Advanced Project Management

3

Cost management – Risk management

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COST MANAGEMENT

- Cost Management

Processes involved in planning, estimating, budgeting, financing, funding, managing, and controlling costs so that the project can be completed within the approved budget:

1. Plan cost management
2. Estimate cost
3. Determine budget
4. Control costs

In projects with small scope these processes can be merged in one single process

1. Plan Cost Management

- The process of establishing the policies, procedures, and documentation for planning, developing, managing, executing, and controlling project costs
  - Inputs: charter; scope baseline; schedule baseline; other information
  - Tools: expert judgment; analytical techniques; meetings

1. Plan Cost Management

Outputs - the cost management plan can establish the following:

- Units of measure
- Level of precision
- Level of accuracy
- Organizational procedures links
- Control thresholds
- Rules of performance measurement
- Reporting formats
- Process descriptions
- Additional details

2. Estimate costs

- The process of developing an approximation of the monetary resources needed to complete project activities (likely costs)

  - Cost estimates are a prediction that is based on the information known at a given point in time; cost estimates include the identification and consideration of costing alternatives to initiate and complete the project
  - Cost trade-offs and risks should be considered, and the sharing of resources in order to achieve optimal costs for the project

2. Estimate costs

- Cost estimates should be reviewed and refined during the course of the project to reflect additional detail as it becomes available and assumptions are tested; the accuracy of a project estimate will increase as the project progresses through the project life cycle

- Costs are estimated for all resources that will be charged to the project. This includes labor, materials, equipment, services, and facilities, as well as special categories such as an inflation allowance, cost of financing, or contingency cost

2. Estimate costs

Inputs:

- Cost management plan
- Human resource management plan
- Scope baseline (scope statement, WBS)
- Project schedule
- Risk register
- Environmental factors
- Organizational process assets

2. Estimate costs

Tools:

- Expert judgment
- Analogous estimating
- Parametric estimating
- Bottom-up estimating
- Three-point estimating
- Reserve analysis (contingency allowances)
- Cost of quality
- Project management software
- Vender bid analysis
- Group decision-making techniques

2. Estimate costs

Tools:

- Analogous estimating

  When estimating costs, this technique relies on the actual cost of previous, similar projects as the basis for estimating the cost of the current project. It is a gross value estimating approach, sometimes adjusted for known differences in project complexity.

  Analogous cost estimating is frequently used to estimate a value when there is a limited amount of detailed information about the project, for example, in the early phases of a project, and it's usually less costly and less time consuming

2. Estimate costs

Tools:

- Parametric estimating

  This method uses a statistical relationship between relevant historical data and other variables (e.g., square footage in construction) to calculate a cost estimate for project work

  It can produce higher levels of accuracy depending upon the sophistication and underlying data built into the model

  Parametric cost estimates can be applied to a total project or to segments of a project, in conjunction with other estimating methods

2. Estimate costs

Tools:

- Reserve analysis (1/3)

  Cost estimates may include contingency reserves (or contingency allowances) to account for cost uncertainty

  Contingency reserves are the budget within the cost baseline that is allocated for identified risks, which are accepted and for which contingent or mitigating responses are developed. They are often viewed as the part of the budget intended to address the “known-unknowns” that can affect a project

2. Estimate costs

Tools:

- Reserve analysis (2/3)

  The contingency reserve may be a percentage of the estimated cost, a fixed number, or may be developed by using quantitative analysis methods

  As more precise information about the project becomes available, the contingency reserve may be used, reduced, or eliminated

  Contingency should be clearly identified in cost documentation

  Contingency reserves are part of the cost baseline and the overall funding requirements for the project

2. Estimate costs

Tools:

- Reserve analysis (3/3)

  Management reserves are an amount of the project budget withheld for management control purposes and are reserved for unforeseen work that is within scope of the project; they are intended to address the “unknown unknowns” that can affect a project

  This is **not included** in the cost baseline but is part of the overall project budget and funding requirements. When an amount of management reserves is used to fund unforeseen work, the amount of management reserve used is added to the cost baseline, thus requiring an approved change to the cost baseline

2. Estimate costs

Outputs:

- Activity cost estimates
- Basis of estimates
- Updates

3. Determine budget

- The process of aggregating the estimated costs of individual activities or work packages to establish an authorized cost baseline
- The key benefit of this process is that it determines the cost baseline against which project performance can be monitored and controlled

- A project budget includes all the funds authorized to execute the project. The cost baseline is the approved version of the time-phased project budget, but excludes management reserves

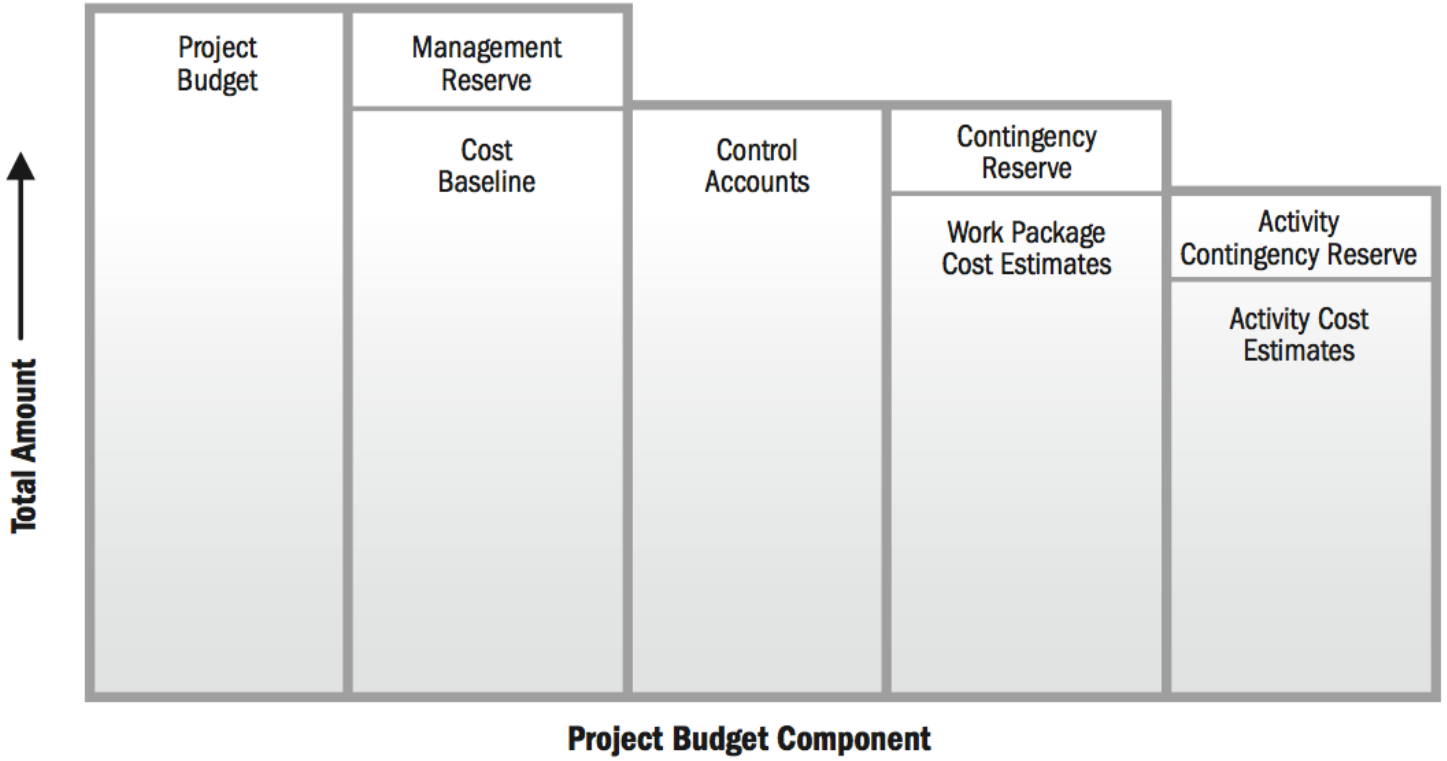
3. Determine budget

Outputs:

- Cost baseline
- Project funding requirements
- Updates

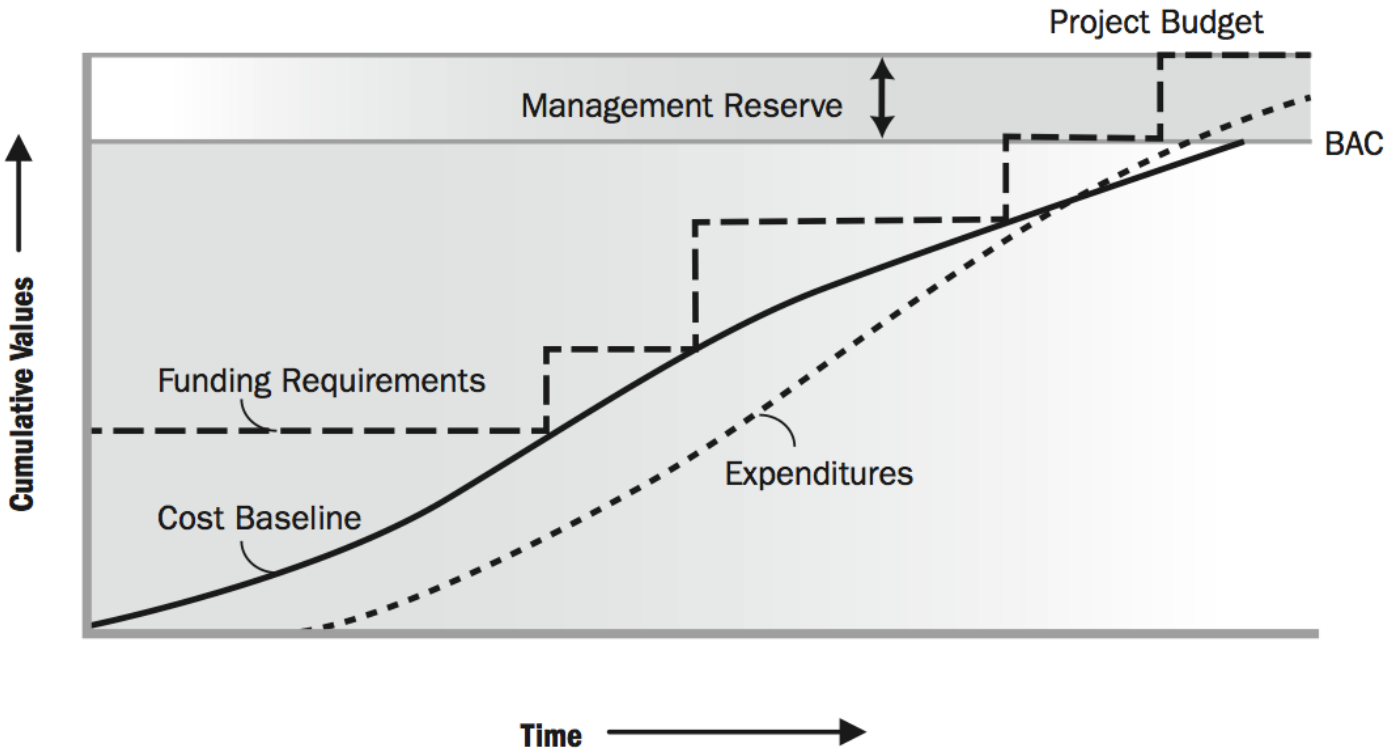
3. Determine budget

Outputs: Cost baseline



3. Determine budget

Outputs: Cost baseline, expenditures and funding requirements



4. Cost control

- The process of monitoring the status of the project to update the project costs and managing changes to the cost baseline
- The key benefit of this process is that it provides the means to recognize variance from the plan in order to take corrective action and minimize risk

  - Updating the budget requires knowledge of the actual costs spent to date; the key to effective cost control is the management of the approved cost baseline and the changes to that baseline

4. Cost control

Cost control includes:

Influencing the factors that create changes to the authorized cost baseline

Ensuring that all change requests are acted on in a timely manner

Managing the actual changes when and as they occur

Ensuring that cost expenditures do not exceed the authorized funding by period, by WBS component, by activity, and in total for the project

/…

4. Cost control

…/ Cost control includes:

- Monitoring cost performance to isolate and understand variances from the approved cost baseline
- Monitoring work performance against funds expended
- Preventing unapproved changes from being included in the reported cost or resource usage
- Informing appropriate stakeholders of all approved changes and associated cost
- Bringing expected cost overruns within acceptable limits

4. Cost control

Inputs:

- Project management plan
- Project funding requirements
- Work performance data
- Organizational process assets

4. Cost control

Tools:

- EVM - Earned Value Management
- Forecasting
- To-complete performance index
- Performance reviews
- Project management software
- Reserve analysis

4. Cost control

Outputs:

- Work performance information
- Cost forecasts
- Change requests
- Updates

Cost management

- Cost control: **Earned Value Management** EVM
  - Commonly used method of performance measurement for projects. It integrates the scope baseline with the cost baseline, along with the schedule baseline, to form the performance baseline, which helps the project management team assess and measure project performance and progress
  - Monitoring the expenditure of funds without regard to the value of work being accomplished for such expenditures has little value to the project, other than to allow the project team to stay within the authorized funding
  - Much of the effort of cost control involves analyzing the relationship between the consumption of project funds to the physical work being accomplished for such expenditures

- Cost control: **Earned Value Management** EVM

EVM develops and monitors three key dimensions: (1/3)

Planned value (PV) is the authorized budget assigned to scheduled work (not including management reserve)

This budget is allocated by phase over the life of the project, but at a given moment, planned value defines the physical work that should have been accomplished

The total of the PV is sometimes referred to as the performance measurement baseline (PMB). The total planned value for the project is also known as **budget at completion (BAC)**

- Cost control: **Earned Value Management** EVM

EVM develops and monitors three key dimensions: (2/3)

Earned value (EV) is a measure of work performed expressed in terms of the budget authorized for that work (that is, the budget associated with the authorized work that has been completed)

The EV being measured needs to be related to the PV, and the EV measured cannot be greater than the authorized PV budget for a component

The EV is often used to calculate the percent complete of a project

Project managers monitor EV, both incrementally to determine current status and cumulatively to determine the long-term performance trends

- Cost control: **Earned Value Management** EVM

EVM develops and monitors three key dimensions: (3)

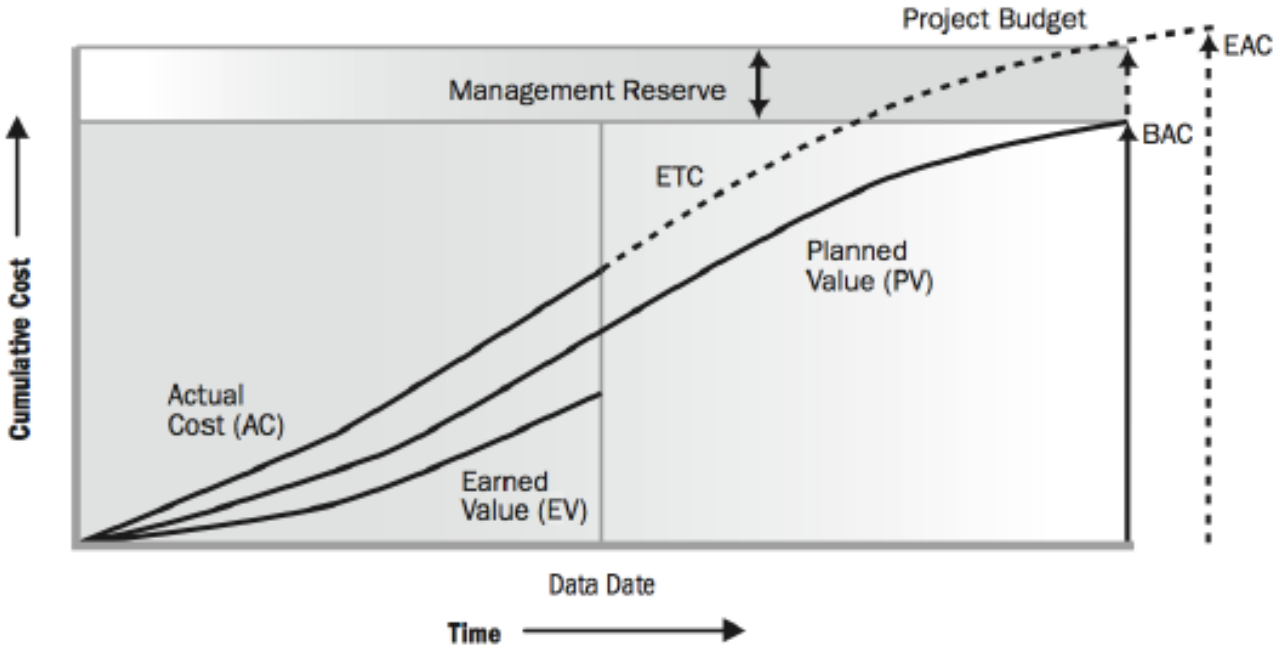
Actual cost (AC) is the realized cost incurred for the work performed on an activity during a specific time period (that is, the total cost incurred in accomplishing the work that the EV measured)

The AC needs to correspond in definition to what was budgeted in the PV and measured in the EV (e.g., direct hours only, direct costs only, or all costs including indirect costs).

The AC will have no upper limit; whatever is spent to achieve the EV will be measured

Cost management

- EVM



- EVM

Variances from the approved baseline will also be monitored: (1/2)

The **schedule performance index (SPI)** is a measure of schedule efficiency expressed as the ratio of earned value to planned value

It measures how efficiently the project team is using its time

An SPI value less than 1.0 indicates less work was completed than was planned; an SPI greater than 1.0 indicates that more work was completed than was planned

$$SPI = EV / PV$$

- EVM

Variances from the approved baseline will also be monitored: (2/2)

The **cost performance index (CPI)** is a measure of the cost efficiency of budgeted resources, expressed as a ratio of earned value to actual cost

It is considered the most critical EVM metric and measures the cost efficiency for the work completed

A CPI value of less than 1.0 indicates a cost overrun for work completed; a CPI value greater than 1.0 indicates a cost underrun of performance to date

$$CPI = EV/AC$$

- EVM

Forecasting: **EAC** (1/2)

As the project progresses, the project team may develop a forecast for the **estimate at completion (EAC)** that may differ from the budget at completion (BAC) based on the project performance

If it becomes obvious that the BAC is no longer viable, the project manager should consider the forecasted EAC

Forecasting the EAC involves making projections of conditions and events in the project's future based on current performance information and other knowledge available at the time of the forecast; the work performance information covers the project's past performance and any information that could impact the project in the future

- EVM

Forecasting: **EAC** (2/2)

EAC is typically based on the actual costs incurred for work completed, plus an estimate to complete (ETC) the remaining work

EAC forecast for ETC work performed at the budgeted rate: this method accepts the actual project performance to date (whether favorable or unfavorable) as represented by the actual costs, and predicts that all future ETC work will be accomplished at the budgeted rate

$$EAC = AC + (BAC - EV)$$

EAC forecast for ETC work performed at the present CPI: this method assumes what the project has experienced to date can be expected to continue in the future

$$EAC = BAC / CPI$$ (in terms of time: $EAC = BAC / SPI$)

- EVM

To-complete performance index: **TCPI**

The **to-complete performance index (TCPI)** is a measure of the cost performance that is required to be achieved with the remaining resources in order to meet a specified management goal, expressed as the ratio of the cost to finish the outstanding work to the remaining budget

BAC: (BAC – EV) / (BAC – AC)

In terms of time:

BAC: (BAC – EV) / (BAC – PV)

RISK MANAGEMENT

- What is risk management?
  - Project **risk** is an uncertain event or condition that, if it occurs, has a positive or negative effect on one or more project objectives such as scope, schedule, cost, and quality
  - **Risk management**: processes of conducting risk management planning, identification, analysis, response planning, and controlling risk on a project
  - Objectives: to increase the likelihood and impact of positive events (opportunities), and decrease the likelihood and impact of negative events (threats) in the project

Risk management

- Known and unknown risks
  - Uncertainty is present in all projects. **Known risks** are those that have been identified and analyzed, making it possible to plan responses for those risks. Known risks that cannot be managed proactively, should be assigned a contingency reserve
  - **Unknown risks** cannot be managed proactively and therefore may be assigned a management reserve. A negative project risk that has occurred is considered an issue

- Individual and overall risks
  - **Overall project risk** represents the effect of uncertainty on the project as a whole. It is more than the sum of the individual risks within a project, since it includes all sources of project uncertainty. It represents the exposure of stakeholders to the implications of variations in project outcome, both positive and negative
  - Organizations and stakeholders are willing to accept varying degrees of risk depending on their risk attitude
    - Risk appetite, Risk tolerance, Risk threshold

Risk management

- Individual and overall risks
  - The risk attitudes are driven by perception, tolerances, and other biases, which should be made explicit wherever possible. A consistent approach to risk should be developed for each project, and communication about risk and its handling should be open and honest
  - Risk responses reflect an organization’s perceived balance between risk taking and risk avoidance

Risk management

- Individual and overall risks
  - To be successful, an organization should be committed to address risk management proactively and consistently throughout the project. A conscious choice should be made at all levels of the organization to actively identify and pursue effective risk management during the life of the project

Risk management

- Frequent issues
  - Scope change
  - Never ending projects
  - Exceeding budget
  - Unsatisfied client
  - Major modifications required
  - Absent sponsor
  - Focus on a section of the project
  - Incomplete definition
  - Lack of analysis

Risk management

- Frequent issues
  - Scope change
  - Never ending projects
  - Exceeding budget
  - Unsatisfied client
  - Major modifications required

Risk management

- Context for risk planning
  - Governance
  - PMO (project management office)
    - Portfolio management (resources, money, decisions)
    - Organization management (structure, policies, support)
    - Methods and processes
    - Facilitator

1 Plan risk management

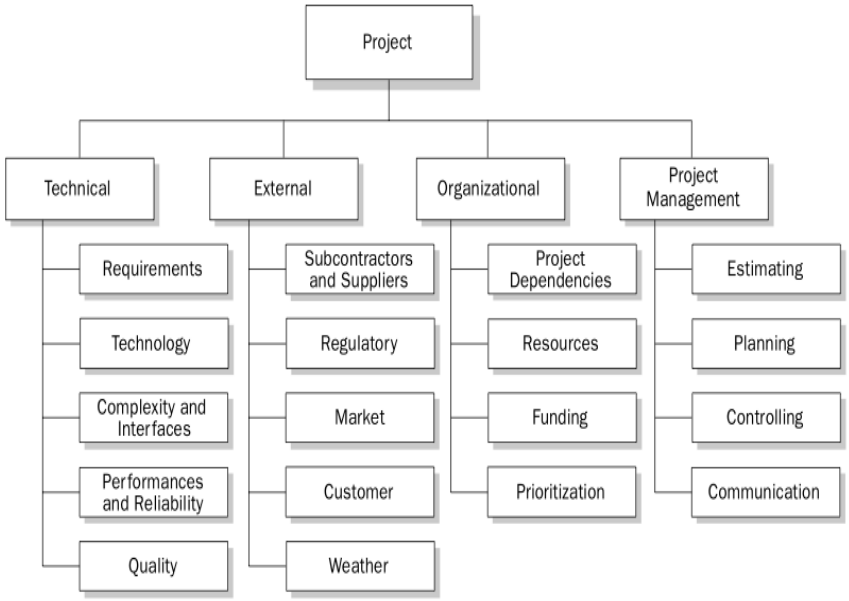
- Process of defining how to conduct risk management activities for a project. The benefit of this process is it ensures that the degree, type, and visibility of risk management are commensurate with both the risks and the importance of the project to the organization
- The risk management plan is vital to communicate with and obtain agreement and support from all stakeholders to ensure the risk management process is supported and performed effectively over the project life cycle

1 Plan risk management

- Tools:
  - Analytical techniques
  - Expert judgment
- Outputs:
  - Risk management plan
    - methodology, roles, responsibilities, budgeting, timing, risk categories, definition of risk probability and impact

1 Plan risk management

- …/ Risk management plan
  - Risk categories - a means for grouping potential causes of risk, which may take the form of:
    - a simple list of categories
    - a **risk breakdown structure** (RBS)



2 Identify risks

- Process of determining which risks may affect the project and documenting their characteristics
- Participants in risk identification activities may include: project manager, project team members, risk management team (if assigned), customers, subject matter experts from outside the project team, end users, other project managers, stakeholders, and risk management experts
- The process should involve the project team so they can develop and maintain a sense of ownership and responsibility for the risks and associated risk response actions

2 Identify risks

- Tools:
  - Document reviews
  - Information gathering techniques (brainstorming, Delphi, interviewing, root cause analysis)
  - Checklist analysis
  - Assumption analysis
  - Diagram techniques (cause-effect, flow charts, influence)
  - SWOT analysis
  - Expert judgment

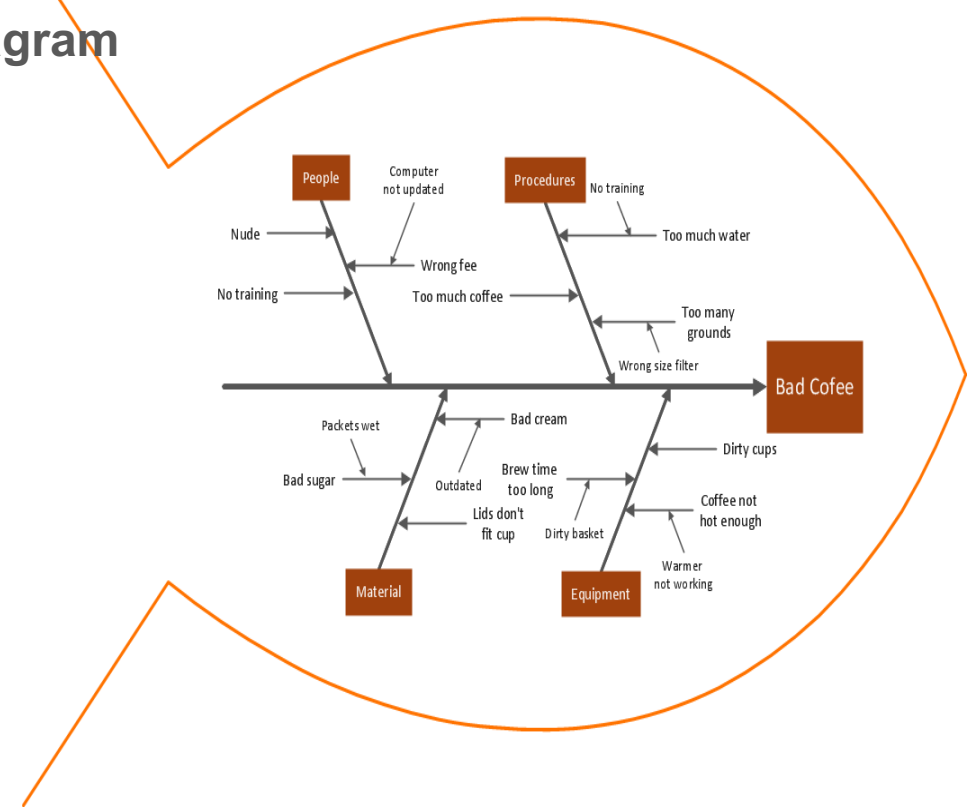
2 Identify risks

- Analyze risks from the perspective of:
  - The project
  - The organization
  - The client
- Identify the risks in terms of causes, not effects

2 Identify risks

- …/ Diagram techniques:

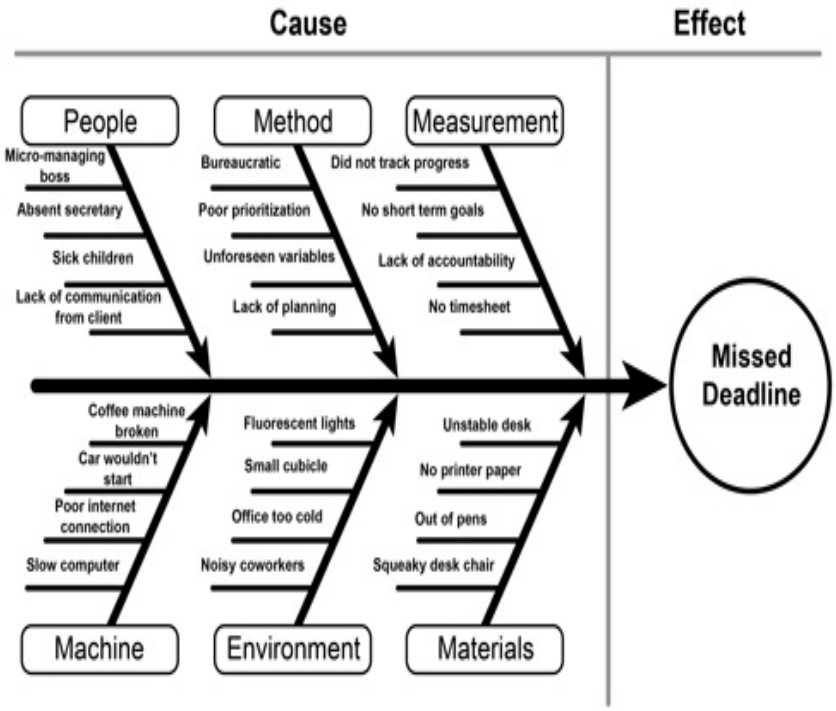
  cause-effect diagram



2 Identify risks

- …/ Diagram techniques:

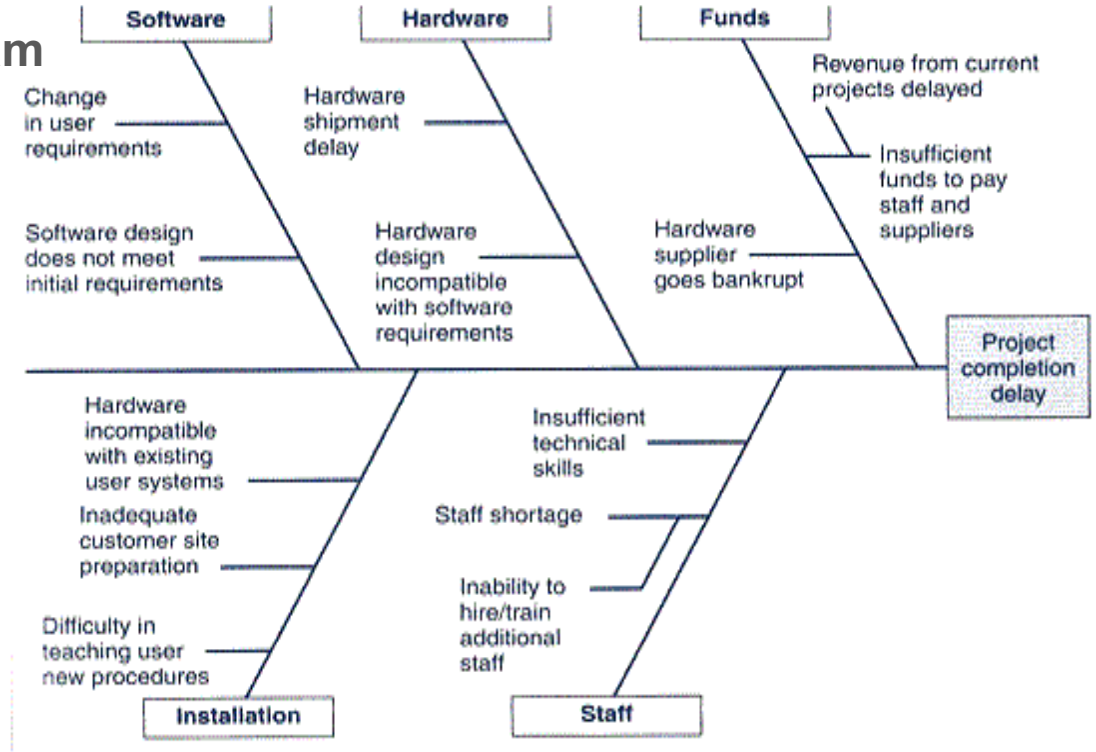
  cause-effect diagram



2 Identify risks

- …/ Diagram techniques:

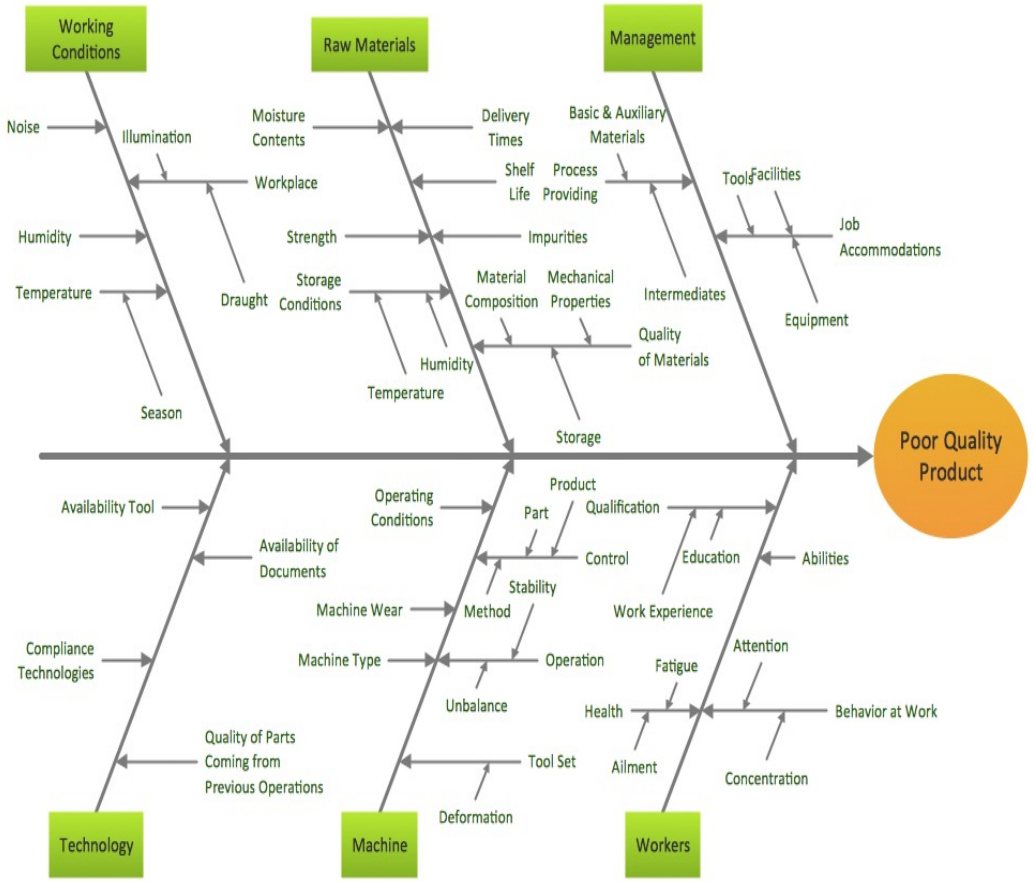
  cause-effect diagram



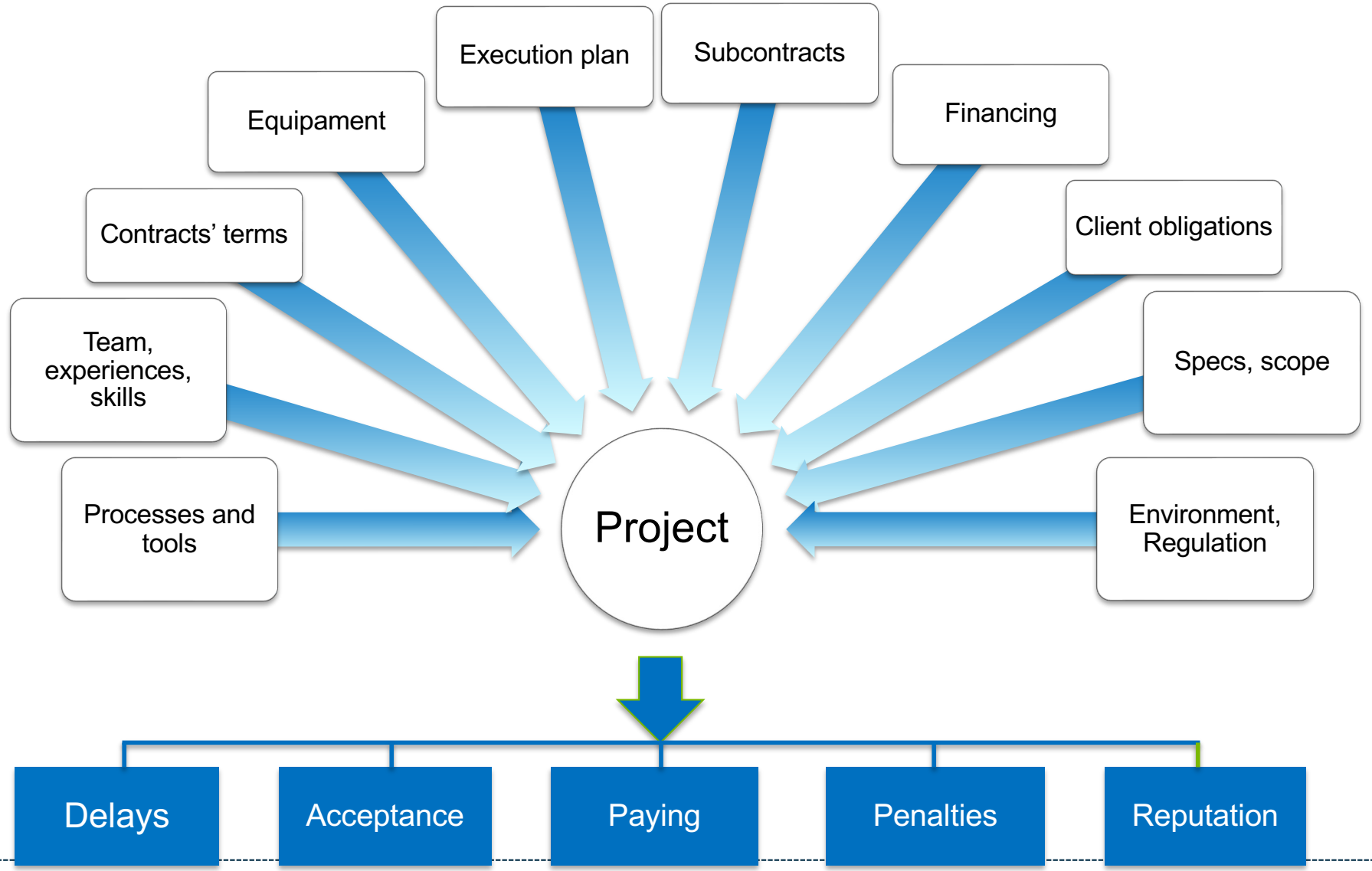
2 Identify risks

- …/ Diagram techniques:

  cause-effect diagram



Risk management

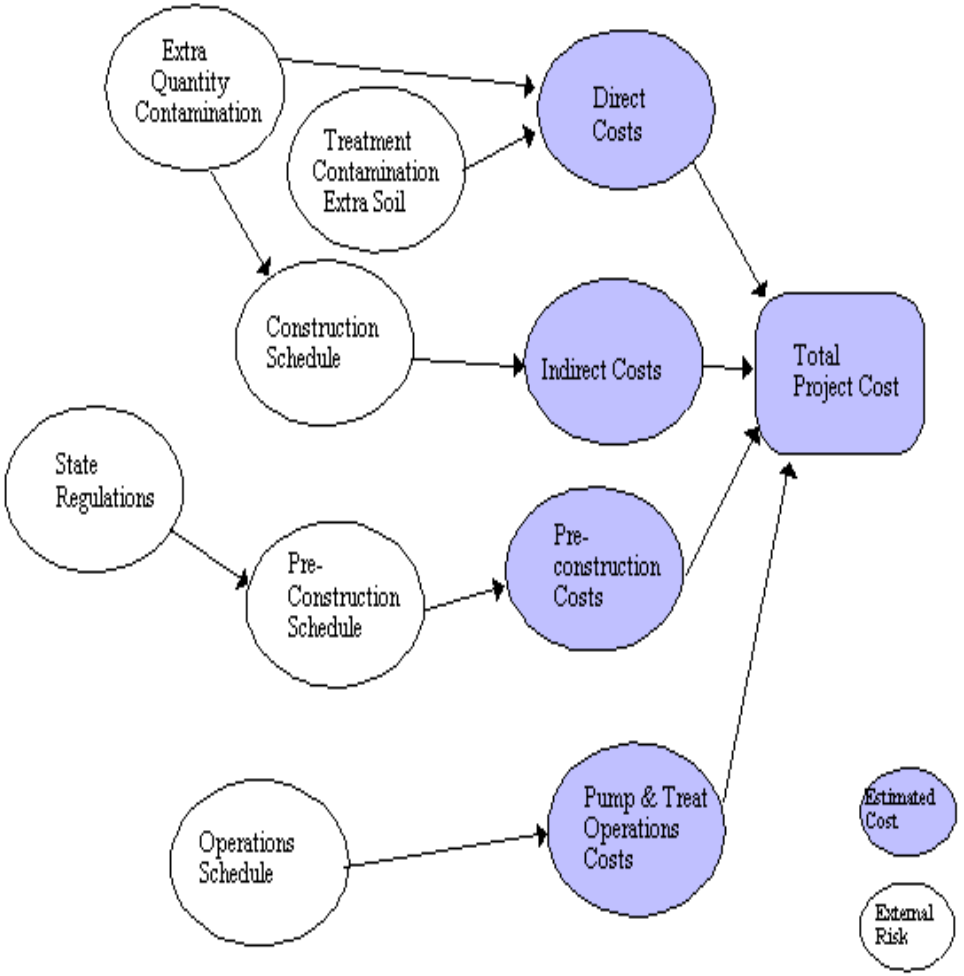


Risk management

2 Identify risks

- …/ Diagram techniques:

  influence diagram



2 Identify risks

- Outputs:
  - **Risk register** - document in which the results of risk analysis and risk response planning are recorded
    - List of identified risks
    - List of potential responses

2 Identify risks

- Risk register - example

Category of risk	Risk	Probability	Impact	Strategies

- Technical
- Contracts
- Financing
- Execution
- ...

- Risk description

- Very low
- Low
- Moderate
- High
- Very high

- Low / Moderate / High
- A value, when possible

- Risk responses / strategies

Risk management

Risk No	Date Identified	Risk Description	Likelihood	Impact	Risk Score (LxI)	Risk Class	Control Measures	Target Risk Score	Target Date	Risk Owner
1	Sep-07	Organisational change within several partner organisations could lead to disengagement in the work of the partnership resulting in non-achievement of objectives	4	3	12	High	Scoping change in partner organisations. Understanding agendas in different organisations. Alert to disengagement. Proactive contact to re-engage people.	4 x 2	Apr-08	Lisa Christensen
2	Sep-07	Lack of coordinated approach to project development leading to disjointed and unconnected activities that collectively do not achieve the objectives of the strategy	4	3	12	High	Clear accountability. Clear reporting, especially where there are difficulties. Formal performance management of projects needs to be put into place.	2 x 2	Apr-08	Tom Savory
3	Sep-07	Lack of partnership funding and resources to deliver the ambition of the partnership taking account of future service demand and demographic growth, places financial pressure on partners to increase contributions or a reduction in service provision	3	4	12	High	Clear focus on priorities. Excellent financial management & budgeting control. Flexibility of response to changing circumstances. Set up of sub group to focus on this area.	3 x 3	Mar-08	Rosalie Monbiot
4	Sep-07	Changes of political leadership from partner organisations may lead to a change of direction from existing priorities	3	3	9	Medium	Ensure clear rationale for priorities. Focus on outcomes. Focus on what works/evidence.	3 x 2	Apr-08	Rosalie Monbiot
5	Sep-07	Lack of representation of the right people to attend at the right level to make decisions for their organisations	3	3	9	Medium	Membership of different elements of partnership reviewed. Review level of active attendance. Strong communication between partners.	1 x 3	Mar-08	Rosalie Monbiot
6	Sep-07	Lack of clear partnership agreement supporting the delivery of activities leads to a lack of accountability and an over-reliance on goodwill which may impede delivery of the outcomes with the potential for breakdown in governance arrangements and controls	3	3	9	Medium	Develop partnership agreements, re joint planning, joint commissioning & integrated services. Develop high level protocols e.g.: re CAF.	1 x 3	Mar-08	Tom Savory

3 Perform Qualitative Risk Analysis

- Process of prioritizing risks for further analysis or action by assessing and combining their probability of occurrence and impact
- Tools:
  - Risk probability and impact assessment
  - Probability and impact matrix
  - Risk data quality assessment
  - Risk categorization
  - Risk urgency assessment
  - Expert judgment
- Outputs:
  - Risk register updates
  - Assumption log updates

3 Perform Qualitative Risk Analysis

		Threats					Opportunities				
*Impact / Probability		Very Low	Low	Medium	High	Very High	Very High	High	Medium	Low	Very Low
		0.05	0.10	0.20	0.40	0.80	0.80	0.40	0.20	0.10	0.05
Very High 71-90%	0.90	0.05	0.09	0.18	0.36	0.72	0.72	0.36	0.18	0.09	0.05
High 51-70%	0.70	0.04	0.07	0.14	0.28	0.56	0.56	0.28	0.14	0.07	0.04
Medium 31-50%	0.50	0.03	0.05	0.10	0.20	0.40	0.40	0.20	0.10	0.05	0.03
Low 11-30%	0.30	0.02	0.03	0.06	0.12	0.24	0.24	0.12	0.06	0.03	0.02
Very Low up to 10%	0.10	0.01	0.01	0.02	0.04	0.08	0.08	0.04	0.02	0.01	0.01

Each risk is rated on its probability of occuring and impact on an objective (e.g., cost, time, scope or quality) 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.

3 Perform Qualitative Risk Analysis

- …/ Risk probability and impact assessment
  - Investigates the likelihood that each specific risk will occur.
- …/ Probability and impact matrix
  - Ratings are assigned to risks based on their assessed probability and impact
  - Such a matrix specifies combinations of probability and impact that lead to rating the risks as low, moderate, or high priority. Descriptive terms or numeric values can be used depending on organizational preference
  - **Risk score = Probability x Impact**

Risk Short Description	Impact	Probability	Significance
Team not staffed in time	4	5	20
Language misunderstandings	3	5	15
Team not experienced	3	5	15
Too many conflicting interests	4	2	8
Project manager overwhelmed	4	2	8
Available resources	2	2	4
Testers not available	2	2	4

4 Perform Quantitative Risk Analysis

- Process of numerically analyzing the effect of identified risks on overall project objectives
  - Performed on risks that have been prioritized by the Perform Qualitative Risk Analysis process as potentially and substantially impacting the project's competing demands
  - It is used mostly to evaluate the aggregate effect of all risks affecting the project. When the risks drive the quantitative analysis, the process may be used to assign a numerical priority rating to those risks individually
- Data gathering
  - Interviewing
  - 3 point estimates
  - Probability distributions

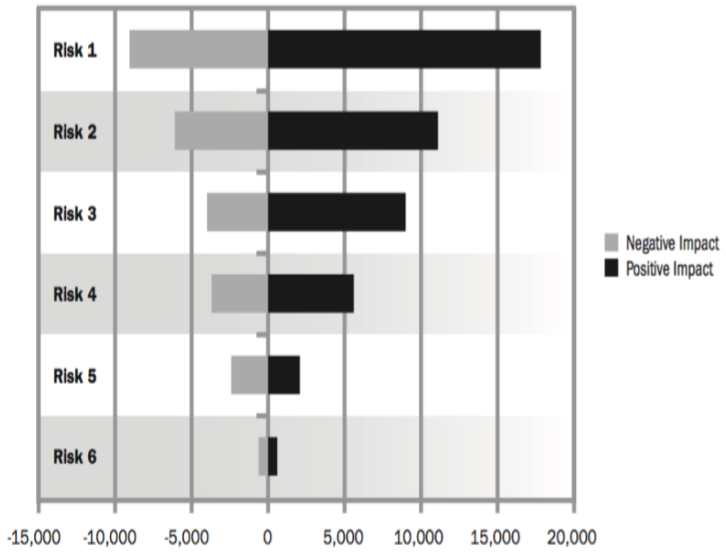
Range of Project Cost Estimates

WBS Element	Low	Most Likely	High
Design	$4M	$6M	$10M
Build	$16M	$20M	$35M
Test	$11M	$15M	$23M
Total Project	$31M	$41M	$68M

Interviewing relevant stakeholders helps determine the three-point estimates for each WBS element for triangular, beta or other distributions.

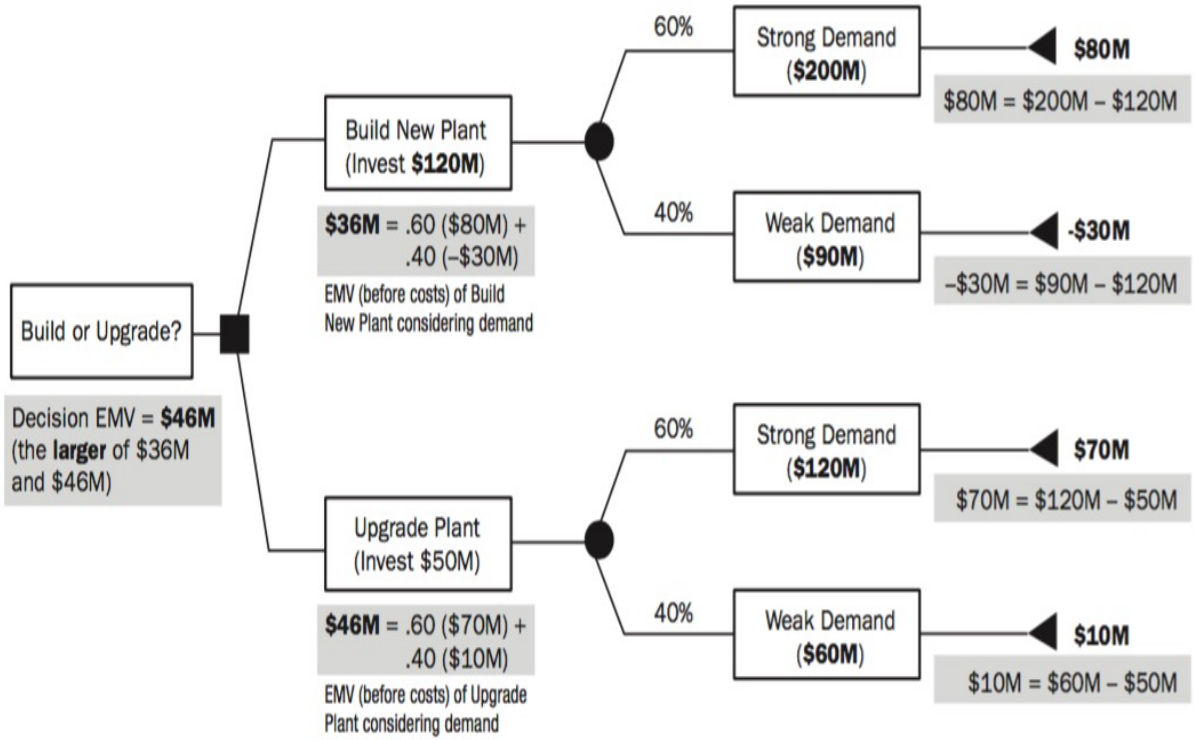
4 Perform Quantitative Risk Analysis

- …/ Quantitative risk analysis and modeling techniques: Sensitivity analysis



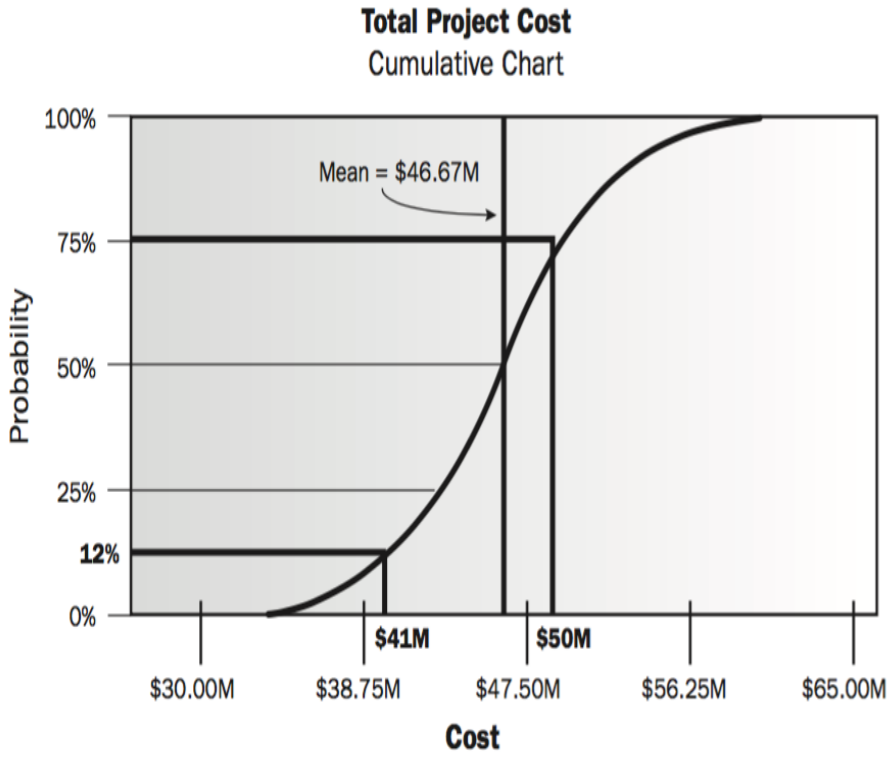
4 Perform Quantitative Risk Analysis

- …/ Quantitative risk analysis and modeling techniques: Decision trees



4 Perform Quantitative Risk Analysis

- …/ Quantitative risk analysis and modeling techniques: Simulation



4 Perform Quantitative Risk Analysis

- Outputs:
  - Probabilistic analysis of the project
  - Probability of achieving cost and time objectives
  - Prioritized list of quantified risks
  - Trends in quantitative risk analysis results

5 Plan risk responses

- Process of developing options and actions to enhance opportunities and to reduce threats to project objectives
- Each risk response requires an understanding of the mechanism by which it will address the risk; this is the mechanism used to analyze if the risk response plan is having the desired effect
- It includes the identification and assignment of one person (an owner for risk response) to take responsibility for each agreed-to and funded risk response
- Risk responses should be appropriate for the significance of the risk, cost-effective in meeting the challenge, realistic within the project context, agreed upon by all parties involved, and owned by a responsible person

5 Plan risk responses

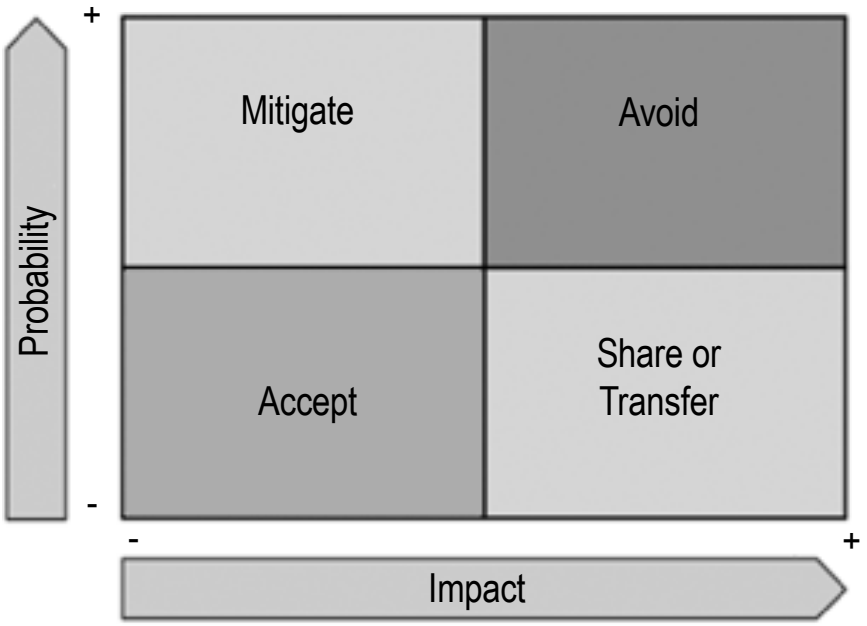
- Tools:
  - Strategies for Negative Risks or Threats

    Avoid Transfer Mitigate Accept
  - Strategies for Positive Risks or Opportunities

    Exploit Enhance Share Accept
  - Contingency response strategies
  - Expert judgment

5 Plan risk responses

- Strategies for negative risks



5 Plan risk responses

- Strategies for negative risks

Mitigation: action taken before the risk occurs, aiming at reducing its probability and/or impact

Contingency: plan to implement in case of risk occurrence

5 Plan risk responses

- Outputs:
  - Updates in management plans and baselines
  - Updates to the risk register
  - Change requests

6 Control risk

- Process of implementing risk response plans, tracking identified risks, monitoring residual risks, identifying new risks, and evaluating risk process effectiveness throughout the project
- The key benefit of this process is that it improves efficiency of the risk approach throughout the project life cycle to continuously optimize risk responses

- Planned risk responses that are included in the risk register are executed during the life cycle of the project, but the project work should be continuously monitored for new, changing, and outdated risks…

6 Control risk

- Tools:
  - Risk reassessment
  - Risk audits
  - Variance and trend analysis
  - Technical performance measurement
  - Reserve analysis
  - Meetings

6 Control risk

- Outputs:
  - Work performance information
  - Change requests
    - Recommended corrective actions
    - Recommended preventive actions
  - Updates

Risk Quantitative Analysis

Risk management: quantitative risk analysis

- **Risk analysis:** example

Activity	Optimistic duration	Most likely duration	Pessimistic duration
A	1	2	3
B	0,5	1	1,5
C	2	4	6
D	4	6	9
E	1	2	3
F	1	2	4
G	2	3	5

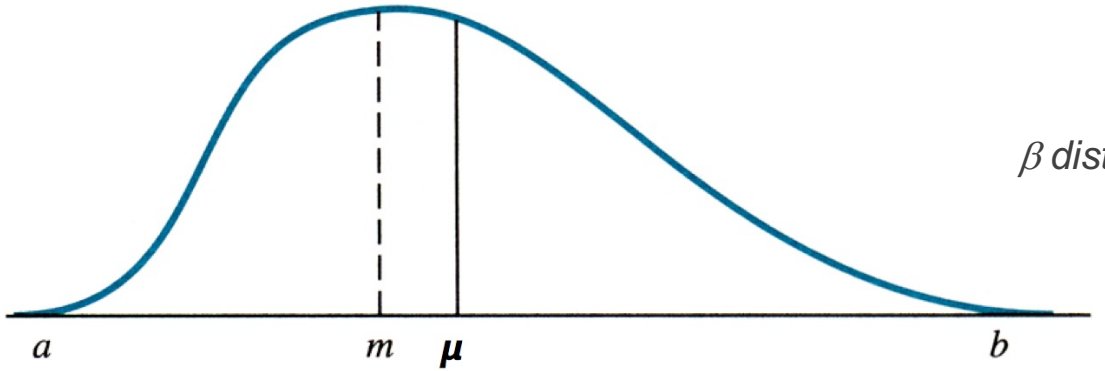
Risk management: quantitative risk analysis

Risk analysis

- *a* is estimated so that the actual time required by the activity will be *a* or greater than *a* about 99% of the times
- *b* is estimated so that the actual time required by the activity will be *b* or less then *b* about 99% of the times

$\mu = (a + 4m + b) / 6$

$\sigma^2 = [(b-a) / 6]^2$



β distribution

Risk management: quantitative risk analysis

Risk analysis

Time expected

Activity	Time Expected μ	Variance σ^2
A	2,00	0,111
B	1,00	0,028
C	4,00	0,444
D	6,17	0,694
E	2,00	0,111
F	2,17	0,250
G	3,17	0,250

Risk management: quantitative risk analysis

Risk analysis

- Uncertainty of project completion time
  - Determine the probability that a project will be completed by a suggested deadline or find the completion time associated with a predetermined level of risk
  - Assuming that the activities are statistical independent of each other, the variance of the set of activities is the sum of the variances of the individual activities comprising the set
  - We are interested in the variances of the critical activities…

Risk management: quantitative risk analysis

Risk analysis

- Uncertainty of project completion time

  In the example, **what are the chances of completing the project in 14 days?**

  D = the desired project completion time

  μ = the critical time of the project (the sum of μ for activities in the critical path)

  σ_μ^2 = the variance of the critical path (the sum of the variances of each task of the critical path)

  Z = the number of standard deviations of a normal distribution (the standard normal deviate)

$$Z = (D - \mu) / \sqrt{\sigma_\mu^2}$$

Risk management: quantitative risk analysis

Risk analysis

- Uncertainty of project completion time

D = 14 days

$\mu = 4 + 6{,}17 + 3{,}17 = 13{,}33$ days

$\sigma_{\mu}^{2} = 0{,}444 + 0{,}694 + 0{,}25 = 1{,}389$

$Z = (14 - 13{,}33) / \sqrt{1{,}389} \approx 0{,}57$

Risk management: quantitative risk analysis

Risk analysis

- Uncertainty of project completion time

  What deadline is consistent with a 0,90 probability of on-time completion?

  First we find the value Z associated with 0,90 in the table (cumulative probabilities of the normal probability distribution) – the value 1,282 is an approximate interpolation

  Solving the equation for D:

$$D = 13{,}33 + \sqrt{1{,}1785} \times 1{,}282 \approx 14{,}84 \text{ days}$$

Risk management: quantitative risk analysis

Risk analysis

- Realistic time estimates

  The expected durations previously calculated were based on estimates of pessimistic and optimistic durations with 1% error; no project manager is comfortable making estimates with such a level of precision

  In practice: estimates are made with lower precision – 0,95; 0,90; 0,80…

  At 0,95, it means that only 1 in 20 times will the actual activity duration be greater than, or less than, the pessimistic or optimistic estimates, respectively.

  In this case, the formula must be modified:

  0,95: $\sigma^2 = [\ (b - a) / 3{,}3\ ]^2$

  0,90: $\sigma^2 = [\ (b - a) / 2{,}6\ ]^2$

Cumulative (Single Tail) Probabilities of the Normal Probability Distribution (Areas under the Normal Curve from $-\infty$ to Z)

z	00	.01	.02	.03	.04	.05	.06	.07	.08	.09
.0	.5000	.5040	.5080	.5120	.5160	.5199	.5239	.5279	.5319	.5359
.1	.5398	.5438	.5478	.5517	.5557	.5596	.5636	.5675	.5714	.5753
.2	.5793	.5832	.5871	.5910	.5948	.5987	.6026	.6064	.6103	.6141
.3	.6179	.6217	.6255	.6293	.6331	.6368	.6406	.6443	.6480	.6517
.4	.6554	.6591	.6628	.6664	.6700	.6736	.6772	.6808	.6844	.6879
.5	.6915	.6950	.6985	.7019	.7054	.7088	.7123	.7157	.7190	.7224
.6	.7257	.7291	.7324	.7357	.7389	.7422	.7454	.7486	.7517	.7549
.7	.7580	.7611	.7642	.7673	.7704	.7734	.7764	.7794	.7823	.7852
.8	.7881	.7910	.7939	.7967	.7995	.8023	.8051	.8078	.8106	.8133
.9	.8159	.8186	.8212	.8238	.8264	.8289	.8315	.8340	.8365	.8389
1.0	.8413	.8438	.8461	.8485	.8508	.8531	.8554	.8577	.8599	.8621
1.1	.8643	.8665	.8686	.8708	.8729	.8749	.8770	.8790	.8810	.8880
1.2	.8849	.8869	.8888	.8907	.8925	.8944	.8962	.8980	.8997	.9015
1.3	.9032	.9049	.9066	.9082	.9099	.9115	.9131	.9147	.9162	.9177
1.4	.9192	.9207	.9222	.9236	.9251	.9265	.9279	.9292	.9306	.9319
1.5	.9332	.9345	.9357	.9370	.9382	.9394	.9406	.9418	.9429	.9441
1.6	.9452	.9463	.9474	.9484	.9495	.9505	.9515	.9525	.9535	.9545
1.7	.9554	.9564	.9573	.9582	.9591	.9599	.9608	.9616	.9625	.9633
1.8	.9641	.9649	.9656	.9664	.9671	.9678	.9686	.9693	.9699	.9706
1.9	.9713	.9719	.9726	.9732	.9738	.9744	.9750	.9756	.9761	.9767
2.0	.9772	.9778	.9783	.9788	.9793	.9798	.9803	.9808	.9812	.9817
2.1	.9821	.9826	.9830	.9834	.9838	.9842	.9846	.9850	.9854	.9857
2.2	.9861	.9864	.9868	.9871	.9875	.9878	.9881	.9884	.9887	.9890
2.3	.9893	.9896	.9898	.9901	.9904	.9906	.9909	.9911	.9913	.9916
2.4	.9918	.9920	.9932	.9925	.9927	.9929	.9931	.9932	.9934	.9936
2.5	.9938	.9940	.9941	.9943	.9945	.9946	.9948	.9949	.9951	.9952
2.6	.9953	.9955	.9956	.9957	.9959	.9960	.9961	.9962	.9963	.9964
2.7	.9965	.9966	.9967	.9968	.9969	.9970	.9971	.9972	.9973	.9974
2.8	.9974	.9975	.9976	.9977	.9977	.9978	.9979	.9979	.9980	.9981
2.9	.9981	.9982	.9982	.9983	.9984	.9984	.9985	.9985	.9986	.9986
3.0	.9987	.9987	.9987	.9988	.9988	.9989	.9989	.9989	.9990	.9990
3.1	.9990	.9991	.9991	.9991	.9992	.9992	.9992	.9992	.9993	.9993
3.2	.9993	.9993	.9994	.9994	.9994	.9994	.9994	.9995	.9995	.9995
3.3	.9995	.9995	.9995	.9996	.9996	.9996	.9996	.9996	.9996	.9997
3.4	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9998