ETM
ENGINEERING & TECHNOLOGY MANAGEMENT

Risk Management System for Brooks Cooperation

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Executive Summary

Brooks Corporation (BC) is a technology company that specializes in the design and manufacturing of wireless communication chips with a variety of clients such as Nokia, Motorola, Intel, Samsung and many others. Since its foundation, BC has striven to provide the best customer satisfaction by delivering its projects within the desired schedule and quality. A recent downturn in operations led BC's main stakeholders to request from senior management an identification of the causes and a cost effective solution. This prompted the formation of an internal team with the purpose of identifying the reasons for the current downturn. The team identified three problems that some of their projects had experienced: reduction of profit margin, negative payoff, and unsuccessful project outcomes. The conclusion of the analysis was that these problems stemmed from the fact that project managers and project teams did not use any risk analysis tools during the development of their projects. For this reason, senior management entrusted the team with the task of developing a company-wide risk management system (RMS) for BC.

The team structured the RMS around six phases of risk analysis (risk planning, risk identification, qualitative risk analysis, quantitative risk analysis, risk response planning, and risk monitoring and control) through which every new project company-wide would go using two different approaches: analysis of internal risks that are intrinsic to the project itself that can be reduced or avoided, and analysis of externals risks that are a product of external market and financial changes or any other external circumstances that cannot be control. The RMS integrates the use of a series of risk analysis tools such as SWOT analysis, prompt lists, Probability-Impact matrix, Monte Carlo analysis, and decision trees among others, with the purpose of helping BC's project managers and project teams to reduce or avoid negative effects on the outcome of a project. The team is convinced and ready to persuade the board members that a company-wide RMS is going to increase BC's payoff in their projects by reducing or avoiding the identified problems while continuing to provide the best customer satisfaction at the lowest cost.

Company Overview

Brooks Corporation (BC) specializes in the design and manufacturing of wireless communication chips. Their main focus is in the development of low-cost wireless chips that can operate on a wide frequency range. Their main customers are companies such as: Nokia, Motorola, Intel, Samsung, and many others. The company was founded by 2 bright engineers who came from the semi-conductor industry 18 years ago, David Jones and Kerry Adams. David and Kerry came up with an idea for how to solve the extremely high data transfer rates within the frequency bands used today. After realizing that they could soon fulfill their dreams working for themselves, they quickly jumped into working on their business plan. David provided the vision for the company while Kerry searched for inspired engineers to work for Brooks Corporation. BC currently employs 500 people including managers, marketing people, engineers, technicians, and support personnel.

BC has been successful in its business and it has received high recognition for providing customer satisfaction, but stakeholders and senior management have recently identified a downturn in their operations due to reductions in the level of profit and losses in a number of its projects. As a result of this, stakeholders have asked senior management to identify the roots of these situations and to provide a cost effective solution.

Identification of the Problem

Senior managers teamed up with lower level managers, project managers and lead engineers to take a closer look at BC operations. They identified that in some cases the company's desire to meet customer demand and to deliver a product at any cost had caused BC to compromise profit margin and in some other cases to incur losses. Another significant issue that was identified was that the final outputs of some projects were not useful to BC once they were completed due to drastic changes of external market and financial conditions. They only drove up cost and did not provide any profit to BC.

They realized that BC project managers had no metrics for selecting projects, which led to both the selection of bad projects and the rejection of good projects. Lack of definition in some bad projects made them look like good projects and did not allow project teams to eliminate them on time; therefore they became a liability down the road as costly and unsuccessful projects. Lack of definition in these projects did not trigger an alarm that additional analysis might have been needed. They also identified high capital investments in projects that were very promising when a decision to do them was made but later external market and financial conditions changed and made the final outcomes of these projects of low or no financial value to BC. There were no reassessments of the external market and financial conditions throughout the project development process that could have stopped those projects and therefore reduced financial losses.

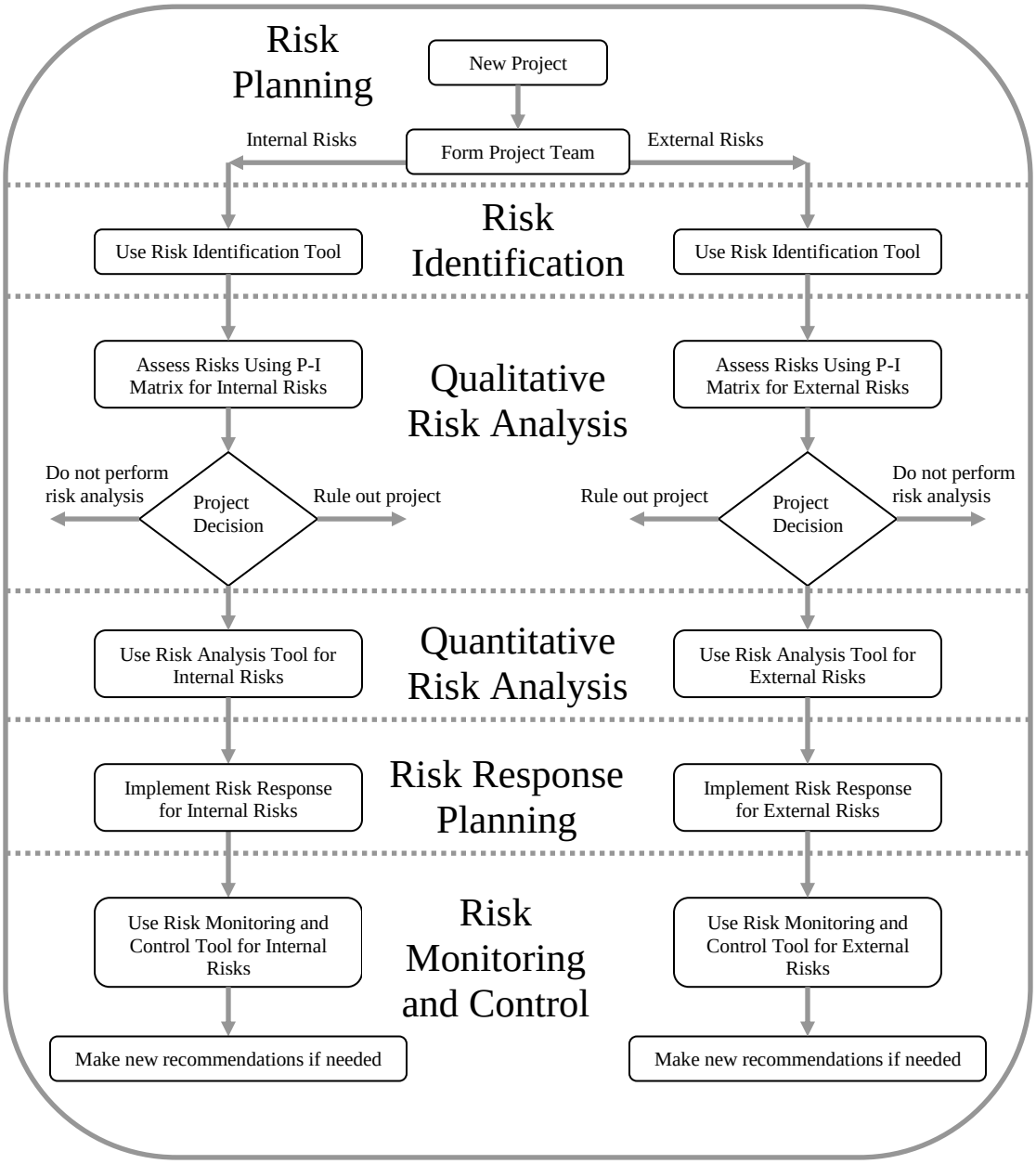
Out of all their analysis, it became very obvious to the team that BC had not used any risk analysis tools that could have helped them prevent or reduce the effects of these situations in their projects. As a result, senior management decided to assign the team they had formed to develop a company-wide risk management system for their internal

operations as well as for the external market, financial and other conditions that affect BC operations.

Risk Management System (RMS)

The first step of the process followed by BC's risk assessment team was to define and structure BC's Risk Management System. The RMS developed for BC is shown in Figure 1.

Risk Management System for Brooks Corporation



-Figure 1-

BC's RMS is structured around six common phases of risk analysis that include: risk planning, risk identification, qualitative risk analysis, quantitative risk analysis, risk response planning, and risk monitoring and control. The risk team decided that every new project company-wide would go through these six phases using two different approaches: (1) analysis of internal risks that are intrinsic to the project itself, and (2) analysis of externals risks that are a product of external market and financial changes. Each phase and each approach includes different risk analysis tools as determined by BC's risk team. The details of each phase for each approach are summarized below:

Internal Risks

a) Risk planning: The first step of this phase is the formation of a project team whenever a new project is evaluated. This team will gather all relevant information to the project such as project scope statement, assembly and part drawings, technical information, quantitative requirements, cost data, tooling cost, manufacturing data, operating service history, special features requirements, market survey, future plans and objectives, competitive situation, environmental regulations, and other potentially useful information.

b) Risk identification: Once all the information about the project has been studied and understood by the project team, they will perform SWOT analysis for the project. Using the results of this analysis the team will prepare a list of identified risks identifying their possible causes. BC created a generic risk breakdown structure (RBS) and a prompt list to assist project teams with risk identification. This RBS and prompt list for internal risk are included in Appendix A. The risk identification and assessment worksheet which would assist the project team in this process is presented in Appendix B.

c) Qualitative risk analysis: In this phase the project team will utilize the list of identified risks from the previous phase to rank them according to their risk level. The team will use a P-I (Probability-Impact) matrix to rank risks in three different categories: high severity, medium severity, and low severity. For this, the team will determine the most appropriate values for the qualitative factors of the probability and impact of internal risks based on the special characteristics of each project. An example of this type of tables is included in Appendix C. The template of a P-I matrix is also included in Appendix C.

After all internal risks have been ranked; the project team will decide their next step with the project. The three possible outcomes of this decision are: (1) the project is ruled out because its risk is higher than what BC's senior management is willing to take; (2) the team will determine which risks will not need any additional risk analysis since they are so low that BC is willing to accept them without further analysis; and (3) the team will determine which risks will need a quantitative risk analysis due to their importance in relation to BC's operations. The decision will be made based on the level of risk that BC's senior management has instructed the team to take. This level of risk will depend on the type of project, BC's financial condition, BC's strategy, market conditions, market

forecast and other factors relevant to the company at the time the project is being evaluated.

d) Quantitative risk analysis: After identifying the high severity risks in qualitative risk analysis, the team will perform a detailed analysis of these risks in order to quantify the probability and impact of the risks to BC's operations and performances. This could be done by using project simulation and modeling tools which help translate the specified uncertainties in the project into the probability along with the associated potential impacts to the project. The project team should utilize the Monte Carlo simulation technique which helps simulate a random number of scenarios of the uncertain elements in the project according to a probability density function. In order to obtain the input variables (uncertainty elements) and their associated probability density function, the project team could gather the necessary data by interviewing the personnel associated with the work elements to come up with three different scenarios of information, namely the optimistic scenario (where risk impact is the lowest), the pessimistic scenario (where the risk impact is the highest), and the most likely scenario where the risk impact lies between the optimistic and the pessimistic scenario. From this information, the project team could estimate the probability density function of input variables for Monte Carlo simulation accordingly.

Moreover, for the project with multiple risk factors, it is recommended that the project team should utilize sensitivity analysis to identify and determine the different level of impact of each risk in the changing conditions. For the presentation of the sensitivity analysis, the team could use both spider plot and tornado plot. Tornado plot displays the list of risks and their degree of uncertainties; the higher the uncertainty and the impact of the risk, the higher the level of that risk in the tornado chart. Spider plot provides the information of the level of the change of the impact of each risk in accordance with the change in project condition. When used together, the project team could quantify the risks with higher uncertainties and impact to the project.

e) Risk response planning: In this phase, the project team will develop the options to respond to the risk that is likely to occur with an appropriate strategy. The risk response plan will be developed based on the information gathered from the earlier phases (risk identification, qualitative and quantitative risk analysis) by listing the risk in prioritized order and assigning one or more project team members to be the risk response owners to take a responsibility in controlling the response for each risk. The contingency plan for each risk would then be developed and the associated additional contingency resources would be identified along with the trigger points that the contingency plans should be put into action. The risk response owners will keep track of the contingency plans, and their associated trigger events. An example of a risk response plan is shown in Appendix D.

f) Risk monitoring and control: In this phase, the project team would continue identifying, analyzing and planning for possible newly emerging risks as well as keeping track of the identified risks and reanalyzing the existing risks. This phase also includes the monitoring system for the trigger of contingency plan for the risk response as well as evaluating the overall risk response performance of the project. This is the on-going and

feed-back process that should be done on a regular basis. The project team is recommended to include the risk monitoring and control system as an agenda item in the periodical project status meetings. The risk response owners for each risk would report the status of their responsible risk items to the project status meeting and the risks which require attention would be discussed in the meeting with the resolved and updated result. The project team should keep the records of each risk in the central risk management database so that they may be of benefit for future projects of BC.

External Risks

a) Risk planning: In order to achieve the best results of the risk management system as to the external risks, the effort needs to be conducted by upper management with the assistance of the project manager for the partial project or the collaborative assistance from all project managers that the particular risk may impact. It is important that upper management and their supporting staff are on constant lookout for competitor's movement, as well as the world economy. It is also important to evaluate what new technologies in the market are in the R&D stage. In essence, this involves constantly evaluating and monitoring the external forces that have both direct and indirect impacts on the business. Although external risk to a project will be initially analyzed at the beginning of a new project, the process will be repeated as many times as needed when significant external changes occur.

b) Risk identification: External risks may stem from different categories including customers, market, partners, contractors/subcontractors, government, and/or environmental agencies. The project team should brainstorm all the potential risks from these categories and others. At this point, all the possible risks should be included without focusing on other details about them. Use the prompt list for external risk (as shown in Appendix A) to organize the brainstorming session with the support of risk identification and assessment worksheet (Appendix B.)

c) Qualitative risk analysis: Before prioritizing the identified risks, two variables for each risk should be assessed: likeliness to happen (probability) and the impact. Use P-I matrix (as shown in Appendix C) for this assessment. Note that the risks positioned in the high severity cells have more priority for the team to analyze them (i.e. more time and resources should be allocated to them for further analysis as well as the development of contingency plans in the subsequent phases – see risk response planning below.) The risks in medium severity and low severity have less priority respectively.

Similar to internal risks, the project team will decide their next step with the project based on external risk. The three possible outcomes of this decision are: (1) the project is ruled out because its risk is higher than what BC's senior management is willing to take; (2) the team will determine which risks will not need any additional risk analysis since they are so low that BC is willing to accept them without further analysis; and (3) the team will determine which risks will need a quantitative risk analysis due to their importance in relation to BC's operations. The decision will be made based on the level of risk that BC's senior management has instructed the team to take. This level of risk will depend

on the type of project, BC's financial conditions, BC's strategy, market conditions, market forecast and other factors relevant to the company at the time the project is being evaluated.

d) Quantitative risk analysis: External risk factors may not be easy to quantify due to a high level of uncertainty as well as the difficulty of attaching numerical values to the impact of the external risk. However, decision tree analysis will provide an approximated EMV (Expected Monetary Value) as to how each external risk will affect the organization and the project in terms of dollar amounts. Example of decision tree is shown in Appendix E. It is useful to develop the decision tree analysis with the assistance of a team of experts from within the company with different organizational roles, insuring proper evaluation of the risk at hand from as many possible perspectives. The team of experts assembled can be formed based on the type of external risk faced, which in turn will allow the most accurate analysis of the risk as well as the most appropriate recommendation to resolve the risk.

e) Risk response planning: Because of the highly competitive nature of the business that Brook Cooperation operates in, external risks are expected. Depending on the assessment of the risk, different strategies could be utilized to resolve the risk. These strategies include risk avoidance, risk transfer and risk mitigation. Associating certain risks with a certain strategy may not be valuable because the same risk under different circumstances may be handled with a different strategy depending on the position of the company as to the availability of technical and financial recourses as well as other internal and external factors that contributes to the assessment of the current risk. Therefore, the response action plan will be drafted for each individual risk. The risk response action plan needs to allocate the sub-category of the risk, with initial research, and recommended action as well as the contingency plan using a form similar to the internal risk response plan as shown in Appendix D.

f) Risk monitoring and control: In order to achieve an effective monitoring and control system, a systematic approach needs to be implemented and followed. In the dynamic global business world, what may be seen as a threat based on current market assessment may easily be resolved through a supporting innovation or the sudden change in market conditions. Nevertheless, as the early signs of risk are observed, a registration of the risk needs to be recorded. More importantly, periodic monitoring of the risk needs to be conducted, to insure accurate assessment and progress of the risk. The higher the impact of the risk, the shorter the time interval should be. In achieving this objective, an internal database can be set up where risks are recoded and monitored. It would also serve to capture the lessons learned for organizational knowledge management. It would be important to allocate the task to a personal capable of handling the job of risk book-keeping. In doing so, the individual or department (as the company grows in the number of their projects) would be responsible to generate reports that would be used in the process of evaluating the current risk at hand.

Conclusion

The reduction of profit margin, negative payoff, and unsuccessful project outcomes that Brooks Cooperation is experiencing with some of their projects can certainly be reduced or avoided by the use of risk analysis tools in their projects. A company-wide RMS will provide a structured framework to project managers and project teams on how to analyze the internal risks associated with a specific project as well as those external risks that can have an effect on BC's corporate operations and therefore have direct effects on a project. With a RMS in place, every single one of these risks will be identified, categorized, analyzed, and monitored so that a specific response plan will be in place to determine the necessary contingencies in case of their appearance. It will also induce BC to clearly lay out their corporate strategy in terms of the levels of risks that the company is willing to take under specific circumstances at the time that their projects are being developed. On the final note, although the RMS presented in this report is focused on potential risks, the same approach can also be used for the opportunities that present to BC as well.

Appendix A

Brooks Corporation
Risk Breakdown Structure

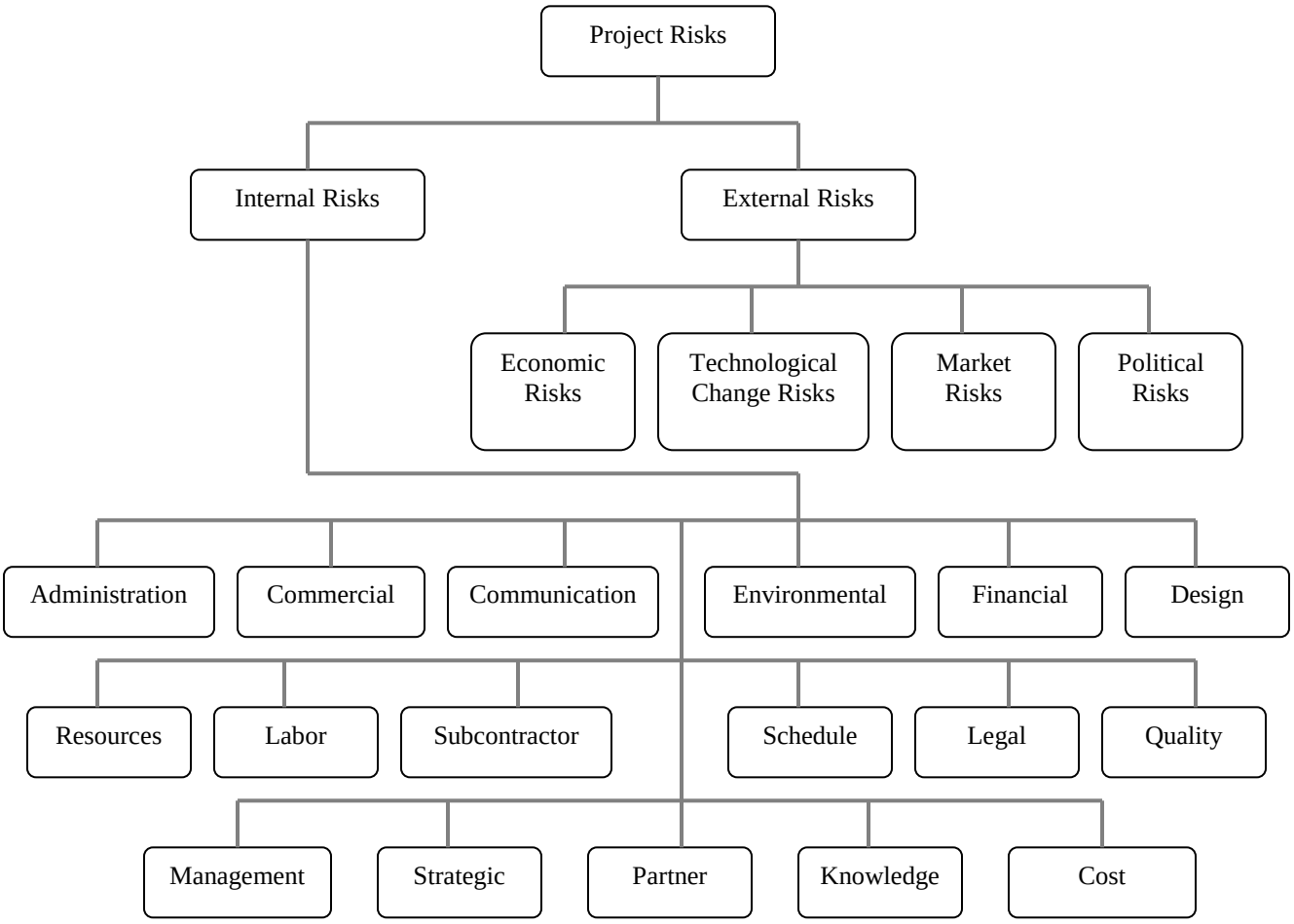


Figure A1-Brooks Cooperation risk breakdown structure

Administration	Schedule
Cost	Quality
Knowledge	Resources
Legal	Communication
Management	Technology
Sponsorship	Workforce
Budget	

Table A1-Prompt list for internal risk

Customer	Partner
Market	Political
Environmental	Industry
Legal	Subcontractor
Competitor	Contractor
Customer	Partner
Strategic	

Table A2-Prompt list external risk

Note: These are not comprehensive categories for possible risks. Its purpose is to prompt initial thoughts and assist you to cover all the possible risks in "Risk Identification and Assessment Worksheet" (see Appendix B)

Appendix B

Brooks Cooperation
Risk Identification and Assessment Worksheet

Project Name:_____
Contact Name:_____ Phone:_____ Department:_____
Check one box: Strategic/External Risks ☐ OR Operational/Internal Risks ☐

Risk #	WBS Item (if any)	Risk Description	Impact Description

Table B1-Risk identification and assessment worksheet

Appendix C

Brooks Corporation
Predefined values for the qualitative factors of the probability and impact of internal risks

Brooks Corporation Predefined Conditions for Impact Scales of Risks on Major Project Objectives					
Project Objective	Very low / 1	Low / 2	Moderate / 3	High / 4	Very High /5
Administration					
Commercial					
Communication					
Environmental					
Financial					
Design					
Resources	Insignificant resources increase	<10% resources increase	10-20% resources increase	20-40% resources increase	>40% resources increase
Labor	Insignificant labor increase	<10% labor increase	10-20% labor increase	20-40% labor increase	>40% labor increase
Subcontractor	Insignificant cost increase	<10% cost increase	10-20% cost increase	20-40% cost increase	>40% cost increase
Schedule	Insignificant increase in schedule	<5% schedule increase	5-10% schedule increase	10-20% schedule increase	>20% schedule increase
Legal					
Quality	Quality degradation barely noticeable	Only very demanding applications are affected	Quality reduction requires sponsor approval	Quality reduction unacceptable to sponsor	Outcome of project is useless
Management					
Strategic					
Partners					
Knowledge					
Cost	Insignificant cost increase	<10% cost increase	10-20% cost increase	20-40% cost increase	>40% cost increase

Table C1-Predefined values for impacts of internal risks

Brooks Corporation Predefined Conditions for Probability Scales of Risks on Major Project Objectives					
Project Objective	Very low / 0.1	Low / 0.2	Moderate / 0.3	High / 0.4	Very High / 0.5
Administration					
Commercial					
Communication					
Environmental					
Financial					
Design					
Resources	Insignificant resources increase	<10% resources increase	10-20% resources increase	20-40% resources increase	>40% resources increase
Labor	Insignificant labor increase	<10% labor increase	10-20% labor increase	20-40% labor increase	>40% labor increase
Subcontractor	Insignificant cost increase	<10% cost increase	10-20% cost increase	20-40% cost increase	>40% cost increase
Schedule	Insignificant increase in schedule	<5% schedule increase	5-10% schedule increase	10-20% schedule increase	>20% schedule increase
Legal					
Quality	Quality degradation barely noticeable	Only very demanding applications are affected	Quality reduction requires sponsor approval	Quality reduction unacceptable to sponsor	Outcome of project is useless
Management					
Strategic					
Partners					
Knowledge					
Cost	Insignificant cost increase	<10% cost increase	10-20% cost increase	20-40% cost increase	>40% cost increase

Table C2-Predefined values for probability of internal risks

Low, Medium, and High severity by P-I scores							
IMPACT	Catastrophic	5					
	Major	4					
	Modest	3					
	Minor	2					
	Insignificant	1					
		Impact/ probability score	1	2	3	4	5
			Rare	Unlikely	Possible	Likely	Almost certain
			Probability				

Table C3-Probaility-Impact matrix for risk prioritization

Legend:

	High severity
	Medium severity
	Low severity

Appendix D

Brooks Cooperation
Example of Risk Response Plan

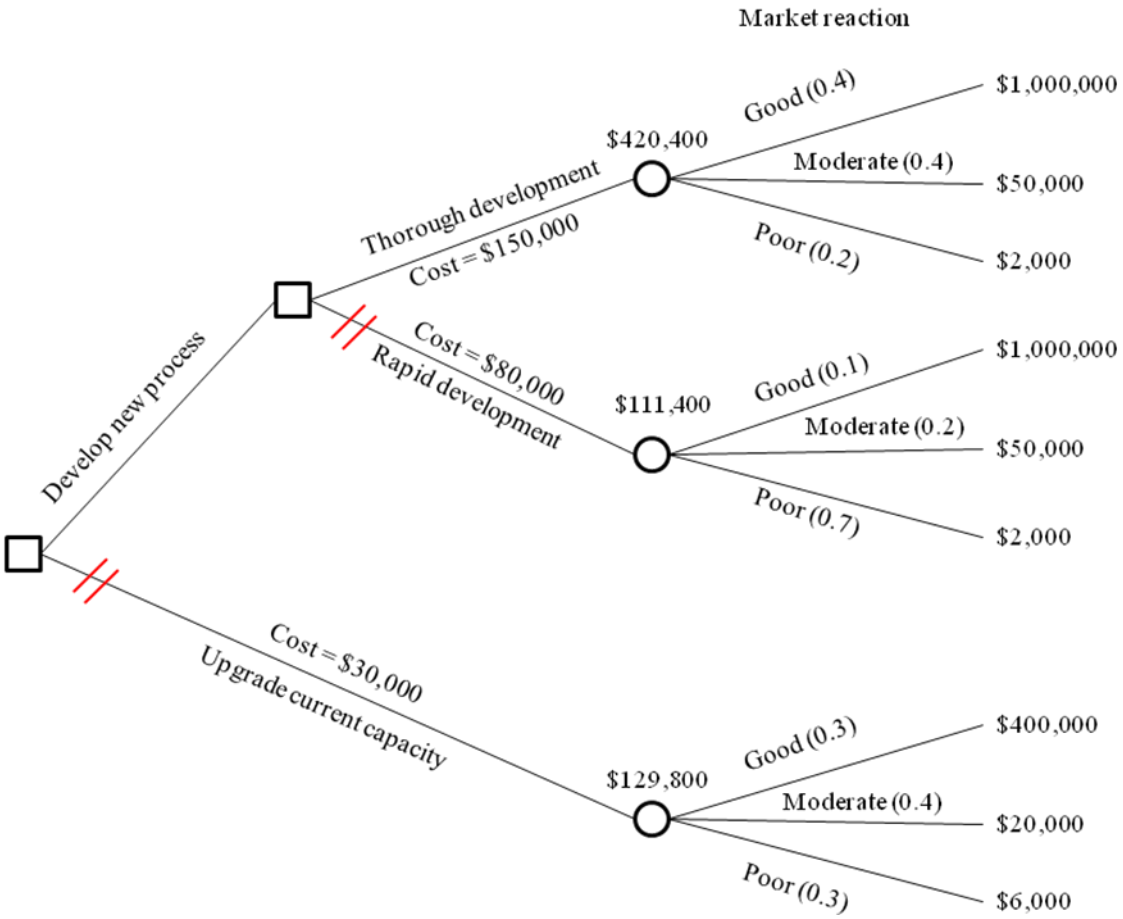
Code	Category	Name of Risk	P-I Scores	Ranking of P-I	How to minimize	Contingency Plan	Risk response owner
1	**Definition**						
1.1	Gather Project requirements	Vague requirements			1. Meet with customer face to face and ask for explanations. 2. Ask for customer specifications		White
1.2	Assign Project Manager	No available of qualified project manager			Hire or contract a qualified PM	1. Borrow an experienced PM from another project 2. Hire or outsource an experienced PM	Smith
		All PMs are staffed for other Projects			Hire or contract a new PM	Reassign one of the low priority PMs	Jackson
1.3	Get system requirements	Unclear or incomplete system requirements			Study system Requirements early in the stage	Reassign one project manager to this project	Hong
1.4	Create Scope	Customer changes the scope			Agree with the customer to freeze the scope. Any scope changes have to be re-negotiated	1. Get more resources 2. Get More budgets from customer 3. Outsource the additions	Hong
1.5	Staff the project	Cannot find qualified talent					Smith
		over committed engineering resources					White
		Employee Attrition			Hire or Counter offer		Jackson
2	**Design and development**						
2.1	Technology availability	The technology is not available as predicted			Partner with others to develop technology	Outsource or license available technology	
		change in customer requirements					
2.2	Scope Change	Customer changes the scope					
2.3	tools	Measurement tool not available			Contract more than one tool developer		
2.4							
3	**Testing**						
3.1	SW Integration and testing	SW delay					
		SW bug					
		SW components integration issues			Have one SW company do it all		

Code	Category	Name of Risk	P-I Scores	Ranking of P-I	How to minimize	Contingency Plan	Risk response owner
3.2	HW Testing	HW bug					
		HW delay					
3.3	System Integration Testing	System integration bug					
		Change in customer test requirements					
3.4	Design / architecture bug	Uncovered a design bug					
4	**Release**						
4.1	Qualification	Customer qualification procedures change					
4.2							
4.3							
4.4							
5	**Training**						
5.1	Create a training plan	Time Limitation					
5.2		Unavailable Resources					
5.3	Implement Training plan	Time Limitation					
5.4							

Table D1-Example of risk response plan

Appendix E

Brooks Cooperation
Example of Decision Tree



Decision tree is a tool for decision making by incorporating the events that the decision maker could choose (depicted with the square nodes) with the chances or the states of the nature that have different outcome according to the probability associated with each chance node (depicted with the circle nodes.) The associated expected monetary value of each outcome is assessed from the end point to the beginning of the decision tree and the decision maker would choose the event that yields the highest expected monetary value.

In this example, the company faces the decision whether to develop the new process or upgrade its current capacity. If it chooses to develop the new process, there is another additional decision to make whether to use thorough development or rapid development. The uncontrollable chances are the market reaction which has different probability and different outcome for each decision. In this example, thorough development yields

expected monetary value of $420,400 while rapid development yields the value of $111,400. After subtracting the cost of the development, it is clear that thorough development yields the higher monetary value and the company should choose this path. When comparing with the upgrade option which yields the expected monetary value of $129,800 and costs $30,000, the option to thoroughly develop the new process yields the highest expected monetary value. Thus, the best decision in this case is to choose the new process development with thorough development option.