Project Risk Management

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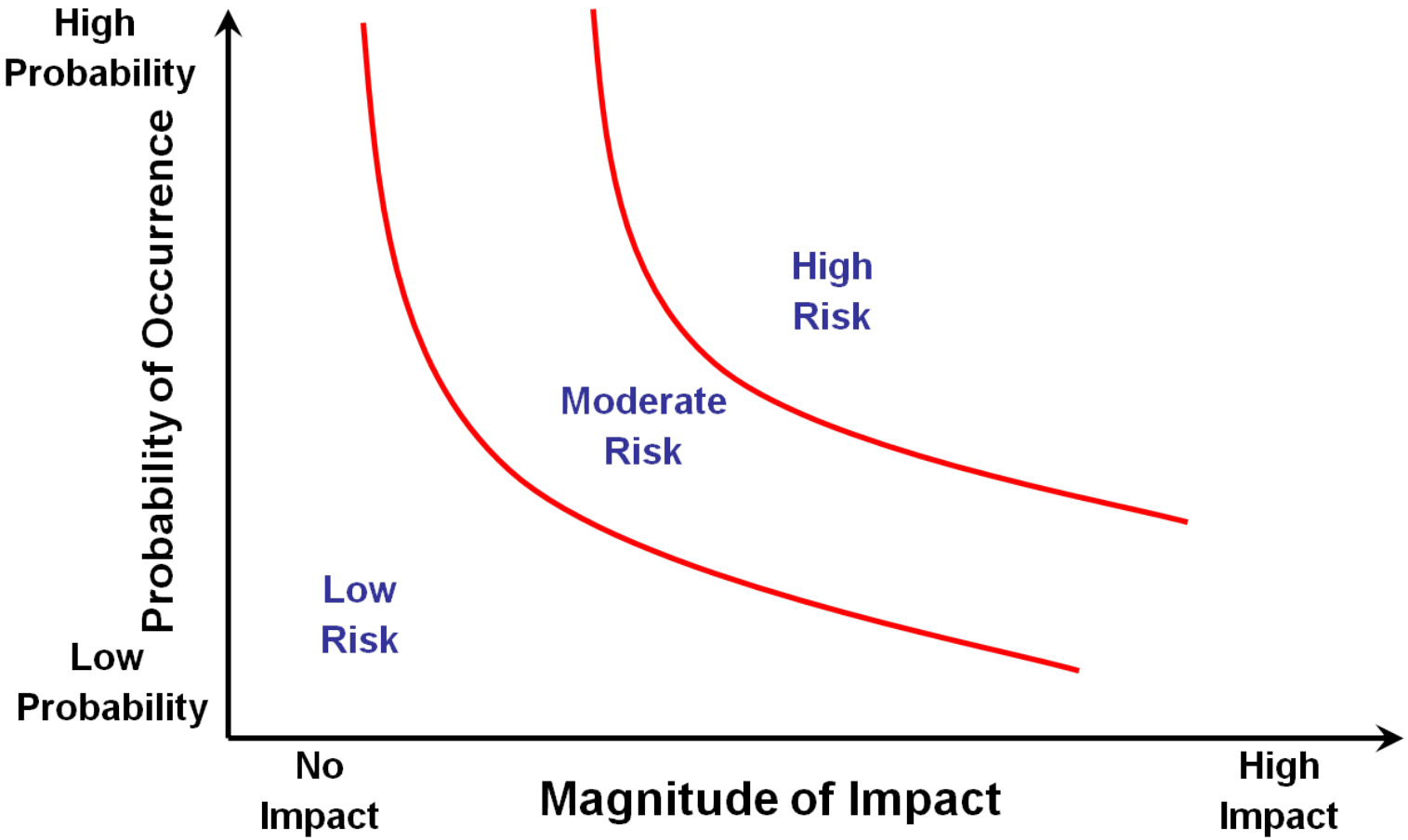
Project Risk Management

Risk is a measure of the probability and consequence of not achieving a defined project goal. Risk has two primary components

- A probability of occurrence of that event - likelihood
- Impact of the event occurring - How much will it cost?

Risk is a function of likelihood and impact

Project Risk Management



Project Risk Management

Risk is, in effect, a lack of knowledge of future events

- Future events that are favourable are called opportunities
- Future events that are unfavourable are called risks

Another element of risk is its cause.

- This can be something present or something missing
- This is referred to as a ‘hazard’

Hazards

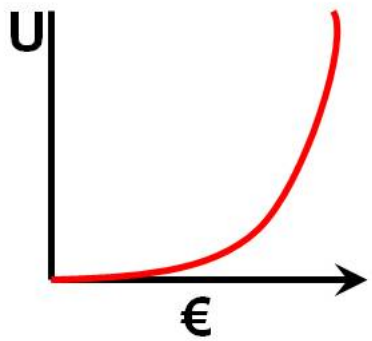
Certain hazards can be overcome by:

- Knowing what they are
- Taking action to overcome them
- So Risk is also a function of the hazard and the safeguard

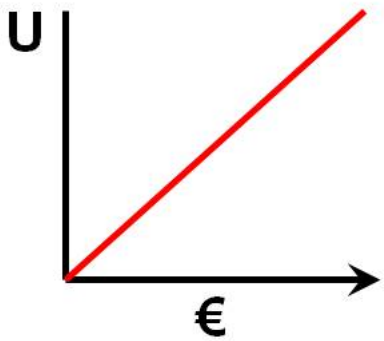
Risk Increases with hazard and decreases with safeguard

Tolerance for Risk

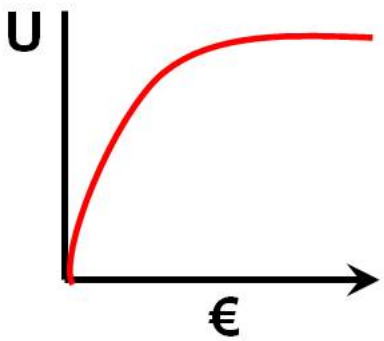
- Depends on individuals and/or organisations.
- Some companies seek out risk, others avoid



Risk Seeker



Risk Neutral



Risk Averter

Project Risk Management

Risk Seeker

- PM's satisfaction increases at a greater rate as more money is at stake

Risk Averter

- Utility rises at a decreasing rate.

As more money is at stake the project managers satisfaction diminishes

Project Risk Management

The objectives of Project Risk Management are

- to increase the probability and impact of positive events
- and to decrease the probability and impact of negative events

Project Risk Management includes:

- Plan Risk Management
- Identify Risks
- Perform Qualitative Risk Analysis
- Perform Quantitative Risk Analysis
- Plan Risk Responses
- Monitor and Control Risks

Plan Risk Management

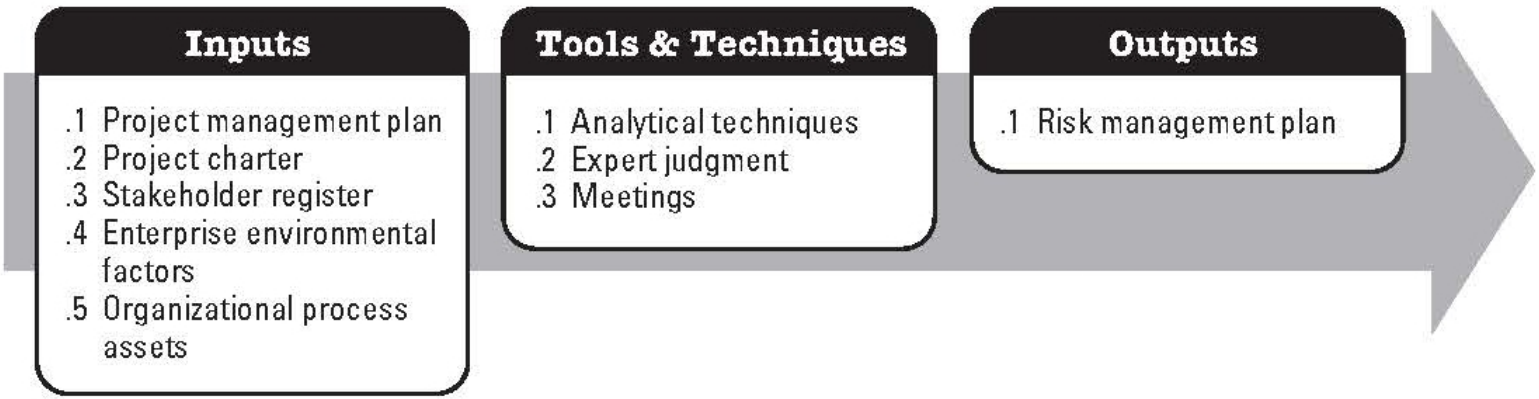


Figure 11-2. Plan Risk Management: Inputs, Tools & Techniques, and Outputs

Part of the Planning Process Group

Plan Risk Management

Inputs

- Enterprise Environmental Factors

Attitude towards risk and the risk tolerance of the organisation, and individuals

- Organisational Process Assets

Predefined approaches to risk management, such as risk categories, standard templates, and authority levels for decision making

- Project Scope Statement
- Cost/Schedule Management Plans

Plan Risk Management

Tools and Techniques

- Planning Meetings and Analysis
- Meeting to develop Risk Management Plan
- Attendees may include PM, PM team, stakeholders

Outputs

- Risk Management Plan
- Methodology
- Roles and Responsibilities
- Budgeting
- Timing
- Risk Categories
- Definitions of Risk Probability and Impact (Probability and Impact Matrix)
- Revised Stakeholders Tolerances
- Reporting Formats

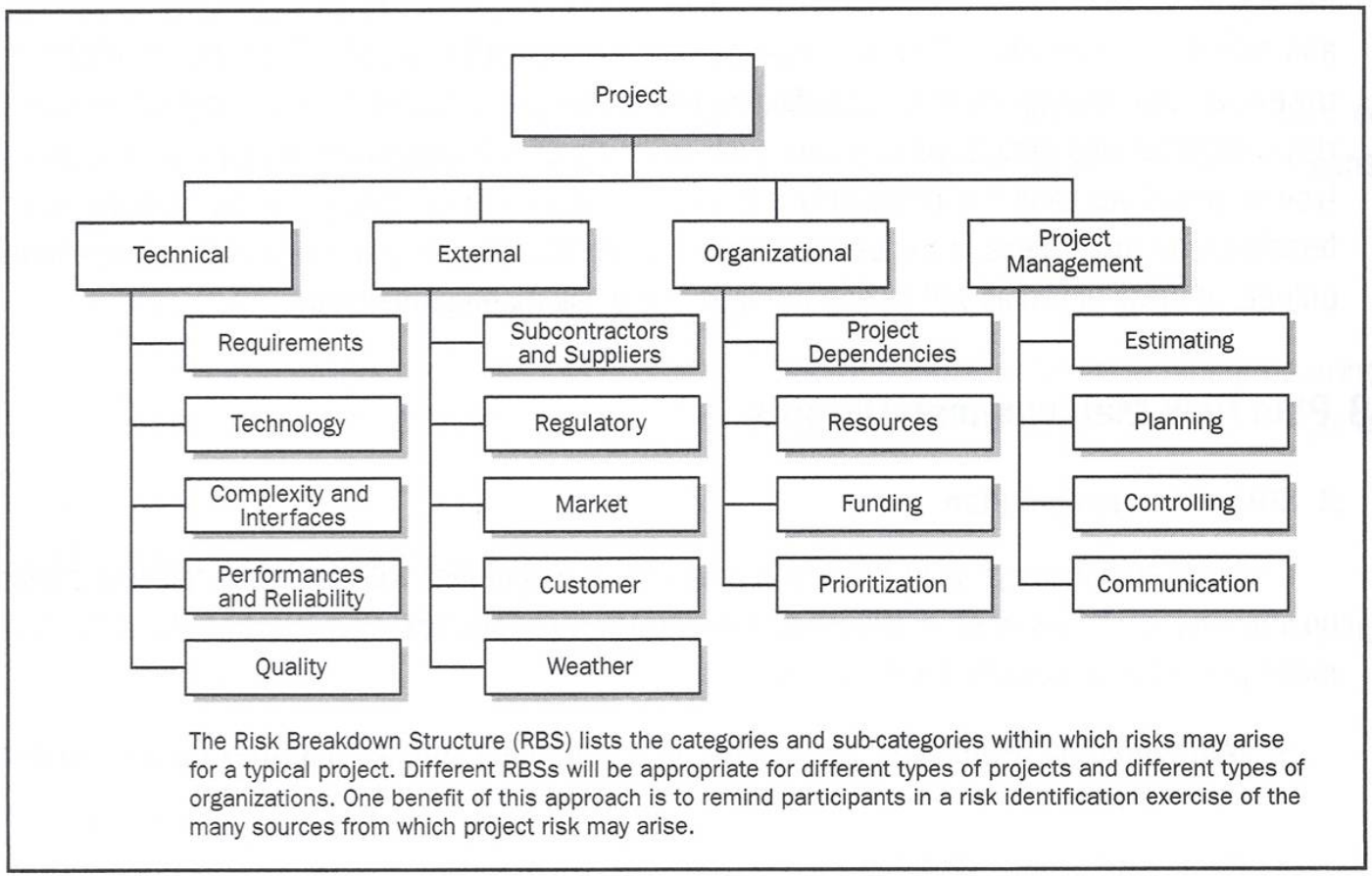
Risk Management Plan

- Methodology
- Defined approaches, tools, and data sources
  - Roles and Responsibilities
- Defines Lead, support and risk management team membership for each type of activity in the risk management plan, assigns people to these roles, and clarifies their responsibility
  - Budgeting
- Assigns resources and estimated costs needed for risk management.
  - Included in the project baseline costs

Risk Management Plan

- Timing
  - Defines when and how risk management processes will be performed
  - Establishes Risk Management activities to be included in project schedule
- Risk Categories
  - Provides a structure that ensures a comprehensive, systematic process to identify risk.
  - Risk Breakdown Structure (RBS)

Plan Risk Management



The Risk Breakdown Structure (RBS) lists the categories and sub-categories within which risks may arise for a typical project. Different RBSs will be appropriate for different types of projects and different types of organizations. One benefit of this approach is to remind participants in a risk identification exercise of the many sources from which project risk may arise.

Figure 11-4. Example of a Risk Breakdown Structure (RBS)

- Risk Breakdown Structure (RBS) From PMBOK 4

Risk Management Plan

Definitions of Risk Probability and Impact

- The Quality and Credibility of the Qualitative Risk Analysis Process
- Assigns a relative scale for probability
  - ‘very unlikely’ to ‘almost certain’
  - Very unlikely = Government not paying contractor
  - Almost certain = Final account dispute
  - May also be 1.0 to 0.0
- Probability and Impact Matrix

Plan Risk Management

Impact Scale

Table 11-1. Definition of Impact Scales for Four Project Objectives

Defined Conditions for Impact Scales of a Risk on Major Project Objectives (Examples are shown for negative impacts only)					
Project Objective	Relative or numerical scales are shown				
	Very low /0.05	Low /0.10	Moderate /0.20	High /0.40	Very high /0.80
Cost	Insignificant cost increase	< 10% cost increase	10 – 20% cost increase	20 – 40% cost increase	> 40% cost increase
Time	Insignificant time increase	< 5% time increase	5 – 10% time increase	10 – 20% time increase	> 20% time increase
Scope	Scope decrease barely noticeable	Minor areas of scope affected	Major areas of scope affected	Scope reduction unacceptable to sponsor	Project end item is effectively useless
Quality	Quality degradation barely noticeable	Only very demanding applications are affected	Quality reduction requires sponsor approval	Quality reduction unacceptable to sponsor	Project end item is effectively useless

This table presents examples of risk impact definitions for four different project objectives. They should be tailored in the Risk Management Planning process to the individual project and to the organization's risk thresholds. Impact definitions can be developed for opportunities in a similar way.

Risk Management Plan

Definitions of Risk Probability and Impact

- Probability and Impact Matrix

Probability and Impact Matrix

Probability	Threats					Opportunities				
0.90	0.05	0.09	0.18	0.36	0.72	0.72	0.36	0.18	0.09	0.05
0.70	0.04	0.07	0.14	0.28	0.56	0.56	0.28	0.14	0.07	0.04
0.50	0.03	0.05	0.10	0.20	0.40	0.40	0.20	0.10	0.05	0.03
0.30	0.02	0.03	0.06	0.12	0.24	0.24	0.12	0.06	0.03	0.02
0.10	0.01	0.01	0.02	0.04	0.08	0.08	0.04	0.02	0.01	0.01
	0.05/ Very Low	0.10/ Low	0.20/ Moderate	0.40/ High	0.80/ Very High	0.80/ Very High	0.40/ High	0.20/ Moderate	0.10/ Low	0.05/ Very Low

Impact (numerical scale) on an objective (e.g., cost, time, scope or quality)

Each risk is rated on its probability of occurring and impact on an objective if it does occur. The organization's thresholds for low, moderate or high risks are shown in the matrix and determine whether the risk is scored as high, moderate or low for that objective.

Risk Management Plan

Revised Stakeholders Tolerances - As project risks are identified, stakeholders may change their tolerance for specific risks.

- Schedule Risks
- Budget Risk
- Quality Risk

Reporting Formats

- Content and Format of Risk Register
- Defines how outcomes of risk management will be documented

Tracking

- Documents how all facets of risk activities will be recorded for the benefit of the current project, future needs, and lessons learned

Project Risk Management

Because of the unique and temporary nature of projects, projects carry a greater level of risk than operations.
Risk may be defined as an uncertain event or condition that, if it occurs, has an effect on the project objectives.

Managing project risk is an integral part of Project Management and critical to project success. Not managing project risk may result in:

- Over Budget
- Over Time
- Poor Project Performance
- Loss of reputation

Risk Management

RM includes the processes concerned with identifying, analysis and responding to uncertainty.
The purpose of risk management is to identify the risk factors for a project and then establish a risk management plan to minimize the probability & impact that the negative risk event will have on the project.
The goal of risk management is to identify project risks and develop strategies, which either significantly reduce them or take steps to avoid them altogether.

Risk Management

A Risk is a potential future problem that has not yet occurred

- A reactive project manager tries to resolve issues when they occur.
- A proactive project manager tries to resolve potential problems before they occur.

Risk Management

- No universal definition of the terms used.
- The scope and quality knowledge areas need review to see opportunities or threats.
- A single risk event may have multiple effects.
- Opportunities for one stakeholder may be a threat for another.
- Mathematical techniques used may create a false impression of precision and reliability.
- Risk probability x Risk value (their product) is a typical risk quantification procedure.
- Responses include: contracting, bonding, contingency planning, insurance, alternative strategies.

Risk Management

- RM includes the processes concerned with identifying, analysis and responding to uncertainty.
- The key principle of Risk Management is to foresee problems before they occur and plan responses to them
- Risk may be defined as an uncertain event or condition that, if it occurs, has an effect on the project objectives.

Risk Management

RM includes the processes concerned with identifying, analysis and responding to uncertainty.

- Risk Identification
- Risk Quantification
- Risk Response Development
- Risk Response Control & Monitoring

Risk Management

IDENTIFICATION:

- Sources, events, probability x amount at stake

QUANTIFICATION:

- Influence diagrams, probability distribution, probability trees, risk modelling, sensitivity profiles

RESPONSE DEVELOPMENT:

- Avoid, transfer, mitigate, retain/accept,

RESPONSE CONTROL:

- Execute plan in event

Risk Analysis

Risk needs to be measured in terms of its potential impact or cost on the project, and the probability that the risk event will actually occur.

Qualitative Analysis

- The overall risk measure against each risk is a combination of both of the probability that it will occur and the impact that the risk would have should it occur.
- Both the probability and impact are qualitative measures based on the team experience and technical knowledge.
- Risk Prioritisation
  - The risks analysed are prioritised for action

Risk Response

For each risk identified a Risk Response Strategy that should be considered. Choices are:

- Risk Avoidance
- Risk Transference
- Risk Reduction
- Risk Acceptance

Risk Levels

- Risk occurs in different ways at every level of an organisation.
- Risk may occur at the strategic level, programme level, project level and operational level.
- Strategic Risk may be described as risk to the business strategy and is the concern and responsibility of the Management team.

Risk Levels - Programme Risk

Risk at this level could be due to:

- Interdependencies between projects
- Overall resource levels
- Changes in approved budget
- Materials supply capability
- The wider system - the political, economic, social, technological environment

These risks affect many projects simultaneously, and are managed by the Programme manager.

Risk Levels - Project & Operational

Project Risks:

- Risks at this level are threats to the success of a single project, and most often impact the principal targets of scope, time, cost, and quality, though may impact other knowledge areas at the same time. Risks that threaten the success of the project are the responsibility of the Project manager.

Operational Risk:

- The day-to-day operations are also subject to risks. Matters such as health and safety, industrial relations are amongst the operational risks faced by an organisation.

The identification of risks at different organisational levels allow identification of who has responsibility for the risk.

Risk and the Project Life Cycle

- The project life cycle which establishes the phases through which a project will pass is so designed to enable the management of risk.
- The Knowledge areas also enable the effective management of projects.
- The process of risk management requires that risk be managed continuously throughout the life of the project.

Risk Identification

- The identification of risk should occur as early as possible - i.e. in the conception and definition phase. Risk identification requires an understanding of the project scope and objectives and deciding what may prevent the achievement of them.
- The project charter will set out the high level risks to the project. It will also identify the success criteria by which the project will be judged later.
  - The potential risks to the project are identified as comprehensively as possible
  - Can be helpful to brainstorm in groups and draw on the experience of the project participants

Risk Identification

- The feasibility study, if required, will identify and assess the risks in determining the best way of undertaking the project and to determine if proceeding with the project is the best option.
- In the planning phase the project manager in the development of the project plan will evaluate the project risk and develop a risk response plan.
- As part of implementation these plans will be executed. The process of risk identification and analysis should be re-applied through the implementation phase of the project to re-evaluate project risks

Risk Categories

Technical Risks
- Robustness of the solution
- Complexity of the system
- Ownership

Business / Management Risk
- Financing
- Revenue / Cost / Margin
- Shareholders

Delivery / Operational Risks
- Training & Training Support
- Human Resource Considerations
- Complexity
- Product Life Cycle
- On going support

Cost Schedule

Risk Recording and Scoring

A table for recording project risks is called a Risk Log.

- All identified risks must be recorded in the Risk Log. Risks with a significant potential impact may cause immediate alteration of the Project Plan, and therefore another iteration of risk identification is required

Risk Analysis

- Risk analysis involves assessing the probability of a risk occurring and its likely impact if it does occur. The ranking or scoring of risk involves the following calculation

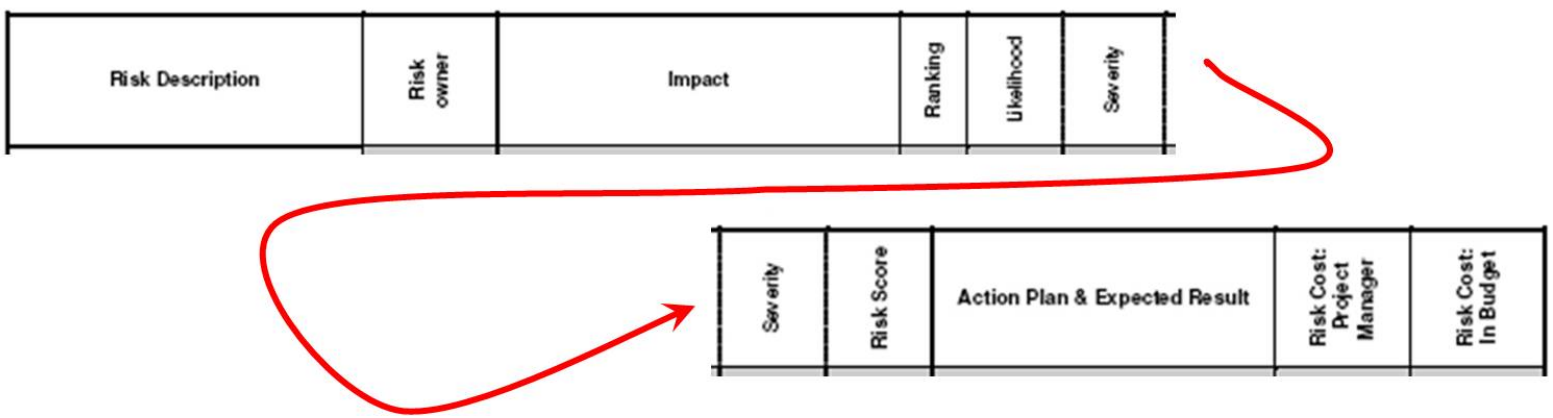
Risk Ranking/Scoring = Probability x Impact

- (High, medium , low)

BID PRICE				ALTERNATIVE PRICE (IF APPLICALBLE)			
BU's share	Total Business Share	Others' Share	**Total**	*BU's share*	Total : Share	Others' Share	**Total**

RISKS TABLE

Risk Description	Risk owner	Impact	Ranking	Likelihood	Severity	Risk Score	Action Plan & Expected Result	Risk Cost: Project Manager	Risk Cost: In Budget
Technical / Process									
• Standards and regulations applicable to the project									
• Uncertainty of the data									
• Innovative process									
• Guarantees of the treatment									
• Commissioning period									
• Expected operating conditions: chemicals, staff ...									
•									



Risk Description
Technical / Process
• Standards and regulations applicable to the project
• Uncertainty of the data
• Innovative process
• Guarantees of the treatment
• Commissioning period
• Expected operating conditions: chemicals, staff ...
•

Risk Description
Financial
• Client's solvency / Country stability
• Inflation
• Payment conditions / retentions
• Currency exchange risk
• Reliability of the financing
•
Guarantees / Bonds
• Bid
• Advance payment
• Performance
•
Taxation / Insurance
• Taxes and duties
• Construction risk insurance
•

Risk Description
Construction
• Site survey and soil conditions
• Manpower
• Suppliers
• Subcontractors
• Schedule of works
• Testing and commissioning
• Default of employer
• Default of consultant
•
Accidental
• Natural
• Human
• Political
•

Risk Description
Construction
• Site survey and soil conditions
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• Schedule of works
• Testing and commissioning
• Default of employer
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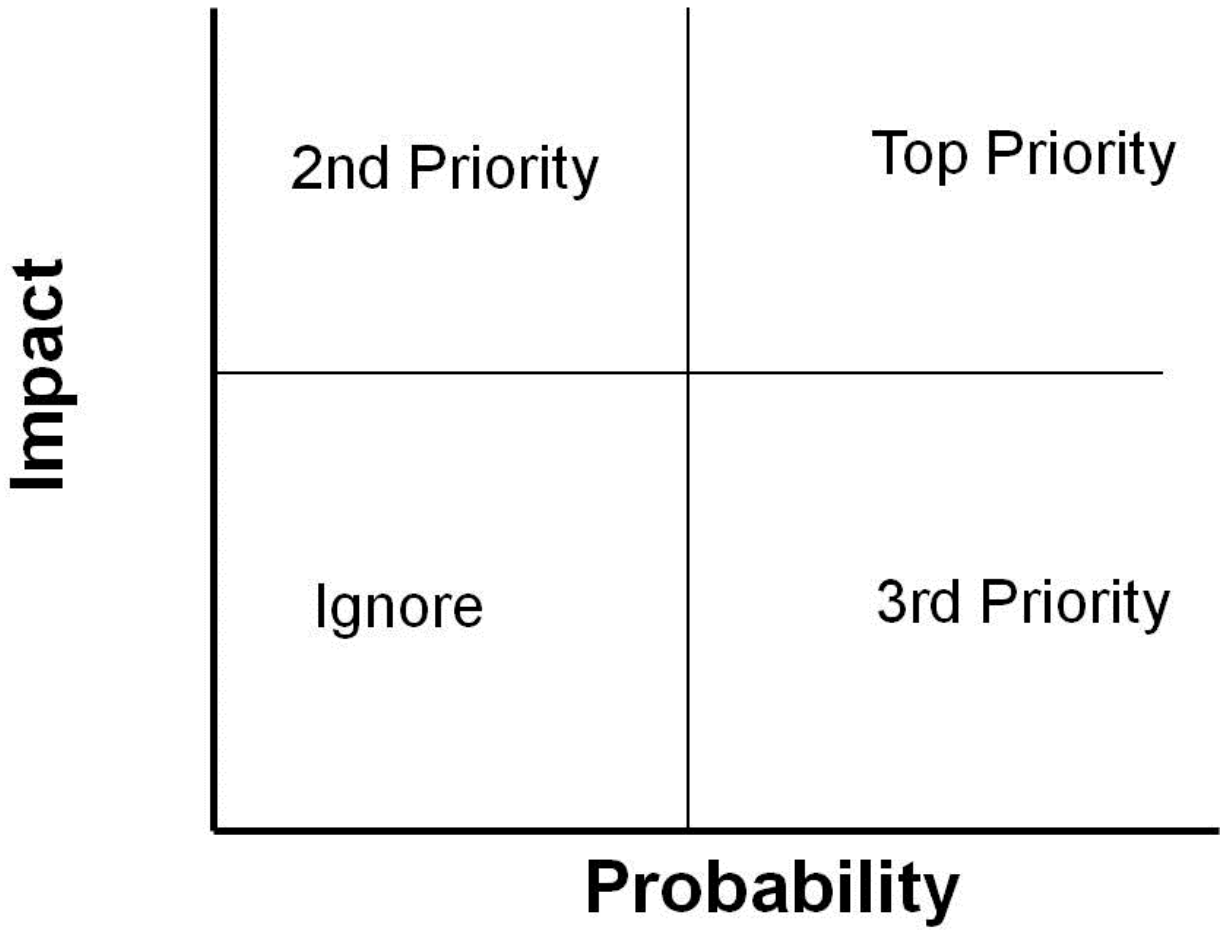
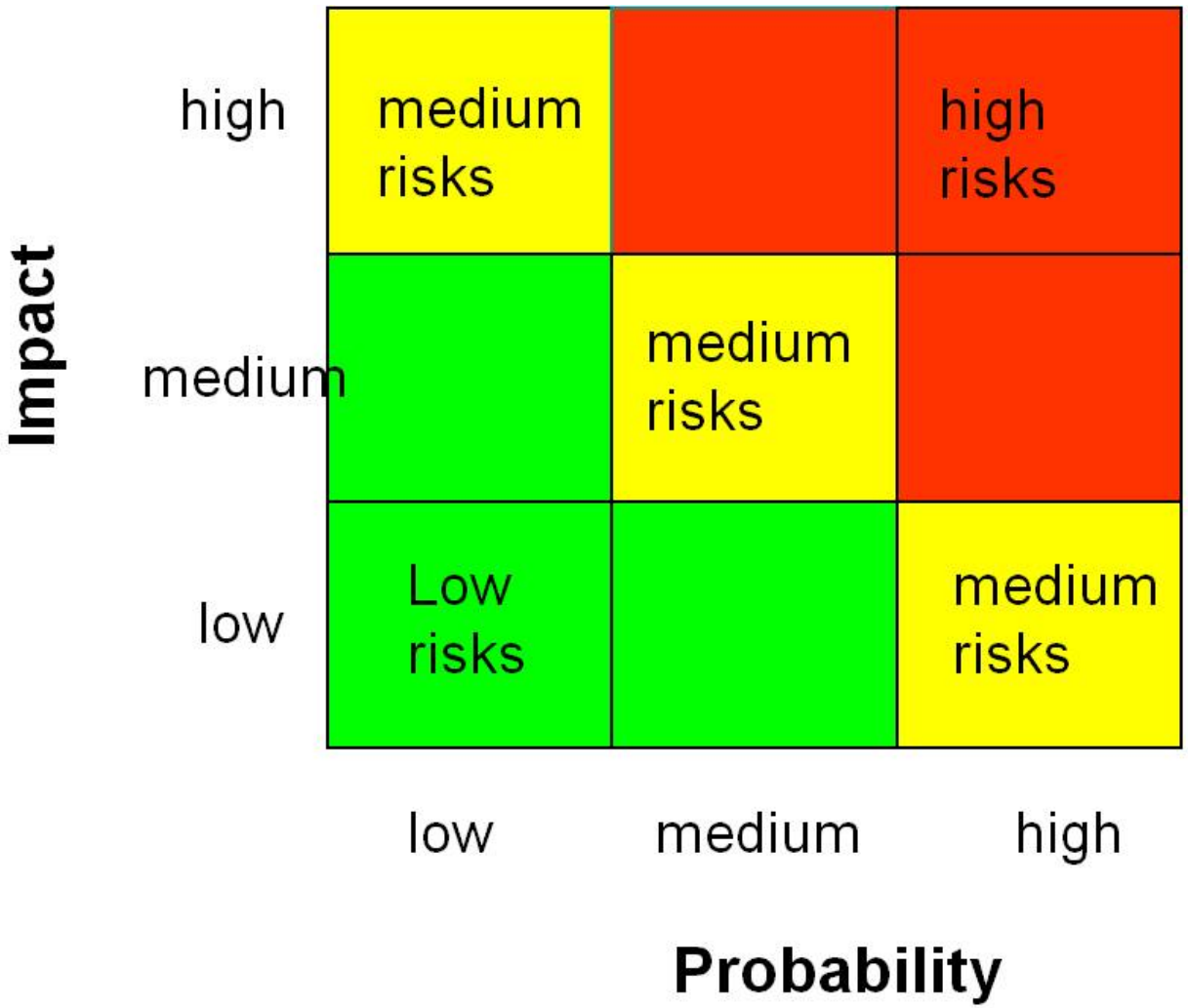
Qualitative Analysis



Risk Importance

- Consider the relative impact each risk will have on the project if it happens.
- Note that low probability risks are often high on impact
- Alternatively the Risk Probability/Impact Matrix maybe used to establish risk ranking by placing each risk in its correct box in the grid.
- The distribution of risks over this matrix gives an overall view of the project risk level.
  - Low-Medium-High

Risk Probability & Impact Matrix



Risk Response

Once the risks are identified, analysed and prioritised, a plan of action to manage them is developed.
There are 5 response types. (PMBOK gives 4) These are

- Avoidance,
- Transfer,
- Reduction,
- Contingency
- Acceptance.

If a risk has more than one response option, put multiple entries in the Risk Register

Risk Response

Response Type	Effect	Reduces Probability	Reduces Impact
Avoidance	This is proactive. Alter the Project Plan to remove the risk or its causes completely. This may need client agreement.		
Transfer	Transfer of risk to another party		
Reduction	This is **proactive.** Introduce additional planning or resources to reduce the risk		
Contingency	This is **reactive**. Have a plan prepared that will only operate if the risk happens.		
Acceptance	Do nothing, either because the probable effect of the risk is acceptable or there is no other possible option.		

Response Selection

- Do not dwell too long on the Response Type - it is more important to record the details of your risk mitigation.
- Responses should be consistent with the project priorities. For example if the schedule is the top priority, try not to plan responses that will add time to schedule.
- Make certain that the response you plan does not end up costing more time or money that the risk you are tying to cover.
  - You may be better off with the problem than the solution
- As you plan each response, identify who is responsible.
- The same risk occurring at different times may require a different response. Note these as separate entries in the Risk Log.
- Given your planned risk responses, reassess the probability and impact ratings for each risk. The aim is reduce each Risk Rating, and therefore the overall project

Risk Monitoring

- Risks change over time. Having created the Risk Log during the Planning stage, these risks are monitored and controlled during the project execution.
- Update the Risk Log as old risks diminish and new risks appear. Reappraise the risk responses in the light of experience and progress. For a long project, this should be done at least monthly.
- Sort the Risk Log in order of reducing rank. Review and monitor risks in order of priority

Risk Reporting

- There may be examples of single, high-ranking project risks that have such a significant impact on the project; they need to be reported singly to the Programme Management Office as required.
- This would include risks that would:
  - Completely halt or unacceptably delay the project or
  - Cause over expenditure for the project,
  - Create a breech of legislation or law, such as Health & Safety Legislation etc.
  - Make the planned scope impossible to deliver

Decision Trees

- Decision trees are composed of nodes(circles, squares and triangles) and branches(lines).
- The nodes represent points in time. A decision node(a square) is a time when the decision maker makes a decision. A probability node(a circle) is a time when the result of an uncertain event becomes known. An end node(a triangle) indicates that the problem is completed -all decisions have been made, all uncertainty have been resolved and all payoffs have been incurred.

Decision Trees

- Time proceeds from left to right. This means that branches leading into a node (from the left) have already occurred. Any branches leading out of a node (to the right) have not yet occurred.
- Branches leading out of a decision node represent the possible decisions; the decision maker can choose the preferred branch. Branches leading out of probability nodes represent the possible outcomes of uncertain events; the decision maker has no control over which of these will occur.

Decision Trees

- Probabilities are listed on probability branches. These probabilities are conditional on the events that have already been observed (those to the left). Also, the probabilities on branches leading out of any particular probability node must sum to 1.
- Individual monetary values are shown on the branches where they occur, and cumulative monetary values are shown to the right of the end nodes. (Two values are often found to the right of each node: the top one is the probability of getting to that end node, and the bottom one is the associated monetary value).

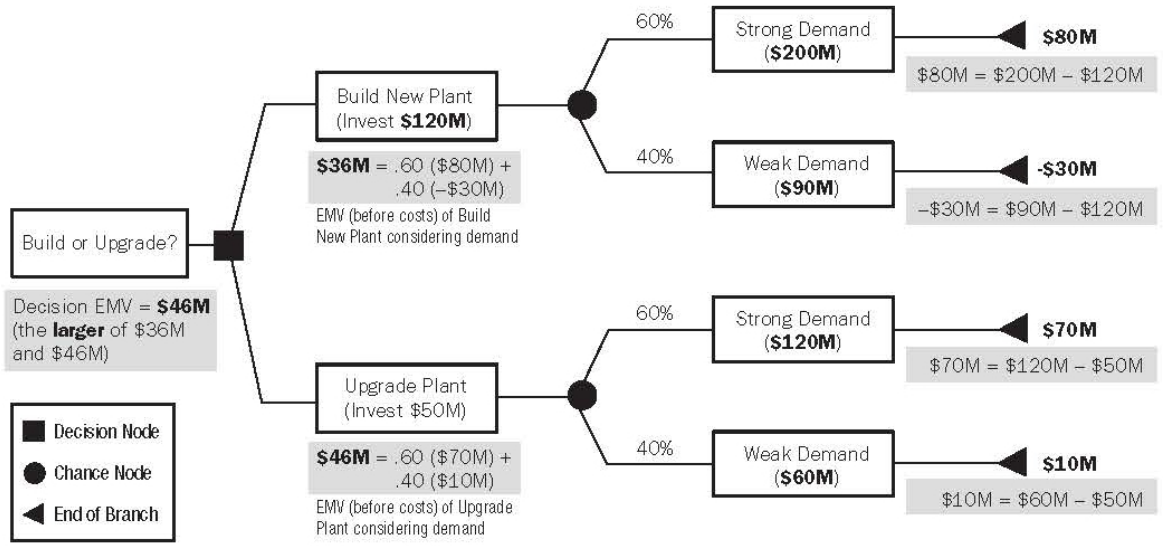
Decision Making

Decision Making Processes:

- collect information
- establish root cause
- generate solutions
- select best option
- implement/monitor

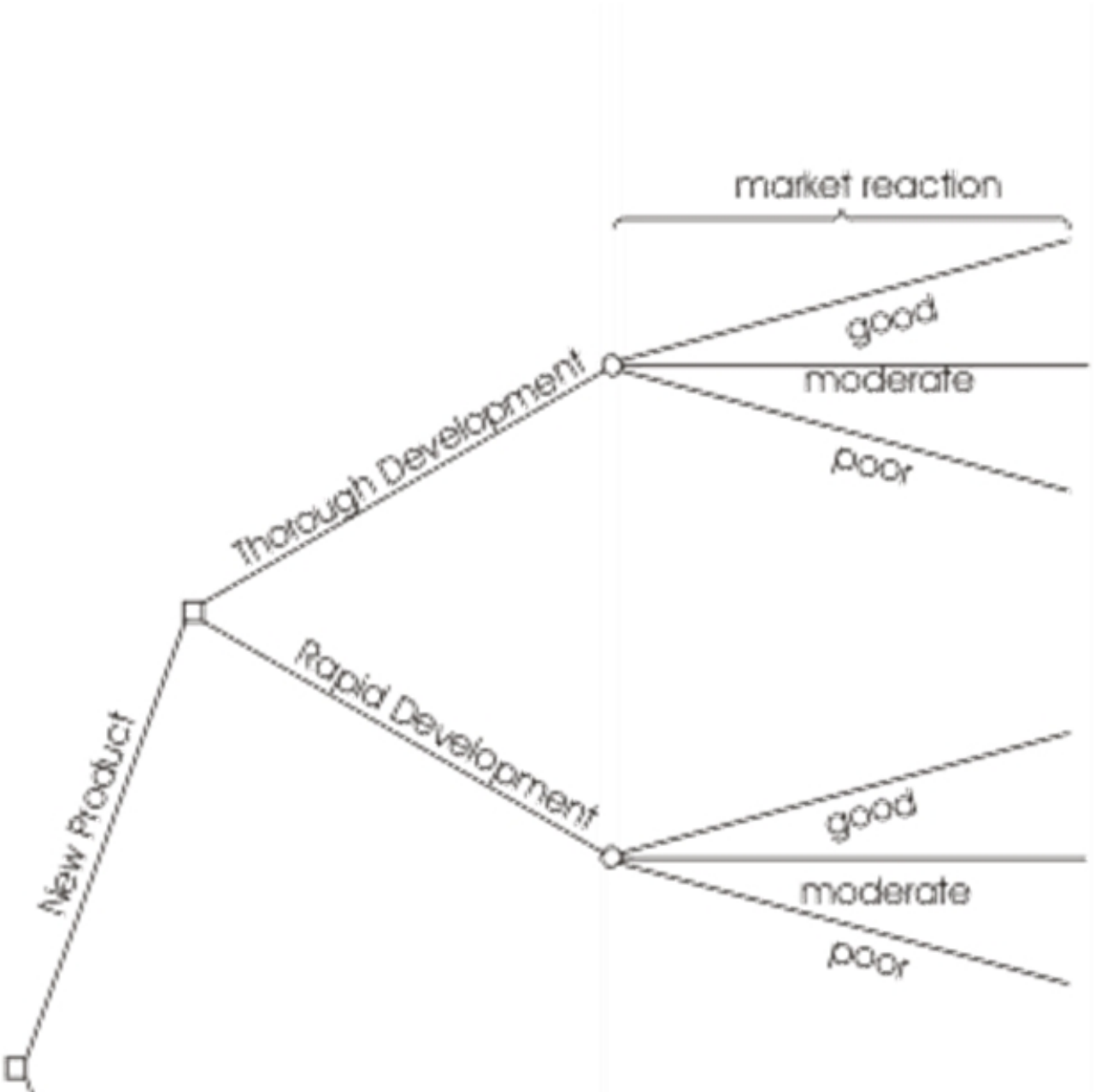
Decision Trees

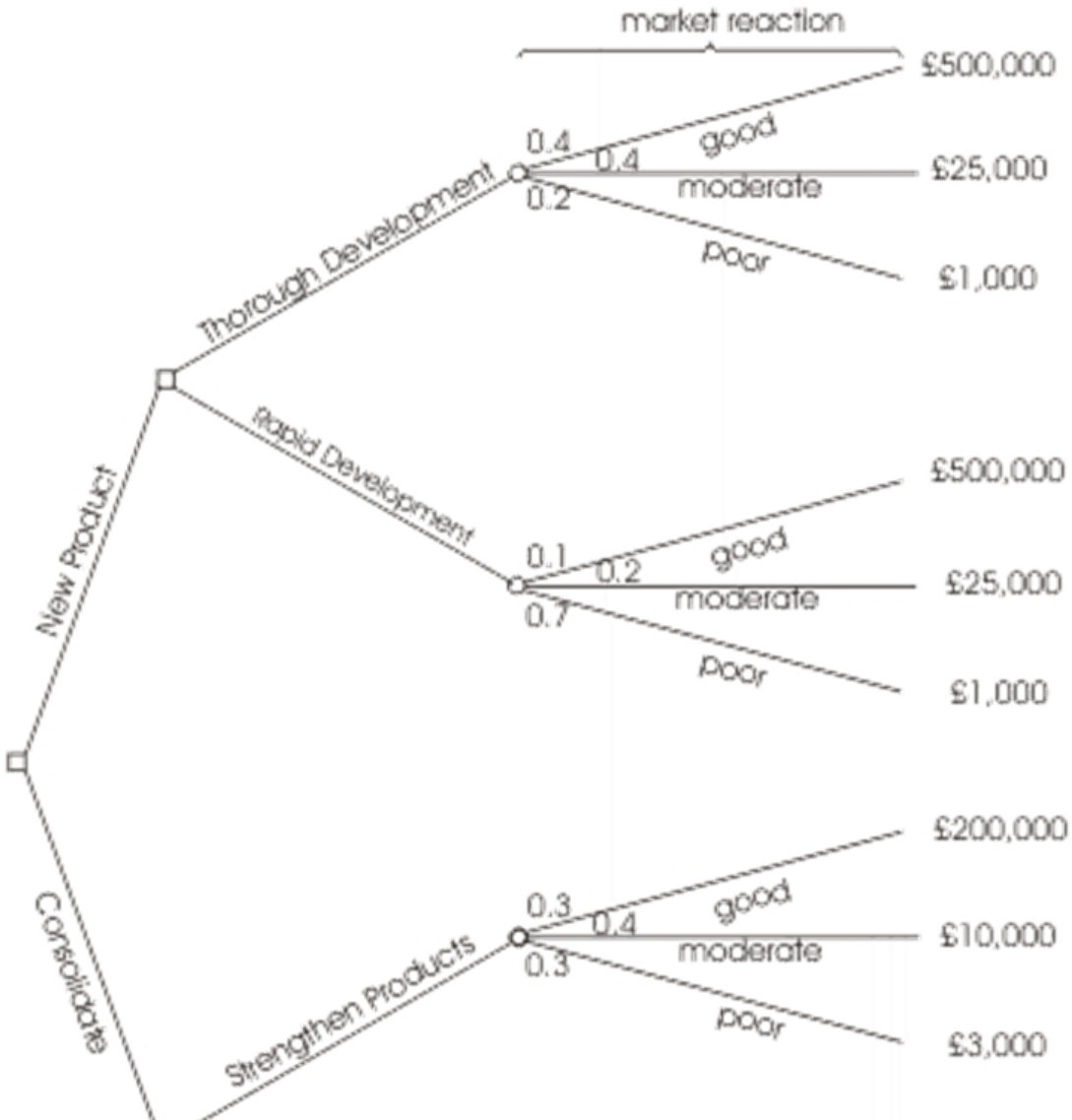
Decision Definition	Decision Node	Chance Node	Net Path Value
Decision to be Made	**Input:** Cost of Each Decision **Output:** Decision Made	**Input:** Scenario Probability, Reward if it Occurs **Output:** Expected Monetary Value (EMV)	**Computed:** Payoffs minus Costs along Path



Note 1: The decision tree shows how to make a decision between alternative capital strategies (represented as "decision nodes") when the environment contains uncertain elements (represented as "chance nodes").

Note 2: Here, a decision is being made whether to invest $120M US to build a new plant or to instead invest only $50M US to upgrade the existing plant. For each decision, the demand (which is uncertain, and therefore represents a "chance node") must be accounted for. For example, *strong* demand leads to $200M revenue with the new plant but only $120M US for the upgraded plant, perhaps due to capacity limitations of the upgraded plant. The end of each branch shows the net effect of the payoffs minus costs. For each decision branch, all effects are added (see shaded areas) to determine the overall Expected Monetary Value (EMV) of the decision. Remember to account for the investment costs. From the calculations in the shaded areas, the upgraded plant has a higher EMV of $46M – also the EMV of the overall decision. (This choice also represents the lowest risk, avoiding the worst case possible outcome of a loss of $30M).


market reaction
good
moderate
poor
Thorough Development
Rapid Development
New Product
good
moderate
poor


market reaction
New Product
Thorough Development
Rapid Development
Consolidate
Strengthen Products
0.4
0.4
good
£500,000
moderate
£25,000
0.2
Poor
£1,000
0.1
0.2
good
£500,000
moderate
£25,000
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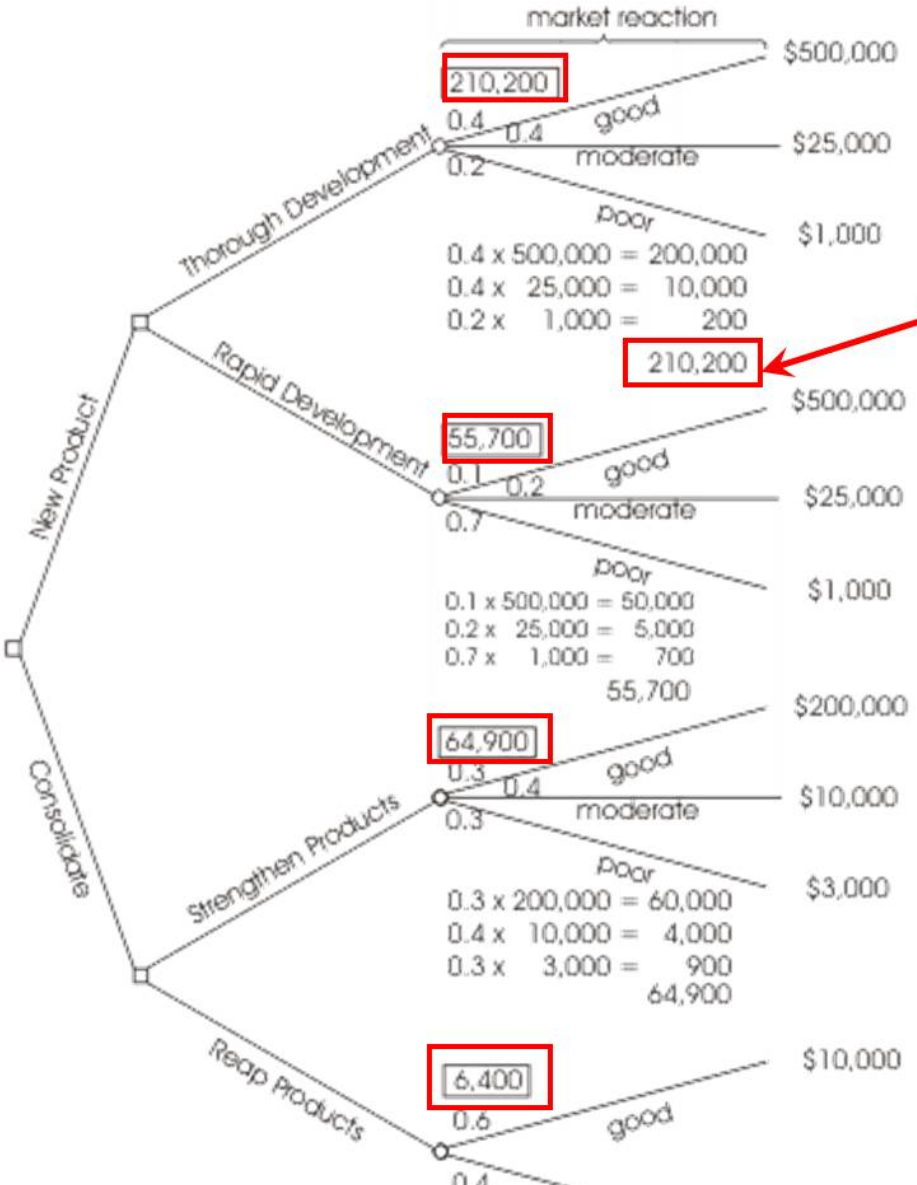
£3,000



Expected Value

Tree Construction

- Identify the decision points and alternatives actions available at each point
- Identify the uncertainties
- Estimate quantitative information (costs of possible outcomes, gains resulting from outcomes, probabilities of chance events)
- Define criteria of desirability
- Evaluate tree

Key Points

Decision trees provide an effective method of Decision Making because they:

- Clearly lay out the problem so that all options can be challenged
- Allow us to analyze fully the possible consequences of a decision
- Provide a framework to quantify the values of outcomes and the probabilities of achieving them
- Help us to make the best decisions on the basis of existing information and best guesses.

Need for Care

- As with all Decision Making methods, decision tree analysis should be used in conjunction with common sense - decision trees are just one important part of your Decision Making tool kit.

Next Lecture:

Reading: ‘A Guide to the Project Management Body of Knowledge’ Chapter 11 Project Risk Management

Project Risk Management

Project Management Year 4

Quantitative Risk Analysis

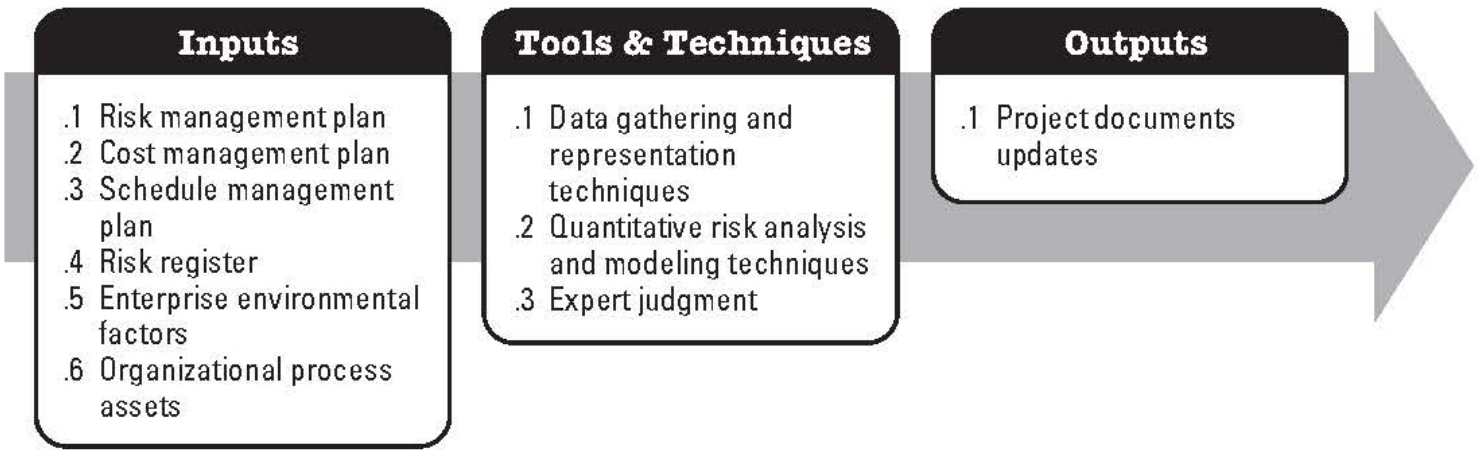


Figure 11-11. Perform Quantitative Risk Analysis: Inputs, Tools & Techniques, and Outputs

- Part of the Planning Process Group

Quantitative Risk Analysis

- Quantitative Risk Analysis is performed on Risks that have been prioritised by the Qualitative Risk Analysis Process
- The Quantitative Risk Analysis process is designed to
  - Quantify the possible outcomes for the project and their probability
  - Assess the probability of achieving specific project goals
  - Identify risks requiring the most attention by quantifying their relative contribution to the overall project risks
  - Identify realistic and achievable cost, schedule, or scope targets, given the project risks
  - Determine the best PM decisions when conditions or outcomes are uncertain

Quantitative Risk Analysis

- Inputs
  - Risk Register
- List of identified risks, relative priority and ranking, etc.
  - Risk Management Plan
- Roles and Responsibilities, Budgets, Schedules, etc.
  - Project Schedule Management Plan
  - Project Cost Management Plan
  - Organisational Process Assets
- Information on prior, similar projects
- Studies of similar projects
- Risk Databases

Quantitative Risk Analysis

- Tools and Techniques
  - Data Gathering and Representation Techniques
- Interviewing
  - Used to quantify the probability and impact of risks on project objectives
- Breakdown into ‘optimistic’, ‘most-likely’, and ‘pessimistic’
- three point estimates
- Can provide information on the reliability and credibility of the analysis
- Probability Distributions
  - Not all probabilities are normally distributed.
  - For our work, we will only consider the normally distributed probabilities (PERT)
- Expert Judgement
  - Internal or External Experts

Quantitative Risk Analysis

- Tools and Techniques
  - Quantitative Risk Analysis and Modelling Techniques
- Sensitivity Analysis
  - Helps to determine which risks have the most potential impact on the project
  - Examines the extent to which an individual project element will affect the project, when all other uncertain elements are held at ‘baseline’.
- Expected Monetary Value Analysis
  - EVM is a statistical concept that calculates the average outcome when the future includes scenarios that may or may not happen.
  - EVM is calculated by multiplying each possible outcome by its probability
  - Used in Decision Tree Analysis
- Decision Tree Analysis
- Modelling and Simulation

Quantitative Risk Analysis

- Tools and Techniques
  - Quantitative Risk Analysis and Modelling Techniques
- Decision Tree Analysis
  - Uses a diagram to describe a situation under consideration, and the implications of each of the available choices
  - Uses EVM
- Modelling and Simulation
  - A project simulation uses a model that translates specified project uncertainties into their potential impact on project objectives
  - Typically the Monte Carlo technique Inputs are randomised, and results computed numerous times. Results are compiled, and a probability distribution is calculated.

Sensitivity Analysis Example

Selection of Alternatives

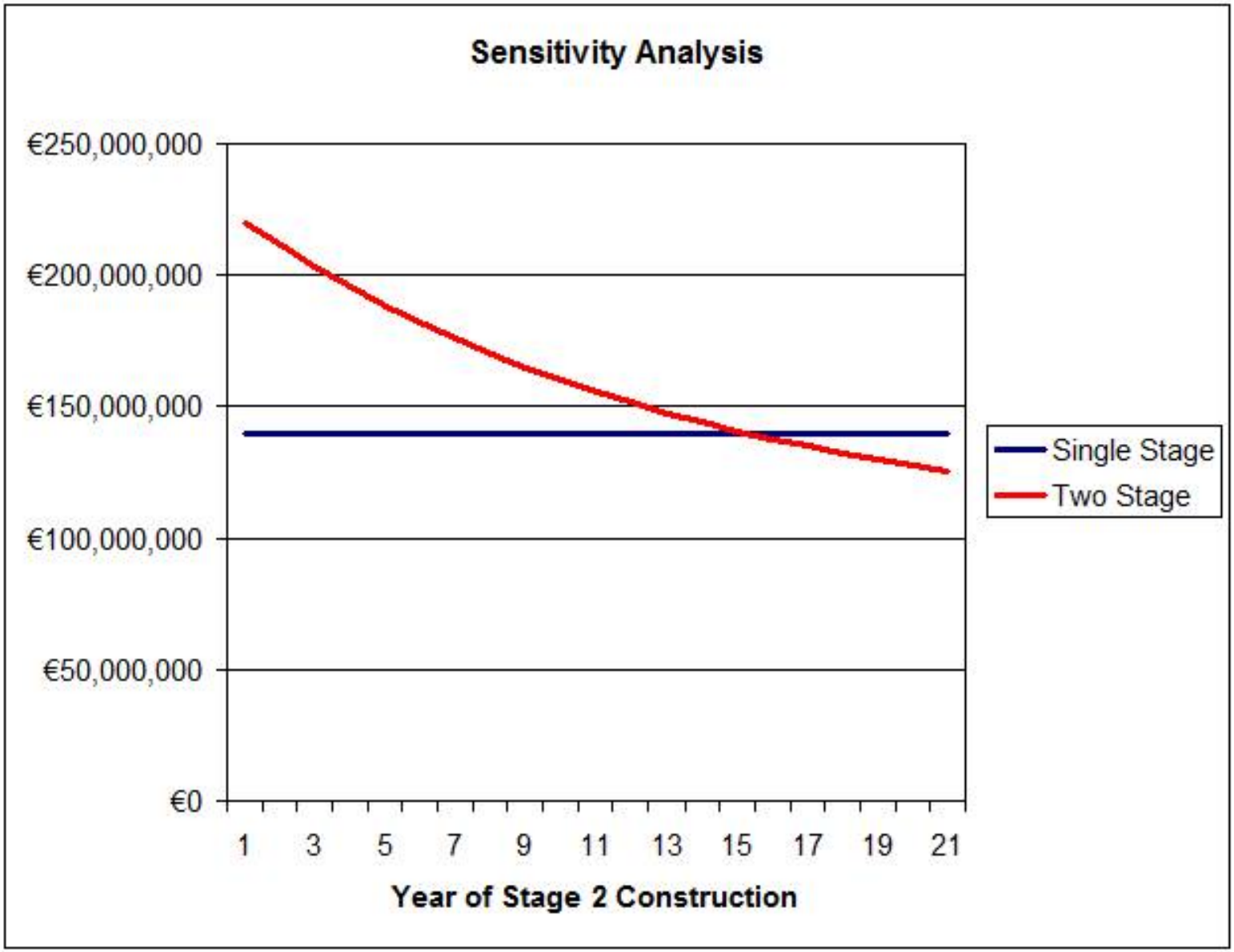
- A new hospital facility can be constructed to meet current and future patient projections over the next 20 years, or in two stages, one now and the next n' years from now
  - Construction Costs
- Full Capacity Construction 140M
- Two Stage: 1st Stage 100M 2nd Stage n' years from now 120M

Sensitivity Analysis Example

- Assumptions
  - In each case the hospital facilities will last 40 years and have zero scrap value
  - Annual O&M Cost are the same for both alternatives
  - 8% interest rate
- Calculation
  - We know the PW of constructing the entire hospital now, so we will use PW analysis
  - We will use MS Excel, and therefore evaluate the option 2 stage construction' each year

Sensitivity Analysis Example

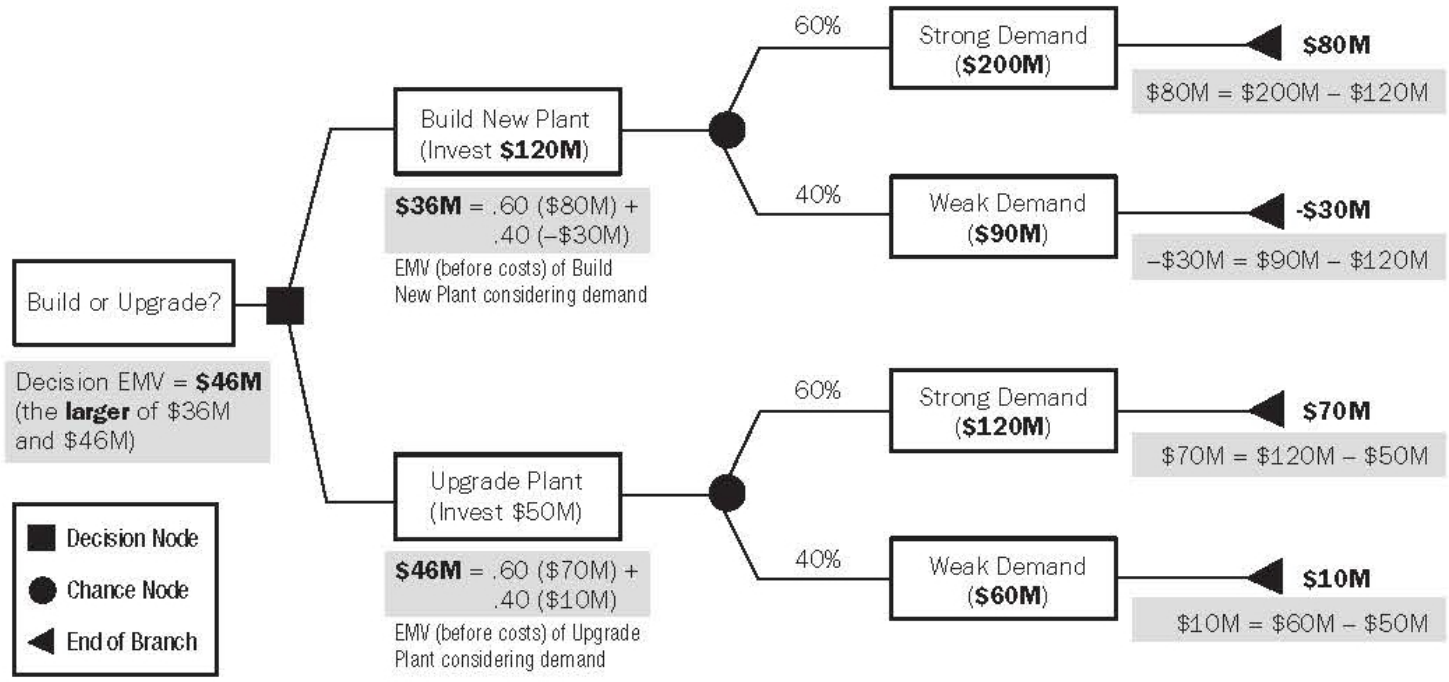
	Single Stage	Two Stage			
Year		Stage 1	(P/F,8%,n)	Stage 2	Total
0	€140,000,000.00	€100,000,000.00	1	€120,000,000.00	€220,000,000.00
1	€140,000,000.00	€100,000,000.00	0.9259	€111,108,000.00	€211,108,000.00
2	€140,000,000.00	€100,000,000.00	0.8573	€102,876,000.00	€202,876,000.00
3	€140,000,000.00	€100,000,000.00	0.7938	€95,256,000.00	€195,256,000.00
4	€140,000,000.00	€100,000,000.00	0.735	€88,200,000.00	€188,200,000.00
5	€140,000,000.00	€100,000,000.00	0.6806	€81,672,000.00	€181,672,000.00
6	€140,000,000.00	€100,000,000.00	0.6302	€75,624,000.00	€175,624,000.00
7	€140,000,000.00	€100,000,000.00	0.5835	€70,020,000.00	€170,020,000.00
8	€140,000,000.00	€100,000,000.00	0.5403	€64,836,000.00	€164,836,000.00
9	€140,000,000.00	€100,000,000.00	0.5002	€60,024,000.00	€160,024,000.00
10	€140,000,000.00	€100,000,000.00	0.4632	€55,584,000.00	€155,584,000.00
11	€140,000,000.00	€100,000,000.00	0.4289	€51,468,000.00	€151,468,000.00
12	€140,000,000.00	€100,000,000.00	0.3971	€47,652,000.00	€147,652,000.00
13	€140,000,000.00	€100,000,000.00	0.3677	€44,124,000.00	€144,124,000.00
14	€140,000,000.00	€100,000,000.00	0.3405	€40,860,000.00	€140,860,000.00
15	€140,000,000.00	€100,000,000.00	0.3152	€37,824,000.00	€137,824,000.00
16	€140,000,000.00	€100,000,000.00	0.2919	€35,028,000.00	€135,028,000.00
17	€140,000,000.00	€100,000,000.00	0.2703	€32,436,000.00	€132,436,000.00
18	€140,000,000.00	€100,000,000.00	0.2502	€30,024,000.00	€130,024,000.00
19	€140,000,000.00	€100,000,000.00	0.2317	€27,804,000.00	€127,804,000.00
20	€140,000,000.00	€100,000,000.00	0.2145	€25,740,000.00	€125,740,000.00


Sensitivity Analysis
€250,000,000
€200,000,000
€150,000,000
€100,000,000
€50,000,000
€0
1
3
5
7
9
11
13
15
17
19
21
Year of Stage 2 Construction
Single Stage
Two Stage

Quantitative Risk Analysis

Decision Tree

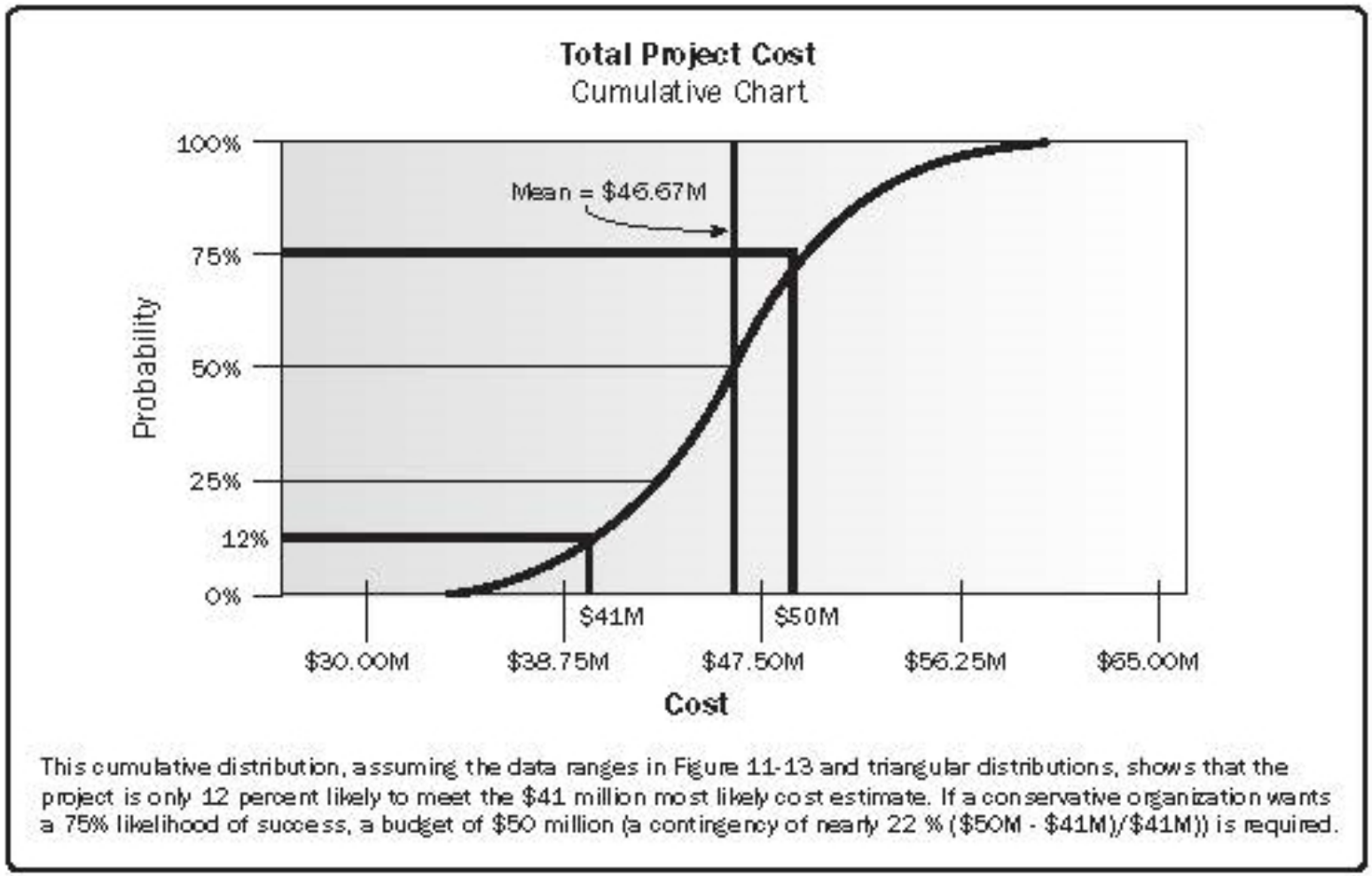
Decision Definition	Decision Node	Chance Node	Net Path Value
Decision to be Made	**Input:** Cost of Each Decision **Output:** Decision Made	**Input:** Scenario Probability, Reward if it Occurs **Output:** Expected Monetary Value (EMV)	**Computed:** Payoffs minus Costs along Path



Note 1: The decision tree shows how to make a decision between alternative capital strategies (represented as "decision nodes") when the environment contains uncertain elements (represented as "chance nodes").

Quantitative Risk Analysis

- Modelling and Simulation (Monte Carlo)



This cumulative distribution, assuming the data ranges in Figure 11-13 and triangular distributions, shows that the project is only 12 percent likely to meet the $41 million most likely cost estimate. If a conservative organization wants a 75% likelihood of success, a budget of $50 million (a contingency of nearly 22 % ($50M - $41M)/$41M)) is required.

Quantitative Risk Analysis

- Outputs
  - Risk Register (Updates)
- Probabilistic Analysis of the Project
  - Estimates of potential project schedule and cost outcomes
  - Usually expressed as a cumulative distribution Fig. 11-13
- Probability of achieving cost and time objectives
  - From fig 11-13, there is a 12
- Prioritised list of Quantified Risks
  - List of risks that pose the greatest threat, or the greatest opportunity to the project
- Trends is Quantitative Risk Analysis Results
  - As analysis are repeated, trends may become apparent.

Plan Risk Responses

Figure 11-18. Plan Risk Responses: Inputs, Tools & Techniques, and Outputs

- Part of the Planning Process Group

Plan Risk Responses

- Risk Response Planning is the Process of developing options, and determining actions to enhance opportunities and reduce threats to the project's objectives.
  - Much of Risk Management focuses on negative risks; don't forget about opportunities
- Risk Response Planning addresses risks by their priority by including resources, and activities into the budget, schedule, and PM plan, as needed.
- Selecting the best response from several possible approaches is very common

Plan Risk Responses

- Inputs
  - Risk Management Plan
- Roles and Responsibilities
- Risk Analysis definitions,
- Risk Thresholds
- Refer to book and previous notes
  - Risk Register
- Defines root cause of risks
- Includes potential responses, risk owners, symptoms, and warning signs
- Includes Relative Rating of Risks

Plan Risk Responses

- Tools and Techniques
  - Strategies for Negative Risks or Threats
- Avoid
  - Change PM Plan to eliminate risk or threat.
  - Isolate project objectives from risk's impact
  - Some risks can be avoided by clarifying requirements, obtaining information, improving communications, or acquiring expertise
- Transfer
  - Shift negative impact of a threat, along with ownership of the response, to a third party (Insurance, Bonds, etc.)
  - Does not eliminate the risk; just transfers liability
- Mitigate
  - Reduce the probability and/or impact to an acceptable level

Process Improvement, Communications, Testing, Sign-off, etc.

Plan Risk Responses

- Tools and Techniques
  - Strategies for Positive Risks or Opportunities
- Exploit
  - Measures to ensure positive risk is realised.

  Bonus-Penalty Clause in Contract
- Share
  - Allocating ownership to a third party who is best able to capture the opportunity for the benefit of the project

  Joint Ventures..
- Enhance
  - Maximisation of the opportunity or positive risk by identifying key drivers

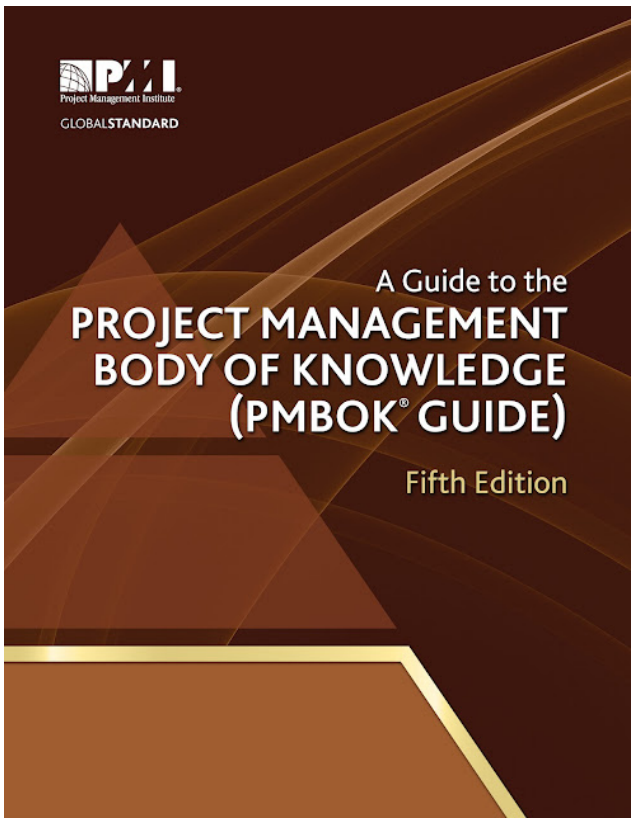
  Lobbying for New Road to new/planned Industrial/Commercial Complex

Plan Risk Responses

- Strategy for Both Threats and Opportunities
  - Acceptance
- Can be passive or active
- Most common strategy for acceptance is the allocation of contingency reserves
  - Contingent Response Strategy
- Responses designed to only come into operation or effect when predefined conditions occur
- Trigger events: milestones, negative trends on CPI or SPI etc.

Next Lecture

Reading: ‘A Guide to the Project Management Body of Knowledge’
Chapter 11 - Project Risk Management



Project Risk Management

Project Management Year 4

Risk Response Planning

Figure 11-18. Plan Risk Responses: Inputs, Tools & Techniques, and Outputs

- Part of the Planning Process Group

Risk Response Planning

- Outputs
  - Risk Register Updates
- After Risk Response Planning, the Risk Register needs to be updated to include the agreed Risk Responses
  -
  - Refer to book for further details of Risk Register
  - Project Management Plan Updates
- PM plan is likely to require changes via the Integrated Change Control Process in order to cater for changes in Budget, Schedule, Scope, etc., due to Risk Response Planning
  - Risk-Related Contractual Agreements

Risk Response Planning

- Outputs
  - Risk-Related Contractual Agreements
- Such as Insurances, Bonds, Allocation etc.

Risk Monitoring and Control

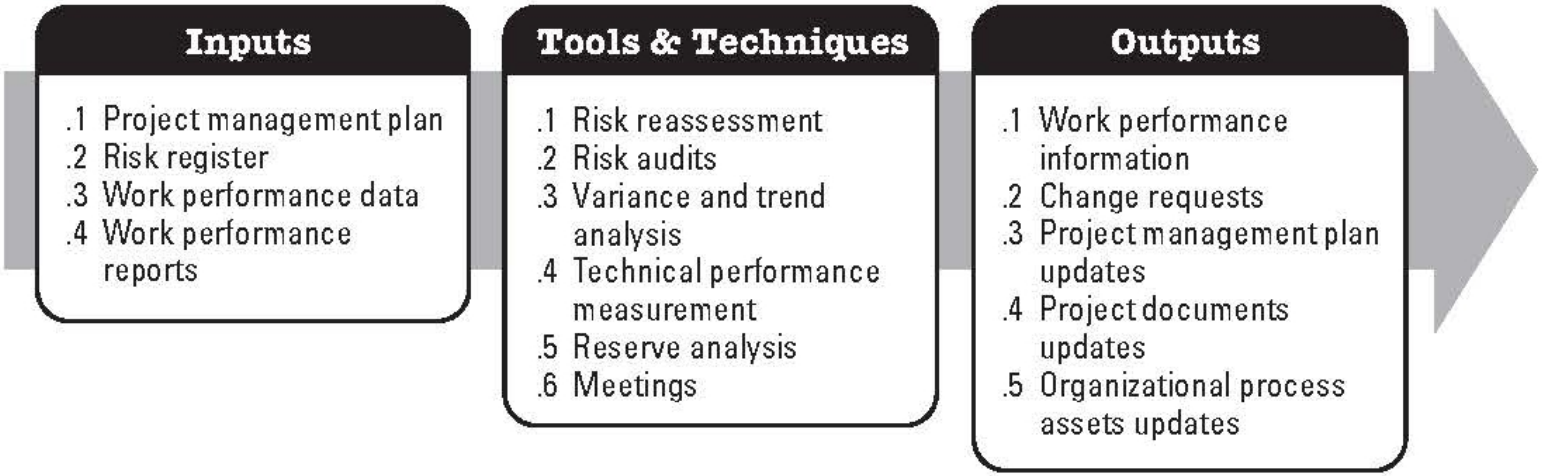


Figure 11-20. Control Risks: Inputs, Tools & Techniques, and Outputs

- Part of the Monitoring and Controlling Process Group

Risk Monitoring and Control

- Once Risk Responses are in place, it is still necessary to monitor and control risk throughout the project life-cycle.
- Risk Monitoring and Control is the process of
  - Identifying, and planning for newly arising risks
  - Keeping track of identified risks and those on the watch-list
  - Reanalysing existing risks
  - Monitoring trigger conditions
  - Monitoring residual risks
  - Reviewing the execution of risk responses
  - Evaluating the effectiveness of risk responses

Risk Monitoring and Control

- Other purposes of Risk Monitoring and Control are to determine if:
  - Project assumptions are still valid
  - Risk, as assessed, has changed from its prior state
  - Risk Management policies and procedures are being followed
  - Modifications are required to contingency reserves
- New risks, unidentified risks, etc.

Risk Monitoring and Control

- Risk Monitoring and Control can involve
  - Choosing alternative strategies
  - Executing a contingency plan
  - Taking corrective action
- Also includes
  - Updates to organisational process assets
- Risk Database
- Lessons Learned Data
- Risk Management Templates

Risk Monitoring and Control

- Inputs
  - Risk Management Plan
  - Risk Register
  - Approved Change Requests
- Can include changes to work methods, contract terms, scope and schedule
  - Work Performance Information
- Deliverable Status; Corrective Actions; etc.
  - Performance Reports
- Provide information on project work performance

Risk Monitoring and Control

- Tools and Techniques
  - Risk Reassessment
- Identification of new risks, validation of previous risk assessments, etc.
- Should be scheduled at regular intervals throughout the course of the project
  - Risk Audits
- Examination and Documentation of the effectiveness of risk responses
  - Variance and Trend Analysis
- Earned Value Management et al
  - Technical Performance Measurement
- Actual Technical Performance against Baseline Plans
  - Reserve Analysis
- Comparison of actual reserves against planned reserves throughout the project life-cycle to determine if remaining reserves are adiquate

Risk Monitoring and Control

- Outputs
  - Risk Register Updates
- Outcomes of risk assessments, risk audits and periodic risk reviews
- Actual outcomes of project risks
  - Helps in determining risk probability; feeds into Risk Database etc.
  - Change Requests
- Implementing Contingency Plans often involves changes to the overall Project Management Plan; these need to be run through the Integrated Change Control Procedures
  - Recommended Corrective Actions
- Contingency Plans and Workarounds
- Require Integrated Change Control

Risk Monitoring and Control

- Outputs
  - Recommended Preventative Actions
- Recommendations to bring project back into compliance
  - Organisational Process Assets Updates
- Risk Template Updates
- Risk Database Updates
  - Project Document Updates

Monte Carlo Simulation Example

A project is expected to cost 120,000. Six independent risks and one opportunity have been identified during 'Risk Identification'.

- A, cost of occurrence: 7,500; probability of occurrence 0.20
- B, cost of occurrence: 5,000; probability of occurrence 0.35
- C, cost of occurrence: 6,500; probability of occurrence 0.15
- D, cost of occurrence: 2,000; probability of occurrence 0.40
- E, cost of occurrence: 4,000; probability of occurrence 0.35
- F, cost of occurrence: 2,500; probability of occurrence 0.10
- X, opportunity value: 3,500; probability of occurrence 0.12

Expected Monetary Value Example

- Using simple Expected Monetary Value (EMV) analysis, the expected cost of the project is determined to be:

Project Cost			**€120,000.00**
Risks	Probability	Value	EMV
A	0.20	€7,500.00	€1,500.00
B	0.35	€5,000.00	€1,750.00
C	0.15	€6,500.00	€975.00
D	0.40	€2,000.00	€800.00
E	0.35	€4,000.00	€1,400.00
F	0.10	€2,500.00	€250.00
Opportunity			
X	0.12	-€3,500.00	-€420.00
Total Cost of Risks			€6,255.00

Monte Carlo Simulation Example

- Further simple analysis will yield
  - Max Project Cost: 147,500
  - Min Project Cost: 116,500
  - This yields a mean cost of 132,000

Monte Carlo Simulation Example

- You do not need to assign probabilities for a Monte Carlo Simulation

Simulation Iteration Number	A	B	C	D	E	F	X	Sum Risks and Opportunity	Total Project Cost	Average of Total Cost
	€7,500.00	€5,000.00	€6,500.00	€2,000.00	€4,000.00	€2,500.00	-€3,500.00			
1	€664.27	€3,662.63	€1,094.88	€631.11	€3,800.59	€1,611.40	-€786.55	€10,678.34	€130,678.34	**€132,207.03**
2	€6,147.69	€4,796.58	€1,007.12	€1,099.64	€1,525.24	€1,515.77	-€1,889.87	€14,202.19	€134,202.19	
3	€6,200.67	€4,113.38	€2,069.31	€1,498.10	€3,704.84	€2,423.15	-€1,834.58	€18,174.87	€138,174.87	
4	€4,049.14	€3,692.41	€4,311.26	€254.76	€2,429.12	€1,382.16	-€1,103.99	€15,014.86	€135,014.86	
5	€3,805.82	€1,335.82	€5,296.67	€137.80	€289.40	€1,040.25	-€2,499.93	€9,405.83	€129,405.83	
6	€4,511.96	€1,765.74	€2,826.48	€585.93	€1,422.05	€1,857.41	-€191.69	€12,777.88	€132,777.88	
7	€6,933.04	€1,928.94	€15.97	€1,827.11	€583.82	€1,029.40	-€93.84	€12,224.43	€132,224.43	
8	€7,140.49	€3,351.27	€2,219.38	€1,734.19	€852.49	€647.63	-€1,915.04	€14,030.41	€134,030.41	
9	€4,352.51	€4,251.83	€3,432.45	€651.10	€1,555.01	€853.02	-€2,797.74	€12,298.18	€132,298.18	
10	€7,215.92	€1,777.97	€4,273.40	€232.78	€3,058.86	€1,021.87	-€1,586.15	€15,994.66	€135,994.66	
11	€3,087.49	€1,716.91	€318.92	€868.26	€3,150.58	€1,145.96	-€1,705.32	€8,582.80	€128,582.80	
12	€253.01	€1,589.79	€5,134.91	€888.28	€3,777.27	€4.19	-€1,021.03	€10,626.41	€130,626.41	
13	€7,441.43	€4,466.30	€4,362.14	€425.46	€263.29	€2,346.29	-€3,011.20	€16,293.71	€136,293.71	
14	€6,367.71	€3,350.31	€2,021.63	€141.07	€665.64	€986.29	-€275.85	€13,256.80	€133,256.80	
15	€295.75	€2,211.92	€2,910.69	€673.42	€3,912.41	€1,539.18	-€1,086.73	€10,456.65	€130,456.65	
16	€5,120.02	€3,168.38	€1,039.37	€1,991.95	€961.29	€2,124.36	-€413.74	€13,991.64	€133,991.64	
17	€7,189.66	€391.14	€4,202.29	€438.73	€3,070.15	€322.92	-€3,360.34	€12,254.55	€132,254.55	
18	€4,011.63	€3,111.40	€4,052.49	€1,744.79	€2,333.09	€1,319.98	-€2,468.83	€14,104.56	€134,104.56	
19	€5.97	€3,404.52	€4,683.44	€445.01	€934.28	€1,956.77	-€2,968.30	€8,461.70	€128,461.70	

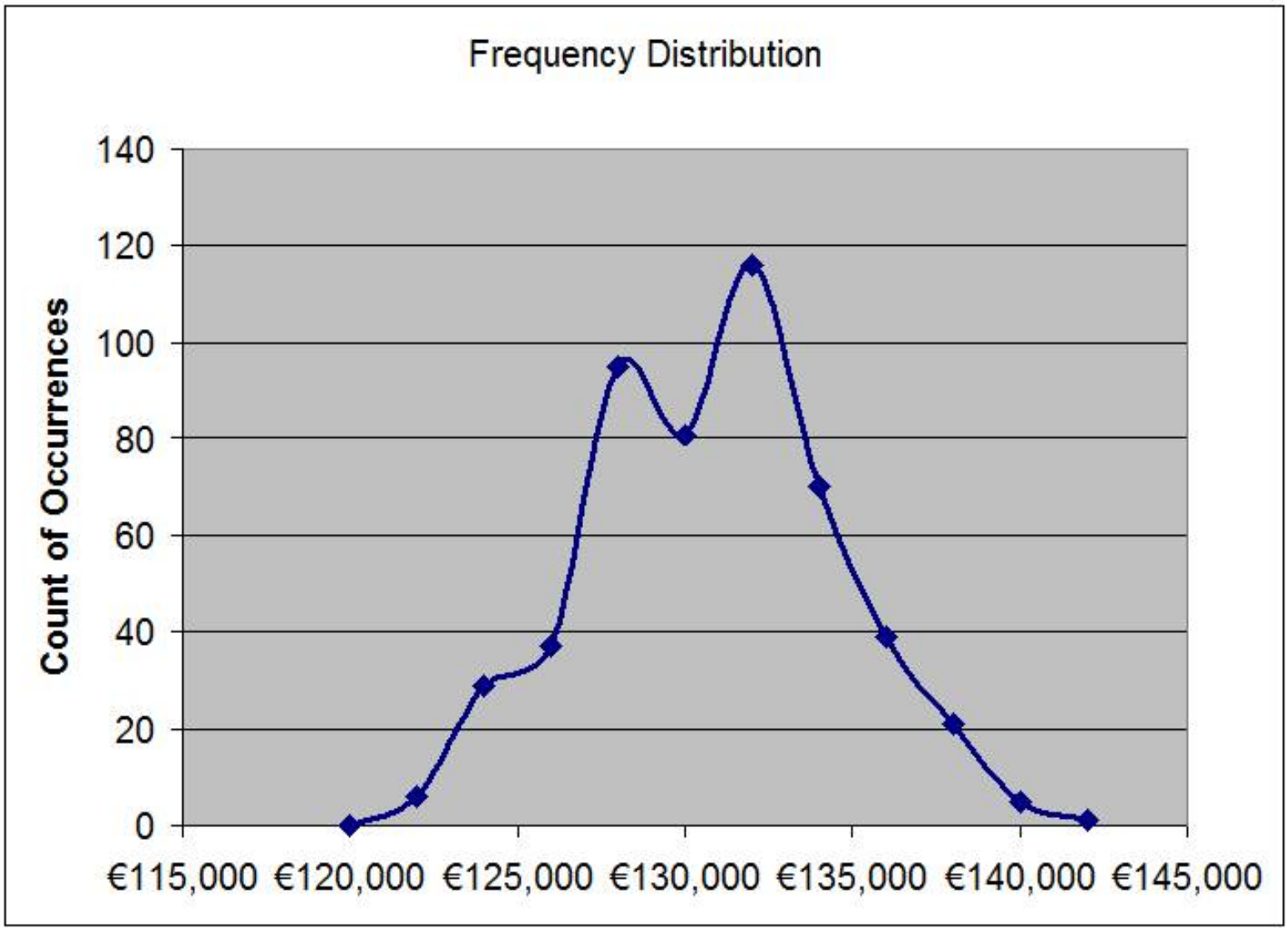
- The average figure ties in with the average determined by the max and min Project Costs

Monte Carlo Simulation Example

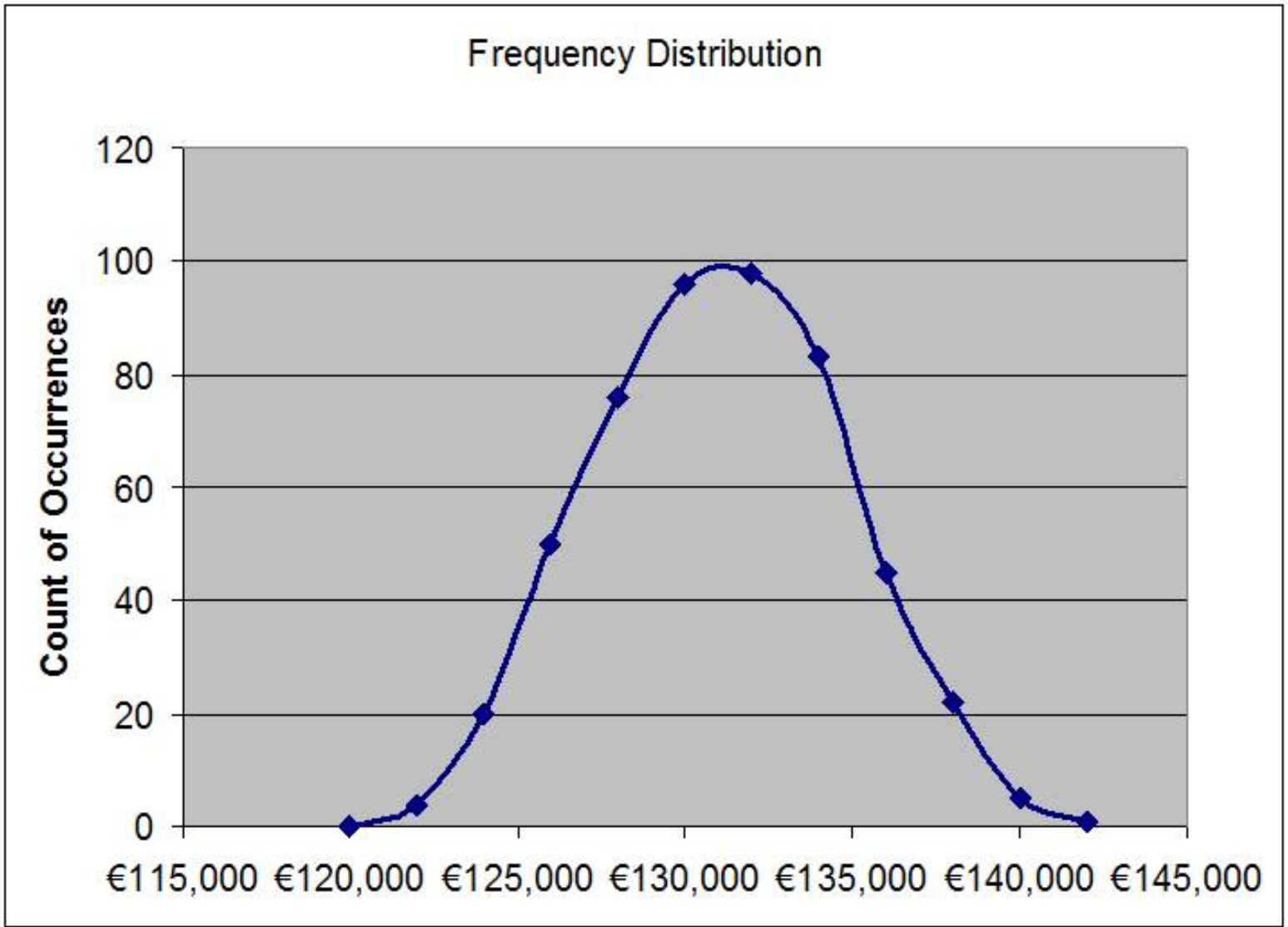
- So why undertake a Monte Carlo?
  - By undertaking an Monte Carlo simulation, additional information can be obtained, such as the standard deviation. (circa 3638.00)
  - Risks can also be modelled to more detail
- For instance, If the cost of Risk Event a was a range as opposed to an exact figure, this aspect can also be modelled. Range of A from 2,000 to 8,000; Yields Average of circa 130,000

Simulation Iteration Number	A €2,000.00 €8,000.00		B €5,000.00	C €6,500.00	D €2,000.00	E €4,000.00	F €2,500.00	X -€3,500.00	Sum Risks and Opportunity	Total Project Cost	Average of Total Cost
1	€3,209.75	€248.02	€4,928.44	€1,381.89	€921.93	€1,714.36	€2,271.52	-€2,202.42	€9,263.76	€129,263.76	**€130,673.66**
2	€4,491.84	€4,046.52	€1,130.30	€4,796.03	€1,630.84	€568.44	€1,079.65	-€928.77	€12,323.00	€132,323.00	
3	€5,909.71	€5,164.02	€170.90	€646.74	€1,430.44	€2,901.74	€1,975.56	-€1,849.93	€10,439.48	€130,439.48	

Monte Carlo Simulation Example



Monte Carlo Simulation Example



Next Lecture

Reading: ‘A Guide to the Project Management Body of Knowledge’
Chapter 12 - Project Procurement Management