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STRATEGIC MANAGEMENT OF SOFTWARE PROJECTS: COST, RISK, CONTINGENCY, BUDGET AND SCHEDULE

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ABSTRACT
This research introduces a unified simulation and modeling approach for strategically managing software development projects. It connects cost estimation, risk assessment, and contingency reserves directly to the project's budget and schedule. The model demonstrates how various strategic choices impact these key project elements. Recognizing that different strategies carry unique risks requiring specific cost and contingency allocations, the study shows how each strategic decision leads to a distinct project management plan with its own budget and timeline. The simulation framework quantifies cost, risk, and contingency for different strategic options and then uses these figures to shape the project's budget and schedule through simulated project management planning. Ultimately, this framework helps business leaders and project managers understand the advantages and disadvantages of different strategic decisions, enabling them to choose a strategy that better aligns with the overall corporate goals. A case study illustrates how different strategic decisions affect cost, risk, and contingency, and consequently, how they determine the budget and schedule of a software project.

Keywords:
Strategic Management, Simulation Modelling, Decision Analysis, Risk Analysis, Cost Estimation.

INTRODUCTION

The increasing complexity of software projects means we need new ways to manage them. The fast-paced market, new technologies, and strong competition make it really important for software projects to have clear strategies, which is why we need better management approaches. Software companies often struggle to make strategic choices for their projects because each choice can affect the project in different ways. Business leaders and project managers in software need to think not just about the actual development work, but also about picking the best strategic path from all the options to make sure the project is managed well and efficiently. Strategic decisions are usually made early on in a project, when we don't have all the details yet. Because of this, using simulations to understand these decisions can give us valuable insights into how they might impact the project. Simulating and modeling how software development works has been used in different situations, including when making strategic decisions for software projects (Kellner et al., 1999) [19]. Even though software engineering has grown a lot, it hasn't really taken advantage of what's been learned in business and strategic management. This shows that we really need to connect these two areas (Kakihara, 2006) [16]. Using strategic management ideas could be very helpful in dealing with the challenges that come with the rapid growth of software development. However, there hasn't been much research specifically on how to strategically manage software projects within the field of software engineering. This lack of understanding about how strategic management affects things can make it harder to develop software projects, especially when things are changing quickly.

The process of strategic management involves both coming up with and putting into action important strategic decisions. Business leaders are usually the ones who come up with these decisions, while project managers are responsible for making them happen through project management (Jacques and Andre, 2007) [15]. Different strategic decisions can have different levels of impact on a project. If we don't clearly understand these impacts, we might end up choosing project management plans and development approaches that aren't the best. Strategic management gives the overall direction and management for how a project develops (Papadakis and Barwise, 1997) [27], while project management makes sure these strategic decisions are actually carried out (Jacques and Andre, 2007) [15]. So, strategic decisions are made real through project management plans (Shenhar, 1999) [32]. For example, a company might strategically decide to develop and test software themselves, but they could

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also plan to hire an outside company to do the testing, or even the entire development. Each of these strategic choices will have different costs, different risks, and will need different amounts of backup funds. Because of this, each strategy will require its own budget and timeline, and therefore a unique project management plan. So, it's really important to understand how each strategic decision influences things like cost, risk, backup funds, budget, and schedule, as well as the overall project management plan.

When there are several strategic options for developing a software project, using simulations to figure out the numbers for different aspects of the project can really show how each strategic decision will affect these aspects. At the same time, modeling the project planning process helps connect these numbers to a project management plan. So, simulation and modeling act like a bridge, linking strategic decisions with project management plans through these quantified aspects.

Simulating and modeling the strategic management process involves estimating the different aspects of a project under each strategic decision and then showing how these estimates can shape the project management plans. This approach gives us a way to look at the consequences of strategic decisions on both the project itself and the project management plans. This helps business leaders and project managers choose a strategic decision that fits with their available money and backup funds, their budget, and their management style. As a result, instead of just jumping into implementing strategic management decisions during actual software development, simulation and modeling can help us avoid choosing options that might not work well (de Juan et al., 1999 [11], Law and Kelton, 1991) [23].

Management and Development Processes of Software Projects

In software development, having well-defined steps, methods, and ways of doing things is key to managing projects and developing software effectively. Because of this, we often use simulations and models to represent different parts of these management and development processes. Some of the earliest work in this area was done by Morecroft and Abdel-Hamid (1983) [26], who came up with a basic model to simulate the software development process. Abdel-Hamid and Madnick (1989) [1] later built on this model and made it more detailed. Madachay (1994) [25] created a simulation model to study how checking the quality of work during software development affects the project. Kouskouras and Georgiou (2007) [22] developed a simulation model to show the different stages that software development projects go through one after another. Ruiz et al. (2004) [31] suggested a simulation model that combined different approaches and was specifically designed for the Capability Maturity Model (CMM), which is a framework for improving software development processes. Additionally, Kellner (1999) [19] argued for creating general, adaptable models that could be easily used in various management and development situations.

Similarly, people have also used models to help with strategic management. Kiper and Feather (2005) [20] presented a strategic management model that used risk and cost analysis to help make strategic decisions in software development. They looked at ways to use early information about a project, relying on what experts thought or on past project data. Then, they based strategic decisions on which risk-reducing strategies would be most cost-effective. Williford and Chang (1999) [37] discussed a strategic planning model for predicting long-term budgets and staffing needs for a company's IT operations. Kakihara (2006) [16] described three ways to strategically manage the development of software web applications: focusing on the company's position in the market, its resources, and using a simple set of rules. He argued that the "Simple Rule" strategy is best for software that's constantly evolving on the internet because the market and technology keep changing. More recently, Uzzafer (2013a) [35] proposed a framework that uses simulation and modeling for the strategic management of software projects. In this framework, the costs and risks are estimated through simulations and then connected to the project's budget and schedule using project management models. This framework shows how strategic decisions affect costs and risks and how these are linked to project management plans, ultimately revealing the budget and schedule of the project.

Improved Integrated Modelling

Building upon Uzzafer's (2013a) [35] simulation and modeling framework for the strategic management of software development projects, this research introduces an enhanced model. A key innovation of this proposed model is the integration of a novel risk measurement technique, which subsequently improves the contingency estimation for software projects. By more effectively estimating contingency reserves, which directly influence project cost and schedule, the extended model provides broader insights and facilitates a deeper understanding of strategic alternatives. Contingency reserves, whether monetary or human, are provisions allocated to mitigate the risks inherent in software development projects. Consequently, the proposed strategic management process

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simulation and modeling framework is an integrated approach that connects strategic decisions with cost estimation, risk assessment, risk measurement, and contingency estimation, and then maps these elements to project management planning. The framework is designed to be generic, featuring modular, plug-and-play components with clearly defined interfaces, allowing for the integration of various estimation and assessment models and project planning tools for simulation and modeling purposes. This integrated simulation and modeling framework assists software development organizations and project managers in selecting the most suitable strategic decision from a range of alternatives to improve the management and development of software projects.

This research paper is structured as follows: Section 2 details the strategic management process for software development projects, emphasizing project parameters, development phases, and project management modeling. Furthermore, this section introduces the proposed framework for the strategic management process of software projects. It continues by discussing the construction details of the framework and explaining the contingency estimation model used for its development in the context of software development projects. Section 3 presents a case study that expands upon Uzzafer's (2013a) [35] case study, applying the proposed model to analyze the changes in cost, risk, budget, and schedule resulting from the model's extension to include contingency. Finally, Section 4 provides concluding remarks.

Strategic Management Process: Simulation and Modelling Requirements

Simulation and modelling of a strategic control procedure requires a cautious consideration of initiatives' parameters. moreover, it's miles equally important to model exclusive stages of a software program development undertaking to simulate the outcomes on unique parameters as software development progresses thru special levels to completion. In-addition, modelling of the challenge management making plans requires described steps to map quantified parameters to venture management plans. these requirements are discussed in the following sections.

It's important to carefully think about all the different aspects of a project when we're using simulation and modeling to plan how to strategically control it. Also, it's just as important to model each separate stage of a software development project. This helps us see how things might turn out for different aspects of the project as it moves through each stage until it's finished. On top of that, when we're modeling how to plan the project management, we need to have clear steps for how we'll connect the numbers we've come up with to the actual project management plans. We'll talk about these needs in the sections that follow.

Strategic Management Process: Project Parameters

Simulating the various parameters of a software development project yields crucial information. Researchers have identified key parameters in software development processes, including cost, risk, budget, schedule, quality, and specifications (Law and Kelton, 1991) [23]. Various cost estimation models exist for quantifying software project costs ((Pfleeger and Atlee, 2006 [28]; Karen et al., 2003 [18]; Alkoffash, 2008 [2])), and similarly, different risk assessment models are available for quantifying software project risk (Bannerman, 2008) [3]. Risk management, on the other hand, encompasses activities aimed at identifying and analyzing the impact of risks in software development projects (Boehm, 1991) [5]. Within software engineering research, there's a trend to represent cost by integrating the impact of risk, aiming to capture a cost figure that reflects the inherent risks of software development projects (Fairley, 1995 [12], Kansala, 1997 [17], Kitchenham and Linkman, 1997 [21], Gregroy, 2010 [13], Pfleeger and Atlee, 2006 [28]). This risk-integrated cost is considered vital for the strategic management of software projects (Carstea et al., 2008 [9], Lence and Hayes, 1994 [24], Reilly and Brown, 2004 [30]). Furthermore, contingency resources (both monetary and human) are deployed to mitigate the impact of risks and safeguard a project against undesirable outcomes. Uzzafer (2013b) [35] proposed a contingency estimation model based on measuring the risk associated with software projects, ensuring that estimated contingency reserves account for this inherent risk. Budget and schedule are additional critical project parameters for the strategic management of software projects (Uzzafer, 2013a) [35]. Project management planning utilizes the quantified cost and contingency to determine the budget and schedule of software projects. Therefore, budget represents the conversion of cost and contingency into monetary terms, while schedule represents their conversion into the project's calendar duration (Pfleeger and Atlee, 2006) [28]. Researchers have figured out that some key things to look at in software development are cost, risk, budget, how long it will take (schedule), quality, and what exactly the software needs to do (specifications) (Law and Kelton, 1991) [23]. There are different ways to estimate how much a software project will cost ((Pfleeger and Atlee, 2006 [28]; Karen et al., 2003 [18]; Alkoffash, 2008 [2])), and similarly, there are different ways to figure out the

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risks involved in a software project (Bannerman, 2008) [3]. Risk management, on the other hand, is about finding and understanding the impact of risks in software development projects (Boehm, 1991) [5].
In software engineering research, people often try to include the impact of risk when they're calculating the cost. The goal is to get a cost estimate that already takes into account the potential risks of the project (Fairley, 1995 [12], Kansala, 1997 [17], Kitchenham and Linkman, 1997 [21], Gregroy, 2010 [13], Pfleeger and Atlee, 2006 [28]). This cost, which includes risk, is seen as really important for making strategic decisions about software projects (Carstea et al., 2008 [9], Lence and Hayes, 1994 [24], Reilly and Brown, 2004 [30]).
Furthermore, we set aside extra resources (both money and people) to help deal with risks and protect the project from bad outcomes. Uzzafer (2013b) [36] suggested a way to estimate how much extra we need by measuring the risk in software projects. This makes sure that the extra resources we plan for are enough to cover the potential risks. Budget and schedule are also very important things to consider when strategically managing software projects (Uzzafer, 2013a) [35]. When we plan a project, we use the estimated cost and the extra resources to figure out the total budget and how long the project will take. So, the budget is basically the cost and the extra resources turned into a dollar amount, while the schedule is how long the project will take in terms of calendar time (Pfleeger and Atlee, 2006 [28]).

Strategic Management Process: Project Development Phases

Software development processes outline various development phases and their order. Different software development processes exist, such as waterfall, spiral (iterative and incremental), and rapid (Wysocki, 2006) [38], each with distinct phases and a unique emphasis on the sequence of these phases. For instance, the waterfall model prohibits revisiting previous phases, with the development progressing to the next phase only upon completion of the current one. In contrast, the spiral model (Boehm, 1988) [4] permits the iteration of phases throughout a project's development lifecycle. Similarly, rapid development models allow for the repetition of phases as software requirements evolve during the development lifecycle. Agile development is an example of a rapid model that prioritizes development phases over extensive planning phases. The waterfall model is unsuitable for projects with continuously changing requirements (Collyer and Warren, 2009) [10]. However, the spiral and rapid software development process models can be employed for such projects because they incorporate feedback mechanisms that link a phase back to previous ones. The proposed strategic management process model utilizes feedback; therefore, only a software development process that includes feedback mechanisms is compatible with the proposed model.
Software development usually involves a set of different stages that happen in a certain order. There are various ways to approach this, like the waterfall method, the spiral method (which involves repeating steps and building in stages), and rapid development methods (Wysocki, 2006) [38]. Each of these has its own set of phases and a different focus on how these phases should follow each other. For example, with the waterfall method, you can't go back to a previous step once you've moved on to the next. You have to finish the current phase completely before starting the next one. On the other hand, the spiral method (Boehm, 1988) [4] lets you go back and repeat phases as needed throughout the project. Similarly, rapid development methods allow you to repeat phases because the software requirements might change as the project goes on. Agile development is a type of rapid method that focuses more on the development phases themselves rather than spending a lot of time on detailed planning upfront. The waterfall method isn't a good fit for projects where the requirements keep changing (Collyer and Warren, 2009) [10]. However, the spiral and rapid development methods can work well for these kinds of projects because they have ways to get feedback that allows you to revisit earlier phases. The strategic management process model we're suggesting also uses feedback, so it will only work with a software development process that includes this kind of feedback mechanism.

Strategic Management Process: Project management planning

Project management planning establishes a connection between the various project parameters and the resulting project management plans. This planning process models the different project phases, their sequence, and any iterations between them. According to PMI (2004) [29], a project management plan defines how the different phases of a project can be interconnected, outlining four distinct logical relationships. Consequently, project management planning utilizes the quantified parameters of cost and contingency for the various project phases. Furthermore, it involves identifying and assigning human resources to specific project activities. Thus, the modeling inherent in project management planning generates the budget and schedule for software projects by leveraging the quantified cost and contingency parameters.

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Project management planning is what ties together all the different aspects of a project and turns them into the actual plans for how the project will be managed. This planning process figures out the different stages of the project, the order they'll happen in, and if any stages will need to be repeated. According to PMI (Project Management Institute) in 2004 [29], a project management plan shows how the different parts of a project relate to each other, and they describe four main ways these connections can work. Because of this, project management planning uses the numbers we have for things like cost and the extra resources (contingency) needed for each stage of the project. It also involves figuring out who will work on what tasks. So, the modeling that happens during project management planning is what creates the final budget and schedule for software projects, using the information we have about costs and contingency.

Strategic Management Process: Proposed Simulation and Modelling Framework

The proposed approach is a unified simulation and modeling framework. The simulation component is a computerized process that estimates cost, risk, and contingency. The modeling component encompasses the modeling of strategic planning, cost analysis, risk identification and assessment, and project management planning. Strategic planning identifies various strategic decisions for software project development. Risk assessment modeling identifies risks associated with each strategy and then evaluates their potential impacts and probabilities. Cost analysis modeling selects values for cost estimation. The computerized simulation then utilizes the quantified cost and risk from the cost estimation and risk assessment stages, respectively. Subsequently, the simulation generates a quantified cost that incorporates risk and an estimated amount for contingency reserves. Finally, the project management planning modeling phase transforms these quantified parameters into project management plans, ultimately producing the project's budget and schedule.

Here's a simpler way to understand the approach we're suggesting: It's like having a complete system for planning and managing software projects. One part of this system uses computer simulations to estimate how much things will cost, what risks we might face, and how much extra we should set aside just in case. The other part involves creating models for different things like making strategic plans, analyzing costs, figuring out and evaluating risks, and planning the actual project management.

First, we use strategic planning to come up with different ways we could develop the software project. Then, we use risk assessment models to identify the potential problems with each of these strategies and figure out how likely they are to happen and how bad they could be. Cost analysis models help us choose the right numbers for estimating the costs. After that, the computer simulation takes the cost estimates and the risk information and calculates a total cost that includes the potential risks, as well as an estimate for how much extra money or resources we should have as a backup. Finally, the project management planning part of the system takes all these numbers and turns them into concrete project management plans, which ultimately give us the project's budget and timeline.

Assume that 1 is the random overall risk impact on the cost, $\Re \in [0,1]$, and Ψ is the random estimated cost; the random cost integrated with the risk is X which is defined as: $(X_i)_j = (\Psi_i)_j \times \{(\Re_i)_j + 1\}$, where i and j represents a development phase and a strategy, respectively. Furthermore, the contingency is defined as $(\mathcal{C}_i)_j$.

The proposed integrated framework of simulation and modeling is presented in Figure 1, the flowchart symbols are from Hebb (2011) [14]. Note that the shaded boxes represent the modeling part of the framework whereas the un-shaded boxes represent the computerized simulation steps.

The framework defines the following generic steps: strategic planning, risk management, cost estimation, contingency estimation and project management. The strategic planning process conducts the strategic management planning and develops strategic decisions for the development of software projects. The risk management process performs the risk identification and assessment for a strategic decision and using a risk estimation model determines the random overall impact of the risk, $(\Re_i)_j$ and through feedback the risk assessment is repeated for each phase.

The cost estimation process performs the cost analysis to select the parameters for the cost estimation model that produces the random estimated cost in man-months, Ψ, which is further integrated with the random overall risk, $\Re$ resulting in $(X_i)_j$. The contingency estimation process produces the contingency based on $(X_i)_j$. The project management process determines the budget and the schedule for the development of a software project. The simulation begins with business management conducting strategic management planning to determine various strategic decisions for the software development project. Subsequently, the project manager chooses a specific strategic decision, identifies the potential risks associated with the project's initial development phase, and

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assigns impact levels and probabilities to each identified risk. Furthermore, the project manager establishes the initial parameters for the cost estimation and contingency estimation models.
The computerised simulation then generates $(\mathfrak{R}_{i=1})_{j=1}$, $(\Psi_{i=1})_{j=1}$, $(X_{i=1})_{j=1}$, and $(\mathcal{C}_{i=1})_{j=1}$ for the first project phase, $i = 1$, and the first strategic decision, $j = 1$. Following the initial setup, the project manager analyzes the feedback received and conducts risk identification and assessment for the subsequent development phase. This process yields a new set of risk impacts and probabilities. Additionally, the inputs for cost estimation are defined for this next phase. This iterative process continues for all development phases until the entire software project lifecycle is simulated under the chosen strategic decision.
Upon completing the simulation for the first strategic decision, the project manager performs project management planning using the quantified cost and contingency values. This planning determines the corresponding budget, budget contingency, schedule, and schedule contingency, broken down for each phase of the software project.
The simulation and modeling process is repeated for each strategic decision in the manner previously outlined. As a result, upon completion of the entire simulation and modeling cycle, the costs, contingencies, and their corresponding budgets and schedules are determined for all identified strategic decisions for the software project's development. These outcomes can then be analyzed and compared to select the strategic decision that best aligns with the organization's objectives.
The proposed integrated simulation and modeling framework elucidates the relationship between project development strategies and project management plans, quantifying the effects on cost, contingency, budget, and schedule for different phases under various strategic decisions. Furthermore, the framework's utilization of generic plug-and-play components with clearly defined interfaces provides users with the flexibility to integrate different sets of cost estimation and risk management models, as well as various project management tools.

Strategic Management Process: Model Construction

This section provides a detailed explanation of how the proposed simulation model was constructed. Uzzafer (2013a) previously outlined risk management strategies, cost estimation models, and project management tools relevant to building the simulation and modeling framework. The subsequent discussion in this section will focus on the specific contingency estimation model and the risk measure model that were adopted for the construction of the current model. This elaboration aims to assist both software practitioners and academics in understanding and replicating the model's construction.

Strategic Management Process: Software Contingency Estimation Model

Uzzafer (2013b) [36] proposed the following contingency estimation model:

$$\mathcal{C} = \rho(X) - \mathbb{E}[X] \quad (1)$$

Where $\mathcal{C}$ is the estimated contingency, $\mathbb{E}[X]$ is the expectation of random cost X and $\rho(X)$ is the measured risk of software projects. Risk measure is the expected risk which is measured from X based on a pre-defined probabilistic confidence on X as follows (Uzzafer, 2015) [34]:

$$\rho(X) = \frac{\sum_{k=t_\varepsilon}^{t_\alpha} \mathbb{x}_k f(\mathbb{x}_k)}{\sum_{k=t_\varepsilon}^{t_\alpha} f(\mathbb{x}_k)} - \mathbb{x}_{t_\alpha}\left(P\{X \le \mathbb{x}_{t_\alpha}\} - \alpha\right) + \mathbb{x}_{t_\varepsilon}\left(\varepsilon - P\{X \le \mathbb{x}_{t_\varepsilon}\}\right) \quad (2)$$

X is discrete random variable representation the cost of a software project, t_α and t_α are the sample index and $\mathbb{x}_{t_\varepsilon}$ and $\mathbb{x}_{t_\alpha}$ are the 100 εth and 100αth percentiles of X.

Case-Study of a Software Project

Uzzafer (2013a) presented a case study, utilizing the simulation and modeling application to illustrate the implementation of the proposed strategic management process for a software development project. This research builds upon that work by further extending the case study and applying the newly proposed integrated framework to investigate the impact of contingency on the strategic management process of software projects.
In the case study outlined by Uzzafer (2013a) [35], a software development project was considered. The modeling of strategic decision planning showed that the organization was evaluating three strategic options for the project's development:
Strategy 1: Conducting all software development and testing activities internally.
Strategy 2: Performing software development in-house and outsourcing the testing phase.
Strategy 3: Completing in-house development and testing, supplemented by additional training in software testing.

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The risk identification modeling revealed that under Strategy 1, software testing posed a significant risk. According to the SEI risk taxonomy (Carr, 1993) [8], this included risks related to Testability and the Testing and Environment attributes within the SEI Product Engineering class, the Formality and Product Control attributes within the Development Process class, and the Staff risk attribute within the Program Constraints class. Identifying risks associated with Strategy 2 highlighted coordination, monitoring, and communication challenges arising from distributed locations and multiple teams. These risk events were linked to the Process Control, Monitoring, and Communication risk attributes of the Development Environment class and the Type of Contract attribute within the Program Constraints class. Because Strategy 3 involved additional training, it was identified as potentially affecting the software project's development activities and leading to issues with software maintenance and reliability. These risks were associated with the Maintainability and Reliability attributes of the Product Engineering class, as well as the Human Factor and Specification attributes also within the SEI Product Engineering class.

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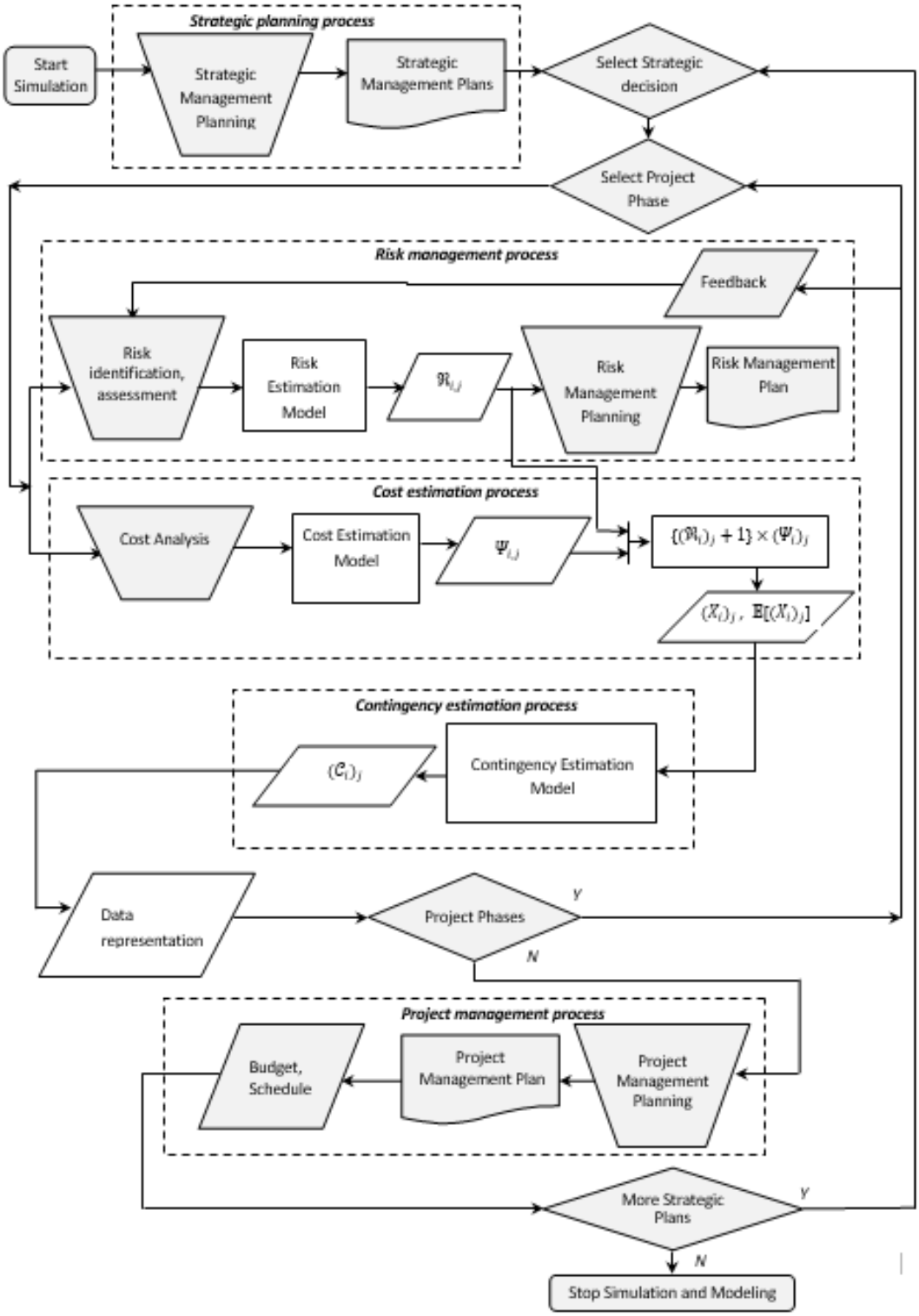

Figure 1: Simulation Model for Strategic Management Process of Software Projects

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For the design phase of the project under Strategy 1, the risk assessment modeling assigns an impact value between 0 and 1 to each identified risk, as detailed in Table A.1 (Appendix A). It's noted that some SEI attributes contribute to the overall project risk regardless of the chosen strategy, while other SEI attributes were not identified as risks and therefore were not assigned impact values. During the cost analysis modeling for the design phase under Strategy 1, the values for the COCOMO-II (Boehm, et al. 2000, 2010) [6] [7] parameters were selected, as shown in Table A.2 (Appendix A).

The contingency is estimated at 75% probability. The computerized simulation generates $(\Re_{i=1})_{j=1}$, which is the overall histogram of the random risk impact for Strategy 1 and phase 1. Figure 2 illustrates the risk impact histograms for the design phase for all the SEI classes (Product Engineering, Development Process, Program Constraints) under Strategy 1, along with the overall risk impact $(\Re_{i=1})_{j=1}$. The simulation inputs the COCOMO-II inputs and produces the cost for the design phase under strategy 1, i.e., $(\Psi_{i=1})_{j=1}$ and integrates it with $(\Re_{i=1})_{j=1}$, which produces the cost integrated with the risk $(X_{i=1})_{j=1}$. The simulation continues to simulate the risk measure and contingency estimation models and produces $\rho(X_{i=1})_{j=1}$ and $(\mathcal{C}_{i=1})_{j=1}$ for the first phase of the project under Strategy 1.

The simulation and modeling process continues through the development, test, and integrate phases of the software project. At the beginning of each phase, the risk identification and assessment models allow for adjustments to the perceived risks based on feedback from the preceding phase. Similarly, the cost estimation parameters are re-evaluated for each subsequent project phase based on the received feedback. Figure 3 shows the histograms of the cost $(X_{i=1,2,3,4})_{j=1}$, and $\mathbb{E}\left[(X_{i=1,2,3,4})_{j=1}\right]$, $\rho(X_{i=1,2,3,4})_{j=1}$ and $\mathcal{C}(X_{i=1,2,3,4})_{j=1}$ for all the phases under first strategy along with the histogram of the overall cost with the expectation $\mathbb{E}[(X_{i=1})_{j=1}] + \mathbb{E}[(X_{i=2})_{j=1}] + \mathbb{E}[(X_{i=3})_{j=1}] + \mathbb{E}[(X_{i=4})_{j=1}]$.

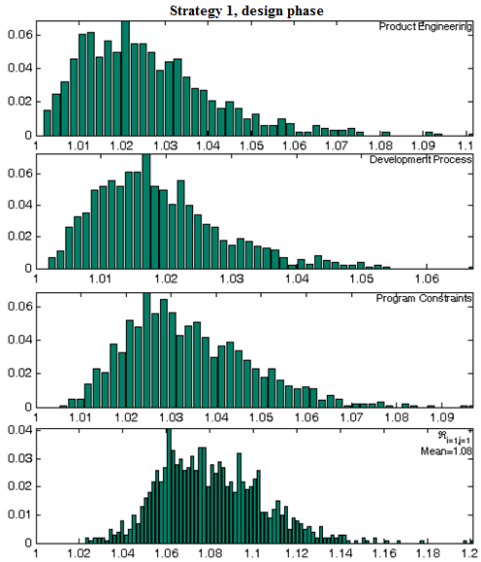

Figure 2: Risk Impact histogram for design phase under Strategy 1

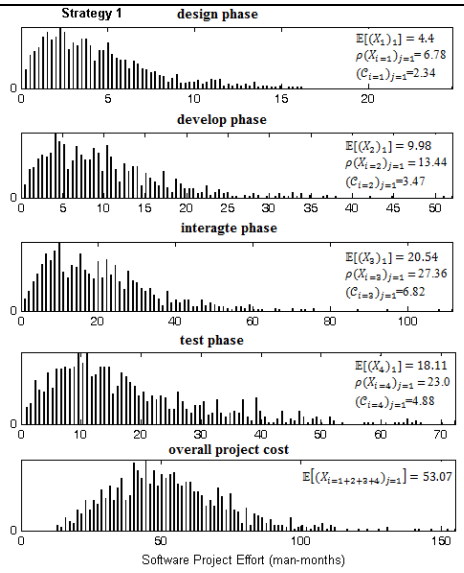

Figure 3: Histogram of Estimated Software Project Costs

Simulation Results

The expected cost of the software project using strategy 1 for each phase is $\mathbb{E}[(X_{i=1})_{j=1}] = 4.4$, $\mathbb{E}[(X_{i=2})_{j=1}] = 9.98$, $\mathbb{E}[(X_{i=3})_{j=1}] = 20.54$ and $\mathbb{E}[(X_{i=4})j =_1] = 18.11$ man-months, Figure 3. The overall expected cost is the sum of the expected costs of all the phases of the software project using a strategy; therefore, for strategy 1 the overall expected cost is $\mathbb{E}[(X_{i=1})_{j=1}] + \mathbb{E}[(X_{i=2})_{j=1}] + \mathbb{E}[(X_{i=3})_{j=1}] + \mathbb{E}[(X_{i=4})_{j=1}] = 53.07$man-months. The measured risk under

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strategy 1 for the design phase is $\rho(X_{i=1})_{j=1}$= 6.78 man-months, while for develop, test and integrate phases the measured risks are $\rho(X_{i=2})_{j=1}$ = 13.44, $\rho(X_{i=3})_{j=1}$ = 27.36 and $\rho(X_{i=4})_{j=1}$ = 23.0 man-months, respectively. Furthemore, the contingency is estimated to be $(\mathcal{C}_{i=1})_{j=1}$=2.34, $(\mathcal{C}_{i=2})_{j=1}$=3.47, $(\mathcal{C}_{i=3})_{j=1}$=6.82 and $(\mathcal{C}_{i=4})_{j=1}$=4.88 man-months for the design, develop, test and integrate phases, respectively, Figure 3.
Following the same, the simulation of strategies 2 and 3 shows expected costs, software risk measures and contingency estimates, where Figure 4 outlines a view of the expected costs $\mathbb{E}[(X_i)_j]$, risk measures $\rho(X_i)_j$, and contingency resources $(\mathcal{C}_i)_j$ for all the phases of the development under each strategy.
Tables 1, 2 and 3 presents the Figure 4 in tabulated form; these expected costs $\mathbb{E}[(X_i)_j]$, risk measures $\rho(X_i)_j$ and contingency requirements $(\mathcal{C}_i)_j$ shows the changes in these parameters during each phase under different strategic options. For example, using strategy 1, the expected cost needed for test phase is $\mathbb{E}[(X_{i=3})_{j=1}]$ =20.54 man-months, while for strategy 2 and 3, the expected cost for the same phase is $\mathbb{E}[(X_{i=3})_{j=2}]$ =3.62 and $\mathbb{E}[(X_{i=3})_{j=3}]$ =22.11 man-months. The contingency for the test phase using strategy 1 is $(\mathcal{C}_{i=3})_{j=1}$=6.82 man-months, while the strategies 2 and 3 requires $(\mathcal{C}_{i=3})_{j=2}$=1.64 and $(\mathcal{C}_{i=3})_{j=3}$=5.00 man-months, respectively.
The design phase under strategy 1 requires the lowest expected cost of $\mathbb{E}[(X_{i=1})_{j=1}] = 4.44$ man-months and the highest expected cost is for the test phase using the strategy 3, $\mathbb{E}[(X_{i=3})_{j=3}] = 22.11$ man-months. Strategy 2 shows the lowest expected cost of $\mathbb{E}[(X)_3]$ =34.99 man-months, i.e., ($\mathbb{E}[(X_{i=1})_{j=3}]$ + $\mathbb{E}[(X_{i=2})_{j=3}]$ + $\mathbb{E}[(X_{i=3})_{j=3}]$ + $\mathbb{E}[(X_{i=4})_{j=3}]$ = 34.99); however, it needs the highest expected cost for the design phase.
Strategy 1 has the highest overall expected cost of 53.07 man-months, but requires the lowest cost during the design phase, i.e., 4.44 man-months.
Strategy 1 has the highest risk of $\rho(X_{i=1+2+3+4})_{j=1}$ = $\rho(X_{i=1})_{j=1}$+$\rho(X_{i=2})_{j=1}$+ $\rho(X_{i=3})_{j=1}$ + $\rho(X_{i=4})_{j=1}$ =70.58 man-months, while strategy 2 has the least risk of $\rho(X_{i=1+2+3+4})_{j=2}$= 47.09 man-months. Strategy 1 and 3 has almost equal risk during the test phase, whereas, strategy 2 has the least risk during the test phase. Similarly, strategy 2 has lowest contingency resources requirement of $(\mathcal{C}_{i=1+2+3+4})_{j=2}$ = 12.08 man-months. Strategy 1 has highest contingency resources of $(\mathcal{C}_{i=1+2+3+4})_{j=1}$ = 17.51 man-months, but needs the least contingency during the design phase.
The previously quantified expected cost and contingency figures are then utilized to model the project management process, which ultimately generates the project's budget and schedule. For this modeling, Microsoft Project 2007© is employed. The hypothetical software development team comprises a software manager and ten software engineers, with seven dedicated to development and three to testing. Additionally, two software engineers are reserved as contingency resources. The software manager is assumed to be involved throughout all project phases, the development engineers in the design, development, and integration phases, and the test engineers in the testing and integration phases. The reserved software engineers are allocated to manage project risks. Furthermore, it is assumed that each software development resource (software manager, development engineers, test engineers, reserved engineers) has an average monthly cost of $10,000. However, under strategy 2, the cost of the software test engineers is 1.5 times the average rate (reflecting their consultant status), and under strategy 3, their cost is 1.2 times the average rate due to the additional testing training. Visual representations of the project human resources in Microsoft Project 2007© for strategies 1, 2, and 3 are provided in Figures A.1, A.2, and A.3 (Appendix A), respectively.

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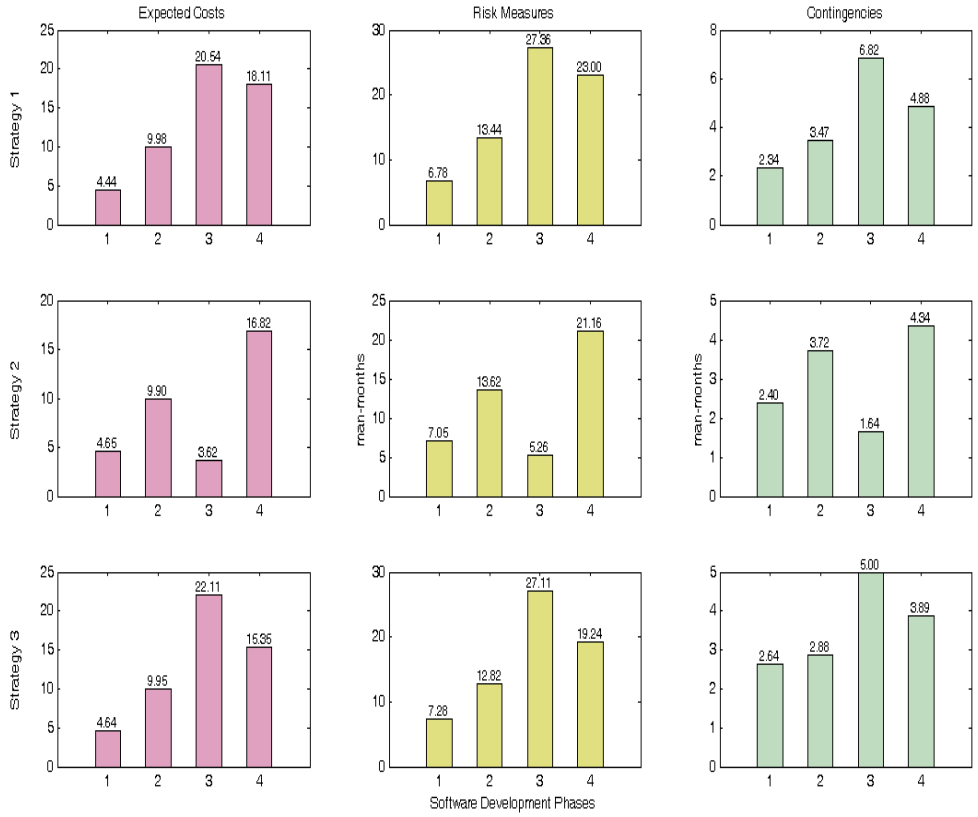

Figure 4: Illustration of cost, risk measure and contingency for different Strategies

	Expected Cost $\mathbb{E}[X_i]_j$				
	Design $i=1$	Develop $i=2$	Test $i=3$	Integrate $i=4$	Overall
Strategy $j=1$	4.44	9.98	20.54	18.11	53.07
Strategy $j=2$	4.65	9.90	3.62	16.82	34.99
Strategy $j=3$	4.64	9.95	22.11	15.35	52.05

Table 1: Expected Costs $\mathbb{E}[(X_i)_j]$ for Different Strategic Management Plans

	$\rho(X_i)_j$				
	Design $i=1$	Develop $i=2$	Test $i=3$	Integrate $i=4$	Overall
Strategy $j=1$	6.78	13.44	27.36	23.00	70.58
Strategy $j=2$	7.05	13.62	5.26	21.16	47.09
Strategy $j=3$	7.28	12.82	27.11	19.24	66.45

Table 2: Risk Measures $\rho(X_i)_j$ for different Strategic Management Plans at 75%

	$(\mathcal{C}_i)_j = \rho(X_i)_j - \mathbb{E}[(X_i)_j]$				
	Design $i=1$	Develop $i=2$	Test $i=3$	Integrate $i=4$	Overall
Strategy $j=1$	2.34	3.47	6.82	4.88	17.51
Strategy $j=2$	2.40	3.72	1.64	4.34	12.1
Strategy $j=3$	2.64	2.88	5.00	3.89	14.41

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Table 3: Contingency Estimates $(C_i)_J$ for Different Strategies at 75%

For modeling project planning, the relationship between consecutive phases is defined as 'finish to start' (PMI, 2004) [29], meaning a successor task begins only after its predecessor is completed. Moreover, at the end of each iteration cycle, the final phase (testing) of the current iteration is linked to the initial phase (design) of the subsequent iteration using a 'start-to-finish' dependency (PMI, 2004) [29], indicating that the predecessor task only concludes once the successor task has commenced.

Furthermore, contingency measures for each project phase are modeled as distinct tasks labeled "contingency tasks." These contingency tasks are designed to be initiated at any point during the execution of their corresponding project phase, establishing a 'start-to-start' relationship. However, the effort associated with these contingency tasks may extend beyond the completion of the phase's primary work. Software contingency engineers are assigned to these tasks. The model assumes that each phase requires three iterations to complete, with each iteration having its own separate contingency plan. This project management process scenario remains consistent across all considered strategic options: Strategy 1, Strategy 2, and Strategy 3.

The modeling of project management planning using Microsoft Project 2007© reveals the individual phase budgets and schedules for the software project under each strategic decision, as well as the overall project budgets and schedules. Snapshots of the Microsoft Project 2007© plans are shown in Figures A.4, A.6, and A.8 (Appendix A), while Figures A.5, A.7, and A.9 display the Microsoft Project 2007© snapshots of the schedules for strategic decisions 1, 2, and 3, respectively.

The project management planning modeling indicates that under Strategy 1, the total schedule for the software project is 8.56 calendar months (Figure A.4). The design phase has a schedule span of 5.89 months, indicating that completing three iterations, each taking 0.19 calendar months, requires this duration (Figure A.5). Similarly, the develop, test, and integrate phases have schedules of 6.12, 7.41, and 6.25 calendar months, with each iteration taking 0.42, 1.71, and 0.55 calendar months, respectively. The budgets for the design, develop, integrate, and test phases are $44,400, $99,900, $205,500, and $181,200, respectively, resulting in an overall budget of $531,000. Additionally, each iteration of the contingency task has schedules of 0.26, 0.39, 0.76, and 0.54 calendar months for the design, develop, test, and integrate phases, respectively, requiring an additional budget of $23,400, $34,800, $68,100, and $48,900. The total contingency budget for Strategy 1 is $175,200, representing the reserved cost for risk management under this strategy. Therefore, the total project budget, including contingency, is $706,200 when Strategy 1 is adopted. This project management plan can be interpreted as follows: the strategic decision for complete in-house software development and testing has a duration of 8.56 calendar months and requires an overall budget of $531,000, with a 75% confidence that the total budget will be $706,200 when the additional contingency budget of $175,200 is included.

The overall schedule for the software project under strategy 2 is 8.13 calendar months (Figure A.6). The design phase takes 5.89 calendar months, with each of its three iterations lasting 0.19 calendar months. Similarly, the develop, test, and integrate phases have schedules of 6.11, 6.0, and 4.78 calendar months, respectively, with per-iteration durations of 0.41, 0.3, and 0.51 calendar months. The budgets for the design, develop, integrate, and test phases are $46,500, $99,000, $49,912, and $191,250, resulting in a total budget of $386,662. Additionally, contingency tasks for each iteration have schedules of 0.27, 0.41, 0.18, and 0.48 months for the design, develop, test, and integrate phases, respectively, requiring additional budgets of $24,000, $37,200, $16,500, and $43,500. The total contingency budget for strategy 2 is $121,200, leading to an overall budget of $507,862 when contingency is included. This project management plan suggests that the strategy of in-house software development with outsourced testing has a development duration of 8.13 months and a base budget of $386,662, with a 75% confidence that an additional contingency budget of $121,200 will be needed.

The overall schedule for the software project under strategy 3 is 8.62 months (Figure A.8). The design phase takes 5.89 calendar months to complete its three iterations, each lasting 0.19 calendar months. Likewise, the develop, test, and integrate phases have durations of 6.12, 7.54, and 6.17 calendar months, with per-iteration durations of 0.42, 1.89, and 0.47 calendar months, respectively. The budget requirements for design, develop, integrate, and test are $46,500, $99,600, $254,265, and $161,978, resulting in a total budget of $562,343. Additionally, the contingency tasks require additional budgets of $26,400, $28,800, $50,100, and $39,000, with per-iteration schedules of 0.29, 0.32, 0.56, and 0.43 calendar months for the design, develop, test, and integrate phases, respectively. The total contingency budget for strategy 3 is approximately $144,300, leading to an overall cost of $706,643 with contingency. This project management plan indicates that the strategy of complete in-house software development and testing with additional testing training has a schedule of 8.62 months and a

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base budget of $562,343, with a 75% confidence that the total budget will be $706,543 including a contingency budget of $144,300.

The calendar schedule for all strategies, including specific start and end dates for each iteration of the development phases, is presented in Table A.3 (Appendix A). For strategy 1, the first iteration of the design phase (Design 1) starts on February 1st and ends on February 6th, at which point the first iteration of the develop phase (Develop 1) begins and concludes on February 17th. The first test phase (Test 1) runs from February 17th to April 5th, followed by the first integrate phase (Integrate 1) from April 5th to April 20th. Thus, the first iteration of all phases spans from February 1st to April 20th. The contingency task for the first design iteration (Design Contingency 1), if needed, can start on February 1st and finish on February 8th, while the contingency for the first develop iteration (Develop Contingency 1) starts on February 6th and ends on February 16th. Test Contingency 1 runs from February 17th to March 9th, and Integrate Contingency 1 starts and ends on April 5th and April 20th, respectively. The second iteration (Design 2) begins on April 20th and continues through its predecessor phases, concluding on July 10th when the third iteration starts, finishing on September 27th. Therefore, using strategy 1, the project starts on February 1st and ends on September 27th, resulting in a schedule of 8.56 months. Similarly, the simulation of project management planning provides the specific dates and durations for the project schedules under strategies 2 and 3.

An examination of the project budget and schedule reveals that across all strategies, the budget remains relatively consistent for most development phases, with the notable exception of the test phase. Strategy 2 demonstrates a lower budget and a shorter schedule for testing compared to strategies 1 and 3. Furthermore, the contingency budget and schedule for the design, develop, and integrate phases are largely similar across the strategies, again with the test phase exhibiting a lower budget and shorter duration under strategy 2 compared to strategies 1 and 3. This difference can be attributed to the varying testing approaches. Strategy 2 yields the lowest overall budget and the shortest overall schedule, suggesting that outsourcing the testing phase to experienced contractors minimizes both budget and schedule, despite the contractors' higher cost (50% more expensive, as shown in Figure A.2). This implies that the contractors' expertise leads to greater efficiency and effectiveness.

Software managers utilize probabilistic confidence levels to estimate cost (Touran, 2003) [33] and contingency (Fairley, 1995) [12]. Consequently, the simulation and modeling process assesses different cost confidence levels. Increasing the confidence level signifies a larger contingency reserve, enabling the software project to better withstand risks with more severe consequences. Therefore, raising the confidence level from 75% to 85% results in a different set of contingency estimates (Table 4). This change in the confidence parameter for contingency leads to different project management plans for the various strategic options. Snapshots of the project management planning at an 85% confidence level are presented in Figures A.10 through A.15 (Appendix A), and the project schedule for all strategies at this confidence level is tabulated in Table A.4 (Appendix A).

The modeling of project management planning shows that with strategy 1, increasing the confidence level to 85% raises the total budget from $706,200 to $858,300 and extends the schedule duration from 8.62 to 9.08 calendar months. Similarly, for strategies 2 and 3, the cost increases to $635,362 from $507,862 and to $845,843 from $706,643, respectively, while the project duration increases to 8.9 from 8.13 and to 9.23 from 8.62 calendar months, respectively.

Moreover, raising the confidence level even further to 95% yields the contingency estimations presented in Tables 5. The corresponding project management plans at this 95% confidence level are illustrated in Figures A.16 through A.21 (Appendix A). The project schedules for all strategies at this 95% confidence level are summarized in Table A.5 (Appendix A). The project management planning reveals that with strategy 1, increasing the confidence to 95% extends the project duration to 10.31 months and increases the total cost to $1,107,600. Similarly, for strategy 2, the project duration increases to 9.57 months, and the cost rises to $769,462. For strategy 3, elevating the confidence level to 95% extends the project duration to 9.83 calendar months and increases the cost to $1,099,643.

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	$(\mathcal{C}_i)_j = \rho(X_i)_j - \mathbb{E}[(X_i)_j]$				
	Design $i = 1$	Develop $i = 2$	Test $i = 3$	Integrate $i = 4$	Overall
Strategy $j = 1$	3.54	6.49	13.14	9.58	32.75
Strategy $j = 2$	3.6	7.18	2.89	11.22	24.89
Strategy $j = 3$	3.97	5.63	9.06	9.68	28.34

Table 4: Contingency Estimates for Different Strategies at 85% confidence

	$(\mathcal{C}_i)_j = \rho(X_i)_j - \mathbb{E}[(X_i)_j]$				
	Design $i = 1$	Develop $i = 2$	Test $i = 3$	Integrate $i = 4$	Overall
Strategy $j = 1$	5.62	11.38	21.65	19.02	57.67
Strategy $j = 2$	5.74	10.94	4.31	17.28	38.27
Strategy $j = 3$	6.31	11.21	21.06	15.14	53.72

Table 5: Contingency Estimates for Different Strategies at 95%

Consequently, enhancing the project's confidence level leads to a larger overall budget and a longer overall schedule, as the project incorporates more contingency to handle more significant risks. Notably, raising the confidence from 75% to 85% increases the software project's overall budget by roughly 5% across all development strategies. However, increasing the confidence further from 85% to 95% results in a budget increase of approximately 14.5% for strategies 1 and 3, while strategy 2 experiences a budget increase of about 10%.

Comparing different strategic decisions enables project managers to select a strategy that aligns with their specific needs regarding cost, risk, contingency, budget, and schedule. For instance, among the three strategies examined, outsourcing the testing phase of the software project appears advantageous in terms of both budget and schedule, potentially leading the organization to pursue this strategy for project development. It's important to recognize, however, that the strategy with the lowest cost, risk, budget, or schedule isn't always optimal. For example, an organization might choose to accept more risk and invest additional resources to maintain market competitiveness. Therefore, organizations and project managers carefully select strategic decisions to ensure the project's business value is realized. Furthermore, external factors beyond the project's immediate scope, such as the project environment, management style, market competition, and technological advancements, can also influence the choice of a strategic decision.

Conclusions

Effectively managing a software project involves overseeing various critical aspects, including cost, risk, contingency, budget, schedule, quality, and specifications. A robust strategic management process should encompass all these key project parameters. To this end, a simulation model for the strategic management of software projects has been proposed, which models how strategic decisions impact a project's cost, risk, contingency, budget, and schedule. Each strategic choice presents a unique risk profile, leading to corresponding changes in cost and contingency, and ultimately resulting in a distinct budget and schedule. The proposed strategic management process model is an integrated simulation and modeling framework that simulates strategic parameters like cost, risk, and contingency, and then uses modeling to link them with project management planning to generate the project's budget and schedule. This framework assists software development organizations and project managers in selecting strategic decisions for software project development by understanding the trade-offs between cost, risk, and contingency and their effects on the budget and schedule.

The proposed simulation model is designed to be generic, featuring interchangeable components with plug-and-play interfaces. This allows for the seamless integration of various assessment and estimation models, and the adoption of any project management planning tool for simulation and modeling. The model provides a basis for simulating and modeling strategic decisions, which can be further developed to include other relevant parameters for a more comprehensive understanding of software projects. Future research could expand upon this work by deploying different sets of assessment and estimation models and management modeling tools to identify optimal combinations for strategic software project management. Additionally, a decision-support

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mechanism, such as a rule-based expert system for analyzing strategic decisions, could be integrated into the strategic management process.

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Appendix A

	Strategy 1				Strategy 2				Strategy 3			
	Phases											
	Design	Develop	Integrate	Test	Design	Develop	Integrate	Test	Design	Develop	Integrate	Test
Product Engineering												
Requirements												
Stability	2	2	2	2	2	2	2	2	2	2	2	2
Completeness	1	1	1	1	1	1	1	1	1	1	1	1
Clarity	4	4	4	4	4	4	4	4	4	4	4	4
Validity	2	2	2	2	2	2	2	2	2	2	2	2
Feasibility	3	3	3	3	3	3	3	3	3	3	3	3
Precedent	1	1	1	1	1	1	1	1	1	1	1	1
Scale	2	2	2	2	2	2	2	2	2	2	2	2
Design												
Functionality	3	3	8	6	3	3	8	6	3	3	8	6
Difficulty	2	2	2	2	2	2	2	2	2	2	2	2
Interfaces	1	1	1	1	1	1	1	1	1	1	1	1
Performance	1	1	1	1	1	1	1	1	1	1	1	1
Testability	5	5	10	9								
Hardware Constraints	3	3	3	3	3	3	3	3	3	3	3	3
Non-Development Software	1	1	1	1	1	1	1	1	1	1	1	1
Code/Unit Test												
Feasibility	2	2	2	2	2	2	2	2	2	2	2	2
Testing	7	7	10	8								
Coding/Implementation	5	5	5	5	5	5	5	5	5	5	5	5
Integration/Test												
Environment	5	7	10	10								
Product	2	2	2	2	2	2	2	2	2	2	2	2
System	5	5	5	5	5	5	5	5	5	5	5	5
Engineering Specialties												
Maintainability									5	5	10	8
Reliability									3	3	8	6
Safety	1	1	1	1	1	1	1	1	1	1	1	1
Security	1	1	1	1	1	1	1	1	1	1	1	1
Human Factors									8	8	10	10
Specifications									3	3	7	5
Development Environment												
Development Process												
Formality	1	1	10	8								
Suitability	4	4	4	4	4	4	4	4	4	4	4	4
Process Control					5	5	10	8				
Familiarity	5	5	8	8	5	5	8	8	5	5	8	8
Product Control	2	2	10	8								
Development System												

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Capacity	2	2	5	5	2	2	5	5	2	2	5	5
Suitability	2	2	2	2	2	2	2	2	2	2	2	2
Usability												
Familiarity	3	3	3	3	3	3	3	3	3	3	3	3
Reliability	1	1	1	1	1	1	1	1	1	1	1	1
System Support	2	2	5	5	2	2	5	5	2	2	5	5
Deliverability	1	1	4	4	1	1	4	4	1	1	4	4
Management Process												
Planning	1	1	7	7	1	1	7	7	1	1	7	7
Project Organization	1	1	1	1	1	1	1	1	1	1	1	1
Management Exp.	2	2	5	5	2	2	5	5	2	2	5	5
Program Interfaces												
Management Methods												
Monitoring					3	3	10	8				
Personnel Management	2	2	3	3	2	2	3	3	2	2	3	3
Quality Assurance	1	1	2	2	1	1	2	2	1	1	2	2
Configuration Management	1	1	1	1	1	1	1	1	1	1	1	1
Work Environment												
Quality Attitude	1	1	1	1	1	1	1	1	1	1	1	1
Cooperation	2	2	2	2	2	2	2	2	2	2	2	2
Communication					4	4	10	8				
Morale												
Program Constraints												
Resources												
Schedule	5	5	5	5	5	5	5	5	5	5	5	5
Staff [(1)]	2	2	10	8								
Budget												
Facilities	2	2	5	5	2	2	5	5	2	2	5	5
Contract												
Type of Contract					3	3	8	6				
Restrictions												
Dependencies	5	5	5	5	5	5	5	5	5	5	5	5
Program Interfaces												
Customer												
Associate Contractors												
Subcontractors												
Prime Contractor												
Corporate Management	3	3	3	3	3	3	3	3	3	3	3	3
Vendors												
Politics												

Table A.1: Risk impacts (shown as percentages) for strategies 1, 2 and 3

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	COCOMO-II Data											
	Strategy 1				Strategy 2				Strategy 3			
	Phase											
	Design	Develop	Integrate	Test	Design	Develop	Integrate	Test	Design	Develop	Integrate	Test
a_c	2.94	2.94	2.94	2.94	2.94	2.94	2.94	2.94	2.94	2.94	2.94	2.94
b_c	0.92	0.92	0.94	0.94	0.92	0.92	0.94	0.94	0.92	0.92	0.94	0.92
EAF	0.32	0.32	0.87	0.78	0.32	0.32	0.15	0.74	0.32	0.32	0.95	0.69
Size	5	12	8	8	5	12	8	8	5	12	8	8
W_i												
PREC	0.81	0.81	1.62	1.62	0.81	0.81	1.62	1.62	0.81	0.81	1.62	1.62
FLEX	1.21	1.21	2.43	2.43	1.21	1.21	1.21	1.21	1.21	1.21	2.43	1.21
RESL	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84
TEAM	0.99	0.99	0.99	0.99	0.99	0.99	1.98	1.98	0.99	0.99	0.99	0.99
PMAT	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
Cost Drivers												
RELY	1	1	1	1	1	1	1	1	1	1	1	1
DATA	1	1	1	1	1	1	1	1	1	1	1	1
CPLX	1	1	1	1	1	1	1	1	1	1	1	1
RUSE	1	1	1	1	1	1	1	1	1	1	1	1
DOCU	1	1	1	1	1	1	1	1	1	1	1	1
TIME	1	1	1	1	1	1	1	1	1	1	1	1
STOR	1	1	1	1	1	1	1	1	1	1	1	1
PVOL	1	1	1	1	1	1	1	1	1	1	1	1
ACAP	0.83	0.83	1	1	0.83	0.83	0.67	1	0.83	0.83	1.22	1
PCAP	0.87	0.87	1	1	0.87	0.87	0.74	1	0.87	0.87	1	1
PCON	0.92	0.92	1	1	0.92	0.92	0.84	1	0.92	0.92	1	1
AEXP	0.89	0.89	1	1	0.89	0.89	0.81	1	0.89	0.89	1	1
PEXP	0.88	0.88	1.12	1	0.88	0.88	0.81	0.88	0.88	0.88	1	0.88
LTEX	0.91	0.91	1	1	0.91	0.91	0.84	1	0.91	0.91	1	1
TOOL	0.86	0.86	1	1	0.86	0.86	0.72	1	0.86	0.86	1	1
SITE	0.78	0.78	0.78	0.78	0.78	0.78	0.92	0.84	0.78	0.78	0.78	0.78
SCED	1	1	1	1	1	1	1	1	1	1	1	1

Table A.2: COCOMO-II parameters data

Resource Name	Type	Max. Units	Std. Rate
Software Manager	Work	100%	$10,000.00/mon
Software Engineer 1	Work	100%	$10,000.00/mon
Software Engineer 2	Work	100%	$10,000.00/mon
Software Engineer 3	Work	100%	$10,000.00/mon
Software Engineer 4	Work	100%	$10,000.00/mon
Software Engineer 5	Work	100%	$10,000.00/mon
Software Engineer 6	Work	100%	$10,000.00/mon
Software Engineer 7	Work	100%	$10,000.00/mon
Software Test Engineer 1	Work	100%	$10,000.00/mon
Software Test Engineer 2	Work	100%	$10,000.00/mon
Software Test Engineer 3	Work	100%	$10,000.00/mon
Software Engineer (Contingency 1)	Work	100%	$10,000.00/mon
Software Engineer (Contingency 2)	Work	100%	$10,000.00/mon

Figure A.1: Project Resources and related Costs for Strategy 1

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Resource Name	Type	Max. Units	Std. Rate
Software Manager	Work	100%	$10,000.00/mon
Software Engineer 1	Work	100%	$10,000.00/mon
Software Engineer 2	Work	100%	$10,000.00/mon
Software Engineer 3	Work	100%	$10,000.00/mon
Software Engineer 4	Work	100%	$10,000.00/mon
Software Engineer 5	Work	100%	$10,000.00/mon
Software Engineer 6	Work	100%	$10,000.00/mon
Software Engineer 7	Work	100%	$10,000.00/mon
Software Test Engineer 1	Work	100%	$15,000.00/mon
Software Test Engineer 2	Work	100%	$15,000.00/mon
Software Test Engineer 3	Work	100%	$15,000.00/mon
Software Engineer (Contingency 1)	Work	100%	$10,000.00/mon
Software Engineer (Contingency 2)	Work	100%	$10,000.00/mon

Figure A.2: Project Resources and related Costs for Strategy 2

Resource Name	Type	Max. Units	Std. Rate
Software Manager	Work	100%	$10,000.00/mon
Software Engineer 1	Work	100%	$10,000.00/mon
Software Engineer 2	Work	100%	$10,000.00/mon
Software Engineer 3	Work	100%	$10,000.00/mon
Software Engineer 4	Work	100%	$10,000.00/mon
Software Engineer 5	Work	100%	$10,000.00/mon
Software Engineer 6	Work	100%	$10,000.00/mon
Software Engineer 7	Work	100%	$10,000.00/mon
Software Test Engineer 1	Work	100%	$12,000.00/mon
Software Test Engineer 2	Work	100%	$12,000.00/mon
Software Test Engineer 3	Work	100%	$12,000.00/mon
Software Engineer (Contingency 1)	Work	100%	$10,000.00/mon
Software Engineer (Contingency 2)	Work	100%	$10,000.00/mon

Figure A.3: Project Resources and related Costs for Strategy 3

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Task Name	Duration	Start	Finish	Cost	Work
Project Plan Strategy 1	**8.56 mons**	**Wed 2/1/12**	**Thu 9/27/12**	**$706,200.63**	**70.62 mons**
1 Project Development Phases	**8.56 mons**	**Wed 2/1/12**	**Thu 9/27/12**	**$531,000.63**	**53.1 mons**
1.1 Design	**5.89 mons**	**Wed 2/1/12**	**Fri 7/13/12**	**$44,400.00**	**4.44 mons**
1.1.1 Design 1	0.19 mons	Wed 2/1/12	Mon 2/6/12	$14,800.00	1.48 mons
1.1.2 Design 2	0.19 mons	Fri 4/20/12	Wed 4/25/12	$14,800.00	1.48 mons
1.1.3 Design 3	0.19 mons	Tue 7/10/12	Fri 7/13/12	$14,800.00	1.48 mons
1.2 Develop	**6.12 mons**	**Mon 2/6/12**	**Thu 7/26/12**	**$99,900.00**	**9.99 mons**
1.2.1 Develop 1	0.42 mons	Mon 2/6/12	Fri 2/17/12	$33,300.00	3.33 mons
1.2.2 Develoe 2	0.42 mons	Wed 4/25/12	Tue 5/8/12	$33,300.00	3.33 mons
1.2.3 Develop 3	0.42 mons	Fri 7/13/12	Thu 7/26/12	$33,300.00	3.33 mons
1.3 Test	**7.41 mons**	**Fri 2/17/12**	**Wed 9/12/12**	**$205,500.00**	**20.55 mons**
1.3.1 Test 1	1.71 mons	Fri 2/17/12	Thu 4/5/12	$68,500.00	6.85 mons
1.3.2 Test 2	1.71 mons	Tue 5/8/12	Mon 6/25/12	$68,500.00	6.85 mons
1.3.3 Test 3	1.71 mons	Thu 7/26/12	Wed 9/12/12	$68,500.00	6.85 mons
1.4 Integrate	**6.25 mons**	**Thu 4/5/12**	**Thu 9/27/12**	**$181,200.63**	**18.12 mons**
1.4.1 Integrate 1	0.55 mons	Thu 4/5/12	Fri 4/20/12	$60,400.31	6.04 mons
1.4.2 Integrate 2	0.55 mons	Mon 6/25/12	Tue 7/10/12	$60,400.31	6.04 mons
1.4.3 Integrate 3	0.55 mons	Wed 9/12/12	Thu 9/27/12	$60,400.00	6.04 mons
2 Project Contingency	**8.56 mons**	**Wed 2/1/12**	**Thu 9/27/12**	**$175,200.00**	**17.52 mons**
2.1 Design Contingency	**5.96 mons**	**Wed 2/1/12**	**Tue 7/17/12**	**$23,400.00**	**2.34 mons**
2.1.1 Design Contingency 1	0.26 mons	Wed 2/1/12	Wed 2/8/12	$7,800.00	0.78 mons
2.1.2 Design Contingency 2	0.26 mons	Fri 4/20/12	Fri 4/27/12	$7,800.00	0.78 mons
2.1.3 Design Contingency 3	0.26 mons	Tue 7/10/12	Tue 7/17/12	$7,800.00	0.78 mons
2.2 Develop Contingency	**6.09 mons**	**Mon 2/6/12**	**Wed 7/25/12**	**$34,800.00**	**3.48 mons**
2.2.1 Develop Contingency 1	0.39 mons	Mon 2/6/12	Thu 2/16/12	$11,600.00	1.16 mons
2.2.2 Develop Contingency 2	0.39 mons	Wed 4/25/12	Mon 5/7/12	$11,600.00	1.16 mons
2.2.3 Develop Contingency 3	0.39 mons	Fri 7/13/12	Wed 7/25/12	$11,600.00	1.16 mons
2.3 Test Contingency	**6.46 mons**	**Fri 2/17/12**	**Thu 8/16/12**	**$68,100.00**	**6.81 mons**
2.3.1 Test Contingency 1	0.76 mons	Fri 2/17/12	Fri 3/9/12	$22,700.00	2.27 mons
2.3.2 Test Contingency 2	0.76 mons	Tue 5/8/12	Tue 5/29/12	$22,700.00	2.27 mons
2.3.3 Test Contingency 3	0.76 mons	Thu 7/26/12	Thu 8/16/12	$22,700.00	2.27 mons
2.4 Test Contingency	**6.24 mons**	**Thu 4/5/12**	**Thu 9/27/12**	**$48,900.00**	**4.89 mons**
2.4.1 Integrate Contingency 1	0.54 mons	Thu 4/5/12	Fri 4/20/12	$16,300.00	1.63 mons
2.4.2 Integrate Contingency 2	0.54 mons	Mon 6/25/12	Tue 7/10/12	$16,300.00	1.63 mons
2.4.3 Integrate Contingency 3	0.54 mons	Wed 9/12/12	Thu 9/27/12	$16,300.00	1.63 mons

Figure A.4: Project Management Plan for Strategy 1 at 75% confidence

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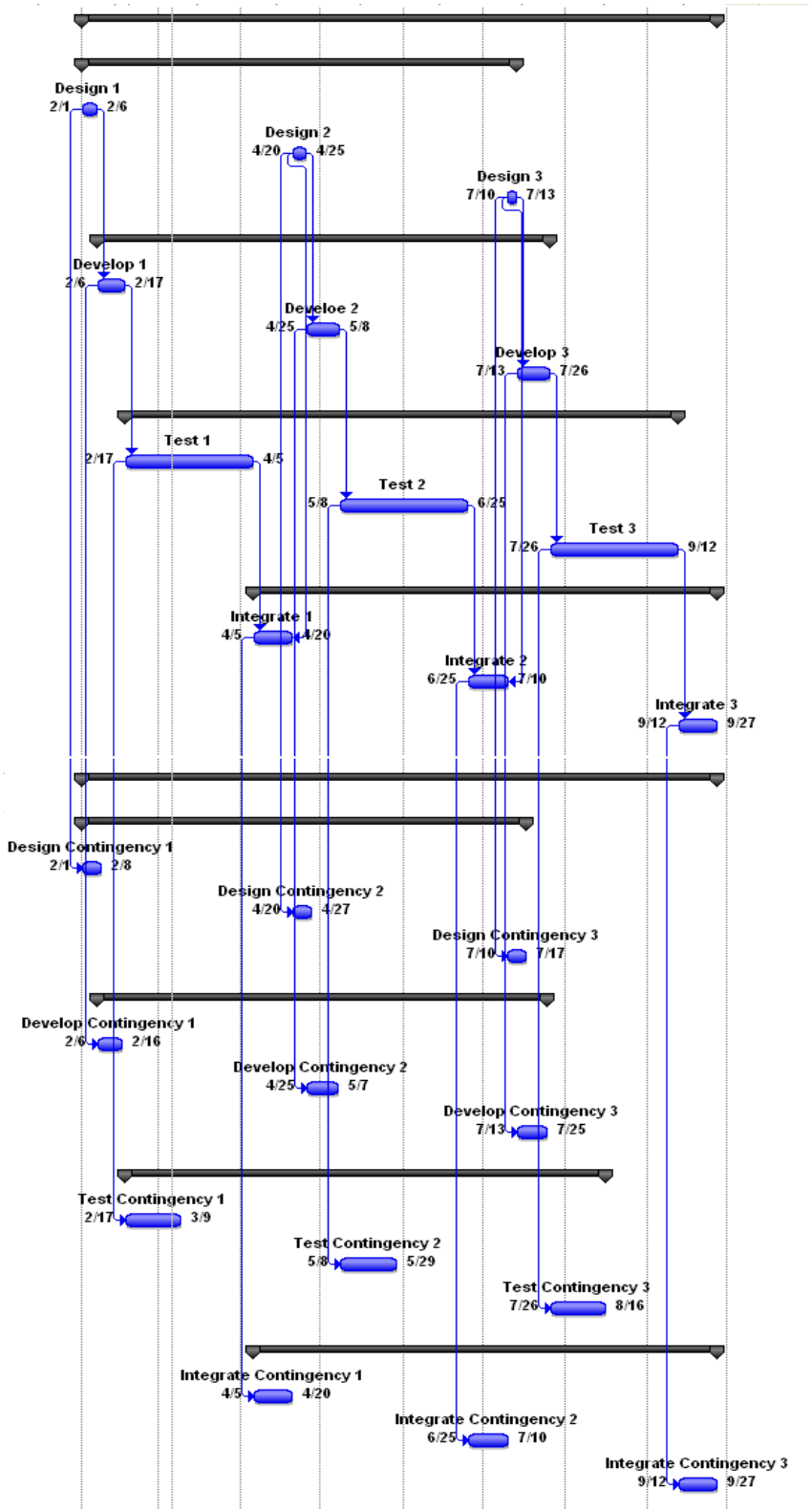

Figure A.5: Project Management Schedule for Strategy 1 at 75% confidence

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Task Name	Duration	Start	Finish	Cost	Work
Project Plan Strategy 2	**8.13 mons**	**Wed 2/1/12**	**Fri 9/14/12**	**$507,862.50**	**47.13 mons**
1 Project Development Phases	**7.12 mons**	**Wed 2/1/12**	**Fri 8/17/12**	**$386,662.50**	**35.01 mons**
1.1 Design	**5.89 mons**	**Wed 2/1/12**	**Fri 7/13/12**	**$46,500.00**	**4.65 mons**
1.1.1 Design 1	0.19 mons	Wed 2/1/12	Mon 2/6/12	$15,500.00	1.55 mons
1.1.2 Design 2	0.19 mons	Fri 4/20/12	Wed 4/25/12	$15,500.00	1.55 mons
1.1.3 Design 3	0.19 mons	Tue 7/10/12	Fri 7/13/12	$15,500.00	1.55 mons
1.2 Develop	**6.11 mons**	**Mon 2/6/12**	**Thu 7/26/12**	**$99,000.00**	**9.9 mons**
1.2.1 Develop 1	0.41 mons	Mon 2/6/12	Fri 2/17/12	$33,000.00	3.3 mons
1.2.2 Develoe 2	0.41 mons	Wed 4/25/12	Tue 5/8/12	$33,000.00	3.3 mons
1.2.3 Develop 3	0.41 mons	Fri 7/13/12	Thu 7/26/12	$33,000.00	3.3 mons
1.3 Test	**6 mons**	**Fri 2/17/12**	**Fri 8/3/12**	**$49,912.50**	**3.63 mons**
1.3.1 Test 1	0.3 mons	Fri 2/17/12	Mon 2/27/12	$16,637.50	1.21 mons
1.3.2 Test 2	0.3 mons	Tue 5/8/12	Wed 5/16/12	$16,637.50	1.21 mons
1.3.3 Test 3	0.3 mons	Thu 7/26/12	Fri 8/3/12	$16,637.50	1.21 mons
1.4 Integrate	**4.78 mons**	**Thu 4/5/12**	**Fri 8/17/12**	**$191,250.00**	**16.83 mons**
1.4.1 Integrate 1	0.51 mons	Thu 4/5/12	Fri 4/20/12	$63,750.00	5.61 mons
1.4.2 Integrate 2	0.51 mons	Mon 6/25/12	Tue 7/10/12	$63,750.00	5.61 mons
1.4.3 Integrate 3	0.51 mons	Fri 8/3/12	Fri 8/17/12	$63,750.00	5.61 mons
2 Project Contingency	**8.13 mons**	**Wed 2/1/12**	**Fri 9/14/12**	**$121,200.00**	**12.12 mons**
2.1 Design Contingency	**5.97 mons**	**Wed 2/1/12**	**Tue 7/17/12**	**$24,000.00**	**2.4 mons**
2.1.1 Design Contingency 1	0.27 mons	Wed 2/1/12	Wed 2/8/12	$8,000.00	0.8 mons
2.1.2 Design Contingency 2	0.27 mons	Fri 4/20/12	Fri 4/27/12	$8,000.00	0.8 mons
2.1.3 Design Contingency 3	0.27 mons	Tue 7/10/12	Tue 7/17/12	$8,000.00	0.8 mons
2.2 Develop Contingency	**6.11 mons**	**Mon 2/6/12**	**Thu 7/26/12**	**$37,200.00**	**3.72 mons**
2.2.1 Develop Contingency 1	0.41 mons	Mon 2/6/12	Fri 2/17/12	$12,400.00	1.24 mons
2.2.2 Develop Contingency 2	0.41 mons	Wed 4/25/12	Tue 5/8/12	$12,400.00	1.24 mons
2.2.3 Develop Contingency 3	0.41 mons	Fri 7/13/12	Thu 7/26/12	$12,400.00	1.24 mons
2.3 Test Contingency	**5.88 mons**	**Fri 2/17/12**	**Tue 7/31/12**	**$16,500.00**	**1.65 mons**
2.3.1 Test Contingency 1	0.18 mons	Fri 2/17/12	Wed 2/22/12	$5,500.00	0.55 mons
2.3.2 Test Contingency 2	0.18 mons	Tue 5/8/12	Fri 5/11/12	$5,500.00	0.55 mons
2.3.3 Test Contingency 3	0.18 mons	Thu 7/26/12	Tue 7/31/12	$5,500.00	0.55 mons
2.4 Test Contingency	**5.79 mons**	**Thu 4/5/12**	**Fri 9/14/12**	**$43,500.00**	**4.35 mons**
2.4.1 Integrate Contingency 1	0.48 mons	Thu 4/5/12	Thu 4/19/12	$14,500.00	1.45 mons
2.4.2 Integrate Contingency 2	0.48 mons	Mon 6/25/12	Mon 7/9/12	$14,500.00	1.45 mons
2.4.3 Integrate Contingency 3	0.48 mons	Mon 9/3/12	Fri 9/14/12	$14,500.00	1.45 mons

Figure A.6: Project Management Plan for Strategy 2 at 75% confidence

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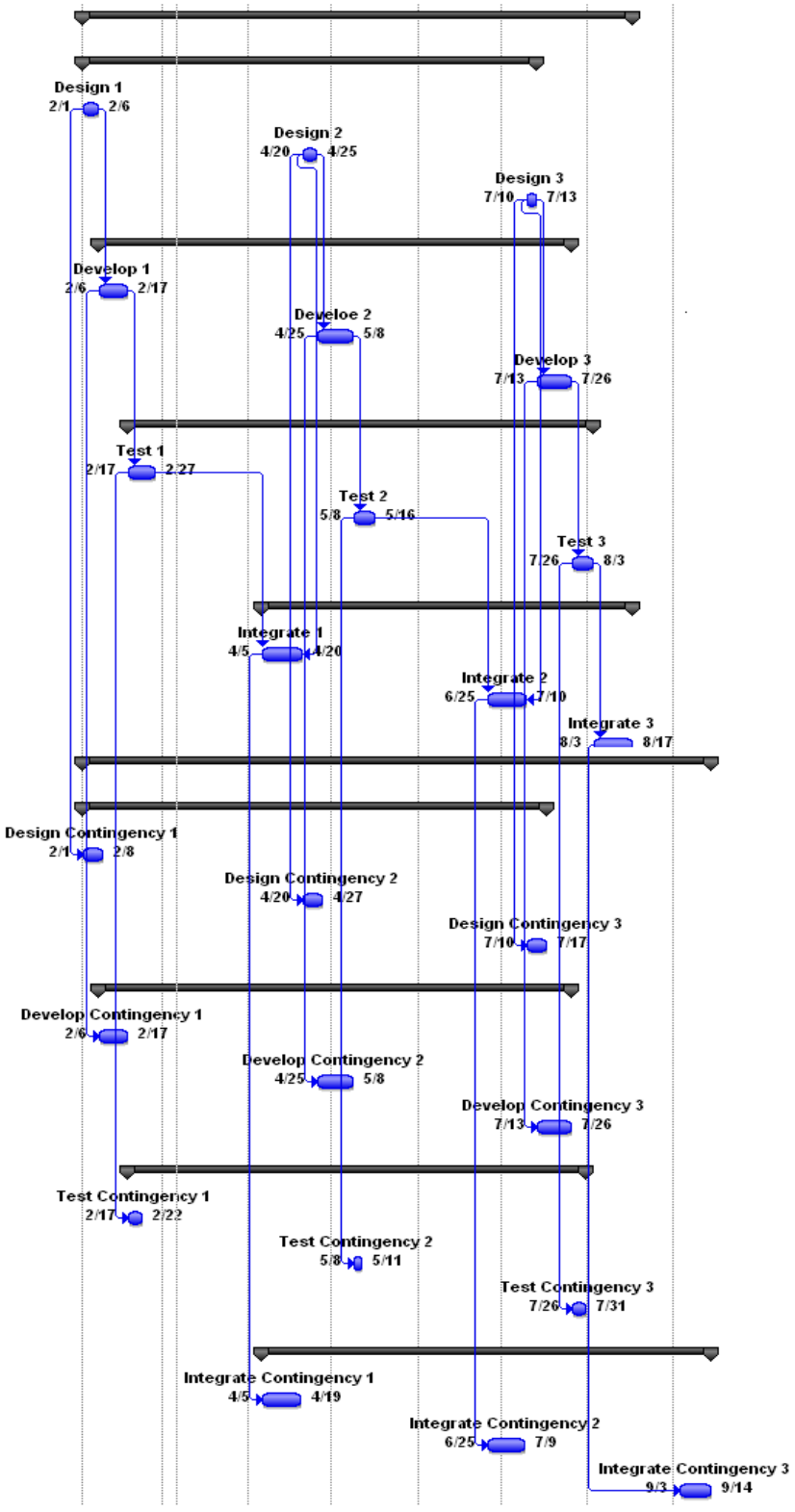

Figure A.7: Project Management Schedule for Strategy 2 at 75% confidence

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Task Name	Duration	Start	Finish	Cost	Work
Project Plan Strategy 3	**8.62 mons**	**Wed 2/1/12**	**Fri 9/28/12**	**$706,643.18**	**66.51 mons**
1 Project Development Phases	**8.62 mons**	**Wed 2/1/12**	**Fri 9/28/12**	**$562,343.18**	**52.08 mons**
1.1 Design	**5.89 mons**	**Wed 2/1/12**	**Fri 7/13/12**	**$46,500.00**	**4.65 mons**
1.1.1 Design 1	0.19 mons	Wed 2/1/12	Mon 2/6/12	$15,500.00	1.55 mons
1.1.2 Design 2	0.19 mons	Fri 4/20/12	Wed 4/25/12	$15,500.00	1.55 mons
1.1.3 Design 3	0.19 mons	Tue 7/10/12	Fri 7/13/12	$15,500.00	1.55 mons
1.2 Develop	**6.12 mons**	**Mon 2/6/12**	**Thu 7/26/12**	**$99,600.00**	**9.96 mons**
1.2.1 Develop 1	0.42 mons	Mon 2/6/12	Fri 2/17/12	$33,200.00	3.32 mons
1.2.2 Develoe 2	0.42 mons	Wed 4/25/12	Tue 5/8/12	$33,200.00	3.32 mons
1.2.3 Develop 3	0.42 mons	Fri 7/13/12	Thu 7/26/12	$33,200.00	3.32 mons
1.3 Test	**7.54 mons**	**Fri 2/17/12**	**Mon 9/17/12**	**$254,265.00**	**22.11 mons**
1.3.1 Test 1	1.84 mons	Fri 2/17/12	Tue 4/10/12	$84,755.00	7.37 mons
1.3.2 Test 2	1.84 mons	Tue 5/8/12	Thu 6/28/12	$84,755.00	7.37 mons
1.3.3 Test 3	1.84 mons	Thu 7/26/12	Mon 9/17/12	$84,755.00	7.37 mons
1.4 Integrate	**6.17 mons**	**Tue 4/10/12**	**Fri 9/28/12**	**$161,978.18**	**15.36 mons**
1.4.1 Integrate 1	0.47 mons	Tue 4/10/12	Mon 4/23/12	$53,992.73	5.12 mons
1.4.2 Integrate 2	0.47 mons	Thu 6/28/12	Wed 7/11/12	$53,992.73	5.12 mons
1.4.3 Integrate 3	0.47 mons	Mon 9/17/12	Fri 9/28/12	$53,992.73	5.12 mons
2 Project Contingency	**8.58 mons**	**Wed 2/1/12**	**Thu 9/27/12**	**$144,300.00**	**14.43 mons**
2.1 Design Contingency	**5.99 mons**	**Wed 2/1/12**	**Tue 7/17/12**	**$26,400.00**	**2.64 mons**
2.1.1 Design Contingency 1	0.29 mons	Wed 2/1/12	Wed 2/8/12	$8,800.00	0.88 mons
2.1.2 Design Contingency 2	0.29 mons	Fri 4/20/12	Fri 4/27/12	$8,800.00	0.88 mons
2.1.3 Design Contingency 3	0.29 mons	Tue 7/10/12	Tue 7/17/12	$8,800.00	0.88 mons
2.2 Develop Contingency	**6.02 mons**	**Mon 2/6/12**	**Tue 7/24/12**	**$28,800.00**	**2.88 mons**
2.2.1 Develop Contingency 1	0.32 mons	Mon 2/6/12	Wed 2/15/12	$9,600.00	0.96 mons
2.2.2 Develop Contingency 2	0.32 mons	Wed 4/25/12	Fri 5/4/12	$9,600.00	0.96 mons
2.2.3 Develop Contingency 3	0.32 mons	Fri 7/13/12	Tue 7/24/12	$9,600.00	0.96 mons
2.3 Test Contingency	**6.26 mons**	**Fri 2/17/12**	**Fri 8/10/12**	**$50,100.00**	**5.01 mons**
2.3.1 Test Contingency 1	0.56 mons	Fri 2/17/12	Mon 3/5/12	$16,700.00	1.67 mons
2.3.2 Test Contingency 2	0.56 mons	Tue 5/8/12	Wed 5/23/12	$16,700.00	1.67 mons
2.3.3 Test Contingency 3	0.56 mons	Thu 7/26/12	Fri 8/10/12	$16,700.00	1.67 mons
2.4 Test Contingency	**6.13 mons**	**Tue 4/10/12**	**Thu 9/27/12**	**$39,000.00**	**3.9 mons**
2.4.1 Integrate Contingency 1	0.43 mons	Tue 4/10/12	Fri 4/20/12	$13,000.00	1.3 mons
2.4.2 Integrate Contingency 2	0.43 mons	Thu 6/28/12	Tue 7/10/12	$13,000.00	1.3 mons
2.4.3 Integrate Contingency 3	0.43 mons	Mon 9/17/12	Thu 9/27/12	$13,000.00	1.3 mons

Figure A.8: Project Management Plan for Strategy 3 at 75% tolerance

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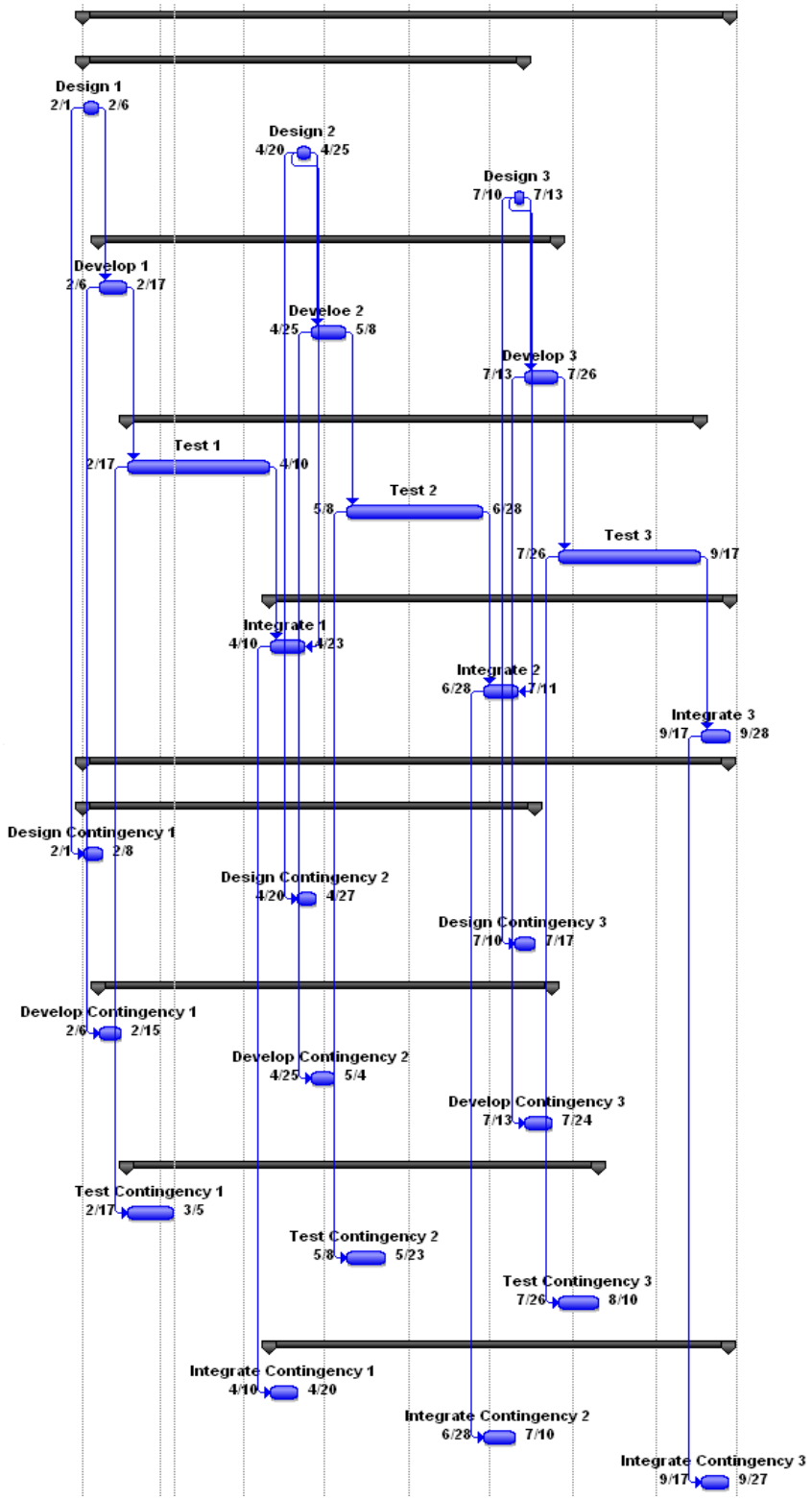

Figure A.9: Project Management Schedule for Strategy 3 at 75% tolerance

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					Contingency			
	Design	*Develop*	*Test*	*Integrate*	*Design*	*Develop*	*Test*	*Integrate*
i	***Strategy 1***							
1	2/1 – 2/6	2/6 – 2/17	2/17 – 4/5	4/5 – 4/20	2/1 – 2/8	2/6 – 2/16	2/17–3/9	4/5–4/20
2	4/20 – 4/25	4/25 – 5/8	5/8 – 6/25	6/25 – 7/10	4/20 – 4/27	4/25 – 5/7	5/8–5/29	6/25–7/10
3	7/10 – 7/13	7/13 –7/26	7/26 – 9/12	9/12 – /9/27	7/10 – 7/17	7/13 – 7/25	7/26–8/16	9/12–9/27
	Strategy 2							
1	2/1 – 2/6	2/6 – 2/17	2/17 – 2/27	4/5 – 4/20	2/1 – 2/8	2/6 – 2/17	2/17–2/22	4/5– 4/19
2	4/20 – 4/25	4/25 – 5/8	5/8 – 5/16	6/25 – 7/10	4/20 – 4/27	4/25 – 5/8	5/8–5/11	6/25–7/9
3	7/10 – 7/13	7/13 – 7/26	7/26 – 8/3	8/3 – 8/17	7/10 – 7/17	7/13 – 7/26	7/26–7/31	9/3–9/14
	Strategy 3							
1	2/1 – 2/6	2/6 – 2/17	2/17 – 4/10	4/10 – 4/23	2/1 – 2/8	2/6 – 2/15	2/17–3/5	4/10–4/20
2	4/20 – 4/25	4/25 – 5/8	5/8 – 6/28	6/28 – 7/11	4/20 – 4/27	4/25 – 5/4	5/8–5/23	6/28–7/10
3	7/10 – 7/13	7/13 – 7/26	7/26 – 9/17	9/17 – 9/28	7/10 - 7/17	7/13 – 7/24	7/26 – 8/10	9/17–9/27

Table A.1: Project's Schedule for Strategies 1, 2 and 3 at 75% confidence

iJETRM
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Task Name	Duration	Start	Finish	Cost	Work
Project Plan Strategy 1	**9.08 mons**	**Wed 2/1/12**	**Thu 10/11/12**	**$858,300.63**	**85.83 mons**
1 Project Development Phases	**8.56 mons**	**Wed 2/1/12**	**Thu 9/27/12**	**$531,000.63**	**53.1 mons**
1.1 Design	**5.89 mons**	**Wed 2/1/12**	**Fri 7/13/12**	**$44,400.00**	**4.44 mons**
1.1.1 Design 1	0.19 mons	Wed 2/1/12	Mon 2/6/12	$14,800.00	1.48 mons
1.1.2 Design 2	0.19 mons	Fri 4/20/12	Wed 4/25/12	$14,800.00	1.48 mons
1.1.3 Design 3	0.19 mons	Tue 7/10/12	Fri 7/13/12	$14,800.00	1.48 mons
1.2 Develop	**6.12 mons**	**Mon 2/6/12**	**Thu 7/26/12**	**$99,900.00**	**9.99 mons**
1.2.1 Develop 1	0.42 mons	Mon 2/6/12	Fri 2/17/12	$33,300.00	3.33 mons
1.2.2 Develoe 2	0.42 mons	Wed 4/25/12	Tue 5/8/12	$33,300.00	3.33 mons
1.2.3 Develop 3	0.42 mons	Fri 7/13/12	Thu 7/26/12	$33,300.00	3.33 mons
1.3 Test	**7.41 mons**	**Fri 2/17/12**	**Wed 9/12/12**	**$205,500.00**	**20.55 mons**
1.3.1 Test 1	1.71 mons	Fri 2/17/12	Thu 4/5/12	$68,500.00	6.85 mons
1.3.2 Test 2	1.71 mons	Tue 5/8/12	Mon 6/25/12	$68,500.00	6.85 mons
1.3.3 Test 3	1.71 mons	Thu 7/26/12	Wed 9/12/12	$68,500.00	6.85 mons
1.4 Integrate	**6.25 mons**	**Thu 4/5/12**	**Thu 9/27/12**	**$181,200.63**	**18.12 mons**
1.4.1 Integrate 1	0.55 mons	Thu 4/5/12	Fri 4/20/12	$60,400.31	6.04 mons
1.4.2 Integrate 2	0.55 mons	Mon 6/25/12	Tue 7/10/12	$60,400.31	6.04 mons
1.4.3 Integrate 3	0.55 mons	Wed 9/12/12	Thu 9/27/12	$60,400.00	6.04 mons
2 Project Contingency	**9.08 mons**	**Wed 2/1/12**	**Thu 10/11/12**	**$327,300.00**	**32.73 mons**
2.1 Design Contingency	**6.09 mons**	**Wed 2/1/12**	**Thu 7/19/12**	**$35,400.00**	**3.54 mons**
2.1.1 Design Contingency 1	0.39 mons	Wed 2/1/12	Fri 2/10/12	$11,800.00	1.18 mons
2.1.2 Design Contingency 2	0.39 mons	Fri 4/20/12	Tue 5/1/12	$11,800.00	1.18 mons
2.1.3 Design Contingency 3	0.39 mons	Tue 7/10/12	Thu 7/19/12	$11,800.00	1.18 mons
2.2 Develop Contingency	**6.42 mons**	**Mon 2/6/12**	**Fri 8/3/12**	**$64,800.00**	**6.48 mons**
2.2.1 Develop Contingency 1	0.72 mons	Mon 2/6/12	Mon 2/27/12	$21,600.00	2.16 mons
2.2.2 Develop Contingency 2	0.72 mons	Wed 4/25/12	Wed 5/16/12	$21,600.00	2.16 mons
2.2.3 Develop Contingency 3	0.72 mons	Fri 7/13/12	Fri 8/3/12	$21,600.00	2.16 mons
2.3 Test Contingency	**7.16 mons**	**Fri 2/17/12**	**Wed 9/5/12**	**$131,400.00**	**13.14 mons**
2.3.1 Test Contingency 1	1.46 mons	Fri 2/17/12	Thu 3/29/12	$43,800.00	4.38 mons
2.3.2 Test Contingency 2	1.46 mons	Tue 5/8/12	Mon 6/18/12	$43,800.00	4.38 mons
2.3.3 Test Contingency 3	1.46 mons	Thu 7/26/12	Wed 9/5/12	$43,800.00	4.38 mons
2.4 Test Contingency	**6.76 mons**	**Thu 4/5/12**	**Thu 10/11/12**	**$95,700.00**	**9.57 mons**
2.4.1 Integrate Contingency 1	1.06 mons	Thu 4/5/12	Fri 5/4/12	$31,900.00	3.19 mons
2.4.2 Integrate Contingency 2	1.06 mons	Mon 6/25/12	Tue 7/24/12	$31,900.00	3.19 mons
2.4.3 Integrate Contingency 3	1.06 mons	Wed 9/12/12	Thu 10/11/12	$31,900.00	3.19 mons

Figure A.10: Project Management Plan for Strategy 1 at 85% tolerance

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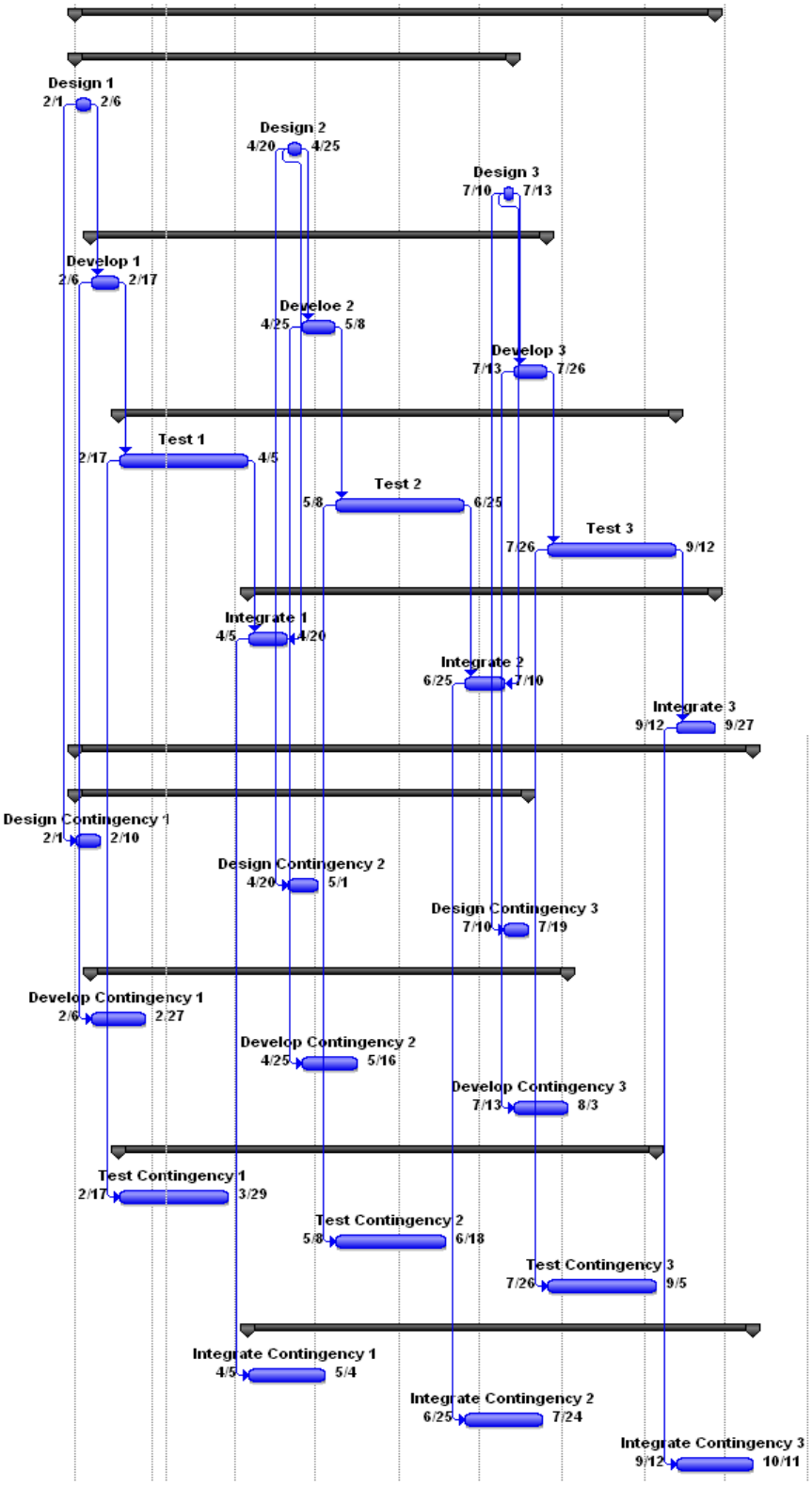

Figure A.11: Project Management Schedule for Strategy 1 at 85% tolerance

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Task Name	Duration	Start	Finish	Cost	Work
Project Plan Strategy 2	**8.9 mons**	**Wed 2/1/12**	**Fri 10/5/12**	**$635,362.50**	**59.88 mons**
1 Project Development Phases	**7.12 mons**	**Wed 2/1/12**	**Fri 8/17/12**	**$386,662.50**	**35.01 mons**
1.1 Design	**5.89 mons**	**Wed 2/1/12**	**Fri 7/13/12**	**$46,500.00**	**4.65 mons**
1.1.1 Design 1	0.19 mons	Wed 2/1/12	Mon 2/6/12	$15,500.00	1.55 mons
1.1.2 Design 2	0.19 mons	Fri 4/20/12	Wed 4/25/12	$15,500.00	1.55 mons
1.1.3 Design 3	0.19 mons	Tue 7/10/12	Fri 7/13/12	$15,500.00	1.55 mons
1.2 Develop	**6.11 mons**	**Mon 2/6/12**	**Thu 7/26/12**	**$99,000.00**	**9.9 mons**
1.2.1 Develop 1	0.41 mons	Mon 2/6/12	Fri 2/17/12	$33,000.00	3.3 mons
1.2.2 Develoe 2	0.41 mons	Wed 4/25/12	Tue 5/8/12	$33,000.00	3.3 mons
1.2.3 Develop 3	0.41 mons	Fri 7/13/12	Thu 7/26/12	$33,000.00	3.3 mons
1.3 Test	**6 mons**	**Fri 2/17/12**	**Fri 8/3/12**	**$49,912.50**	**3.63 mons**
1.3.1 Test 1	0.3 mons	Fri 2/17/12	Mon 2/27/12	$16,637.50	1.21 mons
1.3.2 Test 2	0.3 mons	Tue 5/8/12	Wed 5/16/12	$16,637.50	1.21 mons
1.3.3 Test 3	0.3 mons	Thu 7/26/12	Fri 8/3/12	$16,637.50	1.21 mons
1.4 Integrate	**4.78 mons**	**Thu 4/5/12**	**Fri 8/17/12**	**$191,250.00**	**16.83 mons**
1.4.1 Integrate 1	0.51 mons	Thu 4/5/12	Fri 4/20/12	$63,750.00	5.61 mons
1.4.2 Integrate 2	0.51 mons	Mon 6/25/12	Tue 7/10/12	$63,750.00	5.61 mons
1.4.3 Integrate 3	0.51 mons	Fri 8/3/12	Fri 8/17/12	$63,750.00	5.61 mons
2 Project Contingency	**8.9 mons**	**Wed 2/1/12**	**Fri 10/5/12**	**$248,700.00**	**24.87 mons**
2.1 Design Contingency	**6.1 mons**	**Wed 2/1/12**	**Thu 7/19/12**	**$36,000.00**	**3.6 mons**
2.1.1 Design Contingency 1	0.4 mons	Wed 2/1/12	Fri 2/10/12	$12,000.00	1.2 mons
2.1.2 Design Contingency 2	0.4 mons	Fri 4/20/12	Tue 5/1/12	$12,000.00	1.2 mons
2.1.3 Design Contingency 3	0.4 mons	Tue 7/10/12	Thu 7/19/12	$12,000.00	1.2 mons
2.2 Develop Contingency	**6.5 mons**	**Mon 2/6/12**	**Mon 8/6/12**	**$71,700.00**	**7.17 mons**
2.2.1 Develop Contingency 1	0.8 mons	Mon 2/6/12	Tue 2/28/12	$23,900.00	2.39 mons
2.2.2 Develop Contingency 2	0.8 mons	Wed 4/25/12	Thu 5/17/12	$23,900.00	2.39 mons
2.2.3 Develop Contingency 3	0.8 mons	Fri 7/13/12	Mon 8/6/12	$23,900.00	2.39 mons
2.3 Test Contingency	**6.02 mons**	**Fri 2/17/12**	**Fri 8/3/12**	**$28,800.00**	**2.88 mons**
2.3.1 Test Contingency 1	0.32 mons	Fri 2/17/12	Mon 2/27/12	$9,600.00	0.96 mons
2.3.2 Test Contingency 2	0.32 mons	Tue 5/8/12	Wed 5/16/12	$9,600.00	0.96 mons
2.3.3 Test Contingency 3	0.32 mons	Thu 7/26/12	Fri 8/3/12	$9,600.00	0.96 mons
2.4 Test Contingency	**6.56 mons**	**Thu 4/5/12**	**Fri 10/5/12**	**$112,200.00**	**11.22 mons**
2.4.1 Integrate Contingency 1	1.25 mons	Thu 4/5/12	Thu 5/10/12	$37,400.00	3.74 mons
2.4.2 Integrate Contingency 2	1.25 mons	Mon 6/25/12	Mon 7/30/12	$37,400.00	3.74 mons
2.4.3 Integrate Contingency 3	1.25 mons	Mon 9/3/12	Fri 10/5/12	$37,400.00	3.74 mons

Figure A.12: Project Management Plan for Strategy 2 at 85% tolerance

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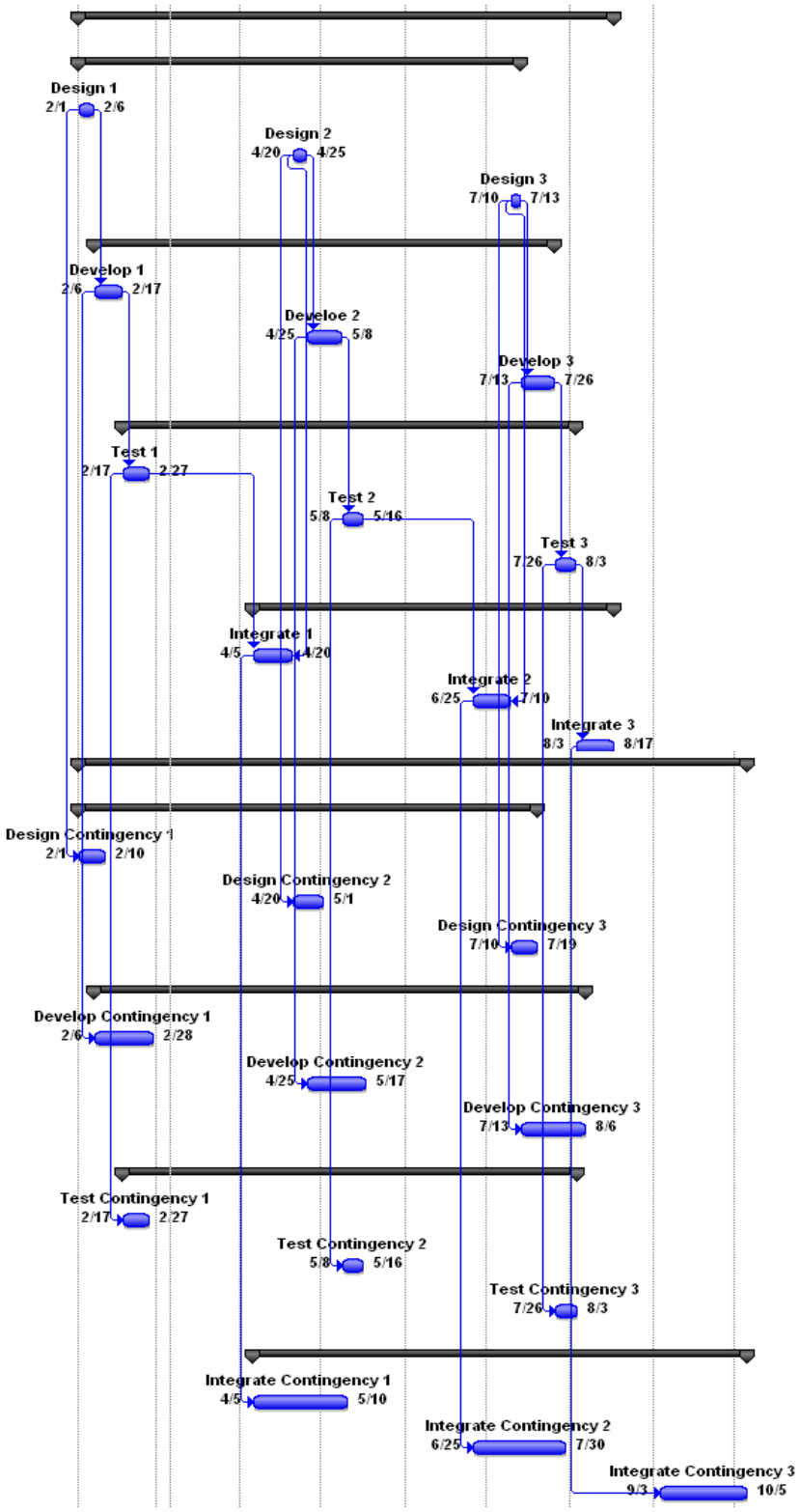

Figure A.13: Project Management Schedule for Strategy 2 at 85% tolerance

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Task Name	Duration	Start	Finish	Cost	Work
Project Plan Strategy 3	**9.23 mons**	**Wed 2/1/12**	**Tue 10/16/12**	**$845,843.18**	**80.43 mons**
1 Project Development Phases	**8.62 mons**	**Wed 2/1/12**	**Fri 9/28/12**	**$562,343.18**	**52.08 mons**
1.1 Design	**5.89 mons**	**Wed 2/1/12**	**Fri 7/13/12**	**$46,500.00**	**4.65 mons**
1.1.1 Design 1	0.19 mons	Wed 2/1/12	Mon 2/6/12	$15,500.00	1.55 mons
1.1.2 Design 2	0.19 mons	Fri 4/20/12	Wed 4/25/12	$15,500.00	1.55 mons
1.1.3 Design 3	0.19 mons	Tue 7/10/12	Fri 7/13/12	$15,500.00	1.55 mons
1.2 Develop	**6.12 mons**	**Mon 2/6/12**	**Thu 7/26/12**	**$99,600.00**	**9.96 mons**
1.2.1 Develop 1	0.42 mons	Mon 2/6/12	Fri 2/17/12	$33,200.00	3.32 mons
1.2.2 Develoe 2	0.42 mons	Wed 4/25/12	Tue 5/8/12	$33,200.00	3.32 mons
1.2.3 Develop 3	0.42 mons	Fri 7/13/12	Thu 7/26/12	$33,200.00	3.32 mons
1.3 Test	**7.54 mons**	**Fri 2/17/12**	**Mon 9/17/12**	**$254,265.00**	**22.11 mons**
1.3.1 Test 1	1.84 mons	Fri 2/17/12	Tue 4/10/12	$84,755.00	7.37 mons
1.3.2 Test 2	1.84 mons	Tue 5/8/12	Thu 6/28/12	$84,755.00	7.37 mons
1.3.3 Test 3	1.84 mons	Thu 7/26/12	Mon 9/17/12	$84,755.00	7.37 mons
1.4 Integrate	**6.17 mons**	**Tue 4/10/12**	**Fri 9/28/12**	**$161,978.18**	**15.36 mons**
1.4.1 Integrate 1	0.47 mons	Tue 4/10/12	Mon 4/23/12	$53,992.73	5.12 mons
1.4.2 Integrate 2	0.47 mons	Thu 6/28/12	Wed 7/11/12	$53,992.73	5.12 mons
1.4.3 Integrate 3	0.47 mons	Mon 9/17/12	Fri 9/28/12	$53,992.73	5.12 mons
2 Project Contingency	**9.23 mons**	**Wed 2/1/12**	**Tue 10/16/12**	**$283,500.00**	**28.35 mons**
2.1 Design Contingency	**6.14 mons**	**Wed 2/1/12**	**Fri 7/20/12**	**$39,600.00**	**3.96 mons**
2.1.1 Design Contingency 1	0.44 mons	Wed 2/1/12	Mon 2/13/12	$13,200.00	1.32 mons
2.1.2 Design Contingency 2	0.44 mons	Fri 4/20/12	Wed 5/2/12	$13,200.00	1.32 mons
2.1.3 Design Contingency 3	0.44 mons	Tue 7/10/12	Fri 7/20/12	$13,200.00	1.32 mons
2.2 Develop Contingency	**6.33 mons**	**Mon 2/6/12**	**Wed 8/1/12**	**$56,400.00**	**5.64 mons**
2.2.1 Develop Contingency 1	0.63 mons	Mon 2/6/12	Thu 2/23/12	$18,800.00	1.88 mons
2.2.2 Develop Contingency 2	0.63 mons	Wed 4/25/12	Mon 5/14/12	$18,800.00	1.88 mons
2.2.3 Develop Contingency 3	0.63 mons	Fri 7/13/12	Wed 8/1/12	$18,800.00	1.88 mons
2.3 Test Contingency	**6.71 mons**	**Fri 2/17/12**	**Thu 8/23/12**	**$90,600.00**	**9.06 mons**
2.3.1 Test Contingency 1	1.01 mons	Fri 2/17/12	Fri 3/16/12	$30,200.00	3.02 mons
2.3.2 Test Contingency 2	1.01 mons	Tue 5/8/12	Tue 6/5/12	$30,200.00	3.02 mons
2.3.3 Test Contingency 3	1.01 mons	Thu 7/26/12	Thu 8/23/12	$30,200.00	3.02 mons
2.4 Test Contingency	**6.78 mons**	**Tue 4/10/12**	**Tue 10/16/12**	**$96,900.00**	**9.69 mons**
2.4.1 Integrate Contingency 1	1.08 mons	Tue 4/10/12	Wed 5/9/12	$32,300.00	3.23 mons
2.4.2 Integrate Contingency 2	1.08 mons	Thu 6/28/12	Fri 7/27/12	$32,300.00	3.23 mons
2.4.3 Integrate Contingency 3	1.08 mons	Mon 9/17/12	Tue 10/16/12	$32,300.00	3.23 mons

Figure A.14: Project Management Plan for Strategy 3 at 85% tolerance

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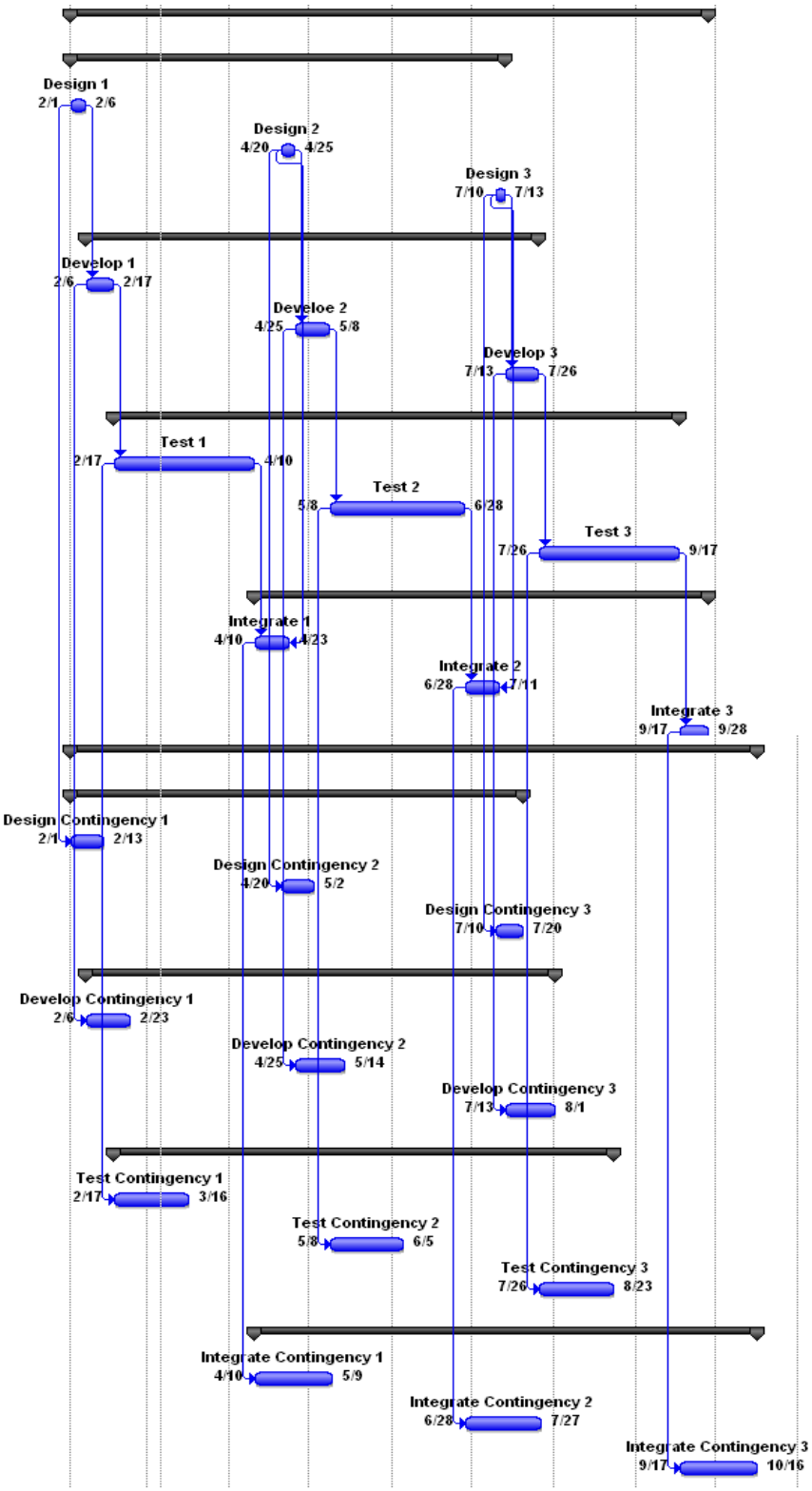

Figure A.15: Project Management Schedule for Strategy 3 at 85% tolerance

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					Contingency			
	Design	*Develop*	*Test*	*Integrate*	*Design*	*Develop*	*Test*	*Integrate*
i	***Strategy 1***							
1	2/1 – 2/6	2/6 –2/17	2/17 – 4/5	4/5 – 4/20	2/1 – 2/10	2/6 – 2/27	2/17 – 3/29	4/5 – 5/4
2	4/20 – 4/25	4/25 – 5/8	5/8 – 6/25	6/25 – 7/10	4/20 – 5/1	4/25 – 5/16	5/8 – 6/18	6/25 – 7/24
3	7/10 – 7/13	7/13–7/26	7/26 – 9/12	9/12 – /9/27	7/10 – 7/19	7/13 – 8/3	7/26 – 9/5	9/12 – 10/11
	Strategy 2							
1	2/1 – 2/6	2/6 – 2/17	2/17 – 2/27	4/5 – 4/20	2/1 – 2/10	2/6 – 2/28	2/17 – 2/27	4/5 – 5/10
2	4/20 – 4/25	4/25 – 5/8	5/8 – 5/16	6/25 – 7/10	4/20 – 5/1	4/25 – 5/17	5/8 – 5/16	6/25 – 7/30
3	7/10 – 7/13	7/13 – /26	7/26 – 8/3	8/3 – 8/17	7/10 – 7/19	7/13 – 8/6	7/26 – 8/3	9/3 – 10/5
	Strategy 3							
1	2/1 – 2/6	2/6 – 2/17	2/17 – 4/10	4/10 – 4/23	2/1 – 2/13	2/6 – 2/23	2/17 – 3/16	4/10 – 5/9
2	4/20 – 4/25	4/25 – 5/8	5/8 – 6/28	6/28 – 7/11	4/20 – 5/2	4/25 – 5/14	5/8 – 6/5	6/28 – 7/27
3	7/10 – 7/13	7/13 – /26	7/26 – 9/17	9/17 – 9/28	7/10 - 7/20	7/13 –8/1	7/26 – 8/23	9/17 – 10/16

Table A.2: Project's Schedule for Strategies 1, 2 and 3 at 85% confidence

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Task Name	Duration	Start	Finish	Cost	Work
Project Plan Strategy 1	**10.13 mons**	**Wed 2/1/12**	**Fri 11/9/12**	**1,107,600.63**	**110.76 mons**
1 Project Development Phases	**8.56 mons**	**Wed 2/1/12**	**Thu 9/27/12**	**$531,000.63**	**53.1 mons**
1.1 Design	**5.89 mons**	**Wed 2/1/12**	**Fri 7/13/12**	**$44,400.00**	**4.44 mons**
1.1.1 Design 1	0.19 mons	Wed 2/1/12	Mon 2/6/12	$14,800.00	1.48 mons
1.1.2 Design 2	0.19 mons	Fri 4/20/12	Wed 4/25/12	$14,800.00	1.48 mons
1.1.3 Design 3	0.19 mons	Tue 7/10/12	Fri 7/13/12	$14,800.00	1.48 mons
1.2 Develop	**6.12 mons**	**Mon 2/6/12**	**Thu 7/26/12**	**$99,900.00**	**9.99 mons**
1.2.1 Develop 1	0.42 mons	Mon 2/6/12	Fri 2/17/12	$33,300.00	3.33 mons
1.2.2 Develoe 2	0.42 mons	Wed 4/25/12	Tue 5/8/12	$33,300.00	3.33 mons
1.2.3 Develop 3	0.42 mons	Fri 7/13/12	Thu 7/26/12	$33,300.00	3.33 mons
1.3 Test	**7.41 mons**	**Fri 2/17/12**	**Wed 9/12/12**	**$205,500.00**	**20.55 mons**
1.3.1 Test 1	1.71 mons	Fri 2/17/12	Thu 4/5/12	$68,500.00	6.85 mons
1.3.2 Test 2	1.71 mons	Tue 5/8/12	Mon 6/25/12	$68,500.00	6.85 mons
1.3.3 Test 3	1.71 mons	Thu 7/26/12	Wed 9/12/12	$68,500.00	6.85 mons
1.4 Integrate	**6.25 mons**	**Thu 4/5/12**	**Thu 9/27/12**	**$181,200.63**	**18.12 mons**
1.4.1 Integrate 1	0.55 mons	Thu 4/5/12	Fri 4/20/12	$60,400.31	6.04 mons
1.4.2 Integrate 2	0.55 mons	Mon 6/25/12	Tue 7/10/12	$60,400.31	6.04 mons
1.4.3 Integrate 3	0.55 mons	Wed 9/12/12	Thu 9/27/12	$60,400.00	6.04 mons
2 Project Contingency	**10.13 mons**	**Wed 2/1/12**	**Fri 11/9/12**	**$576,600.00**	**57.66 mons**
2.1 Design Contingency	**6.32 mons**	**Wed 2/1/12**	**Thu 7/26/12**	**$56,100.00**	**5.61 mons**
2.1.1 Design Contingency 1	0.62 mons	Wed 2/1/12	Fri 2/17/12	$18,700.00	1.87 mons
2.1.2 Design Contingency 2	0.62 mons	Fri 4/20/12	Tue 5/8/12	$18,700.00	1.87 mons
2.1.3 Design Contingency 3	0.62 mons	Tue 7/10/12	Thu 7/26/12	$18,700.00	1.87 mons
2.2 Develop Contingency	**6.96 mons**	**Mon 2/6/12**	**Fri 8/17/12**	**$113,700.00**	**11.37 mons**
2.2.1 Develop Contingency 1	1.26 mons	Mon 2/6/12	Mon 3/12/12	$37,900.00	3.79 mons
2.2.2 Develop Contingency 2	1.26 mons	Wed 4/25/12	Wed 5/30/12	$37,900.00	3.79 mons
2.2.3 Develop Contingency 3	1.26 mons	Fri 7/13/12	Fri 8/17/12	$37,900.00	3.79 mons
2.3 Test Contingency	**8.11 mons**	**Fri 2/17/12**	**Tue 10/2/12**	**$216,600.00**	**21.66 mons**
2.3.1 Test Contingency 1	2.41 mons	Fri 2/17/12	Wed 4/25/12	$72,200.00	7.22 mons
2.3.2 Test Contingency 2	2.41 mons	Tue 5/8/12	Fri 7/13/12	$72,200.00	7.22 mons
2.3.3 Test Contingency 3	2.41 mons	Thu 7/26/12	Tue 10/2/12	$72,200.00	7.22 mons
2.4 Test Contingency	**7.81 mons**	**Thu 4/5/12**	**Fri 11/9/12**	**$190,200.00**	**19.02 mons**
2.4.1 Integrate Contingency 1	2.11 mons	Thu 4/5/12	Mon 6/4/12	$63,400.00	6.34 mons
2.4.2 Integrate Contingency 2	2.11 mons	Mon 6/25/12	Wed 8/22/12	$63,400.00	6.34 mons
2.4.3 Integrate Contingency 3	2.11 mons	Wed 9/12/12	Fri 11/9/12	$63,400.00	6.34 mons

Figure A.16: Project Management Plan for Strategy 1 at 95% confidence

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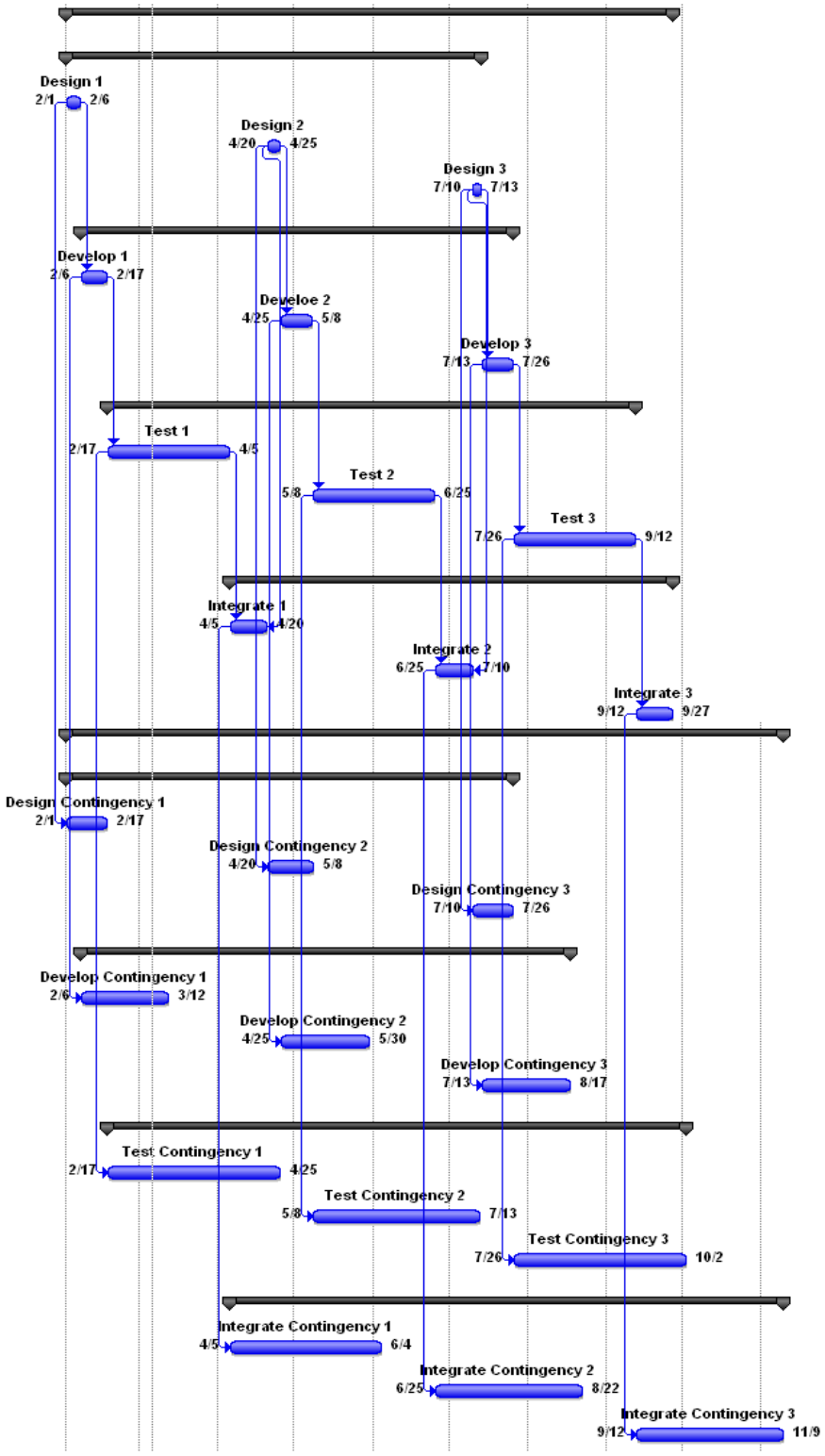

Figure A.17: Project Management Schedule for Strategy 1 at 95% confidence

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Task Name	Duration	Start	Finish	Cost	Work
Project Plan Strategy 2	**9.57 mons**	**Wed 2/1/12**	**Thu 10/25/12**	**$769,462.50**	**73.29 mons**
1 Project Development Phases	**7.12 mons**	**Wed 2/1/12**	**Fri 8/17/12**	**$386,662.50**	**35.01 mons**
1.1 Design	**5.89 mons**	**Wed 2/1/12**	**Fri 7/13/12**	**$46,500.00**	**4.65 mons**
1.1.1 Design 1	0.19 mons	Wed 2/1/12	Mon 2/6/12	$15,500.00	1.55 mons
1.1.2 Design 2	0.19 mons	Fri 4/20/12	Wed 4/25/12	$15,500.00	1.55 mons
1.1.3 Design 3	0.19 mons	Tue 7/10/12	Fri 7/13/12	$15,500.00	1.55 mons
1.2 Develop	**6.11 mons**	**Mon 2/6/12**	**Thu 7/26/12**	**$99,000.00**	**9.9 mons**
1.2.1 Develop 1	0.41 mons	Mon 2/6/12	Fri 2/17/12	$33,000.00	3.3 mons
1.2.2 Develoe 2	0.41 mons	Wed 4/25/12	Tue 5/8/12	$33,000.00	3.3 mons
1.2.3 Develop 3	0.41 mons	Fri 7/13/12	Thu 7/26/12	$33,000.00	3.3 mons
1.3 Test	**6 mons**	**Fri 2/17/12**	**Fri 8/3/12**	**$49,912.50**	**3.63 mons**
1.3.1 Test 1	0.3 mons	Fri 2/17/12	Mon 2/27/12	$16,637.50	1.21 mons
1.3.2 Test 2	0.3 mons	Tue 5/8/12	Wed 5/16/12	$16,637.50	1.21 mons
1.3.3 Test 3	0.3 mons	Thu 7/26/12	Fri 8/3/12	$16,637.50	1.21 mons
1.4 Integrate	**4.78 mons**	**Thu 4/5/12**	**Fri 8/17/12**	**$191,250.00**	**16.83 mons**
1.4.1 Integrate 1	0.51 mons	Thu 4/5/12	Fri 4/20/12	$63,750.00	5.61 mons
1.4.2 Integrate 2	0.51 mons	Mon 6/25/12	Tue 7/10/12	$63,750.00	5.61 mons
1.4.3 Integrate 3	0.51 mons	Fri 8/3/12	Fri 8/17/12	$63,750.00	5.61 mons
2 Project Contingency	**9.57 mons**	**Wed 2/1/12**	**Thu 10/25/12**	**$382,800.00**	**38.28 mons**
2.1 Design Contingency	**6.34 mons**	**Wed 2/1/12**	**Thu 7/26/12**	**$57,300.00**	**5.73 mons**
2.1.1 Design Contingency 1	0.64 mons	Wed 2/1/12	Fri 2/17/12	$19,100.00	1.91 mons
2.1.2 Design Contingency 2	0.64 mons	Fri 4/20/12	Tue 5/8/12	$19,100.00	1.91 mons
2.1.3 Design Contingency 3	0.64 mons	Tue 7/10/12	Thu 7/26/12	$19,100.00	1.91 mons
2.2 Develop Contingency	**6.92 mons**	**Mon 2/6/12**	**Fri 8/17/12**	**$109,500.00**	**10.95 mons**
2.2.1 Develop Contingency 1	1.22 mons	Mon 2/6/12	Mon 3/12/12	$36,500.00	3.65 mons
2.2.2 Develop Contingency 2	1.22 mons	Wed 4/25/12	Wed 5/30/12	$36,500.00	3.65 mons
2.2.3 Develop Contingency 3	1.22 mons	Fri 7/13/12	Fri 8/17/12	$36,500.00	3.65 mons
2.3 Test Contingency	**6.18 mons**	**Fri 2/17/12**	**Wed 8/8/12**	**$43,200.00**	**4.32 mons**
2.3.1 Test Contingency 1	0.48 mons	Fri 2/17/12	Thu 3/1/12	$14,400.00	1.44 mons
2.3.2 Test Contingency 2	0.48 mons	Tue 5/8/12	Mon 5/21/12	$14,400.00	1.44 mons
2.3.3 Test Contingency 3	0.48 mons	Thu 7/26/12	Wed 8/8/12	$14,400.00	1.44 mons
2.4 Test Contingency	**7.23 mons**	**Thu 4/5/12**	**Thu 10/25/12**	**$172,800.00**	**17.28 mons**
2.4.1 Integrate Contingency 1	1.92 mons	Thu 4/5/12	Wed 5/30/12	$57,600.00	5.76 mons
2.4.2 Integrate Contingency 2	1.92 mons	Mon 6/25/12	Fri 8/17/12	$57,600.00	5.76 mons
2.4.3 Integrate Contingency 3	1.92 mons	Mon 9/3/12	Thu 10/25/12	$57,600.00	5.76 mons

Figure A.18: Project Management Plan for Strategy 2 at 95% confidence

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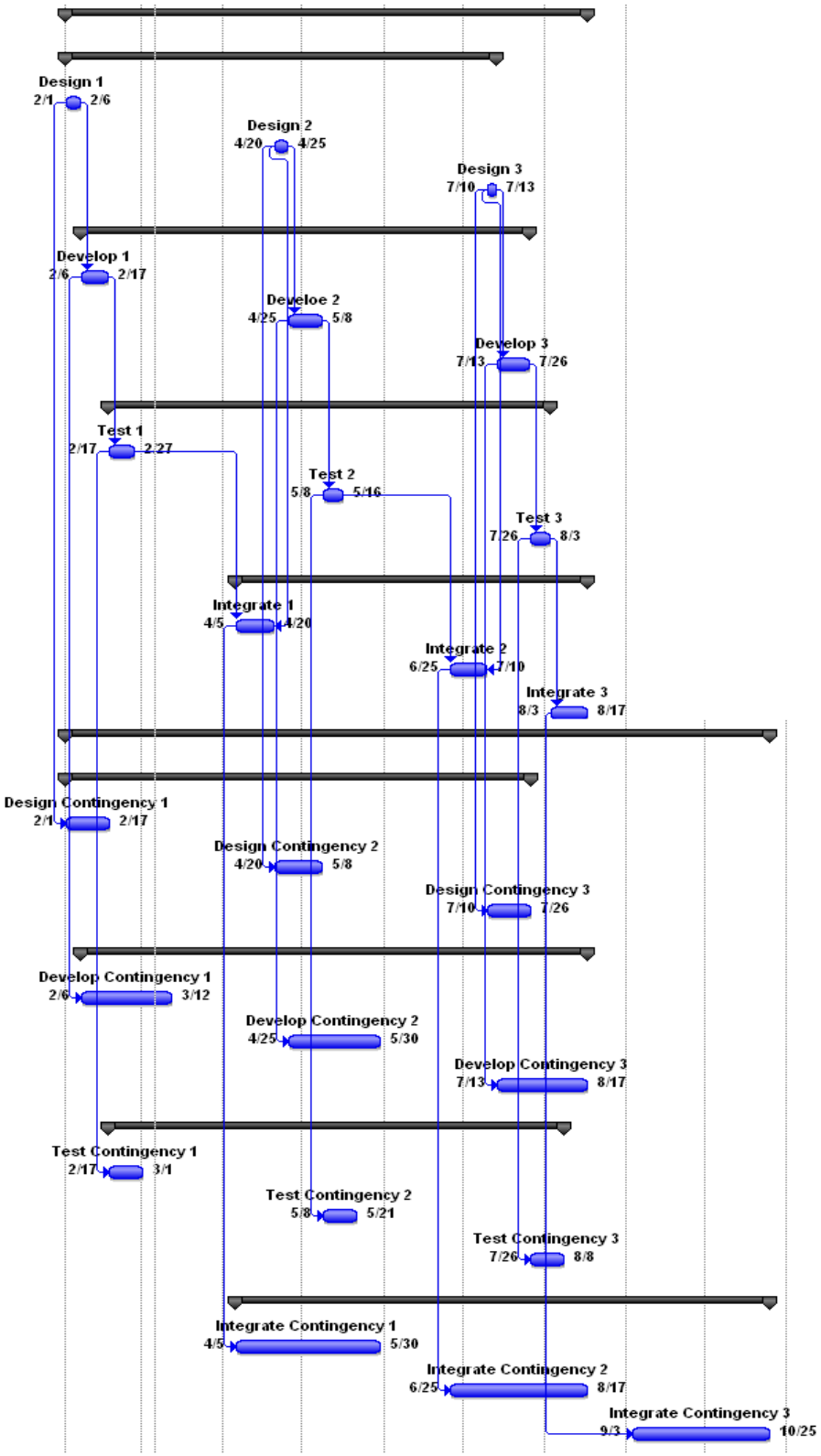

Figure A.19: Project Management Schedule for Strategy 2 at 95% confidence

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Task Name	Duration	Start	Finish	Cost	Work
Project Plan Strategy 3	**9.83 mons**	**Wed 2/1/12**	**Thu 11/1/12**	**1,099,643.18**	**105.81 mons**
1 Project Development Phases	**8.62 mons**	**Wed 2/1/12**	**Fri 9/28/12**	**$562,343.18**	**52.08 mons**
1.1 Design	**5.89 mons**	**Wed 2/1/12**	**Fri 7/13/12**	**$46,500.00**	**4.65 mons**
1.1.1 Design 1	0.19 mons	Wed 2/1/12	Mon 2/6/12	$15,500.00	1.55 mons
1.1.2 Design 2	0.19 mons	Fri 4/20/12	Wed 4/25/12	$15,500.00	1.55 mons
1.1.3 Design 3	0.19 mons	Tue 7/10/12	Fri 7/13/12	$15,500.00	1.55 mons
1.2 Develop	**6.12 mons**	**Mon 2/6/12**	**Thu 7/26/12**	**$99,600.00**	**9.96 mons**
1.2.1 Develop 1	0.42 mons	Mon 2/6/12	Fri 2/17/12	$33,200.00	3.32 mons
1.2.2 Develoe 2	0.42 mons	Wed 4/25/12	Tue 5/8/12	$33,200.00	3.32 mons
1.2.3 Develop 3	0.42 mons	Fri 7/13/12	Thu 7/26/12	$33,200.00	3.32 mons
1.3 Test	**7.54 mons**	**Fri 2/17/12**	**Mon 9/17/12**	**$254,265.00**	**22.11 mons**
1.3.1 Test 1	1.84 mons	Fri 2/17/12	Tue 4/10/12	$84,755.00	7.37 mons
1.3.2 Test 2	1.84 mons	Tue 5/8/12	Thu 6/28/12	$84,755.00	7.37 mons
1.3.3 Test 3	1.84 mons	Thu 7/26/12	Mon 9/17/12	$84,755.00	7.37 mons
1.4 Integrate	**6.17 mons**	**Tue 4/10/12**	**Fri 9/28/12**	**$161,978.18**	**15.36 mons**
1.4.1 Integrate 1	0.47 mons	Tue 4/10/12	Mon 4/23/12	$53,992.73	5.12 mons
1.4.2 Integrate 2	0.47 mons	Thu 6/28/12	Wed 7/11/12	$53,992.73	5.12 mons
1.4.3 Integrate 3	0.47 mons	Mon 9/17/12	Fri 9/28/12	$53,992.73	5.12 mons
2 Project Contingency	**9.83 mons**	**Wed 2/1/12**	**Thu 11/1/12**	**$537,300.00**	**53.73 mons**
2.1 Design Contingency	**6.4 mons**	**Wed 2/1/12**	**Fri 7/27/12**	**$63,000.00**	**6.3 mons**
2.1.1 Design Contingency 1	0.7 mons	Wed 2/1/12	Mon 2/20/12	$21,000.00	2.1 mons
2.1.2 Design Contingency 2	0.7 mons	Fri 4/20/12	Wed 5/9/12	$21,000.00	2.1 mons
2.1.3 Design Contingency 3	0.7 mons	Tue 7/10/12	Fri 7/27/12	$21,000.00	2.1 mons
2.2 Develop Contingency	**6.95 mons**	**Mon 2/6/12**	**Fri 8/17/12**	**$112,200.00**	**11.22 mons**
2.2.1 Develop Contingency 1	1.25 mons	Mon 2/6/12	Mon 3/12/12	$37,400.00	3.74 mons
2.2.2 Develop Contingency 2	1.25 mons	Wed 4/25/12	Wed 5/30/12	$37,400.00	3.74 mons
2.2.3 Develop Contingency 3	1.25 mons	Fri 7/13/12	Fri 8/17/12	$37,400.00	3.74 mons
2.3 Test Contingency	**8.04 mons**	**Fri 2/17/12**	**Fri 9/28/12**	**$210,600.00**	**21.06 mons**
2.3.1 Test Contingency 1	2.34 mons	Fri 2/17/12	Mon 4/23/12	$70,200.00	7.02 mons
2.3.2 Test Contingency 2	2.34 mons	Tue 5/8/12	Wed 7/11/12	$70,200.00	7.02 mons
2.3.3 Test Contingency 3	2.34 mons	Thu 7/26/12	Fri 9/28/12	$70,200.00	7.02 mons
2.4 Test Contingency	**7.38 mons**	**Tue 4/10/12**	**Thu 11/1/12**	**$151,500.00**	**15.15 mons**
2.4.1 Integrate Contingency 1	1.68 mons	Tue 4/10/12	Fri 5/25/12	$50,500.00	5.05 mons
2.4.2 Integrate Contingency 2	1.68 mons	Thu 6/28/12	Tue 8/14/12	$50,500.00	5.05 mons
2.4.3 Integrate Contingency 3	1.68 mons	Mon 9/17/12	Thu 11/1/12	$50,500.00	5.05 mons

Figure A.20: Project Management Plan for Strategy 3 at 95% confidence

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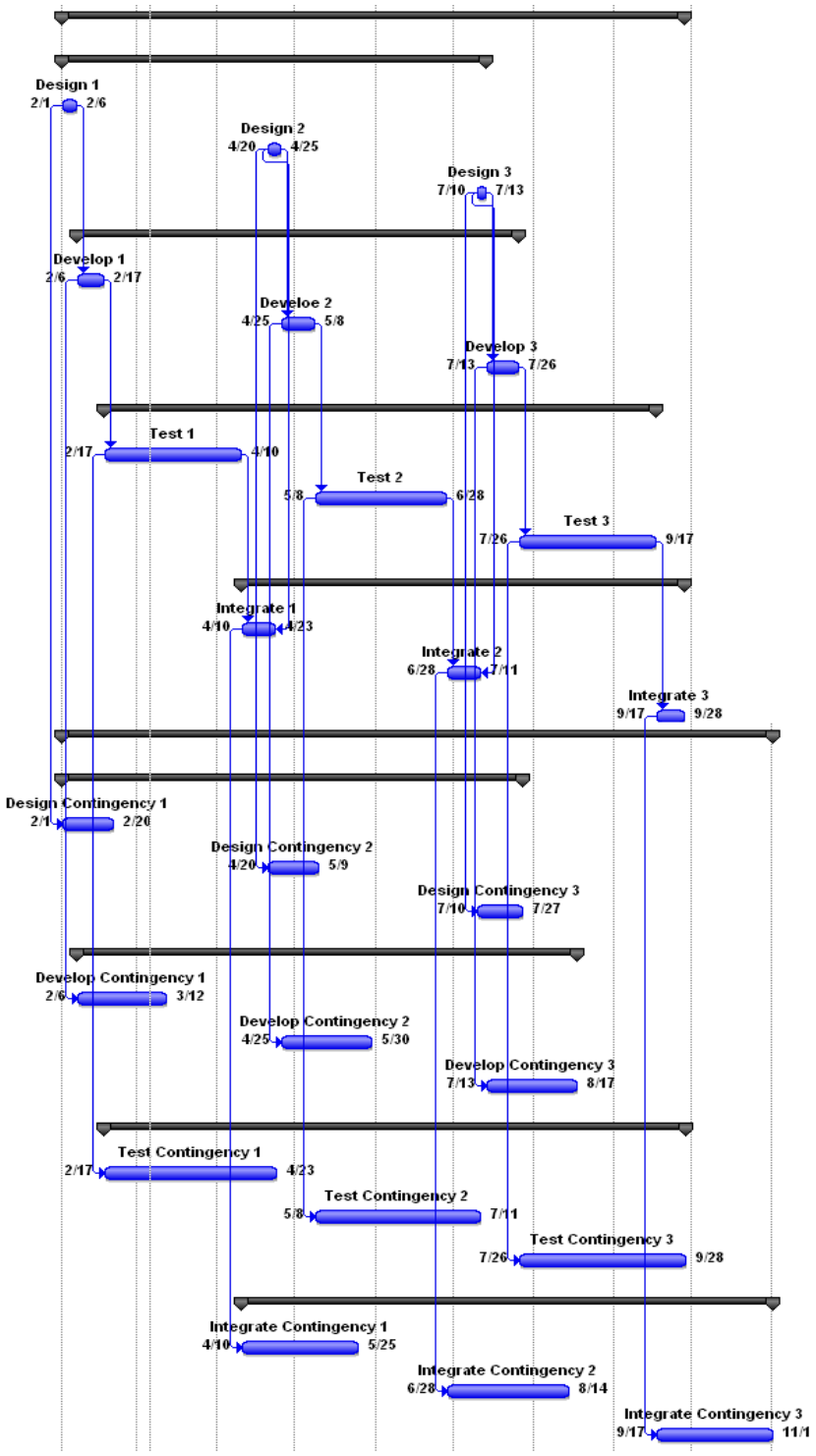

Figure A.21: Project Management Schedule for Strategy 3 at 95% confidence

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					Contingency			
	Design	*Develop*	*Test*	*Integrate*	*Design*	*Develop*	*Test*	*Integrate*
i	***Strategy 1***							
1	2/1 – 2/6	2/6 – 2/17	2/17 – 4/5	4/5 – 4/20	2/1 – 2/17	2/6 – 3/12	2/17 – 4/25	4/5 – 6/4
2	4/20 – 4/25	4/25 – 5/8	5/8 – 6/25	6/25 – 7/10	4/20 – 5/8	4/25 – 5/30	5/8 – 7/13	6/25 – 8/22
3	7/10 – 7/13	7/13 – 7/26	7/26 – 9/12	9/12 – /9/27	7/10 – 7/26	7/13 – 8/17	7/26 – 10/2	9/12 – 11/9
	Strategy 2							
1	2/1 – 2/6	2/6 – 2/17	2/17 – 2/27	4/5 – 4/20	2/1 – 2/17	2/6 – 3/12	2/17 – 3/1	4/5 – 5/30
2	4/20 – 4/25	4/25 – 5/8	5/8 – 5/16	6/25 – 7/10	4/20 – 5/8	4/25 – 5/30	5/8 – 5/21	6/25 – 8/17
3	7/10 – 7/13	7/13 – 7/26	7/26 – 8/3	8/3 – 8/17	7/10 – 7/26	7/13 – 8/17	7/26 – 8/8	9/3 – 10/25
	Strategy 3							
1	2/1 – 2/6	2/6 – 2/17	2/17 – 4/10	4/10 – 4/23	2/1 – 2/20	2/6 – 3/12	2/17 – 4/23	4/10 – 5/25
2	4/20 – 4/25	4/25 – 5/8	5/8 – 6/28	6/28 – 7/11	4/20 – 5/9	5/8 – 7/11	5/8 – 6/5	6/28 – 8/14
3	7/10 – 7/13	7/13 – 7/26	7/26 – 9/17	9/17 – 9/28	7/10 - 7/27	7/13 – 8/17	7/26 – 9/28	9/17 – 11/1

Table A.3: Project's Schedule for Strategies 1, 2 and 3 at 95% confidence

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