

Project Management Road Trip®

**For the Project Management
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**Your Key to PMP
Certification
and Understanding the
PMBOK® Fourth Edition**

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www.PMRoadTrip.com

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Your Key to PMP Certification and Understanding the PMBOK Fourth Edition*

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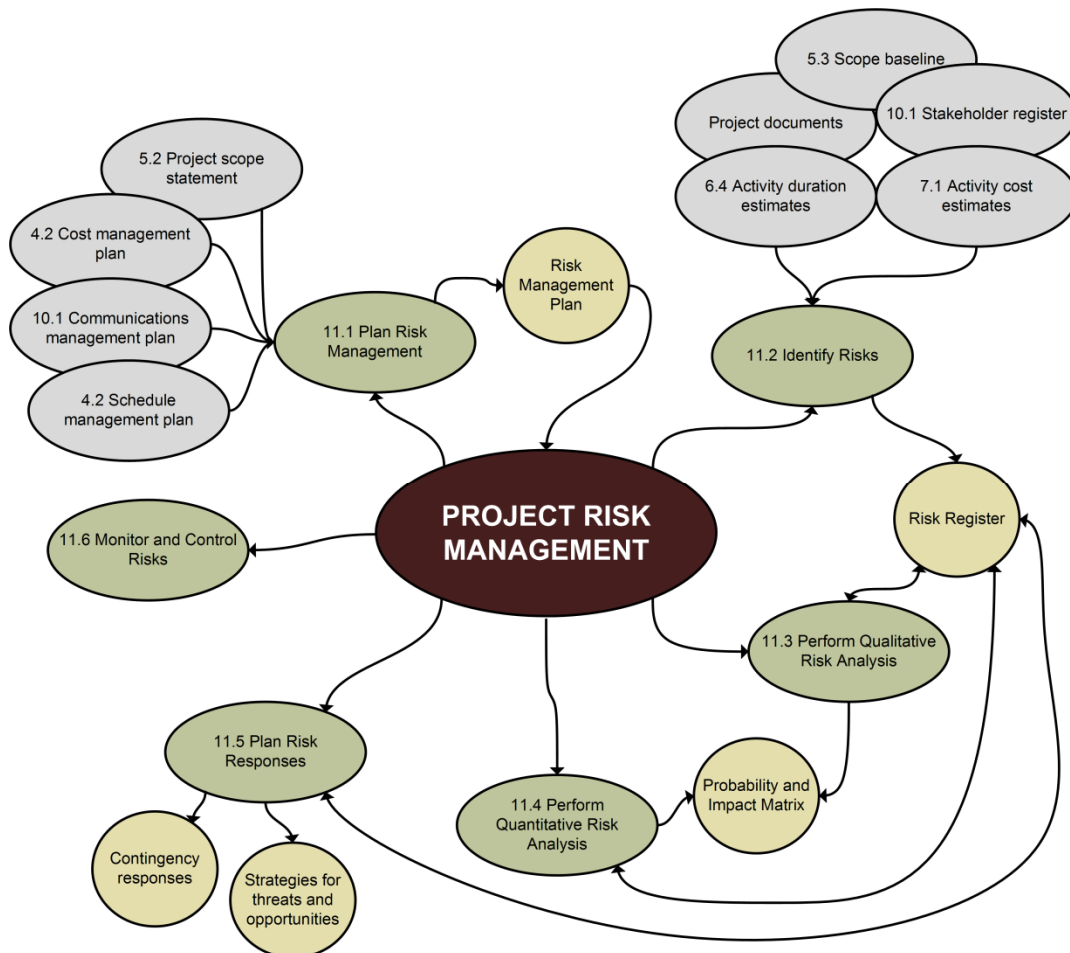
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11.0 Project risk management

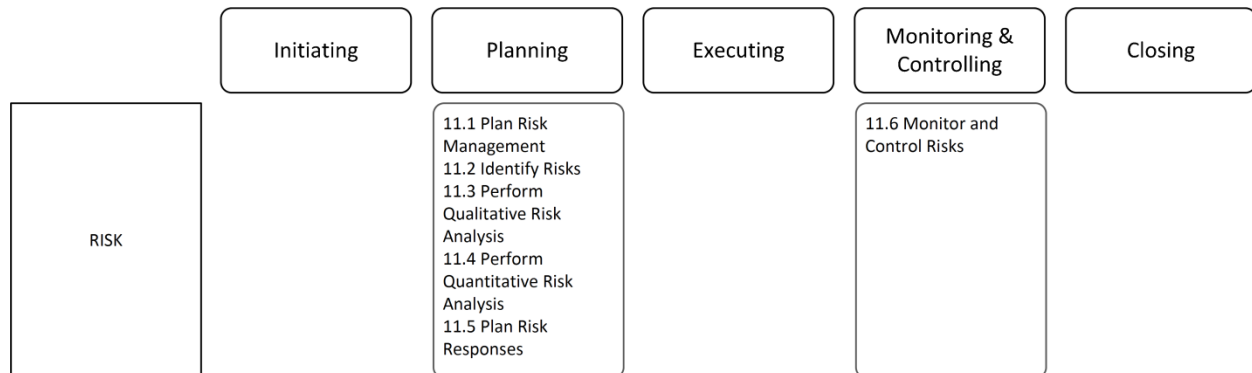
The **Project Risk Management** knowledge area includes the processes that identify, evaluate, respond to, and monitor project risks.



Keywords

- ☐ assumptions analysis
- ☐ assumptions log
- ☐ cause-and-effect diagram
- ☐ checklist analysis
- ☐ contingency plan
- ☐ Delphi technique
- ☐ document review
- ☐ fallback plan
- ☐ impact
- ☐ influence diagram
- ☐ linear scale
- ☐ Monte Carlo analysis
- ☐ non-linear scale
- ☐ probability
- ☐ probability and impact matrix
- ☐ relative scale
- ☐ reserve analysis
- ☐ residual risk
- ☐ risk
- ☐ risk action owner
- ☐ risk audit
- ☐ risk breakdown structure
- ☐ risk manager
- ☐ risk owner
- ☐ risk reassessment
- ☐ risk register
- ☐ Risk responses
 - accept
 - avoid
 - contingent
 - enhance
 - exploit
 - mitigate
 - share
 - transfer
- ☐ risk tolerance
- ☐ risk utility
- ☐ root cause
- ☐ secondary risk
- ☐ SWOT
- ☐ technical performance measurement
- ☐ trigger

Overview



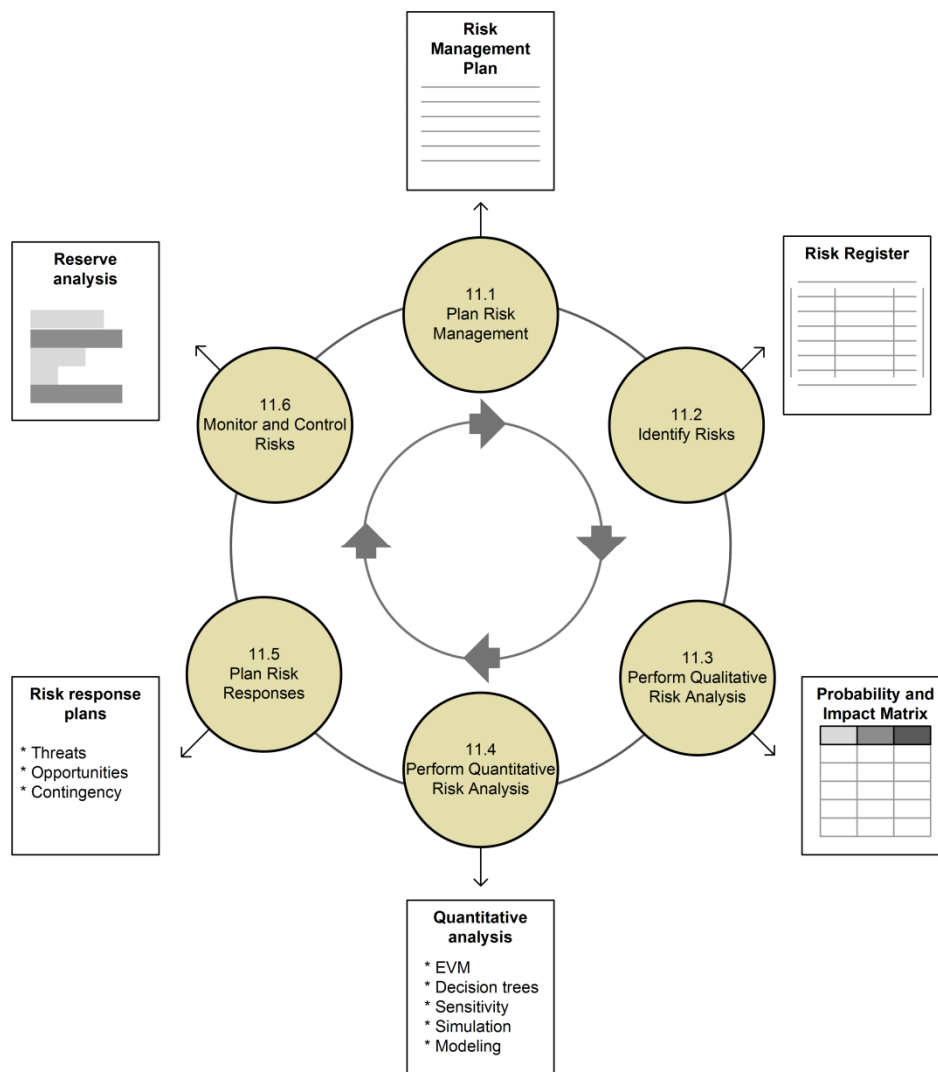
By their very nature of creating a unique product, service, or result and operating within constraints and under assumptions, projects cannot exist without risks. There are risk factors in every project objective, deliverable, and activity that exist starting with the earliest inception phase all the way until closure. Though we often think of risks as being threats with negative consequences, there are also positive risks, called opportunities, that can increase the project's chances of success or which can be exploited to save time or money.

Project risk management can be thought of as a balancing act because innovation, which is so necessary for successful projects, doesn't occur without elements of risk. So the objective of project risk management is not to avoid risks entirely, but *to increase the probability and impact of positive events, and decrease the probability and impact of events adverse to the project*¹. Without risk-taking, new methods of efficiency, originality, and competitiveness can't be achieved, so the project risk processes make sure the costs of risks are weighed against the benefits they provide.

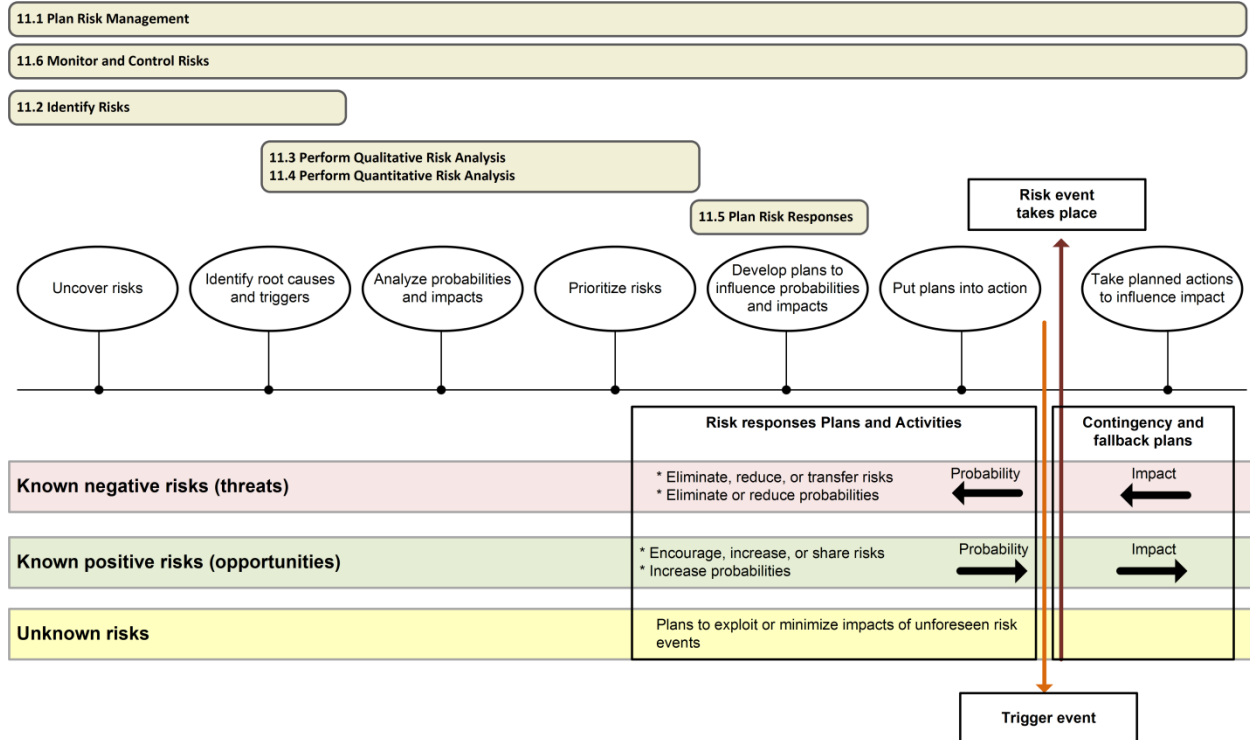
The project manager has the key role in project risk management even if there are professional risk personnel also assigned to the project, and a proactive approach is necessary because risk is the only root cause of project failure. Behind any unsuccessful project objective is an opportunity that wasn't capitalized upon or a risk caused by a false assumption, restrictive constraint, or an event that wasn't sufficiently planned for.

The **Project Risk Management** knowledge area includes the processes that identify, evaluate, respond to, and monitor project risks.

- **Plan Risk Management:** Defining how risk planning processes will be approached and identifying what overall risk management activities will take place.
- **Identify Risks:** Thoroughly uncovering and documenting project risks.
- **Perform Qualitative Risk Analysis:** Assessing the probability and impact of identified risks in order to establish risk priorities.
- **Perform Quantitative Risks Analysis:** Further cost, probability, and impact analysis of individual risks so that probability and impact can be aggregated to the project level.
- **Plan Risk Responses:** Developing an action plan for identified risks, including responses to priority risks should they occur.
- **Monitor and Control Risks:** Tracking identified risks, reporting on risk symptoms and impacts, and watching for new risks.



Risk management concepts



When talking about risks there are a few fundamental concepts that will help us better understand subsequent risk processes.

- **Risk:** Is any uncertain event that impacts one or more project objectives. Risks are considered *uncertain* not because we can't discover them but because we can't be 100 percent sure that they'll take place. Risks that are detrimental to project objectives are also called threats or negative risks while risks that are beneficial to the project are called opportunities or positive risks.
- **Risk response:** These are the actions that will be taken prior to the risk taking place that reduce the probability or impact of a threat should it occur or increase the probability or impact of an opportunity.
- **Root cause:** The factor(s) that is the source of the risk. We need to understand what factors generate the risk so that we can better develop plans to influence the risk. For instance, a risk might be that the delivery of a key component from a supplier might be late, but the root causes of this risk might include order entry errors, miscommunication, or weather-related events.
- **Trigger:** The signs, symptoms, or key event that warns us the risk is imminent or is now more likely to occur. Though triggers are not always easy to identify before the risk occurs, if we can better understand what the triggers might be then we can take additional steps to influence the risk.
- **Probability:** An assessment of how likely it is that the risk event will occur. Risk responses try to influence probability before the risk takes place –our goal is to reduce the probability of negative impacts from occurring and increasing the chances of positive risks.
- **Impact:** The effect the risk will have, usually expressed in monetary, time, quality, or scope measures. Prior to the risk event taking place, our aim is to reduce or eliminate the impact a negative risk will have (should it take place) or to increase the beneficial impact of a positive risk.

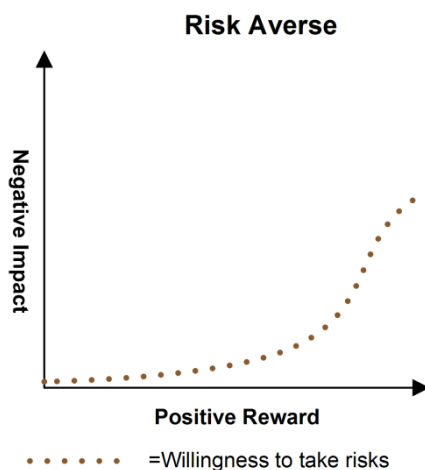
- **Contingency plan:** These are the actions that will be taken in response to a risk event that is imminent or which is occurring. Contingency plans aim to reduce the impact of a negative risk or increase the impact of an opportunity, and are used in combination with risk responses.
- **Fallback plan:** What actions will be taken if the contingency plan proves ineffective.

Risk tolerance

Each project as a whole, its individual objectives, and the people involved have differing levels of risk that are acceptable. Safety, reputation, technical factors, contracts, reliability, cost, and schedule influence what amounts of risk are acceptable. The entities involved, like the customer, organization, and stakeholders, will also have their own attitudes towards risk, which may fluctuate depending upon the exact type of risk involved, what project objectives may be impacted, and what alternatives exist.

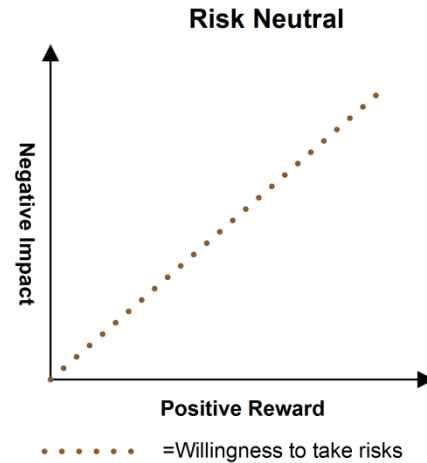
The amount of tolerance a person or organization has for risks is referred to as its **risk utility**, which is a measure of how much negative impact the organization or person is willing to accept in trade for a potential positive benefit. As part of balancing risk, the project manager has to often facilitate an agreement between risk averse and risk tolerant viewpoints.

Risk tolerant/risk seeking: These people have a willingness to accept risks even when the benefit doesn't seem worth the negative impact.



Risk averse: These people have a tendency to avoid risks even when the reward outweighs the potential negative impact.

Risk neutral: These people generally have a logical, balanced approach that is weighted against the pros and cons of the risk.



Risk roles and responsibilities

Risk management activities for the project require roles to be established and personnel named to those assignments. The key roles in project risk management are:

- **Project manager:** The project manager is responsible for overall risk management and ensuring that it's properly coordinated with all other project management activities.
- **Risk manager:** The person responsible for establishing and overseeing risk management processes and coordinating them with the project manager. The risk manager monitors risks and regularly communicating the risk status to the project team and stakeholders. The risk manager will hold some level of decision-making authority, and where that authority begins and ends needs be documented in the risk management plan.
- **Risk owner:** This is the person who has the skills and expertise necessary to best manage a particular risk. This role assists in developing the risk responses, contingency plans, risk actions, and monitors the risk.
- **Risk action owner or risk response owner:** The person responsible for carrying out risk response activities for a particular risk.

The project manager is responsible for ensuring that risk management is properly carried out. The risk manager establishes the overall project risk management methodology and for monitoring and controlling risks.

Each individual risk has a risk owner, who's responsible for managing that risk, and one or more risk action owners, who'll carry out risk response activities.



11.1 Plan risk management



Since risk management activities have a bearing on other risk management activities, including scope, cost, schedule, and quality, risk planning should occur as early as possible

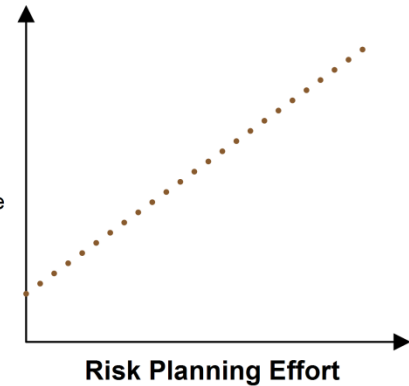
Risk management planning involves:

- Defining what risk management activities will occur
- Establishing the allotted time and cost for risk management activities
- Assigning risk management responsibilities
- Deciding how risk probability and impact will be measured
- Deciding on acceptable risk thresholds and tolerances.

The level of detail necessary for risk planning is proportional to the priority, complexity, cost, and failure impacts of the project. One or more combinations of these may require a more thorough approach than would otherwise be necessary, but this does not imply that a minor project needs no risk management planning. Projects of all types and complexities are susceptible to failure without a thorough risk management plan.

Factors affecting level of risk planning needed

Project complexity
Impacts of project failure
Project cost
Project priority



Performing risk management planning

The project scope and project management plan provide important information to risk planning. The project scope will be an indicator as to the complexity and uniqueness of the project, and it may also contain explicit risk management activities specified by the organization, customer, stakeholders, or the project team. The project management plan and its components, such as the quality management plan, may also include risk management activities.

It's up to the project team to establish exactly how risk management activities will be carried out, but risk management planning is not undertaken by just the project manager and a few members of the project team. Collaboration with a wide range of experts is the method that'll achieve the best risk management plan. At a minimum, risk planning needs to involve the project manager, project team, and key stakeholders. The scope or priority of the project may also necessitate the involvement of vendors, consultants, organizational management, and risk professionals.

The focus on dependencies [in Critical Chain network building] is, in effect, a focus on risk, since missed dependencies in plans and schedules are a serious source of risk. The repeated questioning of "what do you need?" followed by "is there anything else that is needed?" serves to trigger thought of things that could go wrong...²

Frank Patrick, Critical Chain and Risk Management:
Protecting Project Value from Uncertainty

Templates, past projects, and industry best practices can serve as starting points for the risk management plan. Some organizations may have a formal risk management methodology. If the company has risk policies, standardized risk categories, templates, or a common risk lexicon, these should be incorporated into risk planning. But even if the organization doesn't have a risk management methodology, it has to be committed to supporting the project risk management activities with adequate funding in the budget for risk responses.

Risk management plan



Each knowledge area has at least one subsidiary plan focusing on a specific subject as part of the overall project management plan. Preplanning is the purpose of these components, and these plans map out the specific requirements for the deliverables and project management processes that will take place in that knowledge area.

This preplanning may sound like a lot of work, but we can think of these subsidiary plans as being the scope statements for the knowledge area because they describe the who, what, where, why, and how of the project management work that will be performed for that section's subject matter.

The **risk management plan** pre-plans for project risk management. This plan establishes the:

Risk management methodology for the project

- Risk management methodology, describing the approaches, tools, and techniques that'll govern how project risk management will occur
- Risk categories
- Common lexicon of risk terminology
- Probability and impact scales, definitions, and estimating techniques
- Formats and methods that'll be used for risk reporting

Responsibilities for risk management activities

- Risk roles as required for the project (risk manager, risk management team)
- Responsibilities for subsequent risk management processes (risk identification, qualitative and quantitative analysis, risk response planning, and risk monitoring)

Budget, schedule, and frequency of risk management activities

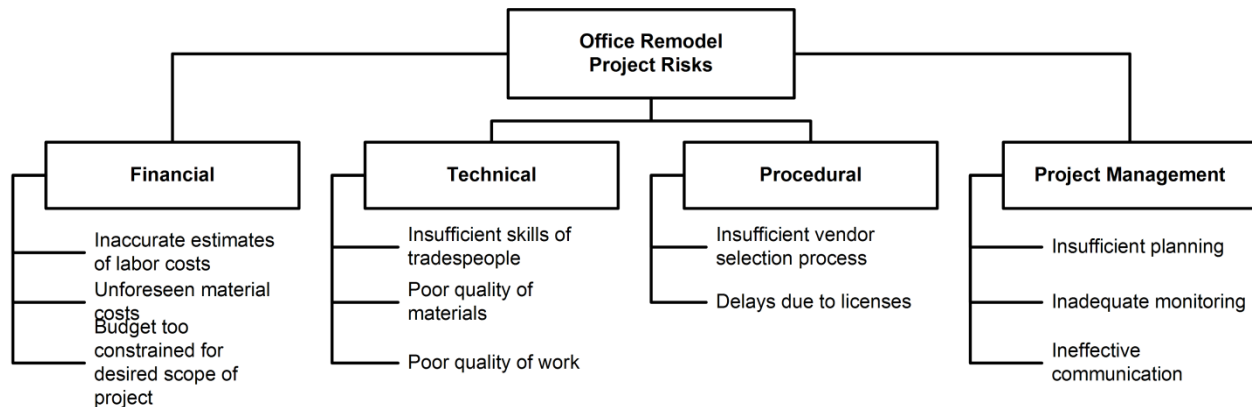
- Activities needed for risk management (and incorporated into the project schedule)
- Resources and costs allocated to risk management and risk activities as later defined and incorporated into project cost baseline
- Frequency of risk management activities, such as risk reassessments and risk audits

Tolerances, thresholds, and authority levels

- Stakeholder risk tolerances
- Tolerance levels and thresholds for risks
- Decision-making authority levels and escalation paths

Risk categories

Risk categories are general classifications that individual risks will be assigned to, and these categories are established as part of the risk management plan. They are helpful for organizing risks, spotting trends, aiding risk identification, and for reporting. These categories can be based on standards set by the organization or industry, or they may be specific to the project type. Risk categories are shown on a **risk breakdown structure**, which is a hierarchical, graphical display of risk categories similar in appearance to the work breakdown structure having multiple tiers of related risk classifications.



Though the exact categories may be more broadly or narrowly defined for the project, first-tier categories are usually derivatives of the following:

Category	Threat Example	Opportunity Example
Financial: Risks related to the marketplace, stock market, interest rates, commodity or raw material price fluctuations.	Unexpected demand creates a scarcity and subsequent price rise in project materials.	A low-rent opportunity makes co-location a viable option for the project team.
Human: Risks related to personnel issues or availability.	An unexpected long-term illness affects the project sponsor's ability to champion the project.	An acquisition increases the pool of skilled personnel the project can draw from.
Nature: Risks related to weather, natural disaster, climate, or environmental effects. Natural disasters are a type of risk known as force majeure , which include any long-term disruptions that can't be reasonably foreseen nor prevented.	A blizzard affects key personnel's ability to get to the office on the day the project's deliverable is scheduled for implementation.	A drier than normal spring allows construction to proceed faster than expected.
Operations: Risks arising from changes or disruptions to normal business functions.	A sudden manufacturing demand delays the availability of equipment needed for the project.	A vendor's expansion of manufacturing capability increases the chances components will be delivered ahead of schedule.

Category	Threat Example	Opportunity Example
Technical: Risks arising from the deliverable approach, design, or components or risks stemming from technology.	An innovative approach to architectural design presents engineering risks.	New computer infrastructure enables upgraded communication tools between the project team and other business units.
Political: Risks related to government, legislative, regulatory, or foreign policy changes.	A new licensing requirement passed by the city council affects work already underway on the project.	Due to flexible design in the project's deliverable, compliance with a new regulatory requirement can be incorporated faster than the competition.
Procedural: Risk caused by business or organizational processes, accountability, or systems.	Multiple accounting systems result in inconsistent project cost reporting.	An organizational quality methodology reduces the risk for project quality control issues.
Project Management: Risks due to project management processes.	Weak requirements lead to poor quality in the deliverable.	A strong change control system reduces the risk for scope creep.
Reputation: Risks stemming from a change in confidence towards the performing organization.	A flawed product release from another project decreases the chances of consumer acceptance for a new project's deliverable.	A technology award given to the organization generates a higher organizational enthusiasm for the project.

Probability and impact scales

Later risk processes will prioritize and assess risks based on their probability and what kinds of impacts they'll have on the project if they occur. Those assessments need to use a consistent approach to be valid, so the risk management plan establishes what scales will be used to measure probability and impact.

The scales need to be clear and well understood by the people involved in the risk processes, and they should be complex enough to accurately represent the risk yet be simple enough so that they're meaningful. For example, having a scale that runs from one to one hundred sounds like it would lead to better risk data, but it might only generate confusion since people could find it difficult to gauge what exactly is the difference between a ranking of say 63 and 68.

Scales also need to incorporate a weighting method for the importance of different project objectives. For instance, if staying within the project is most critical then risks that could have a negative financial impact need to be weighted more heavily.

When establishing probability and impact scales, there are three types of scales that can be used.

A **relative scale** (or ordinal scale) is the most simple and uses indicators such as low, medium, and high. These types of scales are easy to understand but they may not be detailed enough for some projects. Relative scales are usually correlated to a linear or non-linear scale.

Very Low	Low	Medium	High	Very High
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A **linear scale** (or cardinal scale) is numeric, and is commonly used to express the probability of the risk, so a rating of 1 would imply a very low probability while a rating of 9 would indicate a very high probability.

1	2	3	4	5
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A **non-linear scale** is also numeric, but the intervals between the designations aren't equal (e.g., 1, 2, 4, 8, 16). Non-linear scales are used to give more or less weight to an objective or impact.

1	2	4	8	16
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Probability and impact matrix

The **probability and impact matrix** provides a visual and textual, color-coded structure to the scale and scoring for the probability and impact of risks. The matrix will be used later during qualitative analysis, but having a brief overview now helps us to understand more about how the probability and impact scales are used. Key features of the matrix are that:

- It provides clear instructions, formulas, and examples for rating, scales, and scoring methods.
- It provides a legend for the risk's overall score, usually in the form of a RAG rating for red, amber, or green.

Even though at this stage we're not concerned with individual risks, the best way to fully understand the different scales and how they relate to risk scoring and rating is for us to see how all these pieces fit together into the final result. As we look at this example, let's remember that there is no single approach towards establishing scales, scoring formulas, or ranking methods, so what is shown here is only an illustration of a start-to-finish view of how a probability and impact matrix can be used.

Example: For this sample project, the probability is rated using a relative scale in combination with a linear scale. The risk management plan has established a probability rating table that correlates a relative rating to a percentage chance that the risk will occur.

Risk Y was estimated as having a low chance of occurring, which equates to a 30 percent probability chance.

	Very Low 1	Low 2	Medium 3	High 4	Very High 5
Risk X			X		
Risk Y		X			
Risk Z				X	

Probability Rating
Very Low=10% estimated probability
Low=30% estimated probability
Medium=60% estimated probability
High=80% estimated probability
Very High=95% estimated probability

A "low" probability rating for this risk correlates to a pre-defined 30% estimated chance that the risk will occur.

In addition to the probability rating, the impacts of the risk against the project's objectives need to be evaluated. The risk management plan not only defines the impact scale to be used, it also provides descriptive criteria used to evaluate the impact of each risk.

	IMPACT RATING CRITERIA				
	Very Low	Low	Medium	High	Very High
TIME	3 days or less	7 days or less	10 days or less	14 days or less	15 days or more
SCOPE	<10 hrs of effort	<20 hrs of effort	<30 hrs of effort	<40 hrs of effort	>40 hrs of effort
COST	<\$1,000	<\$1,500	<\$2,000	<\$2,500	>\$2,500

In our example, the impact of the risk on time and scope categories is estimated using a linear scale that runs from one to five, while impact upon the cost category uses a non-linear scale. Here, risk Y has a very low impact on time and scope but a high impact on project cost. Because of the non-linear scale that gives more weight to cost, risk Y's impact score is higher than the other two risks.

	TIME					SCOPE					COST					IMPACT RATING
	Very Low 1	Low 2	Medium 3	High 4	Very High 5	Very Low 1	Low 2	Medium 3	High 4	Very High 5	Very Low 1	Low 2	Medium 4	High 8	Very High 16	
Risk X		X				X					X					4
Risk Y	X					X								X		10
Risk Z		X					X					X				6

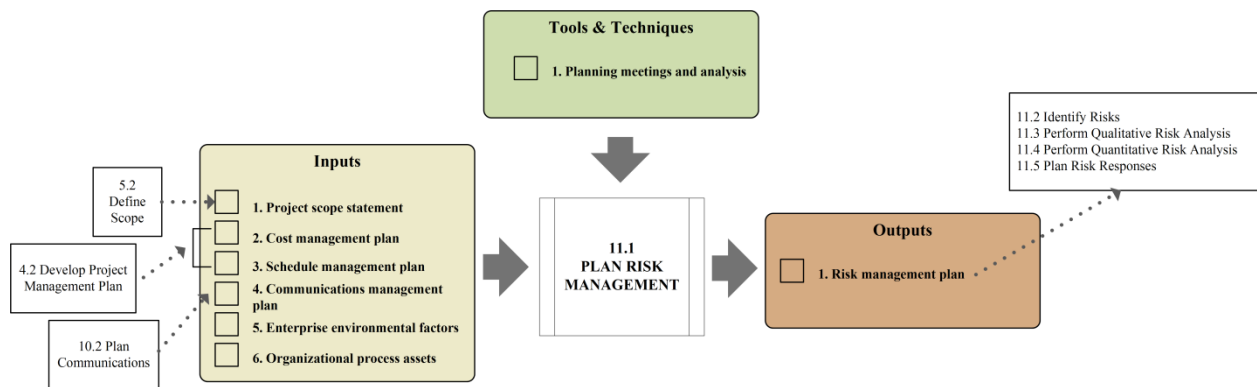
Risk Y's impact rating is its impact on time + its impact on scope + its impact on cost: 1 + 1 + 8 = 10

We can now use the combination of probability and impact to develop an overall risk score. The exact formula to will be is described in the risk management plan, but in our example, we're going to simply multiply the probability rating and impact rating together, giving risk Y an overall risk score of 20 ($2 \times 10 = 20$).

The overall risk score can then be used to help prioritize risks. Risk Y's overall score of 20 works out to be a medium priority risk.

OVERALL RISK RATING					
15	30	50	80	130	≥ 75 = very high priority risk
12	24	40	64	104	≥ 35 and < 75 = high priority risk
9	18	30	48	78	≥ 18 and < 35 = medium priority risk
6	12	20	32	50	≥ 9 and < 18 = low priority risk
3	6	10	16	26	< 9 = very low priority risk

11.1 Process decomposition



Inputs

☐ **Project scope statement**

The project scope statement details the measurable goals, objectives, deliverables, and requirements of the project, and what the acceptance criteria of deliverables will be. It also describes the work required to meet all objectives and deliverables of the project, and it also contains milestones, assumptions, risks, and costs. The project scope provides an indication of the level of risk management that the project will require.

☐ **Cost management plan**

The cost management plan is a part of the project management plan, and it provides guidance for all the cost processes. It establishes how project costs will be planned for, estimated, organized, reported on, forecasted, and managed. For planning of risks, the cost management plan defines how the financial costs of risk management activities will be budgeted for.

☐ **Schedule management plan**

Part of the project management plan, the schedule management plan details how the project schedule will be managed and controlled. For risk planning, it defines how risk management activities will be scheduled.

☐ **Communications management plan**

The communications management plan is a subsidiary plan of the project management plan, and it details the communications needs and requirements of the project and of the stakeholders, assigns responsibility, details the frequency and methods for communication elements, and defines the escalation paths for issues. For risk planning, it defines how data on risk will be communicated.

☐ **Enterprise environmental factors**

Risk planning is affected by the risk tolerances of the organization and its stakeholders.

☐ **Organizational process assets**

Risk planning is affected by the risk management methodology of the organization, standardized risk management templates (risk categories), and risk reporting formats.

Tools and Techniques

☐ **Planning meetings and analysis**

Risk management planning will involve meetings and discussions between the project manager, project team, stakeholders, and others within the organization as needed.

Outputs

☐ **Risk management plan**

The risk management plan is a component of the project management plan. It details and defines the risk management activities for the project. The plan establishes the risk methodology, risk roles and responsibilities, risk categories, probability and impact scales, risk tolerances, frequencies of risk management activities and reporting, and the budget and schedule for risk management activities.

11.2 Identify risks



In the **Identify Risks** process, we'll develop the risk register, which is a comprehensive list of all threats and opportunities that might be encountered on the project. The risk management plan is a key input to this process because it establishes the time and budget allocated to identification activities, and it also describes what activities will be used to uncover risks.

Risk identification should be done early in project planning because later risk processes rely on the risk register and risk decisions may impact the budget, schedule, and scope of the project. Some identified risks may require immediate action.

Risk identification will reoccur throughout the entire project since:

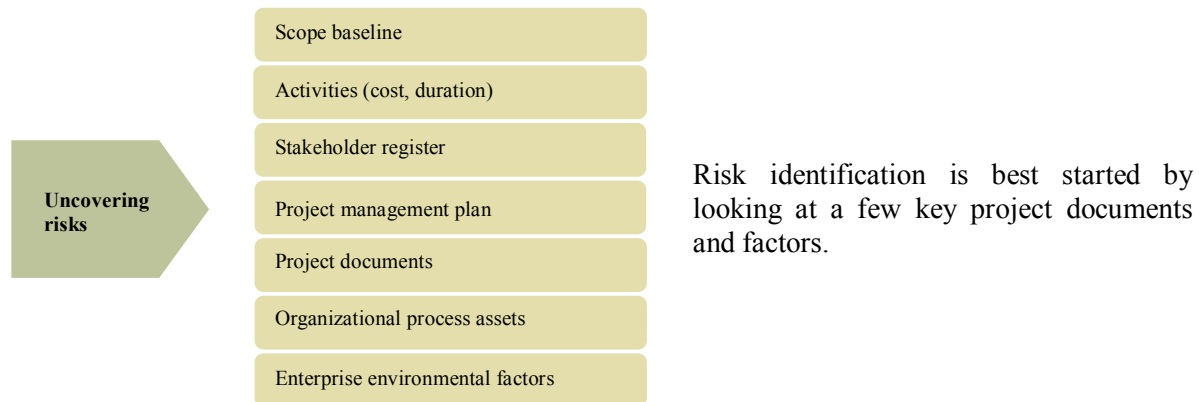
- New risks may become evident only after project execution is underway.
- Approved project changes may introduce risks.
- Changes outside the project boundaries may introduce risk factors.
- Actions taken in response to occurring risks may themselves generate risks.
- Symptoms, risk causes, probability, and impact may not be as originally planned.

Proper risk identification requires a thorough understanding of the work being undertaken, and uncovering risks is a collaborative effort involving the project team, stakeholders, subject matter experts, and possibly consultants, vendors, and risk professionals. The project manager should foster a project culture where everyone on the project is aware of risks and is on the lookout for them. No one should feel hesitant about openly raising risk issues for fear that it'll be perceived as "bad news."

A project for an electronic device required two different contractors to design and build the interface. An electronic engineer worked for one contractor and a computer scientist worked for the other. The 256 connectors were misaligned by one position when the electronic engineer started with the sequence 1 through 256 while the computer scientist started with the sequence 0 through 255. The error resulted in a \$600,000 redesign and build of the connectors.³

Dr. Lew Ireland, Project Complexity: A Brief Exposure to Difficult Situations

Risk identification sources



Project scope baseline

The project scope statement, work breakdown structure, and WBS dictionary are the best places to begin looking for risks since these documents thoroughly explain the project work and identify constraints and assumptions. Anywhere we find a constraint, we should consider it a risk factor since it limits the project's options, usually time, cost, or technology. For instance, a constraint that requires a specific technology to be used could introduce risks. Constraints are risk factors only as long as the constraint is in effect, so once the project successfully fulfills the objective within the constraint (or the constraint is removed) then the risk factor no longer exists.

Though every project is unique, some are more so than others, and the scope statement can also illuminate risks due to unconventional approaches, complexity, or technical elements. Projects using unproven methods, techniques, personnel, or technology have added risks that need subjected to further analysis.

Activities

The activity list, activity attributes, activity resource estimates, and activity duration estimates are useful for risk identification. Risks can be embedded in the technical components of activities, the relationships between activities, their resource needs, or in the durations allotted to the activities.

Project management plan

Risks can also be found in the project management plan and its components. Risk factors can be embedded in any of the management plans (scope, schedule, cost, quality, human resources, communications, or procurement) , as well as the risk management plan itself. The integrative aspects of the component plans and the interplay between time, cost, quality, and scope can generate elements of risk.

In particular, the following subcomponents should be well understood and scrutinized for risk elements:

- Scope baseline
- Cost management plan
- Schedule management plan
- Quality management plan
- Procurement management plan

Project documents

Risk factors can be found in other sets of project documents:

- Earned value measurements can expose early signs of risks related to cost or schedule performance.
- Network diagrams can show risks related to activity dependencies and resource contention.
- Project baselines, like scope, schedule, cost, and quality, can be a risk source when the baseline is too restrictive or aggressive.
- Work performance information should be regularly monitored for signs of risks related to schedule, budget, and quality.
- The issue log should be monitored since it may contain problems that are early signs of risks.
- The change log can also give clues to risks by reviewing what types of changes are being requested.

Enterprise environmental factors

Benchmarking, white papers, commercial databases, or academic studies relating to the project subject matter can expose risk factors. Factors within the organization can also be risk elements, including its culture, portfolio management practices, organizational hierarchy and reporting structures. Even the personalities of the stakeholders and the project team members or their interrelationships can lead to threats or opportunities.

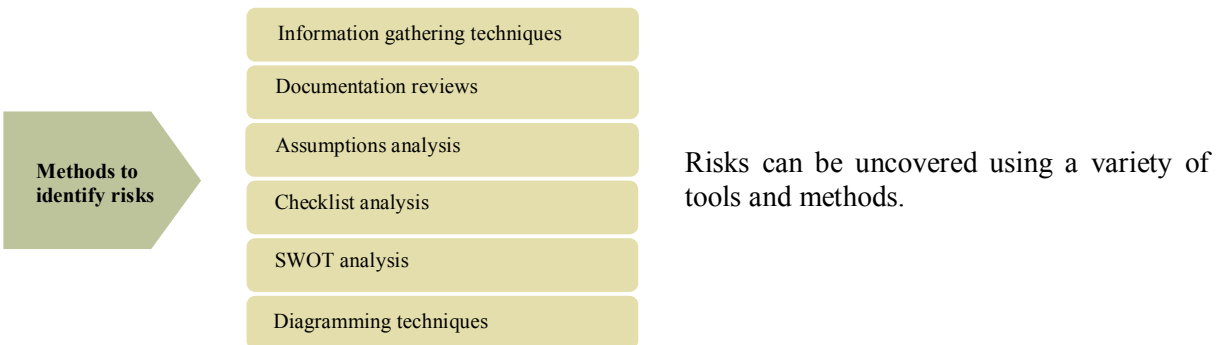
Every time a...product is delivered, somebody gains power and somebody else loses power. You can expect some stakeholders on any complex project to be adversaries. They may not be allowed to act adversarially, but many other possibilities are open to them [that create risk factors].⁴

Tom DeMarco and Tim Lister. Risk Management During Requirements

Organizational process assets

Lessons learned from similar projects can be valuable sources for identifying risks and there may be risk checklists available that can serve as reminders so that risk factors are not overlooked.

Methods to identify risks



Information gathering techniques

Brainstorming

Brainstorming sessions with a mix of diverse and experienced people are critical to finding risks. Risk discussions are best when they include a mix of participants with different backgrounds, experiences, and skills. For risk identification the facilitator will want to encourage participants to think broadly about risks and not focus too narrowly only on what is commonly perceived as "risk." A short introduction to project risk management may be necessary for the project team.

The facilitator can also use specific project objectives and well-worded, leading questions as starting points like "what events might keep us from reaching this goal?" Prompt-driven questions are good for not only uncovering risks, but identifying causes and impacts. For example, if one of the project objectives is to keep the defect rate below one per 10,000 units, the prompt could be:

The defect rate could exceed 1 per 10,000 units if _____ happens because of _____.

The defect rate could exceed 1 per 10,000 units if the die pressure is too great because the equipment wasn't calibrated per specifications.

Interviewing

Some of the best ways to identify risks are listening and asking good questions of people with knowledge in the project's subject areas. Interviewing can be as simple as talking with someone via e-mail, over lunch, or through a structured, sit-down meeting in his or her office. In whatever manner it takes place, the interviewer should be well prepared about the subjects involved and ask open-ended and focused questions. Yes or no answers are generally not helpful, and conversely if the questions are too broad, the interviewee may not be able to provide specific enough answers regarding risks.

Surveys

Surveys, such as the Delphi technique, can be used to gather risk information from subject matter experts. The Delphi technique does this anonymously so that the results can be analyzed by a third party without any bias as to the source of the opinion. The tabulated results can then be used to reach a consensus on project risks.

Root cause analysis

Root cause analysis uses techniques that work to identify and solve the underlying causes to an issue.

Documentation reviews

A review of project documents can expose additional risks. A **documentation review** looks for incomplete, missing, or out-of-date documents, which implies a lack of integrative project management. Document reviews might also uncover assumptions and constraints that were not explicitly identified in the project scope statement. Common risk factors that a documentation review can uncover are:

Integration Management	Lack of coordinated planning across the project management processes; poor business case, executive support, authority and power levels; inadequate change control.
Scope Management	Inadequate scope definition; lack of stakeholder involvement in defining scope; conflicting expectations; poor scope control processes.
Time Management	Inaccurate duration and resource estimates; improperly sequenced activities; activity dependencies not documented; poor schedule control processes.
Cost Management	Inaccurate cost estimates; insufficient tolerances in the budget; inadequate project accounting procedures; poor cost control processes.
Quality Management	Incomplete checklists; Vague quality goals or metrics; poor quality planning.
Human Resource Management	Poor management and leadership skills of the project manager; unclear project responsibilities; inadequate skills of team members.
Communications Management	Incomplete stakeholder identification and analysis; poor communications planning; inefficient communication methods and processes between team members; inadequate issues management.
Risk Management	Incomplete risk identification; improper risk prioritization; lack of contingency plans; inadequate contingency reserves; poor risk planning.
Procurement Management	Incomplete statements of work; poor contract change control.

Assumptions analysis

Assumptions anywhere in the project are risks elements because they are unproven. Assumptions can be explicit, such as those identified in the scope statement, or they may only be indirectly indicated in other project documents. To make it easier to track and update assumptions, they can be documented on an **assumptions log**.

Assumptions are always used with the best of intentions; however, until the assumption is proven otherwise, it's still an uncertainty and all uncertainties are risk factors. The reliability of assumptions should be tested through **assumptions analysis**, which reviews the reliability of each assumption, what consequences will occur if the assumption turns out to be inaccurate, and what risk factors are generated by the assumption. Assumptions that are not likely to hold up or clearly erroneous should be diverted back to the appropriate project management process for replanning rather than trying to manage the assumption as a risk.

Checklist analysis

Checklists can be developed based on the risk categories (used in the risk breakdown structure) or from similar projects. As these checklists are reviewed throughout the project, they should be improved upon so that they're beneficial to subsequent projects. The PMBOK refers to this as **checklist analysis**.

SWOT analysis

SWOT is credited to Albert Humphrey, who led a research study to find out the reasons why corporate planning failed⁵. SWOT is a strategic planning tool based on brainstorming that identifies strengths, weaknesses, opportunities, and threats related to an objective. SWOT results are subjected to additional reviews and converted into action items through **SWOT analysis**. SWOT is best performed in a diverse team setting with one, clearly stated project objective being discussed at a time. Participants then identify factors affecting the objective and write them in the corresponding quadrant on the grid.

- **Strengths:** Positive attributes or elements within the performing organization that will help the project reach the objective.
- **Weaknesses:** Negative attributes or elements within the performing organization that can inhibit the project from reaching the objective.
- **Opportunities:** Positive attributes or elements outside the performing organization that will help the project reach the objective.
- **Threats:** Negative attributes or elements outside the performing organization that can inhibit the project from reaching the objective.

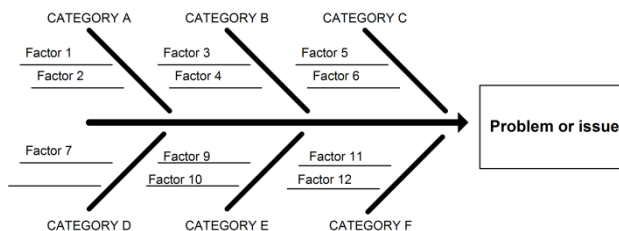
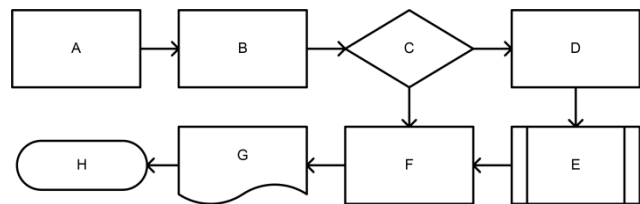
		Helpful	Harmful
Internal		Strengths	Weaknesses
External		Opportunities	Threats

During the SWOT brainstorming session, the participants shouldn't over analyze their responses, especially as they might find that a strength for one objective may turn up again later as a weakness for another goal. After SWOT items have been gathered, each one needs subjected to further questioning and converted into identified risks --how strengths and opportunities can be exploited and how weaknesses and threats can be avoided or mitigated.

Diagramming techniques

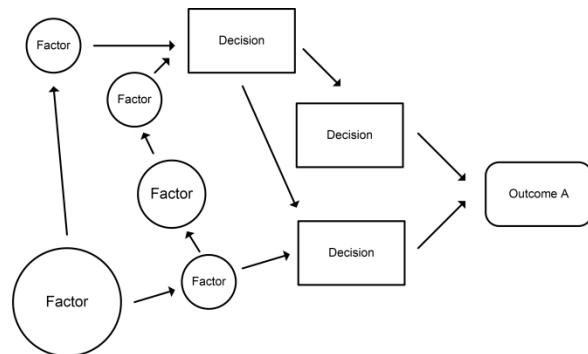
Diagramming techniques can include flowcharts, cause-and-effect diagrams, and influence diagrams. Diagramming techniques can aid in risk identification for the same reasons that they're useful as part of quality control (process 8.3) --they can highlight relationships and dependencies between project factors that might generate risks, and diagrams can help to identify the root causes of risks.

A **flowchart** graphically illustrates the steps, sequences, and decision points in a process. It can identify contention points or relationships in the process that could generate risks.



A **cause and effect diagram** shows what root causes can be contributing to an issue or problem. It's also known as a fishbone diagram or an Ishikawa diagram.

An **influence diagram** is a visual representation of a decision. Influence diagrams offer a way to identify and display the essential elements, including decisions, uncertainties, and objectives, and how they influence each other. Unlike flowcharts, influence diagrams do not show paths in any sequential order.



Risk register

The risk register is an important component of the project management plan. The **risk register** is a complete and running list of project risks, and it's an input to all risk processes. The information about each risk will also be expanded upon in later processes. The full contents of the risk register are described below along with the risk processes where each element is most likely to be collected.

	Process
Risk: The name, description, and a unique identifier for the risk.	11.2
Risk Owner: The risk owner is the person in charge of monitoring and controlling the risk.	11.2
Risk category: The categorization from the risk management plan that the risk falls within. Changes may be requested to the categories originally defined in the risk management plan as risks are identified and analyzed.	11.2
Root cause: The core factor(s) leading to the risk. A risk may have multiple causes as well as multiple impacts.	11.2
Potential response: Responses to risks are planned in Risk Response Planning (11.5), but potential responses may become obvious during risk identification and should be captured in the risk register.	11.2
Impact: The risk register contains the specific details about what will be effected should the risk occur.	11.2-11.4
Probability: The probability of the risk expressed as a percentage or on a scale as defined by the risk management plan.	11.2-11.4
Symptoms/Warning Signs: Any specific conditions likely to trigger the risk or symptoms that the risk is about to occur should be identified. This will help during risk monitoring.	11.2, 11.5
Risk Score: The probability and impact score for the risk. This is obtained from a formula (usually probability x impact) defined in the risk management plan and generated from the probability and impact matrix.	11.3
Risk Ranking/Priority: This is the prioritization or relative ranking for the risk that allows efforts to be spent more effectively on the higher priority risks.	11.3
Risk Response: The strategies and activities that will be taken to encourage and exploit a positive risk, or address a negative risk.	11.5
Risk Response Responsibilities: The risk action owners are people who have risk response actions to take.	11.5
Secondary Risks: Risk responses can often raise new risks.	11.5
Risk Response Budget: This is the budgeted cost to implement approved risk responses.	11.5
Risk Response Schedule: The scheduled activities necessary to put the risk response into action.	11.5
Contingency Plan: These are the actions that will take place should the risk response fail. The contingency plan also establishes under what criteria it's to be enacted.	11.5
Fallback Plan: The fallback plan is a backup to the contingency plan should it fail.	11.5

Risk register – alternate views

As the risk register gets completed, it can provide several alternative views by being reorganized, resorted, or summarized.

Watchlist: Low priority risks should be regularly monitored so make sure they are not occurring and that their probability, impact, or priority hasn't changed (refer to section 11.3).

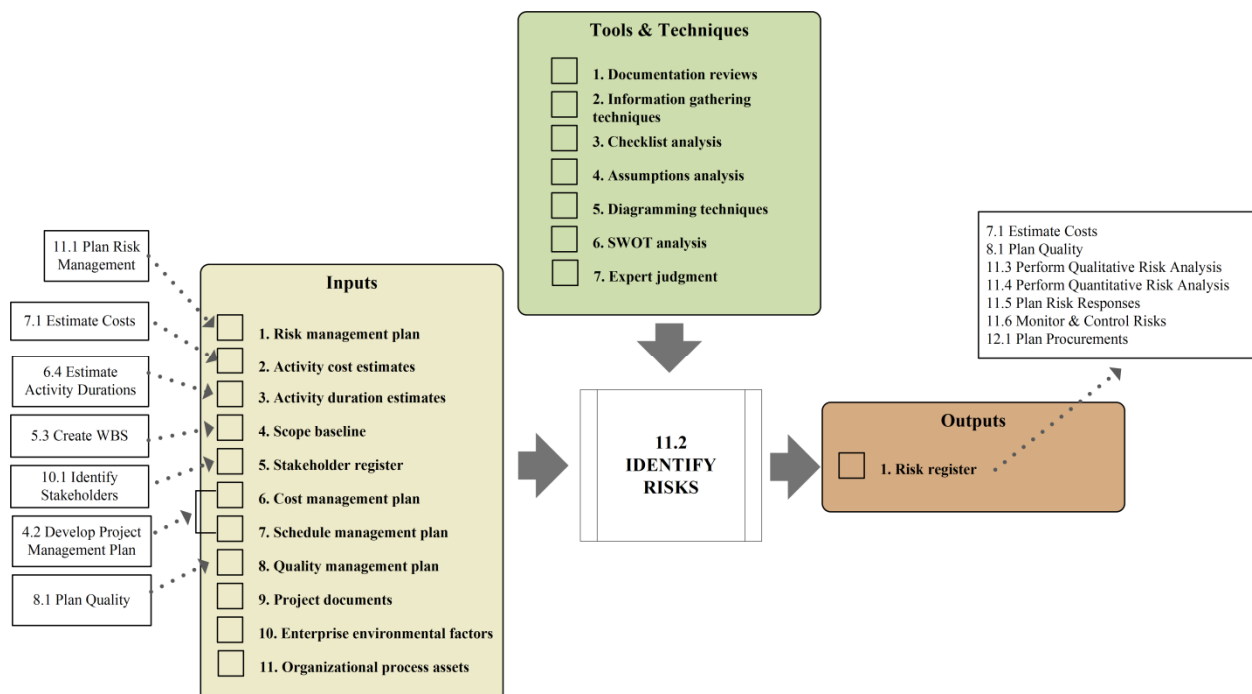
Prioritized risks: Qualitative analysis results in which risks are the highest priority and should receive detailed risk management efforts (refer to section 11.3).

Urgent risks: Risk processes may uncover risks that are already underway or which are imminent. Urgent risks need immediate planning and action (refer to section 11.3).

Trends and common factors: Risk categories, root causes, and impacts may expose trends that can make for more efficient risk response planning or risk monitoring (refer to sections 11.3 and 11.4).

Probabilities: Risk scores can be aggregated and analyzed at the objective, deliverable, or project level to predict how likely it is that the project will reach its objectives. An overall risk level for the project can also be tabulated (refer to section 11.4).

11.2 Process decomposition



Inputs☐ **Risk management plan**

The risk management plan defines the risk management activities for the project, and it establishes the risk methodology, risk roles and responsibilities, risk categories, probability and impact scales, risk tolerances, frequencies of risk management activities and reporting, and the budget and schedule for risk management activities.

☐ **Activity cost estimates**

Activity cost estimates are a complete accounting of all component costs, such as labor, resources, services, fees, licenses, of a scheduled activity. The reliability of these estimates can be a source of project risks.

☐ **Activity duration estimates**

Activity duration estimates are the work periods required to complete a scheduled activity. Since there are many factors that influence duration, including resource availability, duration estimates can be a source of project risks.

☐ **Scope baseline**

The scope baseline is the approved project scope statement, WBS, and WBS dictionary. The scope includes explicit and implicit assumptions (which are risks) and constraints, which are also risks. The scope can also highlight risk elements due to project complexity.

☐ **Stakeholder register**

The stakeholder register identifies all project stakeholders and contains attributes such as the person's name, title, position, project interest, expectations, and influence. Stakeholders should participate in the risk identification process, and their interests and expectations may also be risk factors.

☐ **Cost management plan**

The cost management plan is a part of the project management plan, and it establishes how project costs will be planned for, estimated, organized, reported on, forecasted, and managed. The plan's approach to cost management may increase or decrease project risk factors.

☐ **Schedule management plan**

Part of the project management plan, the schedule management plan details how the project schedule will be managed and controlled. The plan's approach may increase or decrease project risk factors.

☐ **Quality management plan**

The quality management plan is a component of the project management plan. The quality management plan details the quality policy of the project, including how the project management team will address quality assurance, quality control, and continuous improvement for the project. The plan's approach may increase or decrease project risk factors.

☐ **Project documents**

Project documents outside of the project management plan can be used to uncover risk elements.

☐ **Enterprise environmental factors**

Commercial databases, checklists, benchmarking, and industry-specific articles may help uncover risk elements.

☐ **Organizational process assets**

Lessons learned, risk identification templates, and historical project information may help identify risks.

Tools and Techniques☐ **Documentation reviews**

A review of project documentation can expose constraints, assumptions or incomplete documentation that can be sources of risks.

☐ **Information gathering techniques**

Risks can be identified through any combination of information gathering techniques, such as brainstorming, interviewing, SWOT analysis, root cause identification, and the Delphi technique.

☐ **Checklist analysis**

Risk checklists from previous projects can be used to assist in risk identification, or risk checklists can be established. Checklists used should be reviewed and improved upon so that they're useful for later projects.

☐ **Assumptions analysis**

Assumptions analysis reviews the validity and soundness of assumptions since assumptions are always a source of risk.

☐ **Diagramming techniques**

Diagrams can help identify risks by exposing relationship or by delving into the root causes of risks. Risk diagramming techniques include cause-and-effect diagrams, flow charts, and influence diagrams.

☐ **SWOT analysis**

SWOT analysis involves the review and analysis of group discussions on strengths, weaknesses, opportunities, and threats for project objectives.

☐ **Expert judgment**

Expert judgment is based upon the experience and knowledge of subject matter experts.

Outputs☐ **Risk register**

The risk register, a component of the project management plan, is a comprehensive list of all threats and opportunities the project faces. It also contains supplementary data about each risk, including its impact, probability, risk response, budget, risk owner, and contingency and fallback plans.

11.3 Perform qualitative risk analysis



Perform Qualitative Risk Analysis follows risk identification, and it prioritizes risks based on their likelihood of occurring and their potential impact to the project objectives. Prioritization is needed because risk identification uncovers a large number of risks having at least some potential to influence project objectives. However, many of those risks will be of such a low priority or have such a small impact that it isn't cost effective to address them, so qualitative analysis allows the project team to focus on the most important risks.

The risk register provides the list of identified risks to be evaluated, and the risk management plan provides the details on how probability and impact will be assessed and what risk scoring formula and ranking criteria will be used. Risks are prioritized and ranked based on their overall risk rating score, but risks can also be prioritized by their expected monetary value, impact, or any combination of other methods.

Risk data quality assessment

It's best to first make sure that the risk data uncovered so far is solid, otherwise the analysis will be a wasted effort because it could be based on flawed data. **Risk data quality assessment** reviews the quality, reliability, accuracy, and integrity of the risk data collected. This includes making sure each risk and its potential impacts and causes are sufficiently described and reviewing where the risk information came from. Any doubtful, unreliable, or incomplete data should be addressed before qualitative analysis is performed.

Risk urgency assessment

As risks are reviewed, it may be obvious that some risks are more likely to occur in the near term (or are already occurring), making these risks a top priority and requiring them to be fast-tracked to other risk processes for immediate planning and action.

Risk categorization

Grouping and sorting risks in different manners can help to prioritize them. Though one aspect of this tool is resorting risks by the categories established in the risk management plan, that's only one approach so the name of this tool is misleading. Regrouping risks into any helpful classification can expose similarities that could make prioritization and later risk response planning easier. Ways that risks can be grouped include by risk owner, deliverable, phase, or technology.

Risk probability and impact assessment

The two components of any risk prioritization method are the risk's probability and a gauge of its potential impact. Both figures are converted into ratings accomplished through the risk probability and impact matrix.

The risk management plan establishes how the probability and impact assessments are to be made and where the data is to be gathered from. Most of the probability and impact data can be gathered from experts at the same time as risk identification, but additional interviews and meetings may be necessary with subject matter experts and the project team.

Probability is usually estimated as a percentage while impact is estimated as a cost, time, or quality measure. Both estimates are usually quite subjective, and given in ranges. For instance, impact might be given only as "between \$25,000 and \$50,000" or "between 7 days and 14 days." The probability and impact assessments are converted into a rating through the matrix and used to establish a score for the risk.

Risk probability and impact matrix

The **probability and impact matrix** assigns a rating or score to each risk based on its probability and impact assessments. The rating or scoring method is established in the risk management plan, and it converts assessments into linear, non-linear, or relative scales. The matrix can be either paper- or software-based, but in either case it will include columns and rows for recording the probability rating and the ratings for the impacts to different project objectives.

	PROBABILITY SCORE	IMPACT SCORE	OVERALL SCORE
Risk X	3	4	12
Risk Y	2	10	20
Risk Z	4	6	24

In order for assessments to be uniformly converted to ratings there must be unambiguous definitions. If the scale used is not consistent from risk to risk or person to person then subsequent rankings, scores, and priorities will be flawed. The probability and impact matrix often includes a "sample" page where the rating system is explained with descriptive legends.

Probability rating

A legend provides the mechanism for converting probability assessments into a rating that is normally a linear scale. In this example, a relative scale is converted into an estimated probability percentage.

Probability Rating
Very Low=10% estimated probability
Low=30% estimated probability
Medium=60% estimated probability
High=80% estimated probability
Very High=95% estimated probability

Impact rating

The impact scale may be tailored to each project objective, and very clear guidelines are provided for rating the impact assessments. It is very common for there to be different ratings for different project objectives based on their importance, and opportunities (positive risks) often have different scales than threats (negative risks). In this example, the risk impact uses a single, non-linear scale.

IMPACT RATING				
Very Low 1	Low 2	Medium 4	High 8	Very High 16

Scoring formula

The probability rating and the impact rating provide the basis for the overall rating or score for each risk. The formula used can depend upon any combination of policies and personal preferences of the organization, customer, industry, risk manager, or project manager. A simple approach is to multiply the probability rating by the impact rating for each project objective, and then summing these up to obtain the risk score.

Overall risk rating

OVERALL RISK RATING

15	30	50	80	130
12	24	40	64	104
9	18	30	48	78
6	12	20	32	50
3	6	10	16	26

- >=75 = very high priority risk
- >=35 and <75=high priority risk
- >=18 and <35=medium priority risk
- >=9 and <18=low priority risk
- <9 = very low priority risk

The risk score is correlated to a table or legend on the probability and impact matrix that provides the overall risk classification. This is usually a color-coded scale of red (high), amber (medium), and green (low), often called a RAG rating.

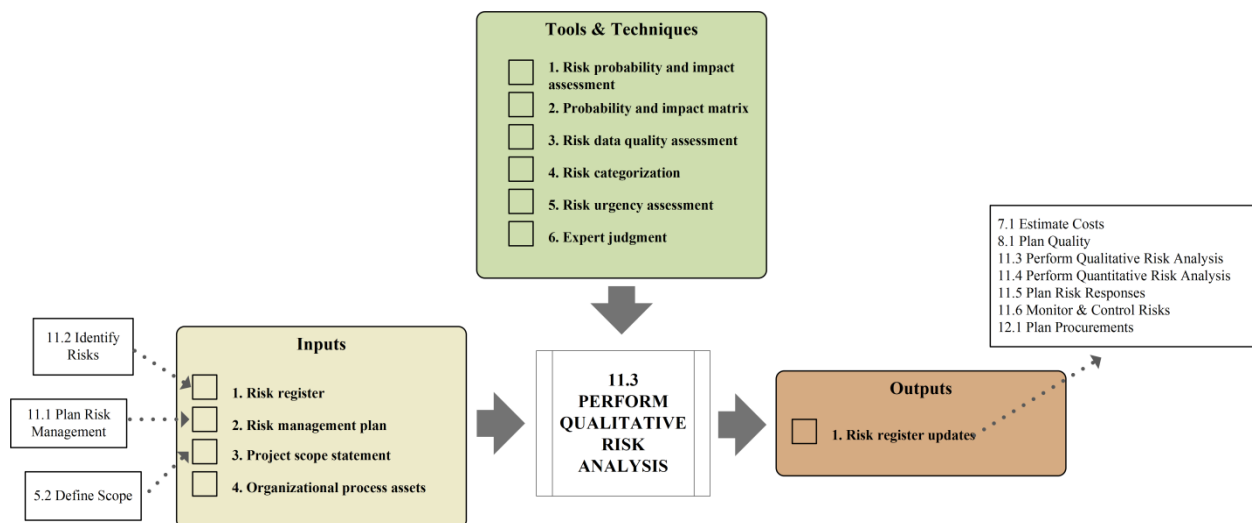
Using the overall risk score, the entire list of identified risks can be ranked into a prioritized list allowing further risk management efforts to focus on the most dangerous or advantageous risks.

Cautionary statements about the risk probability and impact matrix

The probability and impact matrix is a relatively simple and straight-forward way of forming the basis for risk prioritization. However, if it isn't approached with forethought into the rating, scoring, and prioritization methods, it can lead to risk management problems. The drawbacks arise from relying on the matrix as the *only* source for prioritizing risks and from perceiving it as an empirical source of data. There are nearly always additional factors which cannot be represented by the matrix, and though the goal of the matrix is to provide an objective view of the risk, it is based only on subjective estimates.

- First, to keep the matrix from becoming too unwieldy, the impact is shown only for the most important project objectives. In some cases this isn't adequate thus causing a risk's true potential impact not be reflected by the matrix.
- Second, the combination of the probability rating, impact rating, and scoring formula can cause a high impact/low probability risk to end up ranked as a low priority or a low impact/high probability risk to end up being ranked too high.
- Third, the scale and scoring method will need to be different for opportunities versus threats. This is because there's usually different criteria needed to exploit opportunities.

11.3 Process decomposition



Inputs

☐ Risk register

The risk register is a comprehensive list of all threats and opportunities the project faces. It also contains supplementary data about each risk, including its impact, probability, risk response, budget, risk owner, and contingency and fallback plans.

❑ Risk management plan

The risk management plan is a component of the project management plan. It details and defines the risk management activities for the project. The plan establishes the risk methodology, risk roles and responsibilities, risk categories, probability and impact scales, risk tolerances, frequencies of risk management activities and reporting, and the budget and schedule for risk management activities.

❑ Project scope statement

The project scope statement details the measurable goals, objectives, deliverables, and requirements of the project, and what the acceptance criteria of deliverables will be. It also describes the work required to meet all objectives and deliverables of the project, and it also contains milestones, assumptions, risks, and costs. The scope statement helps determine the impact a risk may have on the project's objectives and may help determine its probability.

❑ Organizational process assets

Data from similar, past projects and risk databases will help determine impacts and probabilities.

Tools and Techniques**❑ Risk probability and impact assessment**

This assessment investigates each identified risks to expose the probability and impact to all the project objectives. This data is used to prioritize or rank risks.

❑ Probability and impact matrix

The probability and impact matrix uses an established rating criteria and scoring formula for assigning a score to identified risks based on their probability and impact.

❑ Risk data quality assessment

Before qualitative analysis is performed, the risk data gathered should be reviewed for accuracy, reliability, and integrity. Otherwise, the analysis will be based on flawed data.

❑ Risk categorization

To help in prioritization or ranking, risks can be categorized in any useful method, such as by deliverable, phase, objective, or technology.

❑ Risk urgency assessment

Qualitative analysis may uncover risks that are imminent. These may need fast-tracked into subsequent risk processes for immediate attention.

❑ Expert judgment

Qualitative analysis requires subject matter experts and expert judgment is needed to interpret, evaluate, and present the qualitative data uncovered.

Outputs**❑ Risk register updates**

Qualitative analysis results in prioritization of risks, which is shown on the risk register. The risk register is a comprehensive list of all threats and opportunities the project faces. It also contains supplementary data about each risk, including its impact, probability, risk response, budget, risk owner, and contingency and fallback plans.

11.4 Perform quantitative risk analysis

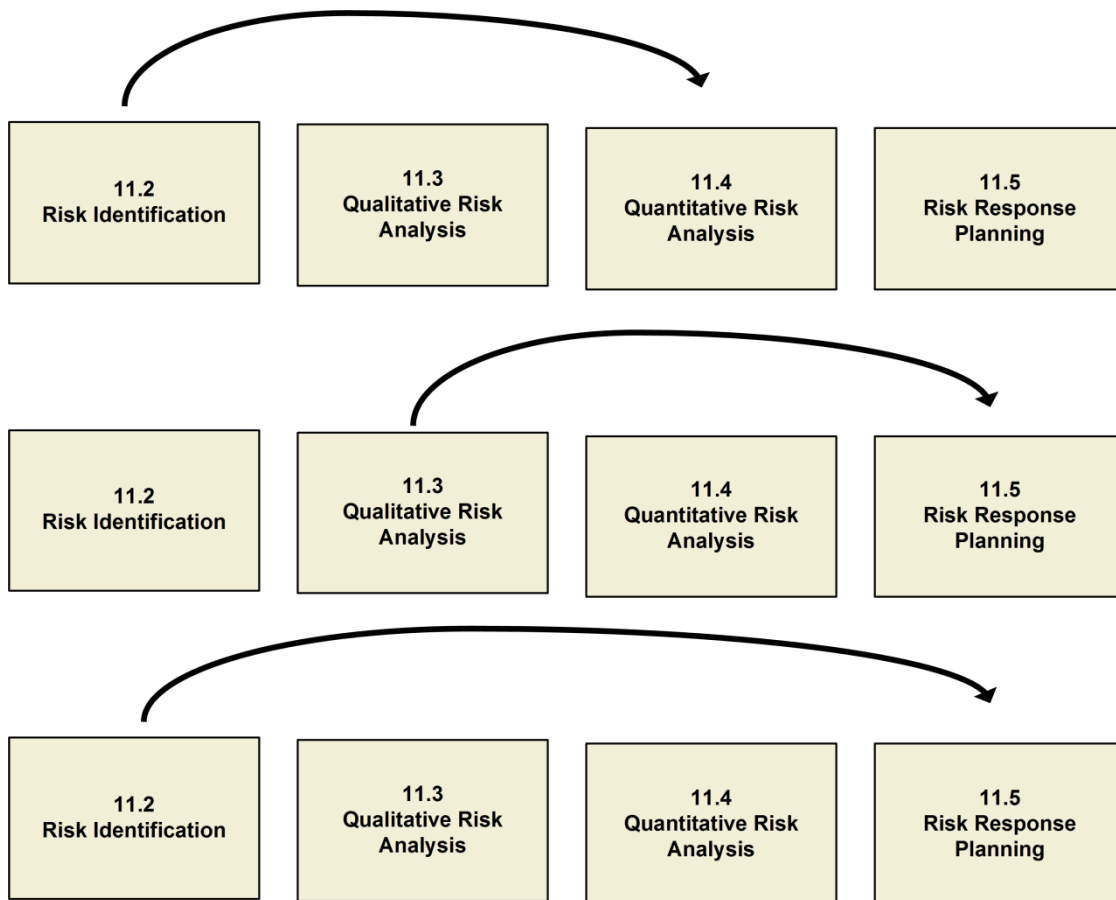


Activities in **Perform Quantitative Risk Analysis** delve further into identified risks by assigning cost or other impact measurements to them. Quantitative analysis at the individual risk level can then be aggregated into estimates for the probability of achieving project objectives, like scope, budget, and schedule. Quantitative analysis will be repeated as new risks are identified or as it's deemed necessary for other identified risks. For project-level risk analysis, quantitative will reoccur frequently during risk monitoring and control to keep tabs on whether the project's overall risk level has changed. Since qualitative analysis is much more time consuming than qualitative, it's normally performed only on high priority risks.

The risk management plan establishes how quantitative analysis is to be carried out and who has what responsibilities for it, and the project schedule and budget indicate the time and money that can be spent on quantitative analysis activities. Quantitative analysis results in updates to the risk register by expanding upon the risk data already collected.

Data needed for quantitative analysis can come from historical information or commercial risk databases, but further interviews with risk professionals, subject matter experts, and the project team may be needed to gather estimates and likely risk scenarios if these weren't fully discussed during risk identification. Though the goals of quantitative analysis may differ between project types and risk types, the broad goal is to establish more definitive probability assessments and solidifying scope, time, cost, and quality ramifications of risks.

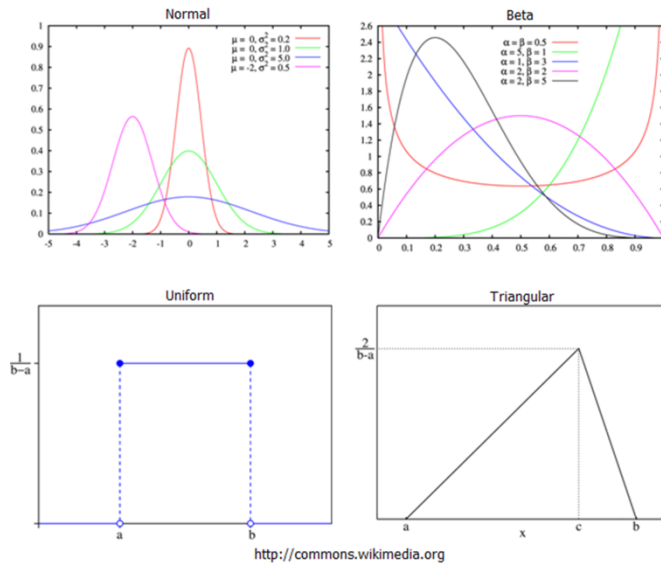
Though quantitative follows qualitative analysis, experienced risk personnel may bypass some processes based on the risk being examined, though this usually means that some elements of the bypassed process are being performed through the earlier risk process. But for the PMP examination we should presume that the project risks processes are followed in the exact order presented by the PMBOK.



Estimating and probability distributions

Estimates will be needed from people to further quantify probability and impact. Three-point estimates can be used to remove some of the unintentional biases that are always inherent in estimates. One person may be overly pessimistic while another may be overly optimistic. A three-point estimate uses a formula based on the optimistic, pessimistic, and most likely predictions to produce a weighted estimate. A commonly used **three-point formula** is:

$$\frac{\text{Pessimistic} + (4 \times \text{Most Likely}) + \text{Optimistic}}{6}$$



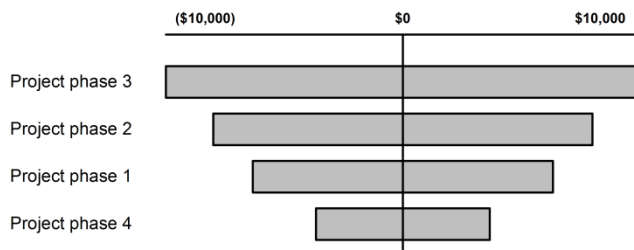
Probability distributions and estimates are closely related because distributions are a mathematical description of uncertainties in the data, and estimates always have some degree of uncertainty. A three-point estimate produces a type continuous probability distribution that looks like a bell curve. If this curve looks familiar, it's because we've seen it as part of standard deviation in quality control. Probability distributions and simulations are rooted in statistics, and for most everyday projects we can rely on three-point estimates without being overly concerned with the different probability distributions.

Simulation and modeling techniques

Simulations and modeling apply different scenarios to project components to expose and highlight risk elements or dependencies that might not otherwise have been visible. **Monte Carlo analysis** is the most common simulation tool, especially in industries like insurance, engineering, and finance. Simulations and modeling are complex, statistical, computer-driven tools that require significant time, effort, and skills to master. Most project managers in general business environments will not encounter the need for Monte Carlo analysis.

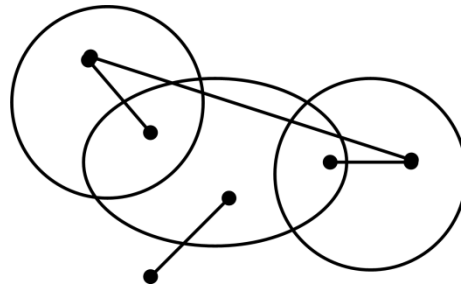
Sensitivity analysis

Sensitivity analysis looks individually at each project objective and measures how uncertainty could impact that objective. This makes it possible to identify what risks have the greatest potential impact, and can show how uncertainty can impact project objectives. For example, if labor cost could fluctuate between -20% and +20%, sensitivity analysis applies this cost range throughout affected project components and then displays which components are most susceptible to this risk.



The results of sensitivity analysis are usually shown as a **tornado diagram** or a spider diagram. A tornado diagram is named due to its funneled appearance.

Spider diagrams are more unusual, and they can appear in a variety of different manners, but they'll look similar to Venn diagrams.



Expected monetary value analysis

Expected monetary value (EMV) is the cost or benefit of an uncertain event. It's calculated by multiplying the monetary impact by probability. EMV is what one could expect over time if the condition is repeated over and over.

For an example, let's assume that there is a carnival game in which there are three shells but only one has a ping-pong ball under it. The game costs \$1 to play and the winner will receive \$2 if he correctly picks the shell with the ball hidden under it. There are two outcomes based on the one-in-three chance of choosing the correct shell: either the player loses 66.66% of the time or he wins two dollars 33.33% of the time. The EVM for this game is:

$$\begin{aligned}\text{EMV} &= (66.66\% \times \$0) + (33.33\% \times \$2) \\ \text{EMV} &= \$0 + \$0.67 \\ \text{EMV} &= \$0.67\end{aligned}$$

EMV incorporates any initial cost for the decision as a negative value (such as cost of goods or services), which in our example is the price of the game:

$$\begin{aligned}\text{Net EMV} &= (-\$1) + \$0.67 \\ \text{Net EMV} &= (-\$0.33)\end{aligned}$$

A negative EMV is a risk cost and a positive EVM is a benefit, so in this example the odds are not in the player's favor over the long term even if he wins \$2 one out of every three tries. But if the game pays out \$5 instead, the odds turn to his favor and he'll win an average of \$0.67 each time he plays.

$$\begin{aligned}\text{EMV} &= (66.66\% \times \$0) + (33.33\% \times \$5) \\ \text{EMV} &= \$0 + \$1.67 \\ \text{EMV} &= \$1.67\end{aligned}$$

$$\begin{aligned}\text{Net EMV} &= (-\$1) + 1.67 \\ \text{Net EMV} &= \$0.67\end{aligned}$$

So over time and repeated many times, the player will come out ahead and make 67 cents each time he plays. But as we can see EMV is really only an average over time, and even at the \$5 level a streak of bad luck could result in the player losing money. But projects get only one chance to reach their objectives, so EMV should be used only as one factor when evaluating risk decisions because it can't definitively predict one-time odds.

Another use of EMV is in establishing the contingency reserve by aggregating the EMV for each known risk:

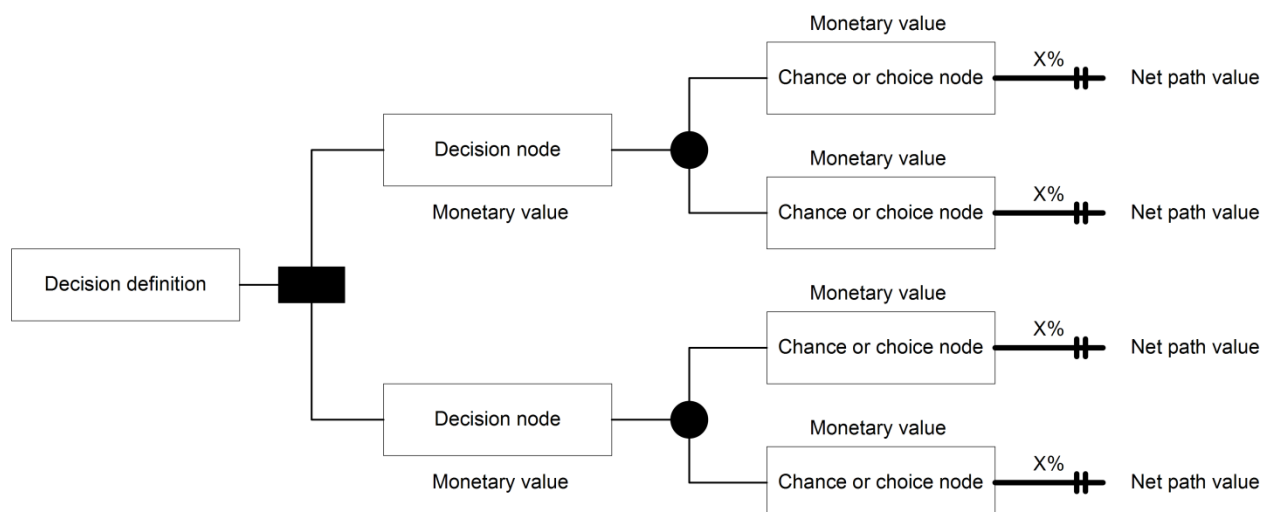
Risk	Probability		Impact		EMV
1	10%	x	(\$2,000)	=	(\$200)
2	20%	x	(\$3,500)	=	(\$700)
3	15%	x	(\$1,700)	=	(\$255)
4	25%	x	(\$1,000)	=	(\$250)
5	40%	x	\$500	=	\$200
				Reserve:	(\$1,205)

Negative impacts are negative risks (threats) and positive impacts are positive risks (opportunities). A negative total represents the potential shortfall in the project budget. The contingency reserve is incorporated into the project cost baseline.

Decision tree analysis

Decision trees visually map out options, and using EMV for each decision point results in a net value for each decision path. Even though a tool of quantitative analysis, decision trees are applicable to many project problems that have choices with levels of uncertainty. Decision trees typically show monetary impacts, but EMV can be used to express any measurement (quantities, units, or time periods). Since EMV is only an average, decision trees do not make an absolute prediction about the result of alternatives, so they should be used only as one factor in the decision-making process. But even with this limitation, decision trees have the added benefits of:

- Forcing the decision to be viewed systematically into all the component parts of the decision.
- Forcing a quantitative approach in establishing probabilities for each alternative (e.g., 90% change of success), and in assigning monetary costs and benefits to each component.



Building a decision tree

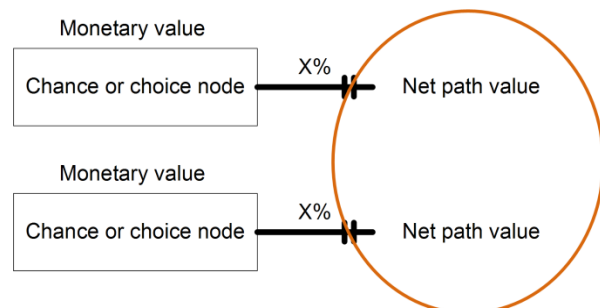
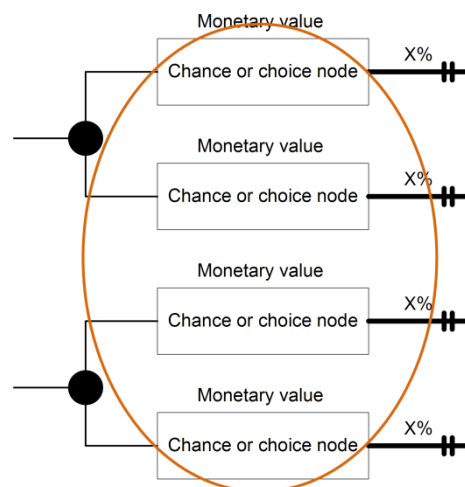
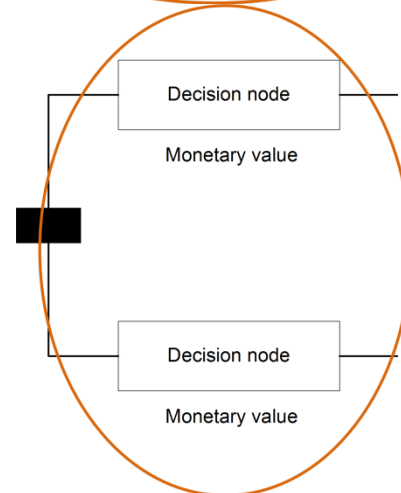
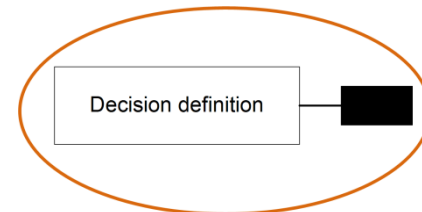
1. Start by defining and decomposing the problem. The decision tree starts with the decision definition, and it's represented by a rectangle.

2. Next, identify the courses of action to solve the problem. These are known as decision nodes, and they become branches off the first node. Within the decision tree, decision nodes should be mutually exclusive so that making one decision excludes the other decision.

3. Now the outcomes from each decision node need to be identified. These are chance nodes or choice nodes, and they're represented by circles. Each choice will have a level of probability associated with it. The probabilities from a single chance node can't exceed 100%.

Chance nodes may branch off into other decision nodes. And because decision trees can become very complex due to multiple decision points and choices, it may be necessary to deliberately stop a node that isn't feasible or realistic in order to keep the decision tree a manageable size.

4. When no further decisions or chances are available, the end of the path is the terminal node, and after later calculations it will have the net EMV of the entire path shown.



5. Each choice node must have a quantified impact, which is then multiplied by its probability to show the EMV for that choice. Negative monetary values are costs or negative impacts while positive values indicate benefits.

6. To determine each path's net value, start at the ending terminal node and work backwards all the way to the decision definition node, summing the EMV for each chance node. Any initial cost at the original decision node will also need to be included.

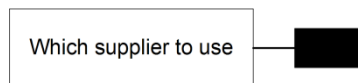
7. The solution to the decision tree is the path with either the minimum loss or the maximum benefit.

Example: Building a decision tree

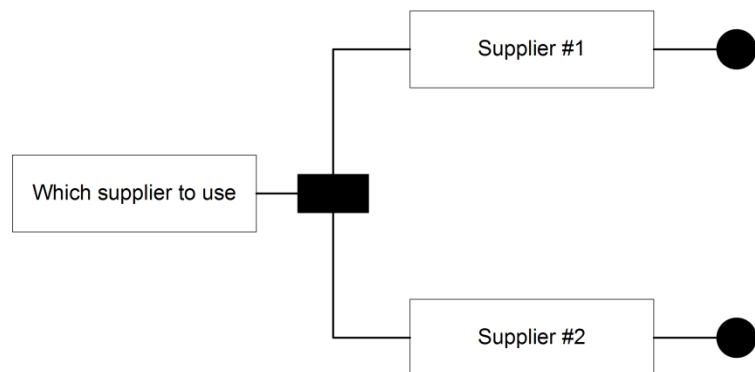
Hypothetical issue: A component needed to construct a deliverable can come from only one of two available suppliers. If the component isn't delivered on time, the project schedule will be negatively affected which will result in additional labor costs of \$2,000 per day.

- Supplier 1: Initial cost is \$75,000, and this supplier has an 80% chance of being on time and a 20% chance of being up to five days late.
- Supplier 2: Initial cost is \$60,000, and this supplier has a 10% of being on time, a 20% chance of being up to five days late, and a 70% chance of being up to 14 days late.

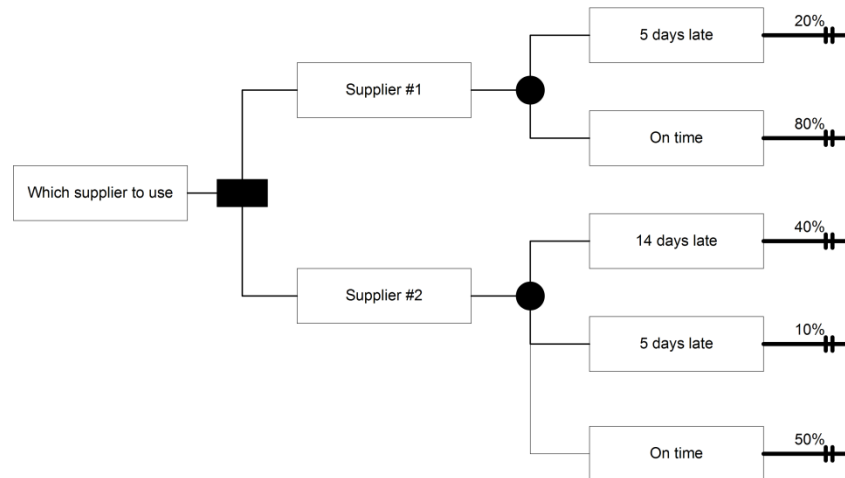
1. Start by stating the problem.



2. Next identify the different courses of action. In this example the courses are either choosing supplier 1 or choosing supplier 2. Draw these decision nodes off the first node.



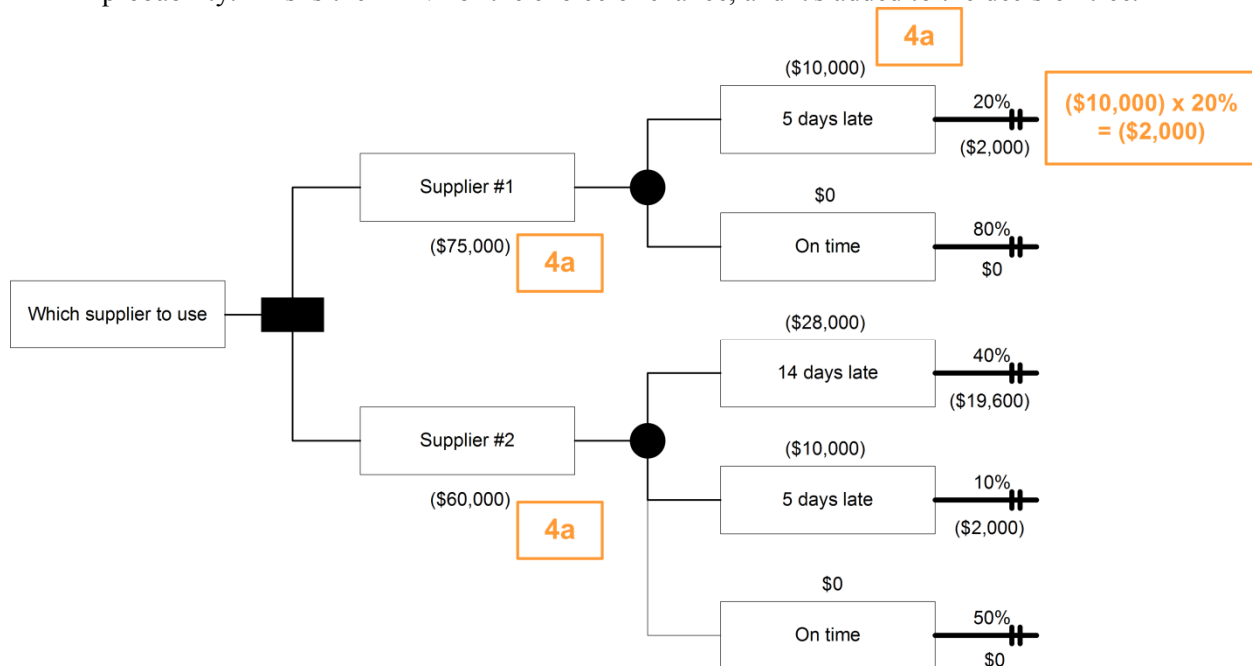
3. Now identify the potential outcomes of each decision by drawing chance nodes and connect these to the decision nodes, and indicate the probability of each chance on the decision tree. If there were other decisions or chance nodes, steps 2 and 3 would continue. But in this example, conclude the paths with terminal end points.



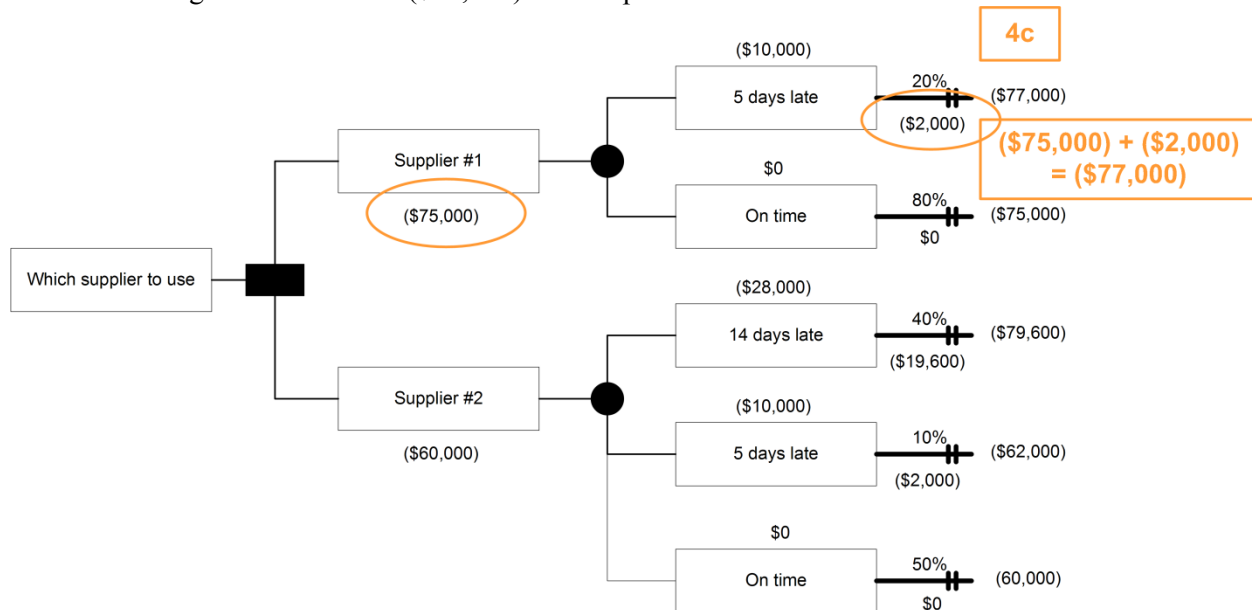
4. Now the monetary values will be added to the decision tree.

4a. Add the initial component costs from each supplier to the tree. Supplier 1 is going to charge \$75,000 and supplier 2 is charging \$60,000. (Note: Opportunity costs would be shown as positive values.)

4b. For each day the component is late the project will incur \$2,000 in labor costs. So if the component is five days late, the extra cost will be \$10,000; if the component is 14 days late the cost is \$28,000. These costs need added to the chance node, and then multiplied by the probability. This is the EMV for the choice or chance, and it's added to the decision tree.

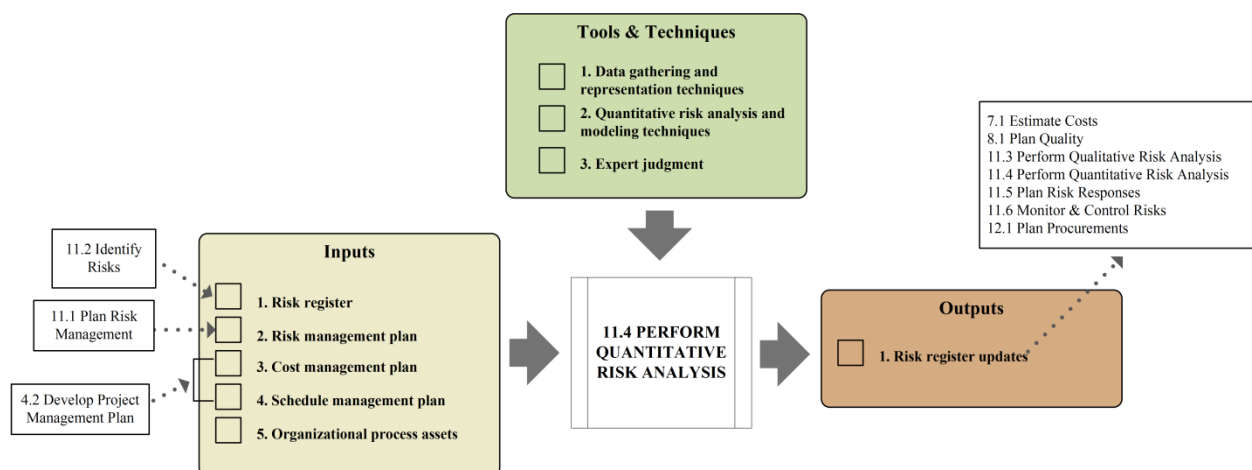


4c. Now each path needs its net EMV calculated. Starting at the ending terminal node on each path, work backwards through each path and sum each EMV on the path and add any initial costs for any decision to this value. In the top-most path, the monetary values are (\$2,000) + (\$75,000), resulting in a net value of (\$77,000) for that path.



We can see through this example why decision trees can't be the only factor used in decision making. Though supplier #2 has two scenarios in which its price is attractive, it also has a good chance of being up to 14 days late. If maintaining cost is more important than maintaining a definitive schedule then supplier #2 provides the most attractive overall scenarios. However, if maintaining a tight schedule is important then it could be argued that supplier #1 is the best choice since it has an 80% chance of being on time and would still be cheaper if supplier #2 ends up being 14 days late.

11.4 Process decomposition



Inputs

☐ **Risk register**

The risk register is a comprehensive list of all threats and opportunities the project faces. It also contains supplementary data about each risk, including its impact, probability, risk response, budget, risk owner, and contingency and fallback plans.

☐ **Risk management plan**

The risk management plan is a component of the project management plan. It details and defines the risk management activities for the project. The plan establishes the risk methodology, risk roles and responsibilities, risk categories, probability and impact scales, risk tolerances, frequencies of risk management activities and reporting, and the budget and schedule for risk management activities.

☐ **Cost management plan**

The cost management plan is a part of the project management plan, and it establishes how project costs will be planned for, estimated, organized, reported on, forecasted, and managed. The plan's approach to cost management may increase or decrease project risk factors.

☐ **Schedule management plan**

Part of the project management plan, the schedule management plan details how the project schedule will be managed and controlled. The plan's approach may increase or decrease project risk factors.

☐ **Organizational process assets**

Historical information from similar, past projects and risk databases can aid in quantitative analysis.

Tools and Techniques

☐ **Data gathering and representation techniques**

Quantitative analysis may require additional risk data that can be gathered from estimates obtained through interviews and expert judgment.

☐ **Quantitative risk analysis and modeling techniques**

Sensitivity analysis, decision tree analysis, expected monetary value, modeling, and simulation help to quantify risks and their impacts.

☐ **Expert judgment**

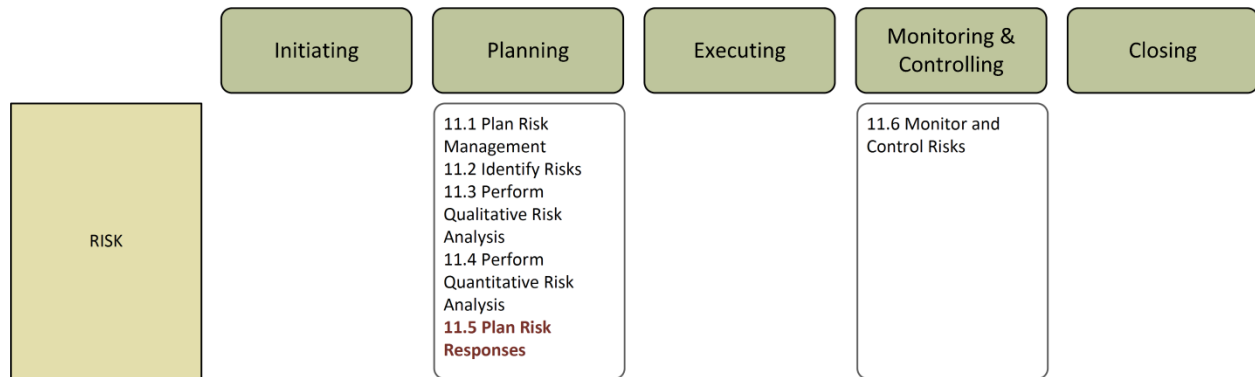
Quantitative analysis requires subject matter experts and expert judgment is needed to interpret, evaluate, and present the quantitative data uncovered.

Outputs

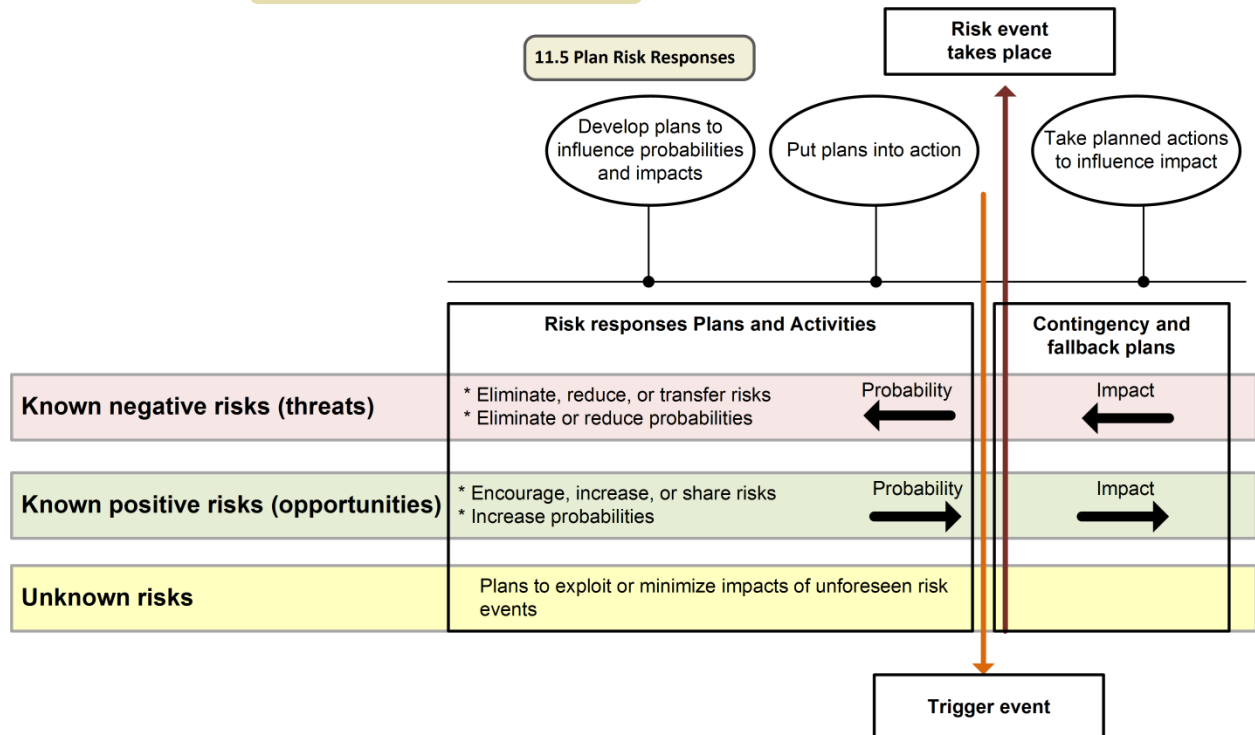
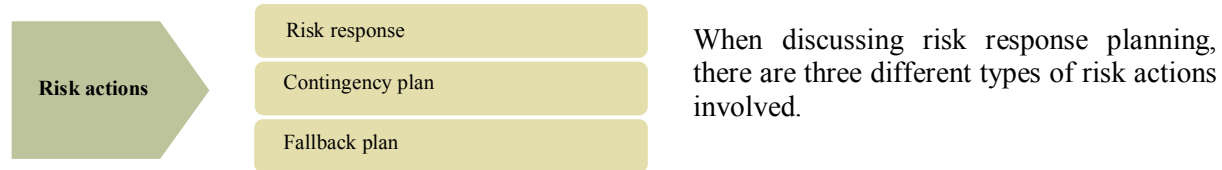
☐ **Risk register updates**

Quantitative analysis results in updates to the risk register, including the probability and impact assessments for risks. Data from the risk register can also be aggregated to provide data for risk analysis at the project level or at the project objective level.

11.5 Plan risk responses



In previous project risk processes, the risks were identified, analyzed, and prioritized but no action plans for the risks were established. In **Plan Risk Responses**, we'll decide on the actions needed to reduce the threat of negative risks or enhance the opportunities for positive risks as well as developing contingency plans. This process occurs after identified risks have been prioritized, and it will generally focus only on the highest priority risks. It'll need to reoccur any time new priority risks are uncovered or as known risks are reassessed, and replanning may be required if the responses previously planned for risks prove to be ineffective.



Risk response

The **risk response** determines the strategy for influencing the probability and impact of the risk *before* it occurs. For negative risks, its aim is to eliminate the risk or reduce its impact should it occur. For positive risks, the response tries to increase the probability or impact of the risk. The activities that support the risk response are taken before the risk occurs. For example, if the risk response strategy was to minimize a schedule risk, the response activities might be reworking the schedule to reduce the risks factors so that the risk never materializes.

Contingent response/contingent plan

Another type of risk action is called a **contingent response**, and it establishes what activities will take place should a specific event or situation occur and when those activities will cease. A contingency plan aims to influence the impact of a risk that is occurring. The risk response occurs *before* the risk and tries to alter the probability and/or impact while the contingency plan only occurs *after* the trigger (usually the risk event) and focuses only on changing the impact. Regardless of the primary risk response strategy, a contingency plan should be in place for all but the lowest priority risks (and even those depending upon what objectives they can impact).

As an example, consider a schedule risk related to resource contention in which there're only a few people within the organization who can perform the needed tasks. The primary risk response might be to mitigate the risk by splitting the main activity into some subcomponents that a junior staff member can perform. But there's still a chance the senior-level resources will not be able to complete their portion by the deadline, so a contingent response is also established that will kick in should the activity fall behind by more than three days. If that happens then an outside expert will be hired to assist the senior-level team members until the task is back on schedule.

Fallback plan

The **fallback plan** kicks in if the contingency plan fails. It can be looked at as a contingency plan for the contingency plan. The fallback plan spells out steps will be taken to recover if the contingency plan fails, and it specifies under what situations and circumstances it is activated and subsequently deactivated.

Risk response considerations

During risk management planning, responsibilities were assigned for *project risk management*. In risk response planning the focus is on *specific* risks and what actions will be taken towards those risks. These activities will result in personnel being assigned to carry them out, so these responsibilities need added to the risk register and to other important project documents like the schedule and the roles and responsibilities document.

Contractual agreements for risk-related issue may be necessary as part of risk responses. These binding agreements will identify the risk responsibilities for the parties involved. Risk response activities and their costs will also be added to the project management plan and baselines. This is because the effort for those activities is planned and approved, and these are scheduled and budgeted just like a normal project execution activity. But contingency and fallback plan activities don't belong in the baselines because they aren't a sure thing --the people assigned to those actions will carry them out only if the trigger occurs, which may never happen, and the costs for these activities are drawn from the contingency or management reserve.

The Hiawatha Light Rail Transit Project constructed a \$715 million 12-mile connection between downtown Minneapolis, airport, and the Mall of America. According to Mark Fuhrmann, chief of staff for the project, the project went smoothly partly because of the innovative risk management techniques adopted. A \$5.5 million shared-risk contingency fund based on 19 key risk items was established with the contractor. At the conclusion of the project, the contractor was allowed to keep 91 percent of what was left in the contingency fund, serving as an incentive to manage risks wisely.⁶

Chris Allen, Reducing Uncertainty

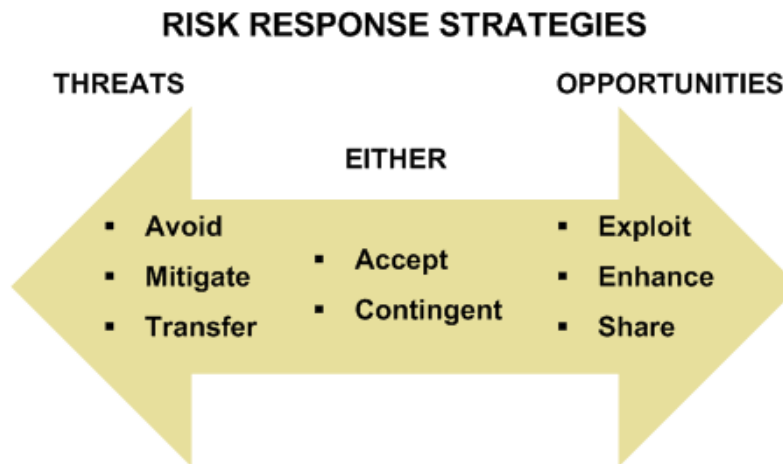
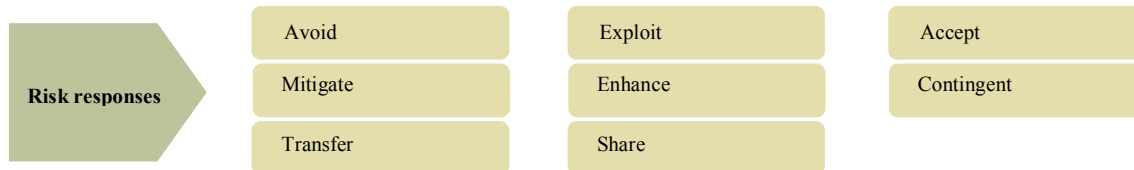
Any response has some element of cost that must be weighed against the risk's potential impact. Though risk responses are not based only on cost, the benefits of the risk response need to be greater than its potential impact --spending 100 hours of effort to encourage an opportunity that will result in saving only 25 hours is not worthwhile. Intangible benefits, like those relating to safety and reputation, may require risk efforts that will exceed the tangible monetary benefit.

Other factors to consider when planning risk responses are the schedule and funding constraints and the reasonableness of the possible actions. The people who'll be tasked with carrying out the responses must also have the skills, capabilities, and authority to carry out those actions. For instance, it would be unwise to expect an entry-level team member to have the skills and authority to renegotiate a major contract with a vendor if that were the mitigation action chosen.

Risks usually have several options as to how they can be responded to, each having its own pros and cons. Careful and thorough analysis of each option is needed so that the one most likely to achieve the desired result in the most effective manner is chosen. **Secondary risks** are those that arise from the primary risk response activities, and sometimes the secondary risks pose a greater threat than the original risk. Since only the highest priority risks will have detailed responses planned there will be risks on the register without an action plan. **Residual risks** are those that remain and whose probability and impact are such that they're acceptable to the performing organization's level of risk tolerance. They can also be those risks in which there are no reasonable responses for.

Types of risk responses

There is only a handful of responses that can be undertaken for risks, and it usually takes a combination of responses to successfully influence risks. As a reminder, risk responses are decided before the risk occurs and their aims are to influence its probability and potential impact should it occur.



Responses for negative risks (threats)

- **Avoid:** Avoidance activities aim to completely eliminate a risk's probability or impact to zero. Avoidance can take several forms, such as restructuring the project activities, scope, schedule, or cost to eradicate the root causes leading to the risk.
- **Mitigate:** If the risk cannot be avoided, actions might be taken to reduce the risk's probability or its impact if it does occur. A mitigated risk response may still require a contingent plan. Since insufficient planning is the root cause of many project risks, mitigation of those risks can be achieved by more thorough project planning. Mitigation usually involves making alternate choices that can be less than ideal. For example, if the risk is related to an untried technology that provides enormous benefits to the deliverable, the risk mitigation strategy might be to first develop a prototype or proof-of-concept model. This would involve additional time and cost, and the risk still isn't avoided because there's still a chance that problems will arise from the technology when work on the deliverables begin, but the extra effort may significantly reduce the probability.

Avoidance and mitigation aren't interchangeable terms. If the risk is completely eliminated then avoidance was achieved, but if the risk's probability or impact is only reduced then mitigation was achieved.

- **Transfer:** Transference assigns all or part of risk to a third party through outsourcing, contracts, insurance, warranties, guarantees, or performance clauses. The risk's probability or impact may not change, but the responsibility for developing an effective strategy no longer resides only with the performing organization. Insurance against property or equipment risk is a good example of transference.

Responses for positive risks (opportunities)

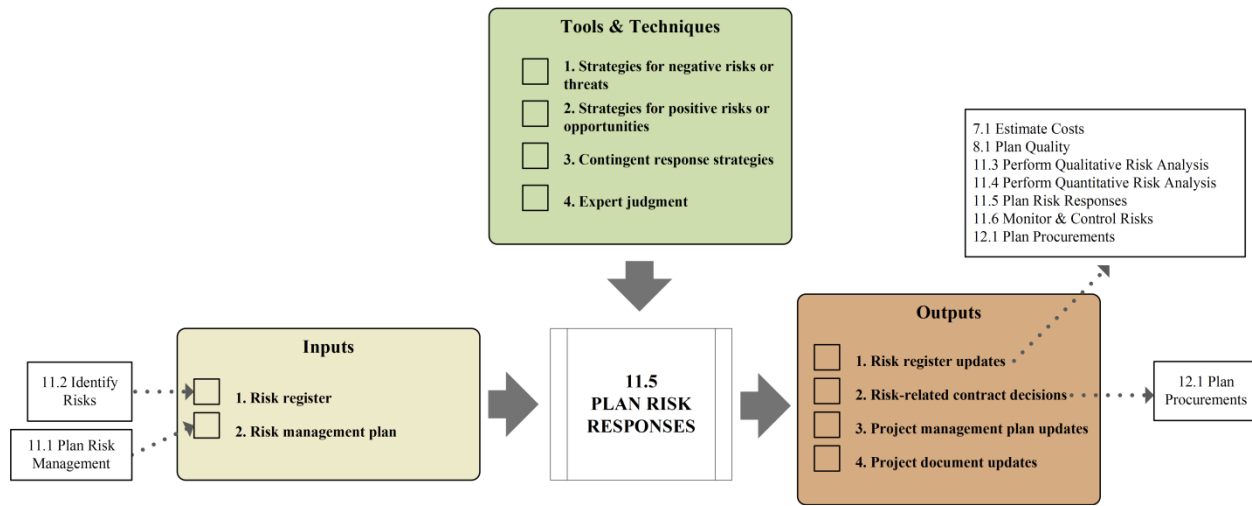
The responses for positive risks are opposing terms of those for negative risks, making them easier to remember.

- **Exploit:** Exploitation aims to ensure that the risk event definitely occurs so that its benefits can be realized. Exploitation can also take advantage of a definitive opportunity by maximizing its benefits. For example, if a warmer than normal weather pattern emerges during the winter, the opportunity can be exploited by immediately adjusting the construction schedule to take advantage of the good weather.
- **Enhance:** If actions can't be taken to guarantee that the opportunity will occur then responses might be taken to enhance its probability or its beneficial impact if it does occur.
- **Share:** Sharing is similar to transference, but its aim is to share the opportunity with a third party who is best able to capitalize on it. Many technology companies establish partnerships with other companies to encourage further development around each other's products. For example, if company A develops a new memory chip it may pre-release the chip to manufacturers so that they can work on incorporating the chip into a next generation of hand-held computing devices. Company A is sharing a marketing opportunity with its partners.

Responses for both negative and positive risks

- **Accept:** For both positive and negative risks, there may be little that can be done except to let things run their course. Acceptance is an option for risks with low probability, low impact, or those that have no reasonable action that can be taken. For example, the negative risk might be that a rare utility problem would cause the co-location facility to lose power, but the probability and impact don't justify the cost of an off-the-grid electric generator. Acceptance of any risk should require contingency and fallback plans, even if done only at a high level for low-priority risks.
- **Contingent:** A contingent response involves a contingency plan, which will be put into effect should the risk response fail. The contingent response identifies the exact situation and circumstances (triggers) in which the contingency plan can be put into effect and when it can be discontinued. This response type is used in combination with another risk response, such as mitigation.

11.5 Process decomposition

**Inputs**☐ **Risk register**

The risk register is a comprehensive list of all threats and opportunities the project faces. It also contains supplementary data about each risk, including its impact, probability, risk response, budget, risk owner, and contingency and fallback plans.

☐ **Risk management plan**

The risk management plan is a component of the project management plan. It details and defines the risk management activities for the project. The plan establishes the risk methodology, risk roles and responsibilities, risk categories, probability and impact scales, risk tolerances, frequencies of risk management activities and reporting, and the budget and schedule for risk management activities.

Tools and Techniques☐ **Strategies for negative risks or threats**

Risk responses for threats are avoid, mitigate, and transfer.

☐ **Strategies for positive risks or opportunities**

Risk responses for opportunities are exploit, enhance, and share.

☐ **Strategies for both threats and opportunities**

Risk responses applicable to both threats and opportunities are accept and contingent.

☐ **Contingent response strategies**

Contingent responses are intended only if certain events occur. The most common contingent response is a contingency plan, which is put into execution should the risk even occur.

☐ **Expert judgment**

Expert judgment is based upon the experience and knowledge of subject matter experts. It's used to assess and evaluate the inputs and the information they contain.

Outputs☐ **Risk register updates**

Risk responses, contingency and fallback plans, and risk action responsibilities are added to the risk register.

☐ **Risk-related contract agreements**

Risk responses may result in contractual elements necessary to put the risk response into action.

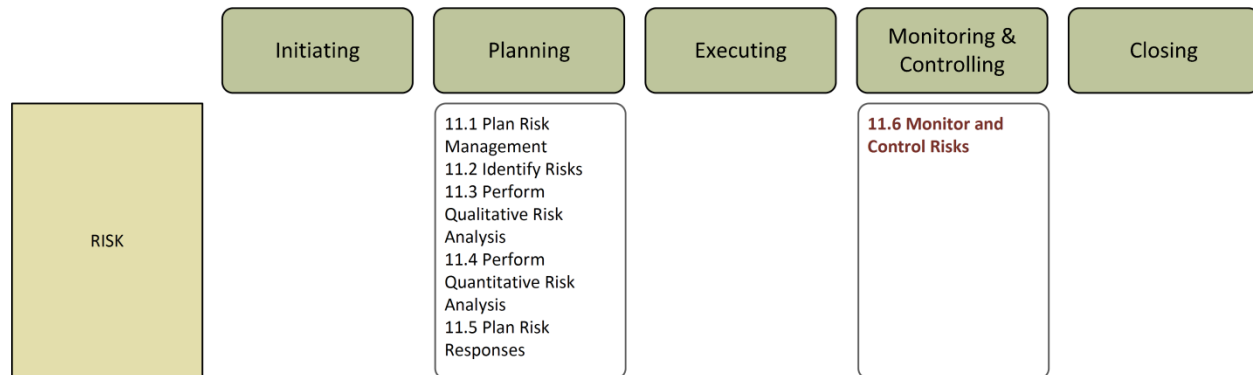
☐ **Project management plan updates**

Risk responses will usually require schedule and cost changes to be incorporated into the project management plan. The project management plan details how the project will be executed, managed, and controlled, including many subsidiary plans as to how changes to major project components, such as scope, budget and schedule, will be handled, and how important factors such as communication, risk, and quality will be managed. The project management plan is the key source of information relating to project management for the project.

☐ **Project document updates**

This process will likely result in updates to documents outside of the project management plan.

11.6 Monitor and control risks



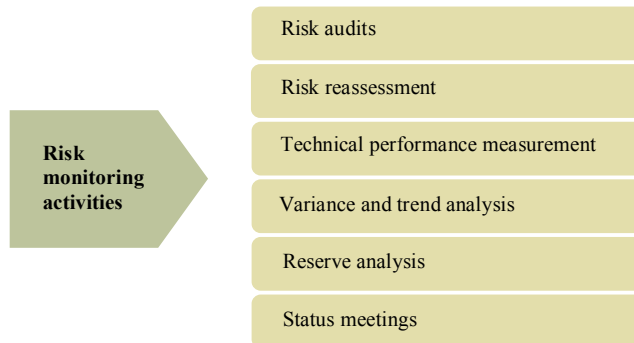
Project risks do not remain static once the risk planning processes are completed. New risks crop up, responses may not work as planned, and the characteristics of risks might change. The risk monitoring and control process begins as soon as risk planning starts and continues until project closure. Activities in the **Monitor and Control Risks process** include:

- Watching for new risks
- Analyzing identified risks for changes in probability or impact
- Determining the need to execute contingency or fallback plans
- Reviewing risk response actions and their effectiveness for risks that are underway, and if necessary determining the need to implement fallback plans
- Keeping a close eye on the risk watchlist
- Monitoring residual risks
- Watching for any assumptions that aren't holding true
- Making sure the risk management plan and risk management policies and procedures are followed
- Analyzing risk data, identifying trends, and producing risk reports
- Ensuring that appropriate records are maintained, including lessons learned documentation about risks
- Instigating recommended changes and preventative or corrective actions as a response to results uncovered from risk monitoring and control.

Risk monitoring activities

During risk monitoring and control, the risk or project manager relies heavily on the risk management plan and the risk register. The risk management plan identifies what monitoring and reporting activities are necessary while the risk register has the characteristics of each risk, including priority, planned response, personnel responsibilities, symptoms, contingency and fallback plans, and the approved schedule and budget.

Work performance information and performance reports provide data the risk manager uses to monitor the effectiveness of risk responses, including whether they're functioning within the time and cost constraints established and that they're having the desired effect. Performance data can also indicate changes in the project environment that are affecting the estimated probability or impact of identified risks.



Risk audits

Risk audits review the overall risk management policies, procedures, and processes. Audits review the effectiveness of the project risk management plan. Risk audits can also refer to analyzing whether the risk response actions were effective and what impact they had on the project's overall risk level.

You should have enough information at a project's inception to know about the biggest risks, such as ineffective sponsorship, a fudged business case or inept project management. Killing projects that exhibit those risks on Day One would save most IT organizations 50% of the money they spend on failed projects.⁷

Richard Hunter, Gartner, Inc.

Risk reassessment

Risk reassessment looks at individual risks to make sure their characteristics remain as originally planned, and it also makes sure that a mechanism and environment are in place so that new risks can be identified. Risk reassessment should be a tool that's part of the project culture and included as an agenda item in status or other project team meetings. Continual reassessment is needed because risks are very prone to change between project planning and project execution. Performance, personnel, environmental, organizational, and technological changes directly influence risks levels. Any desired or needed changes discovered during reassessment are funneled through integrated change control for further review and approval.

Technical performance measurement

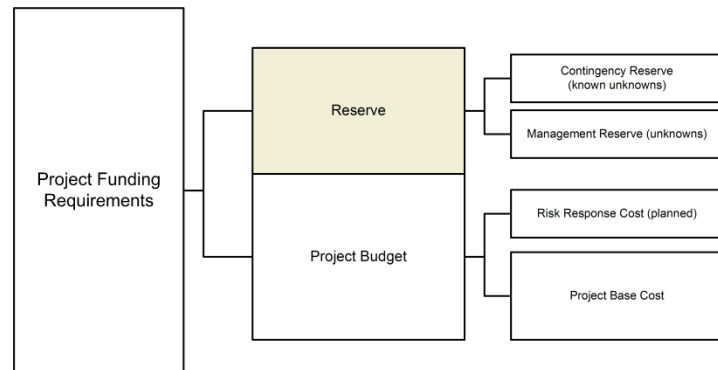
The project deliverables are made up of many specific objectives and characteristics, such as functionality, form, usability, and so forth. **Technical performance measurement** compares those objectives with what is actually being displayed in the deliverables and looks for deviations. Deviations can be caused by the deliverable progress being ahead or behind schedule, or it can be due to extra or missing requirements. Deviations from the planned characteristics are an indicator as to how probable it is that the project will fulfill its scope.

Variance and trend analysis

Variance analysis using performance data can indicate or confirm that threats or opportunities are occurring, and can also be used to forecast project success in meeting budget, time, or quality objectives based on risk factors. Analysis may also uncover trends, such as a common factor leading to an increase in multiple risks, which can make risk management efforts more effective.

Reserve analysis

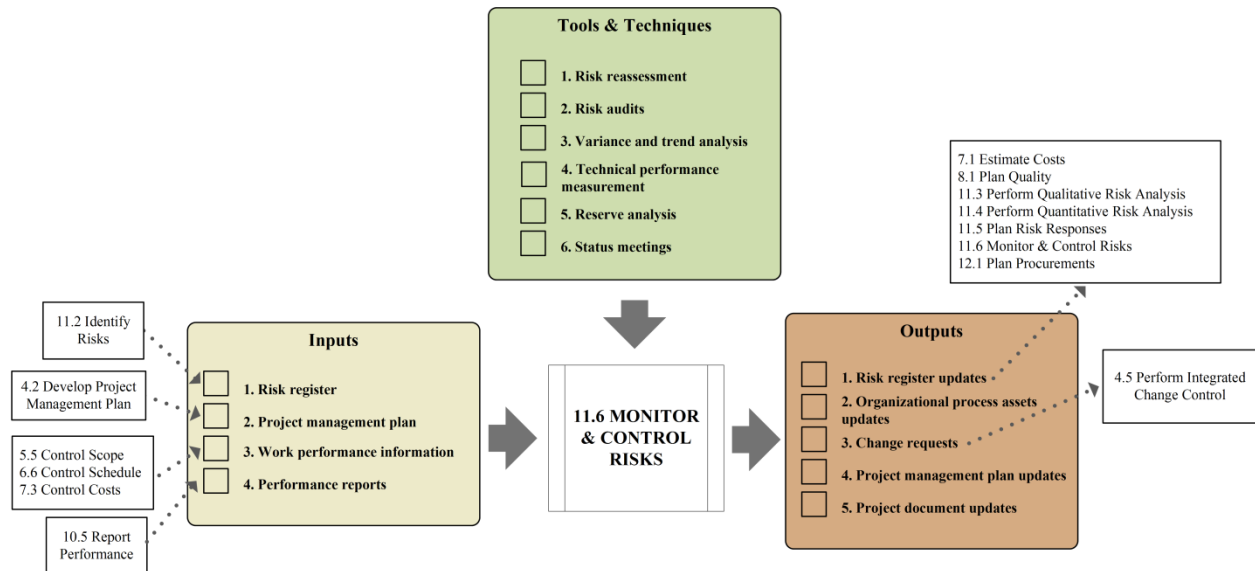
Reserve analysis makes sure that an adequate contingency reserve is available for risks. There can be contingency reserves for cost and time buffers in the schedule. Contingency reserves are tapped for risk contingency and fallback plans, and one or two costly risks may deplete the reserve, making the project susceptible to funding or scheduling deficiencies if additional problems arise.



Status meetings

Risk discussions should be embedded in all regular project meetings because the first signs of a change in risk levels or identification of new risks is usually discovered by those closest to the executing tasks –the project team.

11.6 Process decomposition

**Inputs**☐ **Risk register**

The risk register is a comprehensive list of all threats and opportunities the project faces. It also contains supplementary data about each risk, including its impact, probability, risk response, budget, risk owner, and contingency and fallback plans.

☐ **Project management plan**

The risk management plan is a component of the project management plan. It details and defines the risk management activities for the project. The plan establishes the risk methodology, risk roles and responsibilities, risk categories, probability and impact scales, risk tolerances, frequencies of risk management activities and reporting, and the budget and schedule for risk management activities.

☐ **Work performance information**

Schedule and progress status information, budget and cost status, quality status, estimates to complete, resource utilization information, and lessons learned. Any of this information can be useful for risk monitoring and control.

☐ **Performance reports**

Performance reports provide information on schedule performance. They also can serve as alerts of current or potential problems, which impact individual and overall risk.

Tools and Techniques☐ **Risk reassessment**

Risk reassessment monitors identified risks for changes as well as watching for new risks.

☐ **Risk audits**

Risk audits review the effectiveness of the project's risk management planning and may also be used to evaluate how effective risk response activities are for identified risks.

☐ **Variance and trend analysis**

Deviations from the project plan can be indicators of a change in risk. Project variance tools, such as earned value analysis can indicate that current performance is not in line with what was planned.

☐ **Technical performance measurement**

Technical performance measurement looks at the technical accomplishments achieved to what was planned. For instance, a difference in functionality within the deliverable can indicate a change in risk level for the scope objective.

☐ **Reserve analysis**

Reserve analysis ensures that the amount of money or time in the contingency reserves is adequate for the risks remaining on the project.

☐ **Status meetings**

Risk topics should be a regular agenda item at project meetings.

Outputs☐ **Risk register updates**

Risk Monitoring and Controlling can result in updates to the risk register, such as priority changes, trigger, symptom, or warning sign changes, or a change in risk responses due to the ineffectiveness of the original response.

☐ **Organizational process assets updates**

Variance analysis, the reasons for corrective or preventative actions, and any other lessons learned from risk monitoring and control should be documented as part of the lessons learned process so that they're available for later projects.

☐ **Change requests**

Risk monitoring and control may identify changes that need made to any component of the project management plan to influence risks. These requests are submitted for review to the integrated change control process.

☐ **Project management plan updates**

Risk monitoring and control can result in updates to the project management or any of its components. The project management plan details how the project will be executed, managed, and controlled, including many subsidiary plans as to how changes to major project components, such as scope, budget and schedule, will be handled, and how important factors such as communication, risk, and quality will be managed. The project management plan is the key source of information relating to project management for the project.

☐ **Project document updates**

This process can result in changes to project documents beyond just the project management plan.

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Chapter summary

A risk is any uncertain event with consequences either detrimental to the project (threats) or beneficial to the project (opportunities). The purpose of project risk management is to *increase the probability and impact of positive events and decrease the probability and impact of events adverse to the project*. Risks affect scope, time, cost, or quality objectives, but not every risk will warrant a response if the probability and impact of the risk is acceptable or efforts to respond to the risk would outweigh its benefits.

Activities in the Plan Risk Management process define the approach and methodology for project risk management activities by creating the risk management plan. Risk management should be proactive and applied consistently throughout the project, and the level of risk management planning depends upon many factors, such as the cost, priority, and importance of the project, but even minor projects need a risk management plan. The plan details the risk management methodology, budget, schedule, and responsibilities for risk management. It also defines the risk categories, shown as the risk breakdown structure, and it establishes the probability and impact rating method. The risk ratings and scales are later used on the probability and impact matrix, which "scores" risks against the project's objectives.

The Identify Risk process uncovers all risks and creates the risk register, which is the running list of all risks and their characteristics. Risk identification occurs frequently throughout the project because risks are prone to change, and it may involve a broad range of participants, including the project manager, project team, stakeholders, subject matter experts, risk professionals, vendors, and the customer. Risks are uncovered by reviewing the project management plan components, such as the schedule, and the project scope statement. Further information gathering techniques will also be required like brainstorming, interviewing, and SWOT analysis. Cause-and-effect diagrams, flow charts, and influence diagrams can help uncover risks and root causes.

Perform Qualitative Risk Analysis prioritizes identified risks so that efforts can be focused on high priority risks. Qualitative risk analysis scores risks using the rating system established by the risk management plan and through probability and impact matrices. Qualitative analysis results in a priority list of risks, a watchlist of low priority risks, and a list of risks requiring urgent action. Through qualitative analysis, it may also be found that some risks need more detailed analysis, and those are earmarked for quantitative analysis.

Perform Quantitative Risk Analysis is a more detailed study of risk impacts and probability. Quantitative risk analysis usually relies on three-point estimates to gauge the probability and impact. Expected monetary value (EMV) is the long-term average outcome of a risk, and it's calculated by multiplying the outcome by the probability. EMV is used in decision tree analysis, which is a structured way of presenting the implications of a problem with multiple solutions. Neither EMV nor decision trees provide definite predictions about an outcome.

Plan Risk Responses decides what strategies will be undertaken to influence risks, and what contingency and fallback plans will be executed if the risk occurs. The strategies for threats are avoid, mitigate, and transfer; the strategies for opportunities are exploit, enhance, and share. Accept and contingent responses are applicable to both positive and negative risks. Responsibilities for carrying out the actions are assigned to the risk action owner. The contingency and fallback plans will be executed only under specific circumstances that have been defined, often the occurrence of the risk event.

Risk Monitoring and Control makes sure that risk responses are effective, and if not, determining that contingency or fallback plans should be enacted. This process also analyzes risks for any changes, such as a low-priority risk from the watchlist becoming a high-priority risk. Other activities in risk monitoring include documenting lessons learned and ensuring that risk management policies and procedures are followed. Risk audits determine the effectiveness of the project risk management plan. Requested changes and preventative or corrective actions are often necessary to project components.

Exam summary

- ☐ Risks are any uncertain event that can be detrimental or beneficial to project objectives.
- ☐ Force majeure events are long-term events that cannot be reasonably foreseen or controlled, such as natural disasters.
- ☐ The risk management plan is established through the Risk Management Planning process.
- ☐ The risk management plan defines the project's risk management approach, including:
 - Risk methodology
 - Risk roles and responsibilities
 - Risk budget and schedule
 - Frequency of risk management activities
 - Risk categories
 - Definitions for probability and impact ratings
 - Risk tolerances
 - Risk reporting formats
- ☐ Probability and impact scales can be:
 - Relative (e.g.: low, medium, and high)
 - Linear (e.g.: 1, 2, 3, 4, and 5)
 - Non-linear (e.g.: 1, 2, 4, 8, and 16)

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- ☐ A probability and impact matrix is a tool to score and aid in prioritizing risks.
 - ☐ The probability and impact matrix provides explicit and clear instructions on rating risk probability and impact.
 - ☐ The Risk Identification process creates the risk register.
 - ☐ The risk register contains all identified risks, and other risk characteristics like root cause, probability, impact, symptoms, risk response, risk responsibilities, contingency plan, and fallback plan.
 - ☐ Risks are identified through documentation reviews, brainstorming, interviewing, surveying (Delphi technique), SWOT analysis, checklists, and diagramming techniques.
 - ☐ Risks are prioritized and ranked through the Perform Qualitative Risk Analysis process.
 - ☐ Risk data is evaluated through risk data quality assessment to make sure data gathered is accurate and reliable.
 - ☐ Qualitative risk analysis uses a probability and impact matrix for each risk to assess an overall risk score.
 - ☐ Low-priority risks are added to a watchlist for monitoring.
 - ☐ Risks are evaluated through qualitative analysis for their need for more detailed quantitative analysis.
 - ☐ Perform Quantitative Risks Analysis performs a thorough assessment of high priority risks.
 - ☐ Risk impact and probability usually involves three-point estimating techniques.
 - ☐ Probability distributions are a graphical representation of uncertainty in data.
 - ☐ Sensitivity analysis looks at how risks affect project objectives.
 - ☐ A tornado diagram is a common way of showing the results of sensitivity analysis.
 - ☐ Expected monetary value calculates the average outcome from a scenario.
 - ☐ EMV is calculated by multiplying the probability by the outcome.
 - ☐ A positive EMV is a positive risk (opportunity) and a negative EMV is a negative risk (threat).
 - ☐ Decision trees diagram the options and outcomes from problems with multiple solutions.
 - ☐ Monte Carlo is a simulation technique that can be used for quantitative analysis.
 - ☐ The results from quantitative analysis can be used to predict project-level probabilities of meeting objectives.
 - ☐ Plan Risk Responses develops the strategies and actions that will be taken for risks.

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- ☐ Risk responses are:
 - Avoid (threat)
 - Mitigate (threat)
 - Transfer (threat)
 - Exploit (opportunity)
 - Enhance (opportunity)
 - Share (opportunity)
 - Accept (both)
 - Contingent (both)
 - ☐ Contingency and fallback plans are established during risk response planning.
 - ☐ Risk response planning results in updates to the risk register for risk responses, contingency plans, fallback plans, and risk action responsibilities.
 - ☐ Estimated monetary value can be used for establishing a contingency reserve budget.
 - ☐ Risks are continually reassessed through Risk Monitoring and Control.
 - ☐ Risk audits assess the effectiveness of the risk management plan.
 - ☐ Performance variances (like earned value management techniques) and work performance information can indicate a change in the risk situation.
 - ☐ Reserve analysis ensures that an adequate level of contingency reserve funding and reserve time buffers are in place for the remaining project risks.