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Modeling the Impact of Scheduling Risks on Multi-Team Agile Projects

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by
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Abstract

Title: Modeling the Impact of Scheduling Risks on Multi-Team Agile Projects

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Agile project management allows for a quick response to a changing project environment. This opens possible avenues for new opportunities, but also may expose ongoing projects to previously unknown or unexpected threats. Risks must be continuously monitored as a product is worked on to avoid lost potential.

This paper will propose a discrete event simulation model that multi-team projects may use to predict the impact to the project's schedule. Using discrete event simulation early in the project's planning cycle offers a greater understanding of the possible or probable impact of risks on the schedule. This would help to prepare project managers, planners, and schedulers for challenges they could face.

In this paper, you will find that discrete event simulation was able to accurately characterize the behavior of a risk response system and predict the actual impact to the schedule.

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Chapter 1 Introduction

Introduction

Agile project management allows for a quick response to a changing project environment. This opens possible avenues for new opportunities, but also may expose ongoing projects to previously unknown or unexpected threats. Risks, both positive and negative, must be continuously monitored as a product is developed to avoid lost progress or potential. Risk management is most often done reactively, waiting until a risk becomes apparent to create a mitigation or optimization plan, but the most effective methods are done in preparation for risk event occurrence.

The Project Management Body of Knowledge (PMBOK) identifies seven key risk management tasks over a project's life cycle; Plan Risk Management, Identify Risks, Qualitative Analysis, Quantitative Analysis, Plan Risk Responses, Implement Risk Responses, Monitor Risk. These activities ensure that risks are well understood, clearly considered, and revisited often. Preparing for emergent risks helps to create a resilient project. Most projects focus on event risks but fail to recognize non-event risks such as variability or ambiguity risk. This is especially harmful to projects being developed using agile processes and ideologies. Agile project management has an iterative nature, creating a high-variability environment. [1]

Agile Project management was developed to allow projects, namely software projects, the ability to adapt and change along with the environment they aimed to cater to. This style of project management allows teams to streamline the rigid integrated change control processes that are standard in traditional project management practices. [2] In traditional project management processes, integrated change control helps to monitor risks associated with any decision to change or not change something about a product [3].

Though this process served many programs well, agile provided a more adaptable format for complicated projects with quick development cycles. Agile projects embrace change. These projects better themselves through collaborative review and continuous improvement. A core tenet of agile project management is the iteration of work done. But risk will always accompany change. Whether that risk is one of opportunity or threat, it must be carefully collected, refined, mitigated, discussed, and escalated [4]. Without a good understanding of the risks that surround a project, change may unknowingly put an otherwise successful endeavor on the road to failure. [5]

The need for methods to prepare projects for risks they may encounter, and the risk impacts they would incur open the opportunity for using simulation modeling in risk management. Mathematical modeling and computational development of risk management has long been used to characterize financial behavior and risk. Simulation modeling encourages a proactive and opportunistic stance when it comes to risk management by allowing the user to better understand the behavior of a system of interconnected processes and entities. [6]

The impact of risks to a project's schedule have been modeled using Monte Carlo simulations and continuous simulations. These simulations used key inputs like project duration and number of implemented issues to predict the time and effort required to fix errors in software code [7].

Discrete event simulation is suited to modeling systems that deal with complexity due to variability and interconnectivity over time. This method of simulation uniquely lends itself to modeling the risk management process of an agile project. This paper will offer a new framework for multi-team projects to predict risks to the project's schedule that they may encounter through a product's development cycle.

Chapter 2
Description of Methodology

In this section I will introduce the data set used to characterize and simulate the behavior of an agile project's risk response procedures or risk response system. I will also describe the construction of the discrete event simulation in Arena.

Data Analysis

To simulate an agile project's risk response system, a set of data was analyzed for behavioral trends. A sterilized data set was provided by Collins Aerospace for the identified risks of an Avionics project using Agile project management strategies. The information given in the data set included the risk's most likely realization date (date of occurrence/emergence), association (hardware, software, requirements, certification, etc.), probability of occurrence, cost impact, and schedule impact. Information including risk description, effect description, risk owner, and mitigation strategy had been scrubbed to avoid releasing proprietary information. The full data set included eighty-five risks, thirty-four of which were not "retired".

To simulate the schedule of risk realization, the time between risk emergence was calculated and graphed. After removing outliers, the resulting data was graphed as shown in Figure 1.

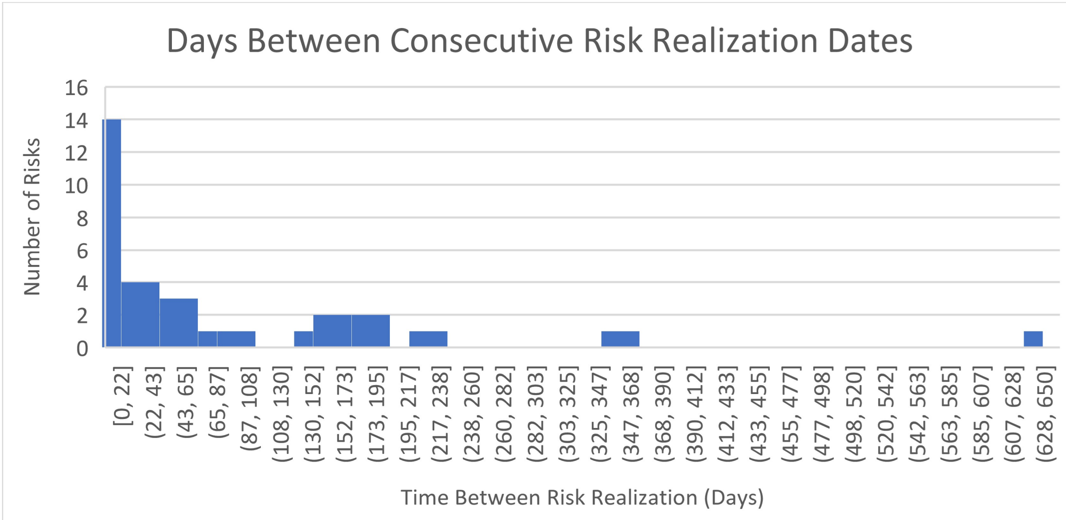

Figure 1 : Number of days between consecutive risk realization dates

The data shown in Figure 1 was then run through Arena's Input Analyzer to generate the best fit distribution. The resulting distribution is shown in Figure 2.

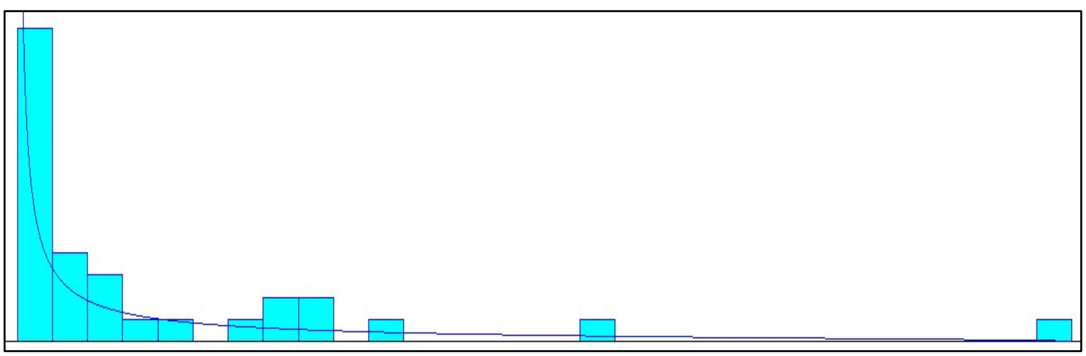

Figure 2: Best fit distribution of the risk realization schedule

The distribution shown in Figure 2 is characterized by Equation 1;

Equation 1

$$-.001 + 650 * BETA(0.194, 1.34)$$

This distribution was verified using the Kolmogorov-Smirnov Test, receiving an acceptable p-value of ≥ 0.05.

To characterize and simulate the effect a risk would have on the project's schedule, the impacts documented in the data set were analyzed. To consider all possible risks rather than only occurring risks, all risks in the data set that had a non-zero risk to the schedule (including retired risks) were considered to create an impact distribution. The impacts given by the risk data set are shown in Figure 3.

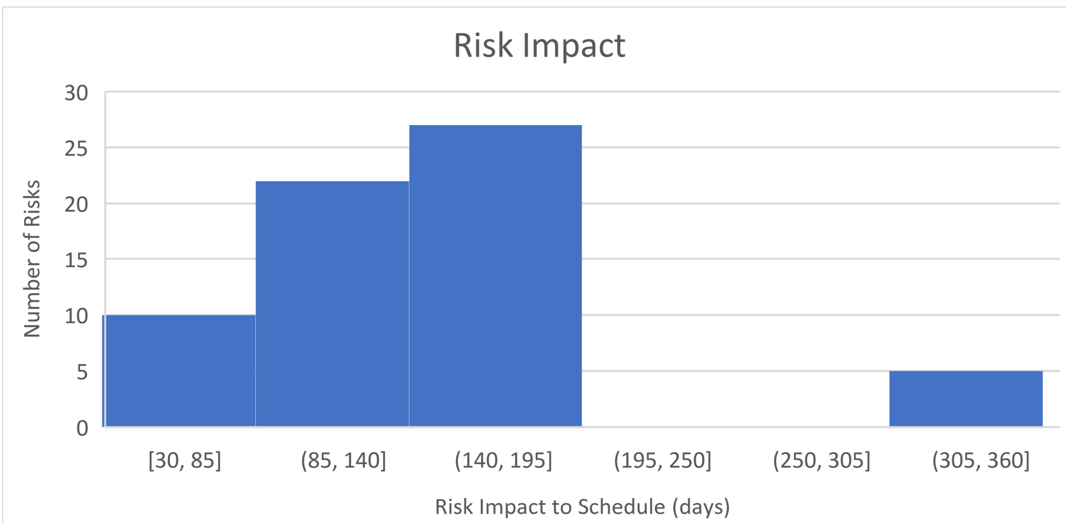

Figure 3 : Risk Impact to schedule across the full data set

The data shown in Figure 3 was run through Arena's Input Analyzer, resulting in the following distribution.

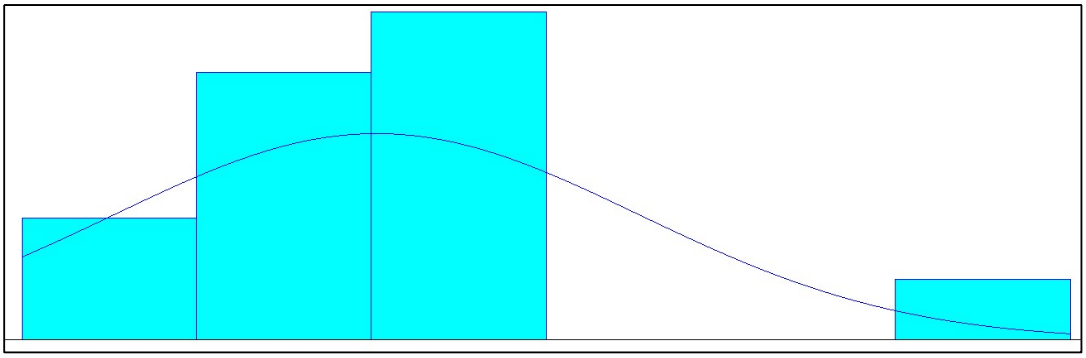

Figure 4 : Best fit distribution of the risk impact

The distribution shown in Figure 4 is characterized by Equation 2;

Equation 2

$$NORM(142, 82.7)$$

This distribution was verified by the Kolmogorov-Smirnov Test, which returned an acceptable p-value of ≥ 0.05.

The distributions shown in Figure 2 and Figure 4 have been identified as opportunities to improve the simulation and are discussed in the Future Work section.

The final data analysis required to characterize the risk response system is the delegation of work to parallel agile teams. This simulation will include three teams: systems, software, and hardware. Using the given association for each risk, the percentage of risks associated with each team was found, as shown in Figure 6.

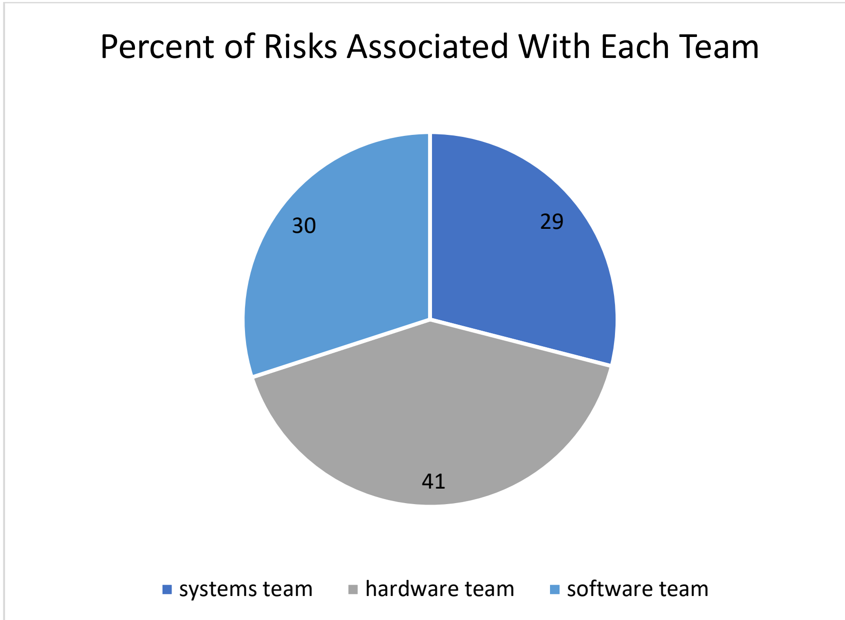

Figure 5 : Percent of risks associated with each team

The risk association will be used to assign risks and their resulting schedule impacts to each team.

Construction of the Discrete Event Simulation

The discrete event simulation of the project's risk response system will be developed in Arena. It is of note that this model was designed with the available data in mind. Were more data available, different design decisions would have been made. This is discussed in the future work section.

The model creates a risk that enters the system, which must be identified through a periodically occurring risk meeting. After this risk meeting, the risk will be sent to either the systems, software, or hardware team to address. While addressing the risk, the team will incur some impact to the schedule. Once that risk's impact has been felt, it should exit the system.

This process is shown fully modeled in Figure 6 of Appendix A.

Figure 6 illustrates the flow of a risk through this project's risk response system. Starting at the left, the risk is created using the risk realization distribution and counted. The "Risk Identified" block represents a uniformly distributed wait time of between zero and 6 days, representing the time between risk realization and the identification of the risk at a weekly risk meeting. Once it is identified, it is assigned to one of the three available teams. Within each team's block, the risk's impact is imposed on the project using the risk impact distribution. Finally, the risk exits the system.

Discussion of Simulation Assumptions

Several assumptions are made in this simulation. The first is that each team will address their assigned risks one at a time. This may add queue times that risks would not otherwise experience. In this simulation, the team is treated as one resource rather than the individual. An assumption is also being made that risks associated with each team can be represented using the same realization schedule and impact distributions. While risk association was provided in the data set, many risks had associations that could have been the responsibility of several teams (re-use, certification, resources, etc.). While calculating the percentage of risks assigned to each team, those with ambiguous associations were considered to have an equal chance of being assigned to each team. Without details on the risks there was not enough data to create distributions specific to each team.

Chapter 3
Discussion of Results

Discrete Event Simulation Results

The simulation was run for a duration of 2555 days (7 years) for 100 replications.

100 replications were selected using the confidence interval with specified precision method as well as graphical analysis to ensure that variance was stable. The duration of the project is based on the spread of the project risk's realization dates and the dates for which the risk realization schedule distribution is viable. The values shown in Table 1 are the results of the simulation.

Table 1: Results of Arena Simulation

	Average	**Average Minimum**	**Average Maximum**
Risks Realized	28.57 (hw = 1.47)	15	60
Risks Finished	27.11 (hw = 1.44)	14	54
Risk Impact	141.48 days (hw = 3.43)	98.88 days	194.78 days

This simulation predicts that a similar project will have about 28 risks realized over its duration with an average risk impact per risk of 141.48 working days.

Validation

Welch's T-Test was used to validate this model. The calculated t-value was 0.451 and the critical t-value was 1.687. When the calculated t-value is less than the critical t-value, the null hypothesis cannot be rejected. This means that the model does a good job of representing the limited data.

Chapter 4
Conclusion of Research

Conclusion

This thesis has described the work done to simulate the risk response system of a project with the goal of predicting the possible impact to the schedule. This simulation model was constructed using a risk register for an Avionics project as the base data set. This paper has shown that the constructed simulation model closely estimates the factored risk impact and provides useful insight into the possible schedule impacts to the project. The data set used is an example of a project that had a schedule impact above what was expected. Using this discrete event simulation could have given the project managers and planners valuable insight into possible and probable maximum impact scenarios. More rigorous methods of quantitative risk impact analysis are valuable to organizations and projects with low risk tolerance and thresholds. In conclusion, this thesis has shown the value that discrete event simulation has the ability to add to standard risk management procedures.

Future Work

The main future work for this topic would be improving the process distributions. Since this simulation model was based on a data set from one project, it is highly customized. Research on the behavior of risk for different teams and the behavior of risk in projects of different type or scale would add to the applicability of this framework. This simulation is highly dependent on the distributions for risk realization and impact, so as it stands, the simulation would only be applicable to similar projects.

A second opportunity for future work would be research specific to each team. It is likely that systems, hardware, and software teams have differing risk realization rates and risk impacts. For lack of data, they were assumed to be the same here, but a deeper dive into the way risk behaves in each team would add to this simulation's ability to replicate real-life behavior.

References

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Appendix

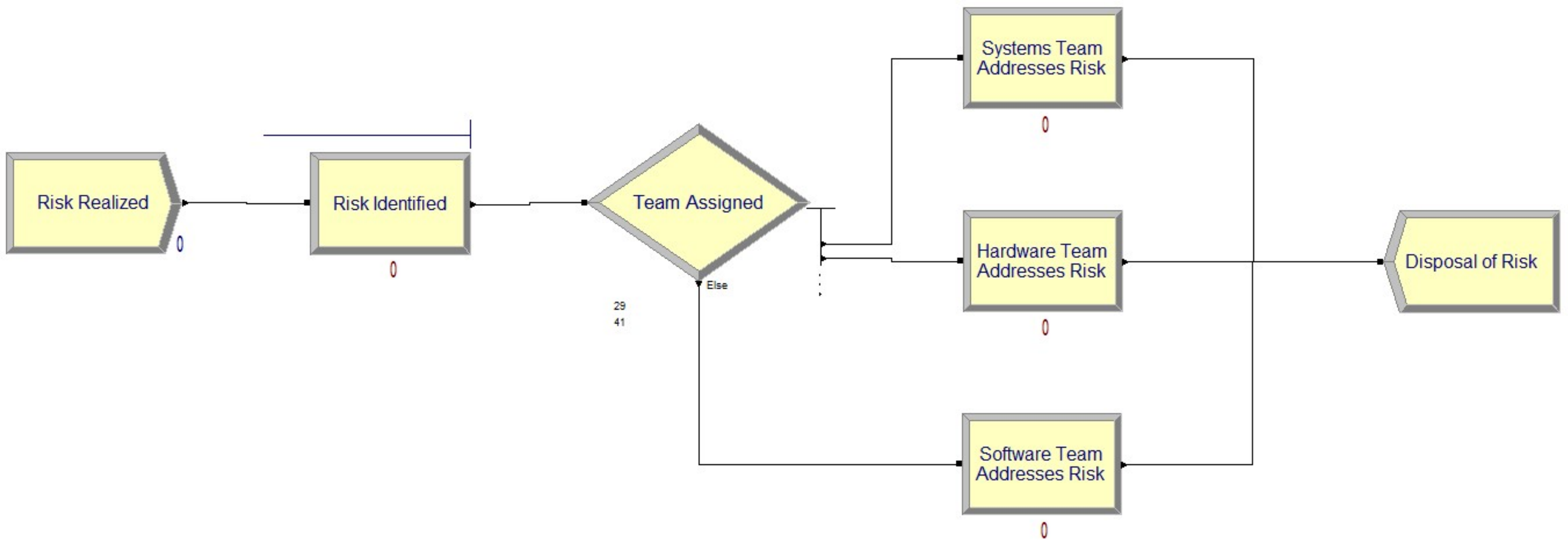

Figure 6 : Fully modeled arena simulation of the risk response system