challenges. Nevertheless, the proposed methodology does not assist in reducing the difficulty of requirement tracking and project tracking. Moreover, the suggested approach does not emphasize difficulties with creating the change request or coordinating and communicating with developers.

Akbar et al. [16] proposed an AZ Model for requirement change management in the global software development (GSD) context. The coordination, analysis, and implementation phases of the suggested model were used to successfully manage the required adjustments. Given that developers employed from different regions of the world may have linguistic, cultural, and time zone disparities, the proposed model did not address the issue of communication gaps among stakeholders. Moreover, the proposed model did not mitigate the challenges of requirement tracing, project progress, and tracking. Akbar et al. [25] presented a study on developing software requirements change management and implementation maturity models for GSD practitioners. To conduct RCM activities, the author used the SLR technique to identify 25 success factors and 72 best practices that were created to successfully meet those obstacles and success factors. The proposed maturity model cannot, however, address issues like requirement traceability, project progress monitoring, and tracking and observing RCM operations. Turki et al. [26] proposed a unified model to manage requirement engineering for global software development. The proposed methodology is built around four stages: comprehending the needs, analyzing the changes, adjusting the conditions, and incorporating the modifications in subsequent projects. Nevertheless, the method for carrying out RCM operations in the GSD setting is not discussed.

Similarly, research has suggested identifying the obstacles and success factors for RCM in the field of GSD. The difficulties have been recognized, best practices have been devised to address them, and industry experts have validated these methods. Likewise, Sajid et al.[21] identified challenges for requirement change management that affect both global and in-house software development. Nine obstacles to the current state of the art were discovered by the study, and an industry expert questionnaire survey was done to confirm the obstacles. Unfortunately, the difficulties with recording RCM activities and GSD personnel training were not highlighted in the planned study. Furthermore, the proposed study cannot present a framework to execute RCM activities in the GSD paradigm. Akbar et al.[27] identified success factors using a systematic literature review (SLR). The author found 23 success characteristics after looking into the contributing aspects to success in 107 primary studies. Eight of these variables were deemed to be particularly important for the RCM process in GSD. The proposed research, however, is unable to provide a framework for carrying out RCM tasks inside the GSD paradigm. Naveed et al.[22] presented a survey based on identifying challenges for RCM activities in the GSD approach. The type of organization and its size, such as small, medium, or large, are the challenges that are categorized. The proposed study, however, did not address issues like documenting and keeping track of RCM artifacts, educating GSD staff, or tracking and monitoring RCM activities.

Akbar et al.[6] prioritized global software requirements using AHP. The findings of AHP demonstrated that collaboration is the most significant barrier to the successful application of RE principles in the GSD process. However, the proposed study did not highlight the challenges like requirement tracking, tracking of RCM activities, communication, and coordination among stakeholders. Arif et al.[24] presented a study on identifying motivators for RCM activities in the GSD paradigm. Using the systematic literature review (SLR) technique, the author retrieved 25 motivators and conducted survey research to assess the SLR findings experimentally. The author discussed motivators according to the size of organizations and the benefits of using them. Kausar et al.[23] presented a study that is based on the identification of RCM challenges in the domain of GSD. The proposed research has successfully identified 12 RCM challenges, and four are highlighted as the most critical RCM challenges. The frequency analysis was used to rank the identified challenges; four are classified as the most fundamental challenges for RCM activities in the domain of GSD. On the other hand, the study cannot present the framework based on the identified RCM challenges. Ahmad et al.[28] proposed a survey based on identifying success factors in Offshore Quality Requirement Change Management. The SLR approach analyzes the existing databases to identify RCM success factors. The author identified 16 success factors, and 14 were classified as the most critical success factors. However, the study cannot address the RCM best practices against each success factor. On the other hand, the presented research cannot develop a framework based on the success factors.

The most recent state-of-the-art analysis shows that the RCM problem, including tracking and monitoring RCM operations, requirement traceability, and project tracking and progress, cannot be mitigated by the existing RCM models. So, a framework is needed to address the identified RCM difficulties and create the necessary adjustments under the allocated funds and timeline.

4 | RESEARCH METHODOLOGY

The following steps highlight the proposed work's adopted research methodology, and Figure 2 represents its graphical representation.

- Selection of Problem Domain
- Literature Review

- Analyzing Existing Models and Frameworks
- Identifying the Limitations
- Presenting a Framework
- Preparing a Questionnaire
- Distributing a Questionnaire
- Industrial Expert-based Validation
- Simulation-based Evaluation of Model

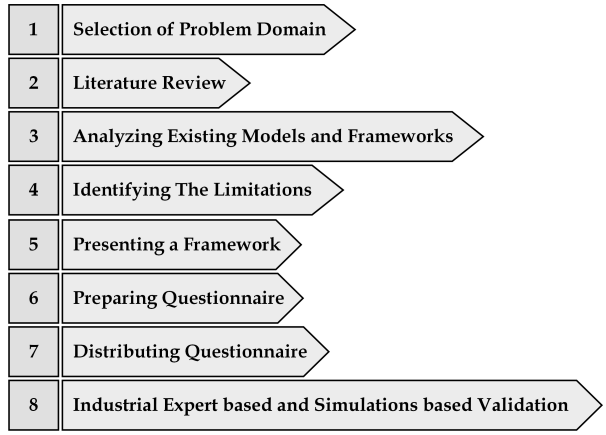

FIGURE 1 The Adopted Research Methodology

4.1 | Selection of Problem Domain

The targeted research process started with identifying existing literature for requirement change management (RCM) in the context of GSD. The existing studies focusing on RCM in the domain of GSD were critically analyzed and it was discovered that the current RCM frameworks could not mitigate the RCM challenges.

4.2 | Literature Review

The most recent state-of-the-art analysis shows that the RCM problem, including tracking and monitoring RCM operations, requirement traceability, and project tracking and progress, cannot be mitigated by the existing RCM models. So, a framework is needed to address the identified RCM difficulties and create the necessary adjustments under the allocated funds and timeline.

4.3 | Analyzing Existing Models and Frameworks

The existing RCM frameworks and models proposed in the domain of GSD were comprehensively analyzed and observed. The main objective of this step was to investigate the execution of RCM activities at distributed locations. Similarly, to explore the RCM challenges, success factors are required to develop RCM models.

TABLE 1 Data Search Sources

Task	Purpose
Elecronic Databases	IEEE Xplore (http://ieeexplore.ieee.org) ACM Digital Library (http://dl.acm.org) Science Direct (www.sciencedirect.com) Wiley Online Library (https://onlinelibrary.wiley.com) IET Digital Library (https://digital-library.theiet.org/)
Searched Items	Journal and conference papers
Search applied on	The papers that don't contain search terms in their title or abstract but relevant to our study object are selected as well
Language	English

4.4 | Identifying the Limitations

Multiple RCM frameworks and models were critically analyzed to identify potential limitations. The main objective of this step is to identify promising research gaps. Based on the specified constraints, the Enhanced AZ-Model is presented in this study.

4.5 | Presenting a framework

Based on the identified limitations in the previous AZ-Model and other RCM models, we have improved and enhanced the current AZ-Model to overcome the identified hurdles and RCM challenges. The proposed Enhanced AZ-Model is based on mitigating the current RCM challenges and managing the demanded changes according to the business objectives and customer satisfaction.

4.6 | Preparing a Questionnaire

To develop an online survey instrument, we use the services like Google Forms. We have prepared two questionnaires, and both questionnaires are based on closed-ended questions. We have prepared the questionnaire using the guidelines mentioned in [29,30]. Each questionnaire consists of six close-ended questions. The underlying objective of this step is to evaluate the present framework's understanding ability and feasibility.

4.7 | Distributing a Questionnaire

The questionnaire was distributed using social media platforms, including Facebook, Linked In, and email.

4.8 | Industrial Expert-based validation

In this step, we have applied frequency and statistical analysis to the responses from industry experts. The main objective of this step is to use numeric functions and represent the results in quantitative form. The frequency analysis represented the number of occurrences, for example, how often an expert agrees or disagrees with a statement. The statistical analysis is based on applying the T-test to responses and accepting or rejecting the alternate hypothesis.

4.9 | Simulation-based Evaluation of Model

The primary purpose of this step is to verify the industry expert's responses in a different dimension. The simulations of the proposed model were conducted using Extend Sim Pro. The simulations were based on a scenario, presenting upcoming change requests from clients for various business objectives.

5 | VALIDATION PROCESS

The validation of the Enhanced AZ-Model is mainly based on two steps. Figure 3 highlights the overall validation process of the proposed study. The first step is to validate the proposed model by industry experts, and the second step is to validate the proposed model by performing simulations. The industry experts-based validation is further based on two steps, the first step is frequency analysis, and the second step is statistical analysis. We used a paired sample T-test for rejecting or accepting the alternate hypothesis for statistical analysis. Finally, we verified the responses in a different dimension by performing simulations of the proposed model.

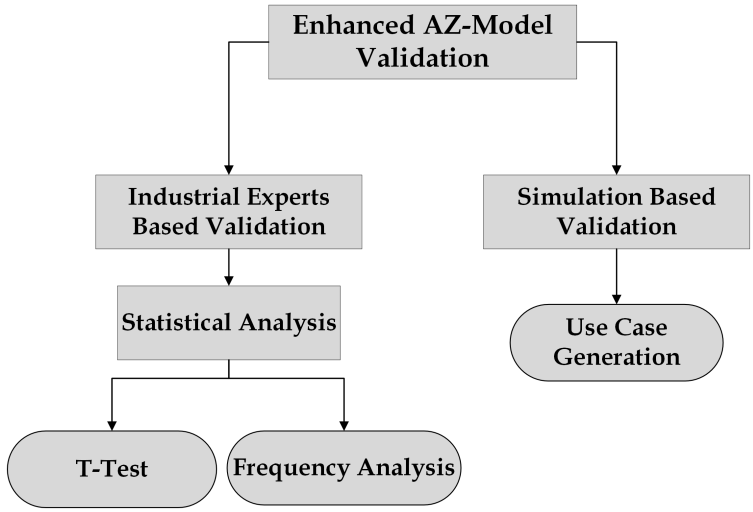

FIGURE 2 Validation Process of Proposed Model

5.1 | Null Hypothesis (H_0)

The null hypothesis (H0) states that the previous AZ-Model and traditional RCM frameworks significantly impact the software project's cost, schedule, scope, risks, and quality.

H_0 = Previous AZ-Model's Impact > Proposed Enhanced AZ-Model's Impact

5.2 | Alternate Hypothesis (H_1)

The alternate hypothesis (H1) states that the proposed Enhanced AZ-Model's features and functionalities significantly impact the software project's cost, schedule, scope, risks, and quality.

H_1 = Previous AZ-Model's Impact < Proposed Enhanced AZ-Model's Impact

6 | PROPOSED METHODOLOGY

The Enhanced AZ-Model is developed to execute requirement change management (RCM) activities in global software development (GSD). The presented AZ-Model is based on four phases, each stage having an input and one output. The proposed architecture of the Enhanced AZ-Model is shown in Figure [4].

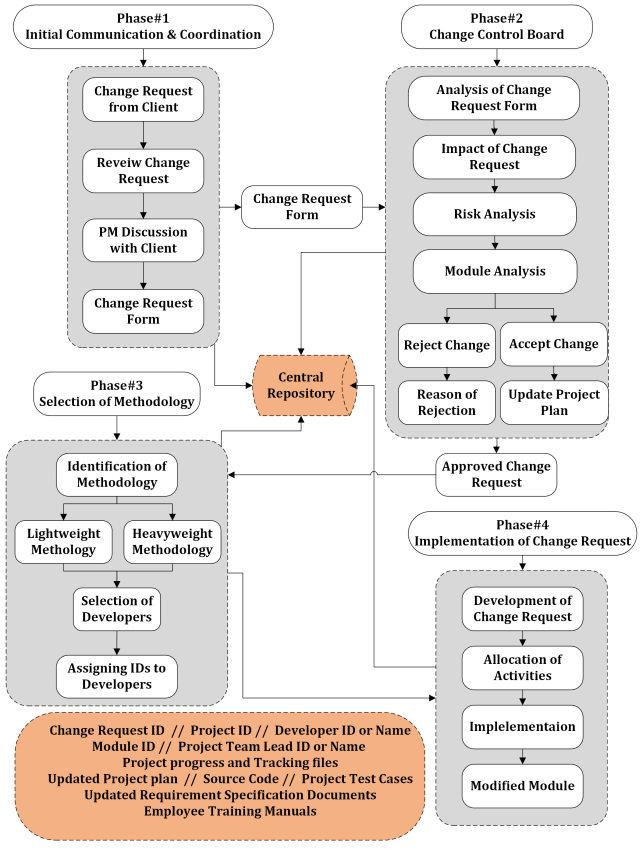

FIGURE 3 The Architecture of the Proposed Model

The components of the enhanced AZ-Model are named as follows:

- Phase #1: Communication and Coordination Phase
- Phase #2: Change Control Board

- Phase #3: Selection of Methodology
- Phase #4: Implementation of Change Requests

6.1 | Components of Enhanced AZ-Model

The Enhanced AZ-Model consists of four components. Each component is designed to perform specific tasks to execute RCM activities. For the smooth execution of RCM activities, each element should be accurately implemented by GSD organizations.

The primary feature of the presented Enhanced AZ-Model is the Central Repository. The central repository is a database to keep project details such as requirement specification (SRS), project plan, design modules, test cases, use cases, and project code files. The central repository structure is shown in Table [2]. For example, when a customer requests a change, the project's files can be accessed easily through the repository. The project manager or other specific person can assign IDs to all employees working on change requests. The central repository creates a bridge between higher authorities and performing teams. The higher authorities may check the progress of the project or change requests. The repository stores instructional videos, audio, pictures, or presentations to train existing and new GSD employees

TABLE 2 Central Repository Structure

Sr. No.	Central Repository Documents
1	Updated Project Plan Document
2	Project ID
3	Change Request ID
4	Developer IDs
5	Project Team Lead ID
6	Project Progress and Tracking Files / Version Control System
7	Project Code Files
8	Requirement Specifications (1.0,1.1)
9	Design Modules of the Project
10	Test Cases of Project
11	Employee Training Handouts

The VCS version control system stores the details of the iterations from the methodologies of the Enhanced AZ-Model. The structure of VCS is shown in Table 3, which highlights some assumed values for the CR ID, Module ID, and other important dates. The project managers can track the project's progress by monitoring the VCS in the central repository. The VCS includes the following: change request ID, module ID, expected completion date, start date, end date, and status of the project under development.

The initial communication and coordination between the project manager and the customer are conducted during this phase. The change is requested from the client (step 1). This stage continues for one to two weeks, during which the project manager collects requirements from the client (step 2). The project manager's role is crucial because he must decide whether this change can be implemented according to his experience, expertise, and available resources

TABLE 3 Version Control System

CR ID	Mod ID	Exp Comp Date	Start Date	End Date	In Progress / Complete	Status
CR100	Mod100	14/08/2022	14/05/22	30/08/22	In Progress	In Review
CR200	Mod200	10/05/2022	10/01/22	10/05/22	Complete	Verified
CR300	Mod300	10/05/2022	10/02/22	20/04/22	Complete	In Review

CR, Change Request; Mod, Module; Exp Comp, Expected Completion.

of the organization. The change request form is given to the client, which is to be filled in by the client (step 3).

The third component of the Enhanced AZ-Model is Change Control Board (CCB), where change can be approved or rejected by the CCB team. We have validated the structure from the industry experts, and members of the CCB team for the proposed model represented in Table 4. The Business Client / Client Representative is part of the CCB team for discussing the budget, schedule, and further important details. The CCB team reviews the change request form, and if there is any mistake or missing element, it will be escalated to the client (step 1).

TABLE 4 Change Control Board Structure

Sr. No.	CCB Team Members
1	Senior Technical Person
2	Senior System Architecture
3	Project Team Lead
4	Project Manager
5	UI/UX Person
6	Senior Developer
7	Business Client / Client Representative / Client Finance Manager / Any other Nominee

CCB, Change Control Board.

The change request may affect multiple project modules, and CCB team members measure the impact for each module (step 2). The impact analysis of the CCB phase is based on business objectives, risk analysis, schedule, cost, and project architecture. The impact analysis of the CCB phase with assumed values is shown in table 5. CCB team considers other potential risks, such as outsourcing, hiring new developers, etc., for change requests (step 3). In the end, if the change is accepted, then the project plan will be updated and stored in the central repository. However, if the change is rejected, the reason for rejection is handed over to the clients (step 4).

The fourth component of the proposed model actuated with selecting or identifying the appropriate methodology for developing the change request (step 1). The project managers can determine or identify suitable methods according to the customer's requirements and the organization's business objectives. For instance, the project managers may choose lightweight (i.e., Agile) or heavyweight methodologies (i.e., Iterative SDLC, Spiral, or V-Shaped SDLC) according to the requirements of the project or change request (step 2). The architecture of the Enhanced AZ-Model methodologies is shown in Figure 4. If customers want to be part of the development process, the project manager will consider the lightweight methodology. The project manager will consider Heavyweight methodologies if customers provide the requirements and want the final product.

TABLE 5 Impact Analysis of Change Request

Business Objectives	Risk Analysis	Schedule	Cost	Architecture	Status
Sales	Low	Medium	High	Medium	Conditionally Accepted
Increase Profits	Medium	High	High	Low	Conditionally Accepted
Sales	Medium	Low	Low	Medium	Accepted

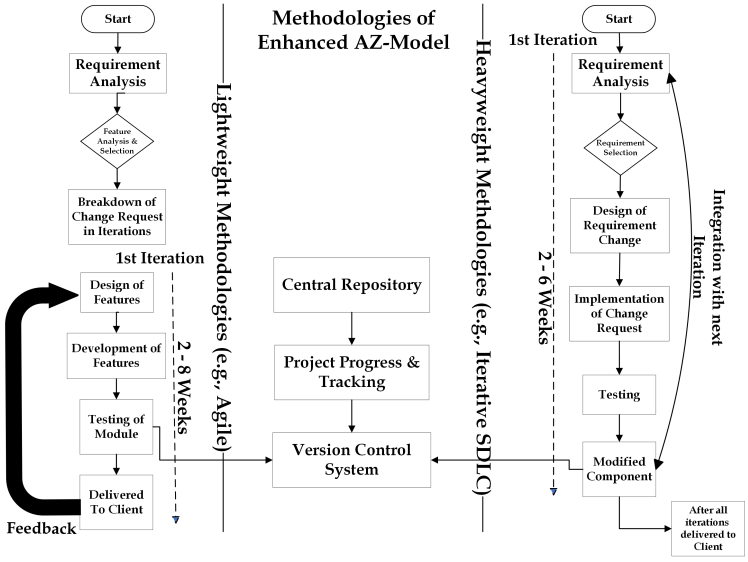

FIGURE 4 Methodologies of Enhanced AZ-Model

In lightweight methodology (i.e., Agile), requirements are recognized as features that are analyzed and selected by the project manager. In the end, the module is tested and delivered to the client. The client's feedback is the input for the second iteration. The first iteration details and version number are stored in the version control system (VCS). On the other hand, in heavyweight methodologies (i.e., Iterative SDLC), the selected requirements are developed under iterations, and the final product is delivered to the client. Once the project manager decides on the appropriate methodology, the next step is to choose specific developers for developing particular change requests (step 3). The main objective is to avoid overlapping development activities in the GSD paradigm due to different time zones. The project manager or team lead selects the developers or development teams and assigns specific IDs. The IDs are stored in the central repository and can be used to distribute tasks among groups or developers. The developers or development teams may update the status of their work progress.

7 | RESULTS AND DISCUSSION

This section aims to validate the proposed Enhanced AZ-Model for GSD organizations executing RCM processes. The industrial expert-based and simulation-based validation techniques were used to validate the proposed model. After collecting feedback from industry experts, we applied the t-test technique for statistical analysis. Moreover, we have further used a simulation-based validation technique to verify the proposed Enhanced AZ-Model in the simulation setup.

7.1 | Industrial-Experts based Validation

For validation purposes, small and medium-sized GSD organizations were selected for validation. Based on our selection criteria, we have selected 31 representatives from various GSD organizations and distributed two different questionnaires. The first questionnaire was designed to analyze the impact of traditional RCM frameworks, and the second questionnaire was designed to validate the proposed Enhanced AZ Model. More than 80 industry experts were asked to be involved in the validation process of the proposed model through different platforms such as LinkedIn, several visits to GSD organizations, and other social media platforms.

7.1.1 | Expert's Opinions on Traditional RCM Frameworks

The validation of Traditional RCM frameworks is based on six factors: schedule, cost, resource usage, quality, risks, and scope. The validation is based on the impact of traditional RCM frameworks on the factors mentioned above, such as whether the traditional models increase or decrease the cost, schedule, scope, and quality of the software product. Besides, it is unclear whether conventional RCM frameworks increase or decrease the risks of managing the required changes in GSD organizations. Table 6 highlights experts' opinions on traditional RCM frameworks in the Global Software Development (GSD) context.

TABLE 6 Expert's Opinions on Traditional RCM Frameworks

Sr. No.	Questions	Responses	Proportion
1	What is the impact of traditional RCM frameworks on "Time duration" in the domain of GSD?	SI	54%
		MI	16%
		RC	16%
		MD	3%
		SD	9%
2	What is the impact of traditional RCM frameworks on "cost" in the domain of GSD?	SI	51%
		MI	13%
		RC	3%
		MD	9%
		SD	22%
3	What is the impact of traditional RCM frameworks on "resource usage" in the domain of GSD?	SI	19%
		MI	51%
		RC	6%
		MD	19%
		SD	12%

TABLE 6 Expert's Opinions on Traditional RCM Frameworks (Continued)

Sr. No.	Questions	Responses	Proportion
4	What is the impact of traditional RCM frameworks on "quality" in the domain of GSD?	SI	6%
		MI	9%
		RC	16%
		MD	6%
		SD	61%
5	What is the impact of traditional RCM frameworks on "risks" in the domain of GSD?	SI	58%
		MI	9%
		RC	6%
		MD	6%
		SD	22%
6	What is the impact of traditional RCM frameworks on "scope" in the domain of GSD?	SI	9%
		MI	54%
		RC	3%
		MD	29%
		SD	3%

SI, Significantly Increased; MI, Minorly Increased; RC, Remained Constant; MD, Minorly Decreased; SD, Significantly Decreased.

According to expert opinion, the impact of traditional RCM frameworks on the cost of software projects gets significantly increased when using traditional RCM frameworks. The experts have agreed that when using conventional RCM frameworks, the cost of the projects and change requests reaches the maximum. The validation results have shown that 64% of the experts agreed that the cost significantly increased. Similarly, the validation results depict that the "resource usage," "schedule," "risks," and "scope" get increased considerably as more than 50% of the experts have agreed, as shown in Figure 6. On the other hand, the "quality" of the software projects gets significantly decreased as more than 50% of experts have agreed.

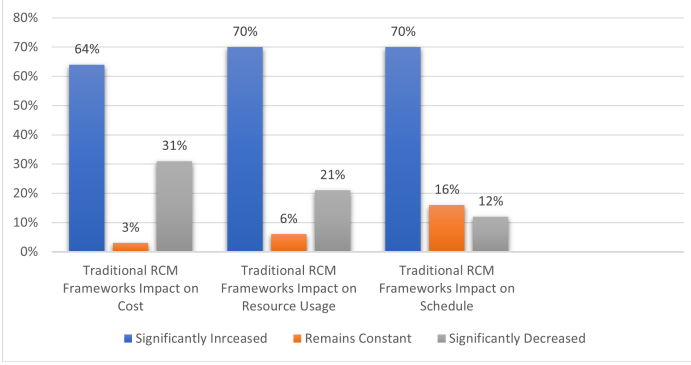

FIGURE 5 Impact of Traditional RCM frameworks

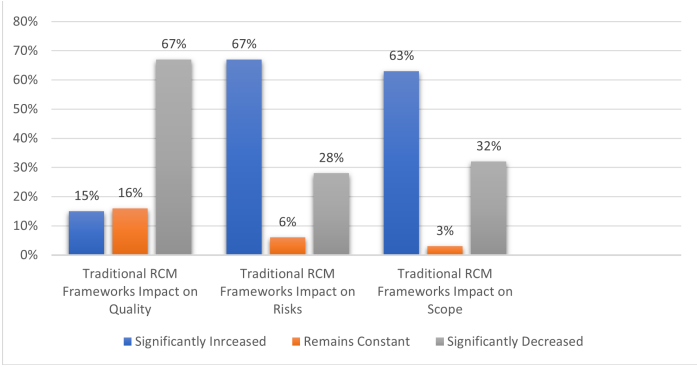

FIGURE 5 Impact of Traditional RCM frameworks (Continued)

7.1.2 | Expert's Opinions on Enhanced AZ-Model

The phases of the proposed Enhanced AZ-Model represent the features of the proposed study. The validation of the Enhanced AZ-Model is based on its core features such as the Central Repository, the Selection of Methodology, and project tracking and monitoring. The experts were asked to assess the proposed model and provide their opinion. The following table 7 highlights the responses from industry experts to Enhanced AZ-Model. We have used to Lickert scale to assess the responses.

According to the expert opinion, the Enhanced AZ-Model is adequate for RCM in the GSD paradigm. The validation results have shown that the 57% of the experts have entirely agreed that the proposed model is sufficient to be used to perform RCM activities. Similarly, 63% of the experts agreed that the Enhanced AZ-Model comprehensively addressed the challenge of communication and coordination.

TABLE 7 Expert's Opinions on Enhanced AZ-Model

Sr. No.	Questions	Responses	Proportion
1	In your opinion, the proposed methodology is adequate for performing RCM activities in GSD organizations.	SA	48%
		A	9%
		N	22%
		D	12%
		SD	6%
2	In your opinion, does the challenges of communication and coordination in Global Software development comprehensively addressed by the Enhanced AZ-Model?	SA	12%
		A	51%
		N	22%
		D	9%
		SD	3%
3	Do you agree that the presented Lightweight and Heavyweight methodologies in the proposed Enhanced AZ-Model are effective for incorporating demanded changes?	SA	19%
		A	51%
		N	6%
		D	19%
		SD	12%

TABLE 7 Expert's Opinions on Enhanced AZ-Model (Continued)

Sr. No.	Questions	Responses	Proportion
4	In your opinion, does this model help the organization in achieving software process improvement by deploying Central Repository?	SA	9%
		A	61%
		N	3%
		D	3%
		SD	22%
5	In your opinion, does this model help the organization achieve requirement traceability, project progress, and tracking?	SA	45%
		A	19%
		N	9%
		D	22%
		SD	3%
6	In your opinion, are the project risks and business opportunities completely managed by the proposed Enhanced AZ-Model?	SA	64%
		A	6%
		N	3%
		D	9%
		SD	16%

Likewise, 60% of the experts have completely agreed that the Enhanced AZ-Model methodologies are effective enough to incorporate demanded changes. The following graph in Figure 7 highlights the overall responses in the context of three major features of the Enhanced AZ-Model. Similarly, 73% of experts have completely agreed that the

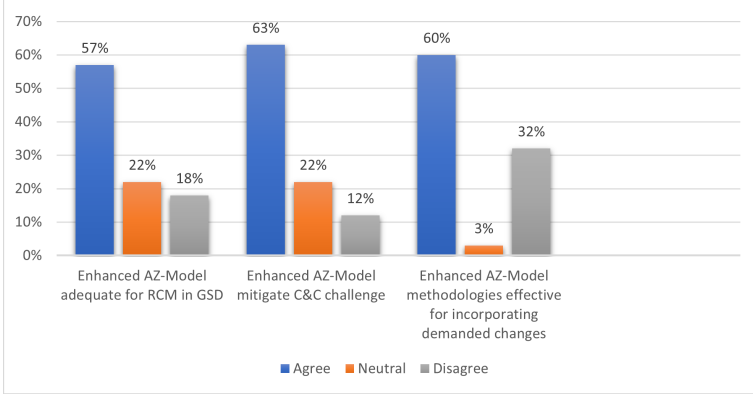

FIGURE 6 Expert's opinion on Enhanced AZ-Model

central repository ensures the improvement of processes in GSD organizations. Likewise, 64% of experts agreed that the proposed Enhanced AZ-Model achieves requirement traceability and project progress tracking. 70% of experts have agreed that the proposed model ultimately manages the project risks and business opportunities associated with the demanded changes. The following graph in Figure 8 highlights the responses of significant features of the Enhanced AZ-Model.

We have used the t-test for our statistical analysis because many authors in the research have recommended this test to evaluate responses. The paired sample t-test assesses two samples from the same population. We have used

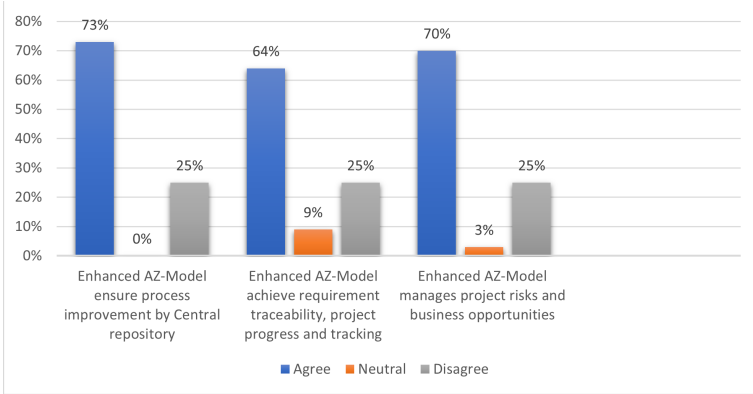

FIGURE 7 Expert's opinion on Enhanced AZ-Model

the SPSS tool to apply a paired-sample t-test. Both questionnaires have six questions, representing 12 columns in the SPSS tool. The first six columns present the traditional RCM frameworks (t1, t2, t2, t4, t5, and t6), and the other six highlight the Enhanced AZ Model (p1, p2, p3, p4, p5, and p6). The responses are added according to the Likert scale in the SPSS tool. We have calculated tmean and pmean of 31 responses using the tool. There was a significant difference between pmean and tmean, plus pmean was greater than tmean.

The most critical value in the t-test is the p-value, and based on the p-value, we can reject or accept the formulated hypothesis. The value of α is a threshold value, and the p-value must be lower than the value of α=005. After applying the paired sample t-test on both samples and using tmean and pmean the SPSS tool calculates the value of p, which is <0.001. The p-value is less than the value of α, which is 0.005. Table 8 highlights the evaluated result of the paired sample t-test.

TABLE 8 Paired Sample T-test

N	Mean Difference	α	p-value	Null Hypothesis (H_0)	Alternate Hypothesis (H_1)
31	0.338	0.005	<0.001	Rejected	Accepted

The N is the number of responses for both samples, i.e., traditional RCM frameworks and the Enhanced AZ Model. The mean difference for both tmean and pmean is calculated as 0.0338. The value of α is standard, and that is 0.005.

$$p = 0.001 < 0.005$$

The value of p is less than the value of α. Thus, we conclude that the null hypothesis is rejected, and the alternate hypothesis is accepted. The alternate hypothesis states that the Enhanced AZ Model features and concepts are valid in the opinions of industry experts.

7.2 | Simulation-Based Validation

Simulation tools help researchers analyze the behaviour of models, frameworks, and real-world scenarios in a sim-

ulator tool. The Extendsim was used to develop simulations of the Enhanced AZ-Model, as shown in Figure 9. The figure shows three queues connected to three activities, and the activities represent the three phases of the Enhanced AZ-Model. We have used a discrete event plotter to represent the simulation results. The discrete event is defined as the events that are completed according to a particular time unit.
We have created three queues in the simulation model representing the upcoming change requests, change request forms and approved change requests. The queues are fundamental elements of the simulation models and the main objective of using queues is to create a wait time between phases of the Enhanced AZ-Model. The maximum length of each queue is set as 20. We have created three activities in the simulation model, presenting three core phases of the Enhanced AZ-Model. We have set a completion delay in each activity because in GSD organizations there might be delays in the progress of processes. The simulations will run for a few weeks to develop the change request according to the schedule.

The calibration of the simulation model is based on the time unit. We have focused on the time in terms of the

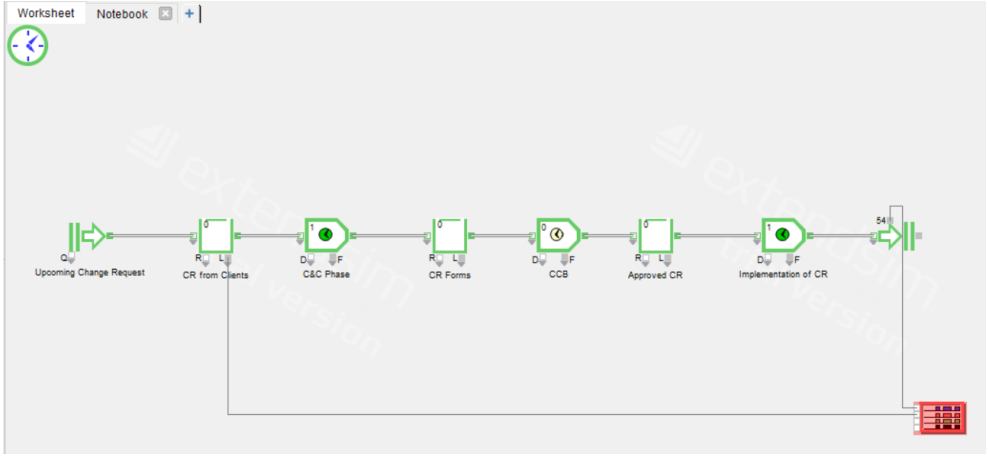

FIGURE 8 Simulation of Enhanced AZ-Model

weeks required for each phase to be completed. We have considered a scenario in which multiple change requests (CR) are processed in the GSD organizations with various business objectives. The simulation tool manages change requests under each activity according to the given time unit. For example, the project manager completes the communication and coordination in one to two weeks. The discrete event plotter represents the output of the simulations, as shown in figure 10.

The graph represents a linear relationship between the CR from the customers and the developed CRs. Moreover, the linear relationship depicts that after each time interval, a discrete event starts along the y-axis. According to the simulation results, 45 changes were requested from the client, and 31 changes were developed. Thus, we conclude that the Enhanced AZ-Model efficiently and effectively manage the demanded changes according to the given schedule. Moreover, more than 50% of experts have agreed with the features of the Enhanced AZ-Model, and the simulation's results verify the opinions of industry experts.

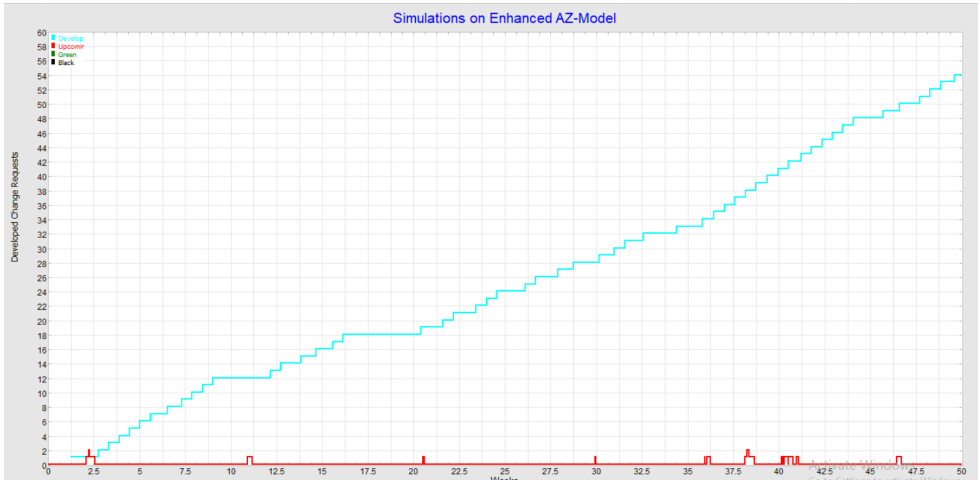

FIGURE 9 Discrete Event Plotter

8 | CONCLUSION

Many firms have implemented the practice of global software development and software requirements may inevitably change throughout development. Several scholars have suggested models and frameworks to reduce the RCM problems while creating high-quality goods to manage the change effectively and efficiently. The difficulties with stakeholder coordination and communication, requirement traceability, and tracking and monitoring RCM activities, however, cannot be eliminated by the existing studies.

To address the issues identified, we provide a quality product and meet customer and company goals, we have upgraded and improved an existing RCM framework. The provided structure is composed of four phases, each of which serves a distinct objective. Project managers might choose an appropriate methodology during the third step, "Selection of Methodology," to create the necessary adjustments. Lastly, we have tested our suggested model using two different ways. The first strategy relies on validation from industrial experts, whereas the second relies on validation from simulation. The majority of experts concur that when cost, schedule, risk, and scope increase when employing standard RCM frameworks, they have less of an impact.

On the other hand, the majority of specialists have endorsed the Improved AZ-characteristics Models and capabilities. The proposed model will be able to track and monitor RCM activities, enable requirement traceability, and create economic prospects, according to the expert's assessment of the upgraded AZ-Model. The second approach relies on simulating an enhanced AZ-Model. After running the simulation, we can conclude that the development of the change request increases with time and is directly proportionate to the change as it happens. After the validation procedure, we conclude that our suggested model can provide the required modifications while mitigating the highlighted obstacles within the time and financial restrictions.

The Enhanced AZ-Model can be extended to address all possible best practices against each RCM challenge identified from the literature or by industry experts. The Enhanced AZ-Model can be designed to address RCM activities in the collocated development environment.

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