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PMP 44 Processes

Process -> Knowledge Area	Initiation	Planning	Execution	Monitoring and Controlling	Closing
Integration	Develop Project Charter	Develop project management plan	Direct and manage project execution	Monitor and control Project work	Close Project
	Develop Preliminary scope statement			Integrated Change control	
Scope		Scope Planning		Scope Verification	
		Scope Definition		Scope Control	
		Create WBS			
Time		Activity Definition		Schedule Control	
		Activity sequencing			
		Activity Resource Estimating			
		Activity Duration Estimating			
		Schedule Development			
Cost		Cost Estimating		Cost control	
		Cost Budgeting			
Quality		Quality planning	Perform quality assurance	Perform quality control	
Human Resource		Human Resource Planning	Acquire Project Team	Manage Project Team	
			Develop Project Team		
Communication		Communication Planning	Information Distribution	Performance Reporting	
				Manage Stakeholders	
Risk		Risk Management Planning		Risk Monitoring and Control	
		Risk Identification			
		Qualitative Risk Analysis			
		Quantitative Risk Analysis			
		Risk Response Planning			
Procurement		Plan purchases and Acquisition	Request Seller Responses	Contract Administration	Contract Closure
		Plan Contracting	Select Sellers		

1 Project Management basics

➢ There are 9 knowledge areas in Project Management. To memorize remember "PRIeST HQ CC".
PRIeST HQ CC – Procurement, risk, integration, scope, time, HR, Quality, Cost, Communication

➢ The below abbreviations are used in this note.
PMM – Project Management methodology
PMIS – project management information system
SOW – Statement of work
EEF – Enterprise environmental factor
OPA – Organizational process assets
PMP – Project management Plan
WBS – Work Breakdown structure
OBS – Organizational breakdown structure
RBS – Resource breakdown structure/Risk breakdown structure
RAM – Resource assignment Matrix
IRR – Internal rate of return
NPV – Net present value
ROM – Rough Order of Magnitude estimate
EMV – Expected Monitory value
CR - Cost reimbursable contract
T&M - Time & Material contract
FP - Fixed price contract
RFP - Request for Proposal
RFB - Request for Bid
RFQ - Request for Quote

➢ Project cost and schedule cannot be finalized without completing risk management.

➢ Delays must be made up by adjusting future work.

➢ All changes mush flow through the change request process and the integrated change control.
➢ *Projects* are temporary and are progressively elaborated.

➢ A *program* is a group of projects. All such projects under a program may use the same resources or are inter-dependent.

➢ Project Management office (PMO) roles:
- provides policies, templates and methodologies for managing projects.
- provides guidance.
- provides PM for different projects.

➢ Projects are completed when the *objectives* are met.

➢ *Management by Objectives* (MBO):
- establish unambiguous and realistic objectives.
- periodically evaluate if objectives are being met.
- implement corrective actions.

➢ *Triple Constraint*:
- cost, time and scope
- quality, risk and customer satisfaction

➢ PMI's organizational maturity model for project management is called OPM_3.

➢ Any differences in requirement between stakeholder should be resolved in favor of customer.

➢ Organizational structures:
   - Functional
     * most common type, grouped by area of specialization.
     * Functional manager has main control.
     * PM has the lowest control.

   - Projectized
     * PM has main control.
     * team members may not have home after project is completed.
     * less efficient use of resources.
     * loyalty to the project.

   - Matrix
     * Mix of strength and weaknesses of Functional and Projectized models.
     * Team members report to two heads, PM and FM.
     * Weak, strong and balanced matrix.
     * In strong matrix, power lies with PM.
     * In weak matrix, power lies with FM, and PM acts as a coordinator or expediter.
     * better horizontal and vertical dissemination of information.
     * higher potential of conflict.

➢ PMP test assumes you are working in matrix organization.

➢ **Project expediter** cannot make decisions, acts as a staff assistant and communication coordinator. **Project coordinator** has some power to make decisions and reports to high level manager.

➢ A **tight matrix** means locating the offices of the project team in the same room, this has nothing to do with the project organization types.

➢ **Product life cycle** lasts from the conception of a product to its withdrawal. **Project life cycle** is what is to be done to get the work done.

➢ **Project Management processes** include initiating, planning, executing, monitoring and controlling and closing. This is similar to *plan-do-check-act* cycle.

➢ Releasing resources is the last activity in the closing process group.

➢ Business needs, strategic plan and product scope description are elements of project statement of work.

➢ Project phases evolve through the life cycle in a series of phase sequences called **handoffs** or **technical transfers**.

➢ Need and demand for a project:
   - market demand
   - business need
   - customer request

- technological advance
- legal requirement
- social need.

➤ *Feasibility study* is done to determine if project is viable and its probability of success.

➤ Output of feasibility study could be the project charter.

➤ A *steering committee* is a group of people comprising of senior managers who represent each functional area in the organization.

➤ *Portfolio Management* helps in determining the projects to be invested in.

2 Integration management

➤ Processes in Integration Management
   - Develop Project Charter (Initiation)

Input	Tools & Techniques	Output
- Contract (if applicable) - Project SOW - EEF - OPA	- Project selection method - PMM - PMIS - Expert judgment	- Project Charter

   - Develop preliminary project scope statement (Initiation)

Input	Tools & Techniques	Output
- Project charter - Project SOW - EEF - OPA	- PMM - PMIS - expert judgment	-Preliminary project scope statement

   - Develop Project Management Plan (Planning)

Input	Tools & Techniques	Output
- Preliminary project scope statement - Project Management processes - EEF - OPA	- PMM - PMIS - Expert judgment	- PMP

   - Direct and Manage Project Execution (Executing)

Input	Tools & Techniques	Output
- PMP - Approved corrective actions - Approved preventive actions - Approved change requests - Approved defect repair - Validated defect repair - Administrative closure procedure	- PMM - PMIS	- Deliverables - Requested changes - implemented change requests - implemented corrective actions - implemented preventive actions

Input	Tools & Techniques	Output
		- implemented defect repair - work performance information

- Monitor and Control Project work (Monitoring and controlling)

Input	Tools & Techniques	Output
- PMP - Work performance information - Rejected change requests	- PMM - PMIS - Expert judgment - Earned value technique	- recommended corrective actions - recommended preventive actions - forecasts - recommended defect repair - requested changes

- Integrated Change control (Monitor and controlling)

Input	Tools & Techniques	Output
- PMP - requested changes - work performance information - recommended preventive actions - recommended corrective actions - recommended defect repair - deliverables	- PMM - PMIS - Expert Judgment	- Approved change request - rejected change requests - PMP updates - Project scope statement updates - approved corrective actions - approved preventive actions - approved defect repair - validated defect repair - deliverables

- Close Project (Closure)

Input	Tools & Techniques	Output
- PMP - Contract documentation - OPA - work performance information - deliverables	- PMM - PMIS - Expert Judgment	- administrative closure procedure - contract closure procedure - Final product, service or result - Organizational process assets updates

➤ A Project Charter formally recognizes the existence of the project, Project does not exist without a project charter. It gives PM the authority to spend money and commit corporate resources.

➤ Project Charter is issued by a sponsor.

➤ Constraints and Assumptions are included in the Project Charter. **Constraints** are factors that limit the team's options such as limits on resources, budget, schedule and scope. **Assumptions** are things that are assumed to be true, which may not be true. The sponsor, the team and other stakeholders can identify constraints and assumptions throughout the project.

➤ Constraints and Assumptions are also reviewed for validity throughout the project. Assumptions

analysis is part of the risk management process.

➢ The ***Project statement of work*** is created by the sponsor/customer and describes their needs, product scope and how the project fits into their strategic plan. It is an input to the Project Charter.

➢ Project Selection Method
  - Benefit Measurement method (comparative approach)
   Murder board, peer review, scoring models, economic models, benefit compared to cost.

  - Constrained optimization method (Mathematical approach)
   Programming methods like Linear, integer, dynamic multi-objective programming.

➢ The preliminary project scope statement is the first attempt to determine the project scope. It is developed based on information from the sponsor.

➢ Project Management Plan (PMP) is a multi-page document based on inputs from the team and other stakeholders. It contains all the management plans and performance measurement baselines. It is a day-to-day tool for managing the project.

➢ Develop project management plan is a process of creating a PMP that is BARF, bought into, approved, realistic and formal.

➢ ***Configuration Management system*** is used to maintain the versions of various components such as scope and schedule. Configuration management activities include:
  - Configuration identification
  - Configuration status accounting
  - Configuration verification and auditing

➢ Configuration Management system may include a ***Change Control system***, a collection of formal, documented procedures, paperwork, tracking systems and approval levels for authorizing changes. These systems are implemented in integrated Change control.

➢ The PMP also contains ***Performance Measurement Baselines*** that will be used to measure performance against. There can be scope, schedule, cost, quality, resource and technical performance baselines. Baselines are used during project execution to measure performance and to help control the project.

➢ The PM integrates all the processes of the executing processes into one coordinated effort to accomplish the PMP, in the ***Direct and Manage Project Execution*** process. Approved Corrective actions, preventive actions and Defect repair are implemented as part of this process.

➢ ***Monitoring and Controlling Project work*** is a control function that is done from project initiating through project closing. The results of this process is recommended changes to the project, as well as recommended corrective actions, preventive actions and defect repair.

- ➢ **_Corrective action_** is any action taken to bring expected future project performance in line with the PMP. Corrective action involves implementing actions to deal with actual deviations from the performance baselines.

- ➢ **_Preventive actions_** deals with anticipated or possible deviations from the performance baselines.

- ➢ **_Defect Repair_** is rework and is necessary when a component of the project does not meet its specifications. These are discovered during the quality management process and formed into a change request during monitoring and controlling project work process, these are approved or rejected in the integrated change control process.

- ➢ **_Integrated Change Control system_** is used to approve or reject the recommendations for changes, corrective actions, preventive actions and defect repair. Changes to any part of the PMP or the product of the project are handled in the integrated change control process.

- ➢ PM should follow the below steps to evaluate changes in the project.
  - Get the details of the changes from the customer
  - Evaluate impact
  - Create options
  - Get internal buy-in
  - Get customer buy-in
  - incorporate in PMP and baseline
  - Communicate to stakeholders

- ➢ Changes to the project charter should be approved by the project sponsor.

- ➢ Changes to performance measurement baselines or project constraints should be approved by the Change Control Board or the project sponsor.

- ➢ Changes in the PMP do not require any approval, PM can do it on his/her own.

- ➢ Process of making changes
  1. Prevent the root cause of the change
  2. Identify change
  3. Create a change request
  4. Assess the change
  5. Look at the impact of the change
  6. Perform integrated change control
  7. Look for options
  8. Change is approved or rejected
  9. Adjust the PMP and baselines
  10. Notify stakeholders affected by the change
  11. Manage the project to the new PMP.

- ➢ If there is a change to the project charter, the sponsor who signed or approved the project charter

has to make the final decision.

➢ The **close project** process is part of the closing project group. Below two procedures are involved
with closing project.
- Administrative closure procedure (focuses on closing the project or project phase)
- Contract closure procedure (focuses on closing a contract that is part of the project)

➢ You always close a project no matter the circumstances under which it stops, is terminated or
completed.

➢ Types of project endings :-
- **Integration** occurs when the resources (personnel, equipment, property etc.) of the project are
reassigned to other areas within the organization or other projects.
- **Addition** occurs when a project evolves into ongoing operations.
- **Starvation** occurs when resources are removed from the project.
The difference between integration and starvation is that starvation results in resource cuts, while
integration results in redeployment of resources.
- **Extinction** occurs when the project end was completed successfully and accepted by
stakeholders.

➢ Monitor and control project work process - > recommended corrective actions + preventive actions
+ (validated) defect repair -> Integrated change control -> approved/rejected corrective actions +
preventive actions + defect repair -> Direct and manage project execution -> implemented
corrective actions + preventive actions + defect repair

➢ **Work Performance information** is an output of Direct and manage project execution process
and is an input to other monitor and controlling processes.

3   Scope Management

➢ Scope management involves managing both product and project scope.

➢ Scope Baseline includes the project scope statement, the WBS and the WBS dictionary.

➢ The processes:
- scope planning (planning)

Input	Tools & Techniques	Output
- EEF - OPA - Project charter - preliminary project scope statement - PMP	- Expert Judgment - Templates, forms, standards	- Project scope management plan

- scope definition (planning)

Input	Tools & Techniques	Output
- OPA - project charter	- Product analysis - alternatives identification	- Project scope statement - requested changes

Input	Tools & Techniques	Output
- Preliminary project scope statement - Project scope management plan - Approved change request	- expert judgment -stakeholder analysis	- project scope management plan updates

- Create WBS (planning)

Input	Tools & Techniques	Output
- OPA - Project scope statement - project scope management plan - approved change requests	- WBS templates - decomposition	- project scope statement update - WBS - WBS dictionary - scope baseline - project scope management plan updates - requested changes

- scope verification (monitoring and controlling)

Input	Tools & Techniques	Output
- project scope statement - WBS dictionary - Project scope management plan - deliverables	- inspection	- accepted deliverables - requested changes - recommended corrective actions

- scope control (monitoring and controlling)

Input	Tools & Techniques	Output
- project scope statement - WBS - WBS dictionary - Project scope management plan - performance report - approved change requests - work performance information	- change control system - variance analysis - re-planning - configuration management system	- project scope statement updates - WBS updates - WBS dictionary updates - Scope baseline updates - requested changes - recommended corrective actions - OPA updates - PMP updates

- ➢ Scope Management Plan can be altered later on as part of planning, to add new scope that is identified as part of other planning processes e.g.: Risk response planning.

- ➢ The output of **scope definition** is Project Scope Statement. **Stakeholder Analysis** is carried out to identify the needs, wants and expectations of stakeholder, which are part of the identified scope.

- ➢ **Product analysis** goes hand in hand with the product scope description. Product analysis is a method for converting the product description and project objectives into deliverables and requirements. Product Analysis includes techniques such as Value Analysis, Functional Analysis, Value Engineering, Product breakdown, Systems analysis and Systems Engineering.

- ➢ **Alternatives identification** is a technique used for discovering different methods or ways of accomplishing the project.

➢ **WBS** is deliverable-oriented. This is a top down effort to decompose the work into smaller pieces called *work packages*. It is created with the help of the team. It helps prevent work from slipping through the cracks. It provides the project team with an understanding of where their pieces fit into the overall project management plan and gives an indication of the impact of their work.

➢ Work not in the WBS is not part of the project.

➢ The top level of the WBS is the project title.

➢ The levels in the WBS are numbered for ease of location later. When the WBS is completed, code numbers are assigned to help distinguish where a work package is in the WBS.

➢ WBS provides a basis for estimating staff, cost and time.

➢ WBS gets team buy-in and builds the team.

➢ WBS can be best thought of as an effective aid for stakeholder communications, including customer.

➢ The level higher in the WBS than a work package is called the *control account* (cost account).

➢ **WBS dictionary** provides a description of work to be done for each work package and helps make sure the resulting work matches what is needed. It contains a number identified, related control accounts, statement of work to be done, who is responsible for doing the work and any scheduled milestones.

➢ The WBS dictionary can be used as part of **work authorization system** to inform team members when their work package is going to start, schedule milestones and other information. Work authorization system clarifies and initiates the work of each work package or activity.

➢ Inputs to **scope verification**
  - Deliverables
  - Project scope statement
  - project scope management plan
  - WBS dictionary

➢ Output of scope verification
  - Accepted deliverables
  - Customer satisfaction
  - Requested changes
  - Recommended corrective actions

➢ Scope verification ensures that products and results are as per the specifications, gaining formal

sign-off. It is done at the end of each project phase in the project life cycle.

➢ Scope verification is also done when a project is terminated to verify the level of completion.

➢ Quality Control is generally done first, but scope verification and quality control can overlap. The primary focus of scope verification is customer acceptance of the deliverables while quality control involves meeting the quality requirements specified for the deliverables and analysis of the correctness of the work.

➢ **Scope Control** involves looking out for changes to scope and limiting the effects. It involves following the change control process setup in the project scope management plan. Scope change is identified during scope control and then *Integrated change control* process followed to accept or reject the change.

➢ **Variance Analysis**: Project performance measurements are used to assess the magnitude of variation. Important aspects of project scope control include determining the cause of variance relative to the scope baseline and deciding whether corrective action is required.

➢ **Objectives** are quantifiable criteria used to measure project success. Quantifiable criteria should atleast include schedule, cost and quality measures. Objectives should be Specific, Measurable, accurate, realistic and time bound (**SMART**).

➢ Types of breakdown structures:
   - WBS
   - OBS: organization breakdown structure
   - BOM: bill of materials
   - RBS : risk breakdown structure.
   - RBS : resource breakdown structure.

4 Time Management

➢ There is no such thing as project management software. You cannot follow software; you must make it conform to your needs.

➢ Estimating should be based on WBS to improve accuracy.

➢ Estimating should be done by the person doing the work whenever possible.

➢ Historical information from past projects (part of organizational process assets) is a key to improving estimates.

➢ **Padding** is not an acceptable project management practice.

> ➢ Time management processes:-
>   - Activity definition (planning)

Input	Tools & Techniques	Output
- EEF - OPA - project scope statement - WBS - WBS Dictionary - PMP	- decomposition - templates - rolling wave planning - expert judgment - planning component	- activity list - activity attributes - milestone list - requested changes

  - Activity sequencing (planning)

Input	Tools & Techniques	Output
- Project scope statement - activity list - activity attributes - milestone list - approved change requests	- PDM - ADM - schedule network templates - dependency determination - applying leads and lags	- project schedule network diagrams - activity list updates - activity attributes updates - requested changes

  - Activity resource estimating (planning)

Input	Tools & Techniques	Output
- EEF - OPA - Activity list - activity attributes - resource availability - PMP	- expert judgment - alternatives analysis - published estimating data - Project management software - bottom-up estimating	- Activity resource requirements - activity attributes updates - resource breakdown structure - resource calendar updates - requested changes

  - Activity duration estimating (planning)

Input	Tools & Techniques	Output

- EEF
- OPA
- project scope statement
- activity list
- activity attributes
- activity resource requirements
- resource calendars
- PMP
  - risk register
  - activity cost estimates
	- Expert judgment
	- analogous estimate
	- parametric estimate
	- three-point estimate
	- reserve analysis
		- activity duration estimates
		- activity attributes updates

  - Schedule development (planning)

Input	Tools & Techniques	Output
- OPA - project scope statement - activity list - activity attributes - project schedule network diagram - activity resource requirements - resource calendars - activity duration estimates - PMP	- schedule network analysis - CPM - Schedule compression - What-if scenario analysis - resource leveling - Critical chain method - project management software - applying calendars - adjusting leads and lags (reserves) - schedule model	- project schedule - schedule model data - schedule baseline - resource requirements updates - activity attributes updates - project calendar updates - requested changes - PMP updates - schedule management plan

Input	Tools & Techniques	Output
- risk register		updates

- Schedule control (Monitoring and controlling)

Input	Tools & Techniques	Output
- schedule management plan - schedule baseline - performance reports - approved change requests	- progress reporting - schedule change control system - performance measurement - project management software - variance analysis - schedule comparison bar charts	- schedule model data updates - schedule baseline updates - performance measurements - requested changes - recommended corrective actions - OPA updates - activity list updates - activity attributes updates - PMP updates

➤ **Schedule Management plan** includes establishment of a schedule baseline for measuring against during the monitoring and controlling process group. It identifies performance measures that is used to identify variances early. It has plans for how variances will be managed and identification of schedule change control procedures.

➤ Schedule Management plan can be formal or informal, but is part of the project management plan. It requires that progress be measured along the way.

➤ **Activity Definition** involves taking the work packages created in the WBS and breaking them down further (decomposing) in order to reach the activity level; a level small enough to estimate, schedule, monitor and manage.

➤ Many PM's skip activity definition because they take their WBS down to the activity level rather than the work package level. Other PM create the network diagram to the work package level instead of the activity level, because it would be too large to do so. Neither of these practices are wrong.

➤ In **rolling wave planning**, high level planning is done, until the project has begun and the work is more clear to plan the lower levels.

➤ Activity Definition, when completed, will also result in an **activity list** and the details of the activities (activity attributes) being completed.

➤ Activity Definition can lead to a discovery that the WBS or some other part of the PMP under development needs to be changed.

➤ **Activity Sequencing** process involves taking the activities and sequencing them in order of how the work will be performed. This results in a **Project Schedule Network Diagram** (or network diagram).

- ➢ Network diagram shows dependencies of activities. If activity duration estimates are added, the network diagram could also show the critical path.

- ➢ If plotted out against time (or placed against a calendar-based scale), the network diagram would be a *time-scaled schedule network diagram*.

- ➢ **Network diagram** help in doing the following:-
    - show interdependencies of all activities.
    - shows the workflow
    - aid in effectively planning, organizing and controlling the project.
    - Help justify your time estimates for the project
    - compress the schedule in planning and through out the life of the project

- ➢ There are two ways to draw network diagram
    - Precedence Diagramming method.
    - Arrow Diagramming method

- ➢ Today most network diagrams are created using PDM

- ➢ PDM is also called **Activity on Node** (AON) method. Nodes or boxes are used to represent activities and connecting arrows show activity dependencies. The activities are mentioned inside the box. For types of dependencies are possible:-
    - Finish-to-start : most common, an activity must finish before a successor can start.
    - start-to-start : an activity must start before the successor can start.
    - finish-to-finish : an activity must finish before successor can finish.
    - start-to-finish : rare, an activity must start before a successor can finish.

- ➢ ADM is also called Activity on Arrow (AOA) method. Arrows are used to represent activities. Activity names are placed on the arrows. ADM uses only finish-to-start relation between activities.

- ➢ ADM may use dummy activities represented by dotted lines.

- ➢ **GERT** is a network diagram that allows for **looping** between activities.

- ➢ The sequence of activities is based on the type of dependency between the activities.
    - **Mandatory dependency**:- Hard logic, required because of the nature of work being done or by contract
    - **Discretionary dependency**:- Preferred, preferential or soft logic, the way the PM prefers to set dependencies.
    - **External dependency**:- Based on the needs or desire of a party outside the project.

- ➢ **Milestones** are significant events within the project schedule. Milestones can be imposed by the sponsor in the project charter or preliminary project scope statement. A list of milestones become part of the project management plan and are included in the project scope statement and WBS dictionary.

- ➢ **Leads and Lags:** a lead may be added to start an activity before the predecessor activity is completed. A lag is inserted waiting time between activities.

- ➢ The creation of a network diagram can easily reveal an additional WBS element, such changes are proposed and addressed as part of integrated change control.

- ➢ **Activity resource estimating** is done once the activity sequencing is completed, to determine the required resources. The following tasks are done as part of this process.
  - review resource pool availability
  - review WBS
  - identify potentially available resources
  - review historical information related to use of resources in similar projects in the past
  - review organizational policies on resource use.
  - analyze alternative ways of completing the work
  - make or buy decision
  - ***bottom up estimating (break the activity down further, if the activity is too complex to estimate)***
  - quantify resource requirements by activity.

- ➢ **Activity Duration estimating** involves identifying the amount of time each activity is expected to take. When possible, it should be done by the person doing the work.

- ➢ Activities are estimated using One-time estimate, Analogous estimating, Parametric estimating, Heuristic, Three point estimate and reserve analysis.

- ➢ **One-time estimate** involves one estimate per activity, based on expert judgement, by looking at historical data or even just guessing. One time estimate should only be used for projects that do not require a detailed highly probable schedule. A ***pad*** is added sometimes to project estimate, this is merely for unidentified risks and uncertainties. **Padding** is a sign of poor project management.

- ➢ **Analogous estimating** is a form of expert judgment. E.g.: the last three similar projects took about 4 months to complete, so we will estimate the same. The exam considers such estimate to be given to the PM by the sponsor or the management. Analogous estimating is *top-down* estimating.

- ➢ **Parametric Estimating** is used if you do not have detailed information on which to base the time estimates. It uses a mathematical model to calculate projected time estimates for an activity based on historical records from previous projects and other information. e.g.: time per line of code, time per installation. This estimating can be done using ***regression analysis*** and ***Learning curve***. Regression analysis is using ***scatter diagram*** where two variables are tracked to see if they are related and a mathematical formula is derived for future parametric estimating. Learning curve relies on improved efficiency e.g.: the 5th setup will take lesser time.

- ➢ **Heuristic** approach follows rule of the thumb. E.g.: 80/20 principle.

- ➢ The results of parametric estimates can become Heuristic.

- ➢ **Three-point estimates** uses a weighted average. Person estimating the activity provides an optimistic, pessimistic and most likely estimate for each activity. The result is that each activity would take x days plus or minus y days.

- ➢ **Reserve analysis** requires project management to accommodate the time and cost risk in a project through the use of reserves. There can be two types of reserves – ***Contingency reserve*** is for the risks remaining after the risk response planning; ***Management reserve*** is any extra

amount of funds to be set aside to cover unforeseen risks.

➢ The cost baseline will include the contingency reserve and the cost budget will include the management reserve.

➢ **Schedule development** process is calendar based. Following are key activities for PM:-
- work with stakeholders' priorities.
- Look for alternative ways to complete the work.
- Look for impacts on other projects.
- Meet managers to negotiate for resource availability.
- Give team a chance to approve the final schedule.
- compress schedule by crashing, fast tracking and re-estimating.
- Simulate the project using Monte Carlo analysis.
- Level resources
- Conduct meetings and conversations to gain stakeholder and management formal approval.

➢ The data collected so far is put into a schedule, called the **schedule model**, and the PM then performs various calculations and alternative what-if analysis to determine the optimum schedule.

➢ Schedule Network analysis is carried out after Schedule model is completed, using following:-
- PERT
- CPM
- schedule compression
- Monte Carlo analysis/What-if *analysis*
- Resource leveling
- Critical Chain Method

➢ Program Evaluation and Review technique (PERT). It is also called **Beta distribution**.

```
PERT = expected duration =  (P + 4M + 0)/6
standard deviation of an activity = (P − 0)/6
variance of an activity = standard deviation squared = [(P − 0)/6]²
```

In order to find the standard deviation of a series of item, you cannot add standard deviations; you must convert standard deviations into variances, add the variances and then take the square root of the total to convert back into standard deviations.

Expected duration estimates = PERT +/- One standard deviation (1 sigma, 68.26)
Expected duration estimates = PERT +/- 2 x standard deviation (2 sigma, 95.46)
Expected duration estimates = PERT +/- 3 x standard deviation (3 sigma, 99.73)

➢ **Triangular distribution** is a more pessimistic form of PERT.
```
Expected duration or mean = (P + M + O)/3
```

➢ **CPM** includes determining the longest path in the network diagram (critical path) and earliest and latest an activity can start and earliest and latest it can be completed. **Critical path** is the longest path in the project but determines the shortest time to complete the project.

➢ Near-Critical Path is close in duration to critical path. The closer the near-critical path and critical path are, the more risk the project has.

➢ CPM determines which activities have *float(slack)* and can be delayed without delaying the project. Three types:-
- Total float: The amount of time an activity can be delayed without delaying the project end date or an intermediary milestone.
- Free float: The amount of time an activity can be delayed without delaying an early start date of its successor.
- Project float: The amount of time a project can be delayed without delaying the externally imposed project completion date required by the customer, management or as committed.

➢ Activities on Critical Path have Zero float.

➢ Critical Path activities that are delayed or have dictated dates can result in negative float.

➢ Float computation:-
```
= LS – ES
= LF – EF
```

➢ To find out the earliest the project can finish is forward pass (ES, EF). To find out the latest a project can finish is backward pass (LS, LF).

➢ *Dummy activity* is used to show interdependencies of activities on an AOA diagram. Critical path can have a dummy activity.

➢ Schedule should be compressed if the project has a negative float.

➢ Schedule compression is done during project planning to see if the desired completion date can be met and what will have to change to meet that date. Objective is to compress the schedule without change in scope. Fast tracking, crashing, reduce scope and quality cut can be done.

➢ *Fast tracking* involves critical path activities in parallel that were originally planned in series. It may result in re-work, increases risk and requires more attention to communication.

➢ *Crashing* is making a cost and schedule trade-off to determine how to obtain the greatest amount of schedule compression for the least incremental cost while maintaining the project scope. It always results in increase in cost.

➢ If moving resources withing the project does not add to the cost, then Crashing is preferable to fast tracking.

➢ Reducing scope could save cost and time, but negatively impact customer satisfaction.

➢ Cutting quality could save cost and resources, but increase risk. It requires good metrics.

➢ *Monte Carlo Analysis* (what-if analysis):- In schedule development, you create a distribution of probable results for each activity and use it to calculate distribution of probable results for the total project. This analysis uses computer to simulate the outcome of a project making use of three-time estimate for each activity and the network diagram. Monte Carlo can also help deal with path convergence places in the network diagram.

➢ *Resource leveling* is used to produce a resource-limited schedule. Leveling lets schedule slip and cost increase in order to deal with limited amount of resources, resource availability and other resource constraints. *Reverse resource allocation scheduling* is a technique used when key resources are required at a specific point in the project. This requires resources to be scheduled in

reverse order so that key resource can be assigned at correct time.

➢ **Critical Chain Method** takes into account both activity and resource dependencies.
Critical chain is a schedule network analysis technique that modifies the project schedule to account for limited resources. The critical chain method adds non-work schedule activities to maintain focus on the planned activity durations, also referred to as **duration buffering**.

➢ **Milestones chart** are similar to bar chart but only show major events. These do not have durations only dates.

➢ **Gantt Chart** (**bar chart**) is a weak planning tool but effective tool for progress reporting and control. There are no lines between activities to show interdependencies, nor are assigned resources shown.

➢ **Project Schedule** is the result of schedule network analysis done with above tools. This becomes part of the PMP as schedule baseline. The schedule can be shown with or without dependencies and can be shown in below formats, depending on needs of the project:-
- Bar chart (good for tracking progress and reporting to the team)
- network diagram (to show interdependencies between activities)
- Milestone chart (to report to senior management)

➢ In **Schedule Control** process, the PM must measure how the project is going and be able to recommend and implement corrective and preventive actions to adjust the project with the baseline. Progress reporting is done as part of this process.

➢ A **progress reporting** is a useful method to control schedule and costs. Using a method like percent completed is a waste of time. Methods like 50/50, 20/80 and 0/100 rule can be used.
- 50/50 rule: when activity is started give it 50, on completion give it 50.
- 20/80 rule: 20 when activity begins, another 80 when it is completed.
- 0/100 rule: No percentage when activity begins, 100% on completion only.

➢ Two types of calendars:
- **Project calendar**: concern all resources involved in the project and specify the working periods for these resources. e.g.: working days, public holidays.
- **Resource calendar**: Looks at a particular resource or group of resources and their availability. e.g.: holidays of a person.

➢ **Hammock activity**, a type of summary activity, describes a group of related scheduled activities aggregated at some summary level and displayed/reported as single activity at summary level.

5 Cost Management

> Processes
> - Cost estimating (planning)

Input	Tools & Techniques	Output

- EEF
- OPA
- project scope statement
- WBS
- WBS dictionary
- Network diagram
- PMP
  - schedule management plan
  - staffing management plan
  - risk register
	- Analogous estimating
	- determine resource cost rates
	- bottom-up estimating
	- parametric estimating
	- project management software
	- vendor bid analysis
	- reserve analysis
	- cost of quality
		- activity cost estimates
		- activity cost estimate supporting details
		- requested changes
		- cost management plan updates

- Cost budgeting (planning)

Input	Tools & Techniques	Output
- Project scope statement - WBS - WBS dictionary - activity cost estimates - activity cost estimate supporting details - project schedule - resource calendar - contract - cost management plan	- cost aggregation - reserve analysis - parametric estimating - funding limit reconciliation	- cost baseline - project funding requirements - cost management plan updates - requested changes

- Cost control (monitoring and controlling)

Input	Tools & Techniques	Output
- cost baseline - project funding requirements - performance reports - work performance information - approved change requests - PMP	- cost change control system - performance measurement analysis - forecasting - project performance reviews - project management software - variance management	- cost estimate updates - cost baseline updates - performance measurements - forecasted completion - requested changes - recommended corrective actions - OPA updates - PMP updates

> Historical information from past projects is a key to improving estimates.

> The cost management may be formal or informal but is part of PMP.

> *Life Cycle costing* looks at the cost of the whole life of the product, not just the cost of the project.

> *Value analysis* is done to find a less costly way to do the same work. It requires the systematic use of techniques to identify the required project functions, assign values to these functions and provide functions at the lowest overall cost without loss of performance. If a team is looking at decreasing project cost but maintaining the same scope, they are performing value analysis.

➢ **Precision** is consistency of repeated measurements that have little variance. **Accuracy** is correctness that the measured value is close to actual value.

➢ Seller bears the cost risk in a fixed price contract.

➢ **Cost estimating** is the process where the estimates for each activity are made. Cost estimating should be based on WBS to improve accuracy. Below are estimated:
- quality efforts
- risk efforts
- PM's time
- cost of project management activity
- costs directly associated with the project
- office expenses for offices directly for the project
- profit when applicable
- overhead such as management salaries.

➢ A cost can be variable or fixed. Variable costs change with the amount of production or the amount of work (cost of material, supplies, wages). Fixed costs do not change as production changes (rental, land).

➢ Cost can be direct or indirect. Direct costs are directly attributable to the work of the project (team wages, cost of material). Indirect costs are overhead items or costs incurred for the benefit of more than one project (taxes)

➢ Cost estimating is done done using one-cost, analogous, parametric, three-point estimate and bottom-up estimating.

➢ **Bottom-up estimating**: detailed estimating is done for each activity or work package and the estimates are then rolled up into an overall project estimate.

➢ Creation of cost estimates are assisted by the use of Project management software, determining resource cost rates, reserve analysis and cost of quality.

➢ Bottom-up estimating is more accurate than analogous estimating but takes time and is expensive. It gains buy-in from the team because the team creates estimates they can live with.

➢ Every company have a different standard for identifying and following **accuracy of estimates**, from preliminary, conceptual , feasibility, order of magnitude to definitive estimates.

➢ **Rough order of magnitude estimate** (ROM) is usually made during initiating process and is in the range of -50% to +100% from actual.

➢ Later during the project the estimates could become more refined to a range of -10% to +15% from actual, called **definitive estimate**.

➢ **Cost Budgeting** combines all the cost estimates into one cost budget. Activity costs are rolled up to work package cost, these are then rolled up to control account costs and finally into project cost. This is called **aggregation**. The next step is to perform reserve analysis.

Activities -> work packages -> control accounts -> project -> contingency reserve -> cost baseline

-> management reserve -> cost budget

➢ **Planning packages** are later converted to work packages when work is determined and detailed.

➢ The next thing after cost budgeting is to check cash flow. Funding may not be available when needed, causing changes to the other parts of the project and iterations of the PMP. The cost baseline therefore is time-phased and may be shown as an **S-curve**.

➢ Reconciliation with any cost constraints in the preliminary project scope statement should also be done before the proposed cost baseline and cost budget become final.

➢ **Cost control** should be included in the cost management plan for controlling the costs of the project, such as meetings on cost, reports, measurements that will be made and their frequency.

➢ **Earned Value analysis** Technique is a method to measure project performance against the project baseline. Results from an EVA indicate potential deviation of the project from cost and schedule baselines. Earned value will lead to new forecasted completion costs, change requests and other items that will need to be communicated.

➢ Acronym
  PV = planned value
  EV = earned value
  AC = actual cost
  BAC = Budget at completion
  EAC = Estimate at completion
  ETC = estimate to complete
  VAC = Variance at completion

➢ Formula
  Cost is dependent on EV and AC. Schedule is dependent on EV and PV.

  ```
  Cost Variance (CV) = EV – AC
  ```
   Negative is over budged, positive is under budget.

  ```
  Schedule Variance (SV) = EV – PV
  ```
   Negative is behind schedule, positive is ahead.

  ```
  Cost performance index (CPI) = EV/AC
  ```
   The amount earned for every $1 spent.

  ```
  Schedule performance index (SPI)= EV/PV
  ```
   The percentage of progress rate compared to original planned.

  Estimate at completion (EAC)=
   - If no variance has occurred from the BAC or you will continue
   the same rate of spending
  ```
       BAC/CPI
  ```
   - Original estimate were fundamentally flawed.
  ```
       AC + ETC
  ```
   - Used when current Variances are thought to be atypical of the future
  ```
       AC + (BAC – EV)
  ```
   - Used when current variance are thought to be typical of the future
  ```
       AC + ((BAC – EV)/CPI)
  ```

Estimate to complete `(ETC) = EAC – AC`
How much more will the project cost.

Variance at completion `(VAC) = BAC – EAC`

- Project Selection methods:
  Two methods: Benefit measurement methods (***decision model***) and mathematical models (***calculation methods***). Decision models examine different criteria used in making decisions regarding project selection. Calculation methods provide a way to calculate the value of the project. Calculation methods are also called ***constrained optimization models***.

- Benefit measurement methods for project selection:
  Present value: value today of future cash flows
  `Present value = Future value / (1 + interest rate)`^{n}
  where n is the number of years.

  Net Present Value (NPV): present value of the total benefits (income or revenue) less the cost over many time periods. ***Select projects with higher NPV***. Time is already taken into account for calculating NPV, this can be ignored in questions.

  Internal rate of return (IRR): The rate at which the project inflows (revenue) and the project outflows (cost) are equal. ***Select projects with higher IRR***.

  Payback period: The number of time periods it takes to recover the investment in the project before profits start coming in. ***Select projects with lower payback period***.

  Benefit Cost Ratio: compares the benefit to the cost of different options. In this case benefits are same as revenue, this is not same as profit. Benefit cost ratio >1 means benefit is greater than cost. ***Select projects with higher Benefit cost ratios***.

- Mathematical Models are linear, dynamic, integer, nonlinear, multi-objective programming in the form of algorithms.

- ***Opportunity costs***: the opportunity given up by selecting one project over another. Project A $40000 and project B is $50000, opportunity of selecting project B is $40000.

- ***Sunk cost***: expended costs, it is already spent. It should not be considered when deciding whether to continue with the troubled project.

- ***Funding Limit reconciliation*** is used to ensure that the expenditure of funds is reconciled with the funding limits imposed by the performing organization.

- Law of diminishing returns: The more you put into something the less you get out of it after a certain stage of saturation is reached.

- ***Working capital:*** Current assets minus current liability, or the amount of money the company has available to invest in projects. The money required to run the company daily operations.

- Depreciation: large assets lose value over time. Two methods of depreciation:-
  Straight line depreciation: fixed amount depreciated every year on the asset.
  Accelerated depreciation: depreciates faster than straight line. Two forms- Double declining

balance and Sum of the Years Digits.

6   Quality Management

> Processes -
> - Quality planning (planning)

Input	Tools & Techniques	Output
- EEF - OPA - Project scope statement - PMP	- Cost benefit analysis - Benchmarking - design of experiments - cost of quality (COQ) - additional quality planning tools	- quality management plan - quality matrix - quality checklist - process improvement plan - quality baseline - PMP updates

- Perform quality assurance (executing)

Input	Tools & Techniques	Output
- quality management plan - quality metrics - process improvement plan - work performance information - approved change requests - quality control measurements - implemented change requests - implemented corrective actions - implemented defect repair - implemented preventive actions	- quality planning tools and techniques - quality audits - process analysis - quality control tools and techniques	- requested changes - recommended corrective actions - OPA updates - PMP updates

- perform quality control (monitoring and controlling)

Input	Tools & Techniques	Output
- quality management plan - quality matrics - quality checklists - OPA - Work performance information - approved change requests - deliverables	- cause and effect diagram - control charts - flow charting - histogram - Pareto chart - run chart - scatter diagram - statistical sampling - inspection - defect repair review	- quality control measurements - validated defect repair - quality baseline updates - recommended corrective actions - recommended preventive actions - requested changes - recommended defect repair - OPA updates - validated deliverables - PMP updates

> **Quality** is defined as the degree to which the project fulfills requirements. It is better to plan in quality than inspect to find quality problems.

> **Quality management** includes creating and following policies and procedures in order to ensure that a project meets the defined needs it was intended to meet.

> Quality theorists
> - Joseph Juran – developed the 80/20 principle, defined quality as fitness for use.

- W. Edwards Deming – developed 14 steps to total quality management, advocated the plan-do-check-act cycle. 55% of quality problems are because of management.
- Philip Crosby – popularized the concept of cost of poor quality, advocated prevention over inspection and "zero defects"

➢ Quality should be considered whenever there is a change to any component of triple constraints.

➢ Quality should be checked before an activity or work package is completed.

➢ **Gold plating** refers to giving the customer extras, it adds no value to the project.

➢ *Quality must be planned in, not inspected in* - because cost of doing so is high.

➢ Optimal quality is reached at the point where the incremental revenue from improvements equals to the incremental cost to secure it, know as **Marginal analysis**.

➢ **Continuous improvement** (Kaizan): Small improvements in products or processes to reduce cost and ensure consistency of performance of products or services.

➢ In **Just in Time (JIT)** approach, suppliers deliver materials just when they are needed, decreasing inventory to close to zero. JIT forces attention on quality.

➢ **Total Quality Management** (TQM) is a philosophy that encourages companies and their employees to focus on finding ways to continuously improve the quality of the business practices and products.

➢ The entire organization has responsibility relating to quality. The PM has ultimate responsibility for the quality of the product of the project. Senior Management has ultimate responsibility for quality in organization as a whole. W. Edwards Deming says 85% of the cost of quality is the direct responsibility of management.

➢ Impact of poor quality:
- increased costs
- low morale
- low customer satisfaction
- increased risks
- rework
- schedule delays

➢ **Quality planning** process requires project charter and project scope statement. It results in the creation of **Quality management plan**. It identifies all relevant standards for the quality of the product of the project and for the quality of the project management efforts.

➢ A **standard** is an agreed upon process to work or achieve a result.
E.g.:

➢ The following is done to accomplish quality planning: Cost-benefit analysis, Benchmarking, Design of Experiments (DOE), Cost of Quality (COQ)

➢ **Cost-benefit analysis** considers the benefits verses the cost of meeting the quality requirements.

➢ **Benchmarking** looks at past projects to determine ideas for improvement on the current project and to provide a basis to use in measurement of quality performance.

➢ **Design of experiments** involves use of experimentation to statistically determine what variables will improve quality. This is time consuming process. DOE is a statistical method that allows you to systematically change all the important factors in a process and see what combination has lower impact on the project rather than slower less accurate way of changing them one at a time.
E.g.: You are trying to determine what cost and schedule trade-off will be most appropriate for your project. You have the option to select either a more experienced person at $ 120 per hour who can do the task in 45 days or a less experienced person at $ 80 per hour who can do the same task in 65 days. A tool you can use to facilitate making the decision is: DOE.

➢ **Cost of quality** looks at how the cost of conformance and non-conformance to quality will cost the project and creating an appropriate balance. COQ includes **prevention cost** and **appraisal costs**. **Failure cost** are cost of poor quality.

➢ Output of quality planning
  - Quality management plan
  - checklist
  - process improvement plan
  - quality baseline
  - quality metrics

➢ **Quality management plan** states what standards will be applied to the project, what metrics will be used to measure, what part of the project will be measured and when etc.

➢ **Checklist** is a list of items to inspect or a picture of the item to be inspected with space to note any defects found. These checklists are created in quality planning and used in quality control.

➢ **Process improvement plan** includes the activities determined to be needed on the project to improve processes. This becomes part of the PMP.

➢ **Quality baseline** is for measuring the efforts of the PM. These baselines exists so that PM can know what is expected of him/her and he can measure the project while the work is being done.

➢ **Quality Metrics** decides what areas of the project are important to measure and decide what measurement is acceptable, like, control limits. These are also known as **operational definition**.

➢ **Perform Quality assurance** process determines whether standards are being met, the work is

continuously improved and deficiencies corrected. It includes identifying improvements that the organization needs to make. This process will result in recommended changes and corrective actions. Tools and techniques of this process are:
- quality audits
- process analysis

> **Quality audits** are done by auditors to see if you are complying with the company policies, standards and procedures; and to determine whether the policies, standards and procedures being used are efficient and effective.

> **Process analysis** is a part of continuous improvement. This is planned in at certain points in the project. E.g.: Process analysis was done after 10 installation to identify improvements and lessons learned, that will be used for the next 100 installations.

> **Quality metrics** include inputs such as test coverage, failure rate, availability, reliability and defect density. Checklist is not an example of Quality metrics.

> **Perform Quality control**: specifies measurement to check on the project quality, its focus is on the correctness of work. It also involves taking action to eliminate the root causes of unsatisfactory project performance. While quality assurance looks at whether standards and procedures are being followed, quality control looks at specific measurements to see if the project and its processes are in control. It results in recommended changes, corrective and preventive actions and defect repair to integrated change control. E.g.: no. of bugs per module, spec of a product, interface file generation etc.

> A major feature of Quality control is **inspection** - checking the quality of work to see if it conforms to standards. Inspection (which is a Tool for Scope Verification) includes activities such as measuring, examining and testing undertaken to determine whether results confirm to requirements. Inspections are variously called reviews, product reviews, audits and walk-through.

> **Sampling** is done for quality control to take a sample of the output if we believe there are not many defects or if studying the entire output would take too long, cost too much and be too destructive.

> Two events are said to be **Mutually exclusive** if they cannot both occur in a single trial. e.g.: flipping a coin cannot result in head and tail.

> **Probability** is the likelihood that something will occur, usually expressed as a decimal or fraction on a scale of 0 to 1.

> a **normal distribution** is the most common probability density distribution chart. It is the shape of a bell curve and is used to measure variations (look at control chart)

> **Statistical independence** is the probability of one event occurring does not effect the probability of another event occurring.

➢ **Standard deviation** or **sigma** is a measure of a range. It is also stated as a measure of how far you are from the mean. Sigma is taken on both sides of the mean, it is the percentage of occurrences to fall between the **two control limits** (also used in control chart)

1 sigma = 68.26%
2 sigma = 95.46%
3 sigma = 99.73%
6 sigma = 99.99985%

➢ Quality control has 7 basic tools
- cause and effect diagram
- flowchart
- histogram
- pareto chart
- run chart
- scatter diagram
- control chart

➢ **Cause and effect diagram** is also called **Fishbone diagram** or **Ishikawa diagram**. It helps in finding *root cause of a defect/problem*. It can be used in quality planning to look forward at what might contribute to the highest quality on the project. It is a creative way to look at the causes or potential causes of a problem. It helps stimulate thinking, organizes thoughts and generates discussion. It can be used to explore the factors that will result in a desired future outcome.

➢ A **flowchart** shows how a process or system flows from beginning to end, and how the elements inter-relate. It can be used in quality control as well as quality planning to analyze potential future quality problems and determine quality standards.

➢ **Pareto chart** is used when you have very little time to spend improving quality on the project. 80% of the problems are due to 20% of the root causes. It address the root cause of the most frequent problems making the greatest impact on quality. It is a type of histogram, data is displayed in form of bars and columns. Higher the bar, more frequent the problem. Pareto chart helps focus attention on most critical issues, prioritizes potential causes of the problems and separates the critical few from the uncritical many.

➢ **Run chart** is used to look at history and see a pattern of variation. It is used to chart progress and looks for trends.

➢ **Trend Analysis**: You already have historical information about the errors and defects that have been identified and you would like to use this information to determine future performance. Trend analysis involves using mathematical techniques to forecast future outcomes based on historical results. Trend analysis is often used to monitor technical performance : how many errors or defects have been identified and how many remain uncorrected.

➢ **Scatter diagram** tracks two variables to see if they are related (part of parametric estimating).

➢ **Control chart** graphically helps you to determine if a process is within acceptable limits. It can be

used to monitor project performance figures such as cost and schedule variances. Most commonly, a control chart helps monitor production and other processes to see if the processes are within acceptable limits and if there are any actions required. A "*special cause variation*" means the process is out of control. Following is found in control chart:

- **Upper and lower control limits**: acceptable range of variation of a process often shown as two dashed lines on a control chart. It is determined by organization quality standard (e.g.: 3 or 6 sigma, you cannot tell from the chart if it is 3/6 sigma). **Data points** within this range are in control, excluding the rule of 7. Data points outside this range means the process is out of control.

-   Mean (average) is a line in the middle of the control chart that shows the middle of the range of acceptable variation of the process.

- **Specification limits** represent the customer's expectations or contractual requirements for performance and quality on the project (control limits represent the performing organization's standards for quality). *The performing organization's control limits must be stricter than the specification limits of the customer*. Hence specification limits are outside the upper and lower control limits.

- A process is said to be **Out of control** when:
  - a data point falls outside the upper or lower control limit.
  - Non-random data points that are still within the upper/lower limits (rule of 7).

- **Rule of 7** is a rule of thumb or heuristic. It refers to non-random data points grouped together in a series of total 7 on one side of the mean.

- **Assignable cause/special cause variation** is a data point or rule of seven that requires investigation to determine the cause of variation.

➤ **Validated defect repair** is the result of a re-inspection of the original defect repair.

➤ **Approved defect repairs** are performed during quality assurance.

7   Human Resource Management

➤ People must be compensated for their work

➤ The processes in this knowledge area:
   - Human resource panning (planning)

Input	Tools & Techniques	Output
- EEF - OPA - PMP - activity resource requirements	- Organization charts and position description - networking - organizational theory	- roles and responsibilities - project organization charts - staffing management plan

   - Acquire project team (execution)

Input	Tools & Techniques	Output
- EEF - OPA - Roles and responsibilities - project organization charts - staffing management plan	- pre-assignment - negotiation - acquisition - virtual teams	- project staff assignments - resource availability - staffing management plan updates

- Develop project team (execution)

Input	Tools & Techniques	Output
- Project staff assignments - staffing management plan - resource availability	- general management skills - training - team building activities - ground rules - co-location - recognition and rewards	- team performance assessment

- Manage project team (monitoring and controlling)

Input	Tools & Techniques	Output
- OPA - Project staff assignments - Roles and responsibilities - project organization charts - staffing management plan - team performance assessment - work performance information - performance reports	- observation and conversation - project performance appraisals - conflict management - issue log	- requested changes - recommended corrective actions - recommended preventive actions - OPA updates - PMP updates

➢ Sponsor provides information for preliminary project scope statement, issues the project charter and gives project manager authority to run the project. Sponsor also sets priorities for different projects and also evaluates the priorities of the triple constraint factors (scope, time, cost, quality, risk, customer satisfaction)

➢ stakeholders can become risk response owners.

➢ It is the responsibility of PM to maintain and manage relationship with the functional manager.

➢ PM should be assigned to project no later than the initiation phase.

➢ PM will be in charge of the project and is not necessarily the resource. PM will create the change control system. PM should be more proactive than facing issues later on.

➢ PM is accountable for project failure.

➢ The team member has control over his activities as long as he meets the triple constraint set by the PM. The member must keep the PM informed of the changes.

➢ If an activity needs more time and will cause the project to be delayed, sponsor is responsible for approving the required changes.

➢ If an activity needs more time without cause any project delays, the PM can take decision in this regard on his own.

➢ **Networking** technique involves developing relationship with people who may be able to assist in the achievement of the objectives. Networking includes proactive correspondence, lunch-on meeting and informal conversation.

➢ PM creates the **project team directory**.

➢ **Human resource planning** is done to ensure all the roles and responsibilities are clearly defined.

➢ **Collective bargaining agreements** are contractual agreements with unions and are input to HR planning.

➢ **Project organization charts** are valuable in communicating assigned responsibilities. Different types of charts are – responsibility assignment matrix, organizational breakdown structure, resource breakdown structure and position description.

➢ **Responsibility assignment matrix** cross-references team members with the activities or work packages they are to accomplish. It talks about primary and secondary responsibilities of the team members. It does not show when people will do their jobs. This is the structure that relates the project organization structure to the WBS to ensure that each element of the project work is assigned to a responsible individual. The RAM is used to link the WBS and project scope definition to assigned roles and responsibilities. RAM can be done using **RACI** (Responsible, accountable, consult, inform), i.e., for each activity to be done you will assign RACI.

➢ **Organizational breakdown structure** is a standard company organizational chart that looks like a WBS but only includes the company department heads and company structure.

➢ **Resource breakdown structure** also looks like a typical organizational chart, but is organized by types of resources.

➢ **Position descriptions** contains common job description created only for project work. This is in text format.

➢ PM also creates the **staffing management plan**, it is a formal plan that informs about how the team will be involved in the project and what roles each individual will play. It also describes when and how team members will be added to and released from the Project and how they will be developed. It also includes timetable for adding staff using a resource histogram. It includes how resources will be protected from hazards.

➢ **Resource Histogram** is a graph that shows the number of resources used per time period and is displayed in bar chart format. It shows where there is spike in the need for resources. PM can use this tool to level resources (**resource leveling**).

- PM should create a reward system to reward each team member individually, to motivate the team.

- Final Project team is acquired during execution phase. Resources may be pre-assigned in the project charter.

- ***Virtual teams*** are made up of people who never or rarely meet.

- ***Halo Effect*** is the tendency to rate high or low on all factors due to the impression of a high or low rating on some specific factors. We assume things based on our opinion. These have negative impact on the project. E.g.: You are a good programmer, hence you can be a good PM.

- ***Develop project team*** is done as part of execution process. As part of this process, PM will hold team building activities, give training to team members where needed, establish ground rules for team member behaviors, create and give recognition and rewards, co-locate the team and asses their performance.

- Forming, storming, norming and performing are stages of team development found in the development project team process.
  - forming: beginning stage of team formation, objectives told.
  - storming: team members confront each other.
  - norming: things begin to cool down and team members are comfortable
  - performing: team is productive and effective.

- ***Team building*** is forming the project team into a cohesive group working for the best interest of the project in order to enhance project performance. *WBS creation is a team building tool.*

- Cost of required ***training*** for the team members that improves the project should be paid by the project.

- Setting ***ground rules*** is more important when the team is managed virtually, these set the standards for acceptable behavior for team members.

- ***Co-location*** is also called ***war room*** and improves communication, reduces conflicts and improves project identity. ***Virtual team*** may have more conflict and decrease productivity, it may impact the schedule and cost also.

- ***Team performance assessment*** is for the team effectiveness, this is done in develop project team process. Where as, ***Project Performance appraisal*** is evaluation of performance of employees by their supervisors, this is performed in Manage project team process. The PM will collect information from the team member's supervisors when project performance appraisals are completed. Where as, team performance assessment is done by the PM in order to evaluate and improve the effectiveness of the team.

- PM has to be proactive in ***Manage project team process***, he/she should observe and keep in

touch with team. Project performance appraisals should be completed. PM should look out for and resolve any unresolved conflicts in the team. PM should use *issue log* in this process.

➢ Project performance appraisal can include input of co-workers and subordinates as well as supervisors, this is *360-degree review*.

➢ *Issue log* is a tool to manage the team and the stakeholders. It keeps track of issues to be resolved on the project.

➢ Powers of PM
   - Formal or Legitimate: power based on PM position
   - Reward: rewarding to team.
   - Penalty or Coercive: capable of penalizing team members
   - Expert: being technical or PM expert or expert of the domain.
   - Referent: PM has reference in high position or authority. It is for relationship also (e.g.: pm playing golf with team members)

➢ The best forms of power are Expert and Reward. Penalty is the worst. Formal, Reward and Penalty are derived from PM's position in the company. Expert power is earned on your own.

➢ Leadership styles for PM:
   - Directing: telling others what to do
   - Facilitating: co-ordinating the input of others
   - Coaching: instructing others
   - Supporting: providing assistance
   - Autocratic: making decisions without input
   - Consultative: inviting ideas from others
   - Consensus: problem solving in a group, with decision-making based on group agreement.

➢ PM should be directing at the beginning of the project and should be coaching, facilitating and supporting during execution phase.

➢ It is not necessary for a PM to do a consensus for every decision taken, PM should have enough information to make decisions on his own and decide when a consensus is needed.

➢ *Conflict* is can be beneficial as it present opportunities for improvements. Conflict is resolved through identifying the causes and best resolved by people who are involved, and their immediate managers if required. Sources of conflict, in order of frequency:

   - schedules
   - project priorities
   - resources
   - technical opinions
   - administrative procedures
   - cost
   - Personality

- ➢ Conflict resolution techniques:
  - confronting or problem solving: facing and solving the real issue, a win-win situation.
  - compromising: solution brings some degree of satisfaction to both parties, lose-lose situation.
  - withdrawal or avoidance: retreating or postponing a decision on a problem.
  - smoothing: emphasizing agreement rather than the differences of opinion. Kind of buttering.
  - forcing: pushing one view-point at the expense of another.

- ➢ Problem solving steps:
  - define the cause of the problem along with the symptoms of the problem.
  - analyze the problem
  - identify solutions
  - implement a decision
  - review the decision and confirm that the decision solved the problem.

- ➢ ***Arbitration*** is the hearing and resolution of a dispute by a neutral party. It is a method to resolve dispute that uses third party to render a decision, it is usually faster and cheaper than courts.

- ➢ ***Perquisites*** are giving perks or rewards to some employees.

- ➢ ***Fringe Benefits*** are standard benefits formally given to all employees.

- ➢ Motivation theory:
  - ***McGregor's theory of X and Y***: X is PM's who watch people every minute and believe that people are incapable, avoid responsibilities and work. Y is PM's that believe that people are willing to work without supervision and want to achieve. People can direct their own efforts.

  - ***Maslow's hierarchy of needs*** is based on a pyramid that shows ascending levels of motivation that we try to achieve one at a time.
  1. Physiological – basic needs such as water, food, house, clothes.
  2. Safety – security and stability, freedom from harm
  3. Social – love and affection, friends, association
  4. Esteem – accomplishment, respect, attention, appreciation
  5. Self actualization – self-fulfillment, growth, learning.

  - ***Herzberg's theory*** talks about hygiene factors and motivating agents. Poor hygiene factors may destroy motivation but improving them will not improve motivation (e.g. - working conditions, salary, security, status, personal life, relationships at work). Motivating agents motivate people, such as – work itself, responsibility, self-actualization, professional growth, recognition.

  - ***Expectancy theory***: expectation or likelihood of the reward is linked to the behavior. e.g.: praising results in better performance. Employees who expect to be rewarded for their work and achievements/accomplishment remain productive.

  - ***Achievement theory***: people are motivated by achievement, power and affiliation.

  - ***Self Efficiency theory*** is a person's belief in their ability to change their behavior.

- ➢ Motivating people is best done by rewarding people and letting them grow. Giving raises may not

motivate.

- ➢ **Pre-assignment** of resources can happen when the project is put out for bid and specific team members are promised as part of proposal, or when internal project team members are promised as a condition of the project.

- ➢ **Staffing management plan** is an output of Human resource planning and is an input to cost estimating process, apart from other HR processes (acquire,develop, manage).

8 Communications Management

- ➢ PM spend about 90% of time on communication.

- ➢ Processes
  - Communications planning (planning)

Input	Tools & Techniques	Output
- EEF - OPA - project scope statement - PMP - constraints and assumptions	- communication requirement analysis - communications technology	- communications management plan

  - Information distribution (execution)

Input	Tools & Techniques	Output
- communication management plan	- communication skills - information gathering and retrieval systems - information distribution methods	- OPA updates - requested changes

  - Performance reporting (monitoring and controlling)

Input	Tools & Techniques	Output
- work performance information - performance measurements - forecasted completion - quality control measurements - PMP - performance measurement baseline - approved change request - deliverables	- information presentation tools - performance information gathering and compilation - status review meetings - time reporting systems - cost reporting systems	- performance reports - forecasts - requested changes - recommended corrective actions - OPA updates

  - Manage stakeholders (monitoring and controlling)

Input	Tools & Techniques	Output
- communication management	- communications methods	- resolved issues

Input	Tools & Techniques	Output
plan - OPA	- issue logs	- approved change requests - approved corrective actions - OPA updates - PMP updates

- ➢ **Communications planning** involves proactively identifying the information and communication needs of the stakeholders.

- ➢ **Communications Model** has three parts – the sender, the message and the receiver. Message is encoded by sender and decoded by receiver based on receiver's education, experience, language and culture.

- ➢ In **Effective communication**, sender should confirm that message is understood.
  - *Nonverbal*: about 55% of the communication, like physical mannerism/body language.
  - *Paralingual*: The pitch and tone of voice.
  - *Feedback*: take feedback of what has been explained.

- ➢ Active listening also involves similar attributes.
  - *Feedback*: request for repeat if not understood.
  - *Active listening*: confirm understanding and request clarification
  - *Paralingual*

- ➢ Communication methods:
  - *Formal written*: for complex problems, PMP, charter, and for long distances.
  - *Formal verbal*: presentations, speeches
  - *Informal written*: memos, e-mails, notes
  - *Informal verbal*: meetings, conversations

- ➢ PM cannot control all communications, but PM should try to do so.

- ➢ Communication channels grow exponentially. The formula is (N * (N - 1)) / 2.

- ➢ Communications planning process results in **communications management plan**, this is very important for all projects. This plan talks about what is to be communicated, why, between whom, the method for communicating, responsible person/team and the frequency of communication.

- ➢ **Information distribution** is implementation of the communication management plan.

- ➢ The **lessons learned** may be created throughout the project and finalized during the project closing or phase closing. Continuous improvement of the project management process cannot occur without lessons learned. These should be shared with other projects without waiting for the project to be over.

- ➢ **Performance reporting** involves collecting the performance data and updating stakeholders on

the status.
- *status report*: informs about where the project stands as regards the performance measurement baselines.
- *progress report*: informs about accomplishment.
- *trend report*: examines project results over time to see if performance is improving or deteriorating.
- *Forecasting report*: predicting future project status and performance.
- *variance report*: compares actual results to baselines.
- *earned value*: integrates scope, cost and schedule measures to assess the performance.
- *lessons learned*

➢ Reports help team to know where they need to recommend and implement corrective actions.

➢ **Forecasts** is performed in performance reporting process, it can help determine recommended corrective actions.

➢ PM should keep open communication channels with stakeholders.

➢ **Communication blockers**:
   - noise
   - distance
   - improper encoding of messages
   - saying "it is a bad idea"
   - Hostility
   - Language
   - Culture

➢ **Fait accompli** - the issue under discussion is no longer an issue or cannot be changed.

➢ Receiver of message is responsible for making sure all information is received and understood in complete.

➢ **Ethnocentrism** often entails the belief that one's own race or ethnic group is the most important and/or that some or all aspects of its culture are superior to those of other groups. This comes into play when two teams from different culture work together and the feeling in each team is that they are far superior than the other team.

9 Risk Management

➢ Proper ***Risk management*** can decrease about 90% of the future problems. PM will have control and grip on the project. It focuses on proactively preventing things that can go wrong and helping things to go write. Risk can be both positive and negative for the project.

➢ Processes:
- Risk management planning (planning)

Input	Tools & Techniques	Output
- EEF - OPA - Project scope statement - PMP	- planning meetings and analysis	- risk management plan

- Risk identification (planning)

Input	Tools & Techniques	Output
- EEF - OPA - project scope statement - risk management plan - PMP	- documentation reviews - information gathering techniques - checklist analysis - assumptions analysis - diagramming techniques	- risk register

- Qualitative risk analysis (planning)

Input	Tools & Techniques	Output
- OPA - project scope statement - risk management plan - risk register	- risk probability and impact assessment - probability and impact matrix - risk data quality assessment - risk categorization - risk urgency assessment	- risk register updates

- Quantitative risk analysis (planning)

Input	Tools & Techniques	Output

- OPA
- project scope statement
- risk management plan
- risk register
- PMP
  - project schedule management
    plan
  - project cost management plan
	- data gathering and representation techniques
	- quantitative risk analysis and modeling techniques
		- risk register updates

- Risk response planning (planning)

Input	Tools & Techniques	Output
- risk management plan	- strategies for negative risks or	- risk register updates

Input	Tools & Techniques	Output
- risk register	threats - strategies for positive risks or opportunities - strategies for both threats and opportunities - contingent response strategies	- PMP updates - risk related contractual agreements

- Risk monitoring and control (monitoring and controlling)

Input	Tools & Techniques	Output
- risk management plan - risk register - approved change request - work performance information - performance reports	- risk reassessment - risk audits - variance and trend analysis - technical performance measurement - reserve analysis - status meetings	- risk register updates - requested changes - recommended corrective actions - recommended preventive actions - OPA updates - PMP updates

> The purpose of **risk management planning** is to decrease the probability and impact of negative events (threats) and increase the probability and impact of positive events (opportunities).

> The investigation of **uncertainties** may help identify risks.

> **Risk factors** that can be evaluated:
> - the probability of its occurrence.
> - impact
> - when and how often it would occur

> One who does not want to take risks is called **risk averse**.

> **Risk tolerances** are areas of risks that are acceptable or unacceptable (yes or no, like risk on reputation is no-no). **Thresholds** are amount of risk that is acceptable (upper limits, like a weeks delay is ok).

> **Utility function** is a commonly used technique to find out the tolerance of a project manager towards risk.

> Almost all major outputs are considered inputs for risk management planning- project background, historical records, lessons learned, stakeholders risk tolerances and thresholds, company culture, charter, scope statement, WBS, Network diagram (check on critical paths and convergence), time and cost estimates (risk reserves), staffing management plan, communications management plan, procurement management plan (contracts are a way to mitigate or transfer risks), assumptions etc.

> **Risk management plan** includes company procedures for risk such as standard probability and impact matrices and adapting to the needs of the project. It includes how to perform risk management, roles and responsibilities, budgeting (cost of risk management processes), timing (when to do risk management), risk categories, definition of probability and impact, stakeholder tolerances, reporting formats and tracking of risks (how risk will be audited).

➢ The **risk management plan** includes budgets and schedules and is an *input to schedule development and cost budgeting*. Hence planning process is *re-iterated* (go back to previous plans) after risk management to adjust the other plans. It is also an input to plan purchases and acquisitions and contracting processes in procurement.

➢ **Risk Categories** help identify and analyze risk on each project in the company. These are at company level and help identify common *sources of risks*. These can be put in an organizational chart or WBS like format called a **Risk breakdown structure**. Some classification are:
- External
- Internal
- Technical
- Unforceable

➢ Everyone should be involved in **Risk Identification** process. It should be done in project planning, but could also be done during any part of the project, especially during project changes, working with resource and dealing with project issues. It cannot be completed unless a project scope statement and WBS has been created. Sponsor may supply a list of risks in preliminary scope statement.

➢ Information gathering techniques:
- Brainstorming: meeting
- Delphi technique: consensus of experts who participate anonymously (unknowingly).
- Interviewing
- Root cause analysis
- SWOT analysis: Strength-weaknesses-opportunities-threats

➢ Risk can be due to Business gain or loss or pure risks (insurable) which are only losses.

➢ Another technique similar to Delphi technique is the **nominal group technique**. Participants are present in one room and are given paper and pencil. Each provides his view on a topic and these are put as sticky notes in the room for further discussions.

➢ **Checklist Analysis** is used to make sure that the risk identification process has addressed all the categories of risks (using above techniques).

➢ **Assumptions analysis** is done to find out what is assumed and if they are valid for identifying more risks.

➢ **Diagramming techniques** such as cause and effect diagrams and flowcharts (all quality tools) are also used here to identify additional risks.

➢ Information regarding risks is stored in **Risk register.** Risk register is an output of other processes also, what is important is to understand what it contains for different processes. As part of risk identification, risk register will include –
- Lists of risks
- List of potential responses
- root causes of risks
- updated risk categories in company records.

➢ **Qualitative risk analysis** is a subjective analysis of the identified risks, like, probability of occurrences and impact. We can use the below tools for this analysis:

- *Probability and impact matrix*: risk are rated and sorted to identify the ones warranting response. It results in evaluation of low, medium and high risks for all projects and improvement in quality of data.
- *Risk data quality assessment*: analyze the precision and accuracy of data about the risk.
- *Risk Categorization*: company level categorization of occurring risks. It gives you the possibility of eliminating many risks at once by eliminating one cause.
- *Risk urgency assessment*: identify risks that may occur very soon or requires a long time to plan a response.

➢ Risk register will have the following after Qualitative risk analysis is performed:
- Risk ranking for the project compared to other projects
- List of prioritized risks and their probability and impact ratings
- Risks grouped by categories.
- Risks requiring additional analysis in near future
- List of risks for additional analysis and response
- Watchlist: non-critical or non-top list
- Trends: to know if risk is increasing or decreasing.

➢ **Watchlist** includes non-critical risks and are later visited during risk monitoring and control process.

➢ The project may be selected, continued or terminated based on Qualitative risk analysis.

➢ **Quantitative risk analysis** is numerical analysis of the probability and impact of the highest risks, to determine which risks warrant a response, overall project risk, identifying quantified probability of meeting project objectives, determine cost and schedule reserves, identify urgent risks and help in creating realistic and achievable targets for triple constraints.

➢ Quantitative risk analysis may be skipped if it is not worth the time, effort and money, and can be moved to risk response planning.

➢ *Risk assessment* includes all the processes of risk identification, qualitative and quantitative risk analysis.

➢ Quantitative risk analysis may further include determining the type of probability distribution to be used, like, triangular, normal, beta, uniform or log normal distributions.

➢ **Sensitivity analysis** can be done as part of quantitative risk analysis to determine which risks have the most impact on the project. Sensitivity analysis examines how variation and uncertainty of individual project element impacts the project objective, assuming all other project elements are held at baseline value. One of the ways of displaying sensitivity analysis is **tornado diagram**.

➢ Quantitative analysis tools for identifying *probability and impact*:
- interviewing
- cost and time estimating
- Delphi techniques
- historical records
- expert judgment
- expected monetary value analysis
- Monte Carlo analysis

- Decision tree

➢ Expected monetary value means probability times impact.
EMV = probability * impact
e.g.: 10% probability * $5000 impact = $500 is EMV.

➢ **EMV** is a tool/technique of quantitative Risk Analysis, and is a statistical concept that calculates the average outcome of project outcomes based on various assumptions and scenarios. EMV is calculated by multiplying the value of each possible outcome by its probability of occurrences, and summing them together. Decision tree analysis is a type of EMV analysis.

➢ **Monte Carlo analysis** is a simulation technique. It uses the network diagram and estimates to perform the project many times to simulate the cost and schedule results of the project. It is a what-if analysis of what will be the outcome for different paths.
- It evaluates the overall risk of the project.
- provides the probability of completing the project on a specific day or specific cost.
- considers path convergence in network diagram.
- considers impact of uncertainties on the project.
- used to asses cost and schedule impacts.
- done using computer
- results in probability distribution

➢ **Decision trees** are primarily used to make decisions regarding individual risks when there is uncertainty.
- takes into account future events
- calculates EMV
- involves mutual exclusivity

➢ Risk register will have the following after Quantitative risk analysis is performed:
- Prioritized lists of quantified risks
- amount of contingency time and cost reserves needed
- possible realistic and achievable completion dates and costs
- quantified probability of meeting project objectives
- trends in quantified risk analysis

➢ **Risk response planning** is done for each top risk. The threats have to be eliminated before they happen. The probability and impact of threats is to be reduced and opportunities to be increased. For residual risks, a contingency plan should be in place if the risk happens. A fallback plan should also be in place if contingency plan is not effective.

Response strategies for threats include:
- Avoid: eliminate the threat by eliminating the cause.
- Mitigate: reduce the probability or impact of the threat, making it a smaller risks and removing it from the top risks on the project. (e.g.: train the team on conflict resolution)
- Transfer: deflect or allocate to another party responsible for the risk through purchasing of insurance, performance bonds, warranties, guarantees or outsourcing the work.

Response strategies for opportunities include:
- Exploit: add work or change the project to make sure the opportunity occurs.
- Enhance: increase the likelihood of the risk event to occur.
- Share: allocate ownership of the opportunity to a third party (partnership, joint venture)

"Accept" is a response strategy for both threat and opportunity, it is doing nothing about the risk. *Active acceptance* may involve creating a contingency plan for the risk and allocating time and cost reserves. *Passive acceptance* leaves actions to be determined as need when risk occurs.

➢ Risk register will have the following after risk response planning is performed:
- Residual risk: risks that remain after the response planning and those that have been accepted for which contingency and fallback plans can be created
- Contingency plans
- Risk response owner: it can be a stakeholder also.
- Secondary risks: new risks created by the implementation of selected risk response strategy.
- Risk Triggers: events that can trigger the contingency response.
- Contracts: for transferring the risk
- Fallback plans: response when contingency plan does not work
- Reserves: There are two kinds of reserves for time and cost – Contingency and Management reserve. Contingency reserves are for risks that have been identified. It is part of the cost baseline. Management reserves are for unknown risks that are not identified as such. These are part of the project budgets and management approval is need to make use of it.

➢ Risk is the most important item to address in project team meetings.

➢ Risk identification is done during risk identification as well as risk monitoring and controlling.

➢ **Workarounds** are unplanned responses developed to deal with the occurrence of unanticipated risk events (as compared to, contingency responses are developed in advance).

➢ Risk register will have the following for risk monitoring and controlling:
- outcomes of risk reassessments and risk audits
- updated to previous parts of risk management
- closing of risks that are no longer applicable.
- details of event when risk occurred.
- lessons learned.

➢ Cardinal scale: numerical values are given to impact
Ordinal scale: high, medium, low ratings are given to impact

➢ **Risk register** is an output from risk processes, and an input to activity duration estimating, schedule development, cost estimating and cost budgeting. Hence iteration takes place after risk processes, and cost/schedule are reassessed.

➢ Risk reviews are performed by the team, while risk audits should be performed by external risk auditors.

10   Procurement Management

➢ You are either a buyer or seller in any procurement. The test assumes you are buyer.

➢ Processes:
- Plan purchases and acquisitions (planning)

Input	Tools & Techniques	Output

- EEF
- OPA
- project scope statement
- WBS
- WBS dictionary
- PMP
  - risk register
  - risk related contractual
    agreements
  - resource requirements
  - project schedule
  - activity cost estimates
  - cost baseline
	- make-or-buy analysis
	- expert judgment
	- contract types
		- procurement management plan
		- contract statement of work
		- make-or-buy decisions
		- requested changes

- Plan contracting (planning)

Input	Tools & Techniques	Output

- procurement management plan
- contract statement of work
- make-or-buy decisions
- PMP
  - risk register
  - risk related contractual
    agreements
  - resource requirements
  - project schedule
  - activity cost estimates
  - cost baseline
	- standard forms
	- expert judgment
		- procurement documents
		- evaluation criteria
		- contract statement of work updates

- Request seller responses (executing)

Input	Tools & Techniques	Output
- OPA - procurement management plan - procurement documents	- bidder conferences - advertising - develop qualified sellers list	- qualified sellers list - procurement document package - proposals

- Select sellers (executing)

Input	Tools & Techniques	Output
- OPA - procurement management plan - evaluation criteria - procurement document package - proposals - qualified sellers list - PMP - risk register	- Weighting systems - independent estimates - screening systems - contract negotiation - seller rating systems - expert judgment - proposal evaluation techniques	- selected sellers - contracts - contract management plan - resource availability - procurement management plan updates - requested changes

Input	Tools & Techniques	Output
- risk related contractual agreements		

- Contract administration (monitoring and controlling)

Input	Tools & Techniques	Output

- Contract
- contract management plan
- selected sellers
- performance reports
- approved changed requests
- work performance information
	- contract change control system
	- buyer conducted performance
	review
	- inspection and audits
	- performance reporting
	- payment systems
	- claims administration
	- records management system
	- information technology
		- contract documentation
		- requested changes
		- recommended corrective
		actions
		- OPA updates
		- PMP updates
		  - procurement management
		   plan
		  - contract management
		   plan

- Contract closure (closing)

Input	Tools & Techniques	Output
- procurement management plan - contract management plan - contract documentation - contract closure procedures	- procurement audits - records management system	- closed contracts - OPA updates

- All contracts are formal and legally binding. All contractual changes must be in writing. All product and project management requirements should be specifically stated in the contract (even meetings requirement should be on the document).

- PM must be assigned before a contract is signed. This allows a PM to complete risk analysis.

- In **centralized contracting**, there is a contracting department and the contract manager may handle many contracts for different projects. In **decentralized contracting**, a contract manager is assigned to one project full time and reports to PM.

- In plan purchases and acquisition process, make-or-buy analysis and contract type selection is carried out.

- **Make-or-buy analysis**: it is better to make if you have an idle plant or workforce, you want to retain control or the work involves proprietary information or procedures.

- A properly selected contract will have proper risk distribution between buyer and seller. It will also provide appropriate incentive for sellers efficient and economical performance.

- Three types of contracts:
  - **Cost-reimbursable** (CR):
    * The sellers cost is reimbursed along with additional amount.
    * The buyer is at risk as total cost is not know.
    * used when buyer can only describe what is needed, but not in details (simple contract SOW)
    * requires less effort to write the scope as compared to FP.

* Seller will write the detailed contract statement of work.
* may be cheaper than FP as seller will not add buffer.
* buyer has to do more work to manage the contract.
* audit is required, buyer may have to perform audit for sellers invoices.
* total price is unknown.
* e.g.: R&D projects, IT projects where scope is unknown.

- ***Time and Material*** (T&M)
  * contract is priced on hourly or per item basis.
  * it is a mix of fixed price and cost-reimbursable contracts.
  * buyer has medium amount of risk as contracts are for small amounts and shorter periods.
  * quick to create
  * buyer needs to have control on the contract and check on the work being done.
  * audit is required.
  * e.g.: operational change requests, carpenter or mason work, consultancy

- ***Fixed price*** (FP)
  * most common contract type in the world.
  * one price is agreed upon for all the work.
  * buyer has list cost risk, if scope is well defined.
  * best if the scope and contract statement of work is completely defined by the buyer.
  * risk of higher cost is borne by seller.
  * less work for buyer to manage.
  * seller has strong incentive to control cost.
  * total price is determined at the beginning.
  * seller may play around to make profits through change orders, as the contract is fixed.
  * audit may not be required.
  * e.g.: support contracts with oracle or Microsoft.

➢ Types of Cost-reimbursable contract:
  - Cost plus fee (***CPF***) or Cost plus percentage of cost (***CPPC***)
    * bad for buyers
    * requires buyer to pay all costs plus percentage of cost as fee.
    * Sellers are not motivated to control cost as benefit is more without it.

  - cost plus fixed fee (***CPFF***)
    * Most common of CR contract.
    * buyer pays all cost but the fee or profit is fixed.
    * Seller realizes that over-spending does not generated additional profit.

  - cost plus incentive fee (***CPIF***)
    * buyer pays all cost and an agreed upon fee, plus a bonus for beating the performance objectives stated in the contract.
    * bonus amount is not pre-defined.

  - cost plus award fee (***CPAF***)
    * buyer pays all cost an apportionment of a bonus based on performance.
    * similar to CPIF, but the award amount is pre-defined.

➢ Types of fixed price contracts:
  - Fixed price incentive fee (***FPIF***)

    * a fixed amount plus incentive given for good performance.

    - Fixed price economic price adjustment (**FPEPA**)
     * fixed price contract allowing for price increases if the contract period is for multiple years.

    - Purchase order
     * simplest type of fixed price contract.
      * signed unilaterally instead of bilaterally.
      * meant for simple procurements.
      * e.g.: purchase order for 10 laptops.

➢ Risk involved for different parties according to the contract, in descending order of risk.
    - Buyer
      CPPC -> CPFF -> CPAF -> CPIF -> T&M -> FPEPA -> FPIF -> FP
    - seller
      FP -> FPIF -> FPEPA -> T&M -> CPIF -> CPAF -> CPFF -> CPPC

➢ **Incentives** help promote to bring the sellers objectives in line with that of the buyer. It is the additional amount given on top of agreed price for exceeding time or cost as per the contract.

➢ **Contract statement of work** (contract SOW) describes what work is to be done under the contract. It should be clear and concise describing all the work that the seller is required to do. It should also include all meeting and communication requirements as well as reporting.

➢ The contract SOW may be revised during the procurement process. It should get finalized by the time the contract is to be signed.

➢ Types of contract SOW:
    - Performance:
     * what the final product should be able to accomplish or achieve.
     * not conveyed is how it should be built or what its design characteristics should be.
     * it is very high level.
     * e.g.: CR contracts SOW, mostly in IT, R&D projects

    - Functional
     * conveys the end purpose or result and its characteristics.
     * specific procedures or how to built is not mentioned.
     * could include the characteristics required for the end product.
     * e.g.: CR contracts SOW, mostly in IT, R&D projects

    - Design
     * conveys what works is to be done.
     * all requirements and how the work should be done are provided.
     * e.g.: FP contracts SOW, mostly in construction, hardware purchasing.

➢ T&M contract SOW can be of performance, functional or design based on the requirements.

➢ **Procurement Management Plan** will describe how the procurement process will be planned, managed and executed.

➢ **Plan contracting** process consist of putting together all the procurement documents that will be

sent to prospective sellers. The following are the procurement documents:
- *Request for Proposal/tender* (RFP): requests for price, detailed proposal on how the work is to be done, company background and experiences and the workforce that will be working. Preferable for CR contracts.

- *Invitation for Bid/Request for bid* (IFB/RFB): Request one price to do all work. Preferable for FP contracts.

- *Request for quotation* (RFQ): request a price quote per item, hour or foot. Preferable for T&M contracts.

- procurement document can also include contract SOW, legal and business terms and conditions, evaluation criteria, pricing forms, guidelines for preparation of response and procedure for replying.

➢ **Non-Disclosure agreement** between the buyer and any prospective seller states what information should be held confidential and in control. It also states who in the organization will have access to the concerned information.

➢ Standard contracts are preauthorized contracts for purchasing goods and services. These are legally sufficient.

➢ The PM may make changes to standard contract, called **Special provisions** or **conditions**, which are required to satisfy the particular needs of the project.

➢ A **breach** occurs when any obligation of the contract is not met. A breach on sellers part cannot be fixed by a breach on buyers part. e.g: if seller does not meet some milestones, buyer cannot hold all payments because of this. A **material breach** is so large that it may not be possible to complete the work under the contract.

➢ **Force Majeure** is a situation that is out of control of humans. e.g.: fire, storm etc.

➢ **Intellectual property** are such things like patents, trademarks, source code, copyrights etc.

➢ **Retainage** is a small percent of money that is withheld from each payment, and is payed once the contract work is over.

➢ **Letter of intent** is not legal or a contract, it shows intention of the buyer to hire the seller.

➢ **Privity** means a contractual relationship. If A is in contract with B, and B is in contract with C, then A cannot talk to C directly.

➢ Forms of non-competitive procurements:
- *single source*: deal directly with the preferred seller (may be the company worked with the seller before).
- *sole source*: there is only one seller, may be because of a patent reason.

➢ **Request seller responses** process consist of handing over the procurement document to the seller, answering sellers queries and sellers preparing proposals.

➢ **Bidder conferences**:(a tool for Request Seller Responses process) are meetings with prospective

sellers prior to preparation of a bid or proposal. They are used to ensure that all the sellers have a clear, common understanding of the procurement.

➢ *Advertising* is done to attract additional sellers.

➢ If buyer often purchases the same type of service, the credentials of prospective sellers will be available as part of *Qualified seller list* (part of OPA)

➢ Seller, in response to procurement, provides a *proposal* or *bid* to the buyer. Seller gives proposal for RFP, price quote for RFQ and bid for IFB.

➢ Seller is then selected based on various evaluation criteria identified in plan contracting process:
  - Weighting system
  - Independent estimate
  - Screening system
  - past performance history
  - presentations
  - negotiation

➢ The objective of a buyer negotiation with seller is to obtain a fair and reasonable price and develop a good relationship with seller.

➢ Negotiation tactics:
  - attacks
  - personal insults
  - good guy/bad guy
  - deadline
  - lying
  - limited authority
  - missing man
  - fair and reasonable
  - delay
  - extreme demands
  - withdrawal
  - fait accompli (a done deal)

➢ A contract offer or acceptance may be oral or written, though preferred in writing. This is required for contract to be legal.

➢ *Contract management plan* is specific to a contract and talks about contract administration. This is an output of *select sellers* process.

➢ The PM monitors and reviews the ongoing work between the buyer and seller as part of *contract administration.* e.g.: documentation, resolve disputes, authorize payment, meetings, report on performance, control quality, review claims, verify scope, identify risk, perform audit etc.

➢ *Buyer conducted performance review* is a meeting where all available data is brought together to see if the seller is performing. The seller may be present to review the data.

➢ *Claims administration* is performed to check on claims made by the seller as a compensation

for some act by the buyer.

➢ ***Contract closure*** is done when the contract ends or is terminated. Contract closure occurs before administrative closure. Contract closure includes product verification, financial closure, update records in *records management system*, final contract performance reporting, create contract file for project archives, procurement audit, lessons learned, and formal acceptance and closure.

➢ All contracts should be closed before taking up *administrative closure*. Administrative closure can be done at the end of each phase or at the end of project, contract closure is done at the end of project only. Administrative closure uses the term "lessons learned", contract closure uses the term "procurement audit".

➢ Contract terms & conditions document will also describe the specific procedures related to contract closure.

11   Professional and social responsibilities

➢ Ensure individual integrity

➢ Put project needs before your own.

➢ Contribute to Project management knowledge base

➢ Enhance personal professional competence

➢ report violations

➢ PMI's PMP code of Professional conduct:
- responsibilities to the profession
 * compliance with all organizational rules and polices
 * advancement of the profession.
- responsibilities to customer and public
 * qualification, experience and performance of professional service
 * conflict of interest situations and other prohibited professional conduct.

12   More on Tools & Techniques

➢ All processes in integration management have the following common tools and techniques. Expert judgment is not required in direct and manage project execution only.
   PMM, PMIS, expert judgment

➢ Variance analysis is a common tool in monitoring and controlling processes.

➢ PDM and ADM concepts are used to create the schedule network diagram in activity sequencing process. This diagram is then analyzed using CPM, PERT, CCM, Monte Carlo, resource leveling and applying calendar tools in schedule development process.

➢ CCM is schedule development process that includes resource leveling.

➢ **Sensitivity analysis** (tornado diagram) checks the impact of changing one variable keeping all other variables at baseline.
   Scatter diagram checks the impact of two variables on each other.
   Design of experiments (DOE) allows systematic change of all important factors to identify the impact of quality.
   Monte Carlo analysis performs the project many times to identify the impact under various circumstances.

➢ Decision tree tool uses EMV analysis, Monte Carlo does not use EMV analysis.

➢ **Reserve analysis** is performed in activity duration estimating, cost estimating, cost budgeting and risk monitoring and control.

➢ **Performance Measurement Analysis** calculates CV, SV, SPI, CPI etc.
   Work Performance information include details on ETC, % complete etc.

➢ Common tools for each process

No	Processes	Tools & Techniques
	Initiation	
1	develop project charter	PMM, PMIS, expert judgment, project selection method
2	develop preliminary scope statement	PMM, PMIS, expert judgment
	Planning	
3	develop project management plan	PMM, PMIS, expert judgment
4	scope planning	templates, forms and standards, expert judgment
5	scope definition	product analysis, alternatives identification, stakeholder analysis, expert judgment

No	Processes	Tools & Techniques
6	create WBS	Decomposition
7	activity definition	decomposition, rolling wave planning, planning component, expert judgment
8	activity sequencing	PDM, ADM, applying leads and lags
9	activity resource estimating	alternatives analysis, bottom-up estimating, expert judgment
10	activity duration estimating	analogous estimate, parametric estimate, three-point estimate, reserve analysis
11	schedule development	schedule network analysis, CPM, PERT, CCM, Monte-Carlo, resource leveling, applying calendar, adjusting leads and lags, schedule model.
12	cost estimating	analogous estimate, parametric estimate, bottom-up estimate, reserve analysis, vendor bid analysis, cost of quality
13	cost budgeting	cost aggregation, reserve analysis, funding limit reconciliation
14	quality planning	cost benefit analysis, benchmarking, DOE, Cost of quality
15	human resource planning	organizational charts and position description, organizational theory, networking
16	communication planning	communication requirement analysis, communication technology
17	risk management planning	planning meetings and analysis
18	risk identification	checklist analysis, assumptions analysis, information gathering techniques
19	qualitative risk analysis	probability and impact assessment and matrix, risk data quality assessment, risk categorization, risk urgency assessment
20	quantitative risk analysis	quantitative risk analysis and modeling techniques, sensitivity analysis, decision tree, Monte-Carlo analysis
21	risk response planning	all strategies for opportunities, risks and threats
22	plan purchases and acquisition	make or buy analysis, expert judgment
23	plan contracting	standard forms, expert judgment
	Execution	
24	direct and manage project execution	PMM, PMIS
25	perform quality assurance	quality audits, process analysis
26	acquire project team	pre-assignment, negotiation, acquisition, virtual teams
27	develop project team	general management skills, ground rules, co-location, recognition and rewards
28	information distribution	communication skills, information gathering and retrieval system, information distribution method
29	request seller responses	bidder conferences, advertisement, develop qualified sellers list

No	Processes	Tools & Techniques
30	select seller	weighting systems, screening systems, seller rating systems, proposal evaluation technique, expert judgment
	Monitoring & Controlling	
31	monitor and control project work	PMM, PMIS, expert judgment, earned value technique
32	Integrated change control	PMM, PMIS, expert judgment
33	scope verification	Inspection
34	scope control	variance analysis, re-planning
35	schedule control	progress reporting, variance analysis, schedule comparison bar charts
36	cost control	forecasting, variance management
37	perform quality control	Ishikawa diagram, control charts, flow charting, histogram, pareto diagram, run chart, scatter diagram, statistical sampling
38	manage project team	observation and conversation, project performance appraisal, conflict management, issue log
39	performance reporting	information presentation tools
40	manage stakeholders	issue logs
41	risk monitoring and control	risk audits, variance and trend analysis, reserve analysis
42	contract administration	buyer conducted performance review, inspection and audit, performance reporting, payment systems, claims administration
	Closing	
43	close project	PMM, PMIS, expert judgment
44	contract closure	procurement audits, record management system

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