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PMP

Study Notes

by Edward Chung, PMP

Preface

Thank you very much for downloading the **PMP Study Notes** based on PMBOK Guide 5th Edition by Edward Chung, PMP. Hope the notes will help you preparing for your PMP Certification Exam.

I originally created the notes for my PMP certification preparation which helped me to pass the PMP exam with 4 proficient and 1 moderately proficient. These study notes were the fruits of hours of reading and studying the PMBOK Guide, the [PM PrepCast](#), the Edwel's PMP Book, Andy Crowe's PMP book and countless practice exams.

After getting my PMP credential, I posted all the PMP study notes as blog posts on my personal blog at <http://www.edward-designer.com/web/pmp>. To my surprise, many fellow PMP aspirants find my notes useful for them and have literally 'printed' all the blog posts for their PMP preparation.

I constantly ask myself: what I can do more to help PMP aspirants as a way to make some contribution to the project management profession. The **PMP Study Notes** you are now reading is my response to the need of PMP aspirants quality study notes for the PMP examination. You can use it from the beginning of your PMP preparation so that you can add any personal notes to it or as a last minute revision notes to check your PMP progress.

The PMP exam is tough, yet with lots of efforts and the right study materials, you can pass too!

Wish you PMP success!

Edward Chung, PMP

P.S. If you would like to get more tips on the PMP application process and how to know you are ready for the PMP exam, please visit my blog <http://www.edward-designer.com/web/pmp>.

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01. Terms and Concepts

- Process - a package of inputs, tools and outputs, there are 47 processes defined by PMI
- **Phases** - a group of logically related activities, produces one or more deliverables at the end of the phase (maybe with exit gate/kill point [probably in a sequential relationship])
- Phase-to-Phase relationship: **sequential** -> finish-to-start; **overlapping** -> for schedule compression (fast tracking); **parallel**
- **Project** - a **temporary** endeavor to create a **unique** product, service or **result** (or enhancement of existing services/products (e.g v.2 development is a project)) as opposed to operation, may hand over the product to operation teams
- Operation manages process in transforming resources into output
- projects have **more risks** and uncertainties than operations and require more **planning**
- **Program** - a group of **coordinated** projects, taking operations into account, maybe with **common goals**, achieving **benefits** not realized by running projects individually, *if only the client/technologies/resource are the same, then the projects should be managed individually instead of a program*
- **Portfolio** - group of programs/projects to achieve organizational strategic goals within the organization/operation management, all investments of the organization, maximize the value by examining the components of the portfolio and exclude non-optimal components
- Why projects: market demand, organizational need, customer request, technological advance, legal requirements, to support organization strategic plan -> projects bring **values**
- **Business Value** is the total values (tangible and intangible) of the organization
- Organization Strategy may be expressed through **mission and vision**
- Use of portfolio/program/project management to bridge the gap between organization strategy and business **value realization**
- **Progressive Elaboration (rolling wave planning)** is one of the methods used in activity planning) - analysis and estimation can be more accurate and elaborated as the project goes (usually in phased projects) such that detailed planning can be made at that point

Project Management

- Project Management - the application of (appropriate) knowledge, skills, tools & techniques to project activities to meet the project **requirements** and achieve customer **satisfactions**
- The most important task is to align **stakeholder expectations** with the project requirements, around 90% of the PM's work is related to **communication** with stakeholders
- PMBOK Guide is a framework/standard but **not** methodology (agile, scrum, PRINCE3, etc.)
- should be aligned with organization governance (through EEF and OPA)
- **Competing constraints:** time, cost, scope, quality, risk, resources
- **Project Management Office (PMO)** - standardizes governance, provides training, shares tools, templates, resources, etc. **across all** projects/programs/portfolios
 - 3 forms: supportive, controlling and **directing** (lead the project as PM)
 - functions: training, resource coordination, methodology, document repository, project management oversight, standards, career management of PMs
 - may function as a stakeholder / key decision maker (e.g. to terminate the projects)

- align portfolios/programs/projects with business objectives and measurement systems
- control shared resources / interdependence across projects at the enterprise level
- play a decisive role in **project governance**
- **Organizational Project Management** (OPM)
- strategy execution framework utilizing portfolios, programs and projects and organizational enabling practices (technology, culture, etc.) for achieving organizational objectives
- linking management principles with strategy, advance capabilities
- **Management by Objectives** (MBO) : is a process of defining objectives within an organization so that management and employees agree to the objectives and understand what they need to do in the organization in order to achieve them.
- **Organizational Project Management Maturity Model** (OPM3) : provides a method for organizations to understand their Organizational Project Management processes and measure their capabilities in preparation for improvement.

Project Manager

- **Project Manager**: knowledge, performance, personal - general (organization, planning, meeting, control) management, interpersonal (communication, leadership, motivation, influence, negotiation, trust building, political and cultural awareness) skills
- **leader** of the project irrespective of the authority
- should consider every processes to determine if they are needed for individual projects
- may report to the functional manager, program manager, PMO manager, operation manager, senior management, etc., maybe part-time or devoted
- identifies and documents **conflicts** of project objectives with organization strategy as early as possible
- skills: leadership, team building, motivation, influencing, coaching, trust building, communication, political awareness, cultural awareness, decision making, conflict management, negotiation
- PM must balance the constraints and tradeoffs, effectively communicate the info (including bad news) to the sponsor for informed decisions
- PM need to involve project team members in the planning process
- Project Team includes PM, project management staff, project staff, PMO, SME (subject matter experts can be outsourced), customer representative (with authority), sellers, business partners, etc., maybe virtual or **collocated**
- **Senior management must be consulted for changes to high-level constraints**

Organization Types

- Organization Types: **Projectized** (project manager has the ultimate authority over the project, team members are often collocated), **Matrix** (Strong, Balanced, Week), **Functional**
- **Composite** - a combination of different types, depending on the actual need
- **Tight Matrix** = co-location, **nothing** to do with the organization type (not necessarily a matrix org.)
- **Functional** organizations => the project manager has little authority, often called project expeditor (no authority) or coordinator (little authority), project coordination among functional managers
- Matrix organization => multiple bosses and more complex
- **Project Based Organization** (PBO) - conduct the majority of their activities as projects and/or privilege project over functional approaches, they can include: departments with functional organizations; matrix organizations; projectized organizations and other forms of organizations that privilege a project approach for conducting their activities, **success is measured by final results** rather than position/politics

Project Lifecycle vs Project Management Lifecycle vs Product Lifecycle

- **Project Lifecycle:** initiating, planning and organizing, carrying out/executing work, closing the project
- **Predictive** [plan driven/waterfall] - scope, time and cost determined early in the lifecycle, may also employ rolling wave planning
- **Iterative** [incremental] - repeat the phases as understanding of the project increases until the exit criteria are met, similar to the rolling wave planning, high-level objectives, either sequential / overlapping phases, scope/time/resources for each phase may be different
- **Adaptive** [change driven/agile] - for projects with high levels of change, risk and/or uncertainty, each iterative is **very short** (2-4 weeks), work is **decomposed** into product backlog, each with a production-level product, scrum is one of the most effective agile methods, stakeholders are involved throughout the process, **time and resources are fixed**, allow **low change cost/keep stakeholder influence high**
- each project phase within the product lifecycle may include all the **five project management process groups**
- **product lifecycle:** development > production > adoption & growth > maturity > decline > end of life

Important Terms

- **Organization Process Assets** is a major input in all planning process, which may be kept at PMO, **directly related to project management**, including **Processes and Procedures** (including templates (e.g. WBS, schedule network diagrams, etc.), **procedures** for issuing work authorizations, guidelines, performance measurements) and **Corporate Knowledge Base**
- The **Configuration Management Knowledge Bases** contain baselines of all organization standards
- **Lessons Learned** - focus on the **deviances** from plan (baseline) to actual results
- **Enterprise Environment Factors** (often are **constraints**) are influences not in the immediate control of the project team that affect the project, intra-organization and extra-organization, e.g. organizational culture, organization structure (functional/matrix/projectized structure), existing human resources, **work authorization system, PMIS**
- **The work authorization system** (WAS) is a system used during project integration management to ensure that **work gets done at the right time and in the right sequence**
- EEF are inputs for all initiating, most planning process, not much in the executing/controlling process, none in closing process
- Organization culture: process-oriented/results-oriented, job-oriented/employee-oriented, professional-oriented/parochial-oriented, open system/closed system, tight control/loose control, pragmatic/normative
- **Project Governance** - for the whole project lifecycle, fits in the organization's governance model, define responsibilities and accountabilities, controlling the project and making decisions for success, alignment of project with stakeholders' needs/objectives, provides a framework for PM and sponsors to make decisions to satisfy both parties, should be described in the PM plan
- Analytical Techniques: used to find the **root cause** or to **forecast**
- **PMIS** includes configuration system and change control system
- Never accept a change request to trim down one element of the triple constraint without changing the rest.
- **Sponsor** - provides resources/support to project, lead the process through initiation (charter/scope statement) through formally authorized, later involved in authorizing

- scope/budget change/review
- Customer - NOT necessarily provide the financial resources, maybe external to the organization, **final acceptance** of the product
- **Business Partners** - certification body, training, support, etc.
- **Organizational Groups** - internal stakeholders
- **Business Case** : background, analysis of the business situation, costs and benefits (cost-benefit analysis), to help in selection of project created by the initiator
- **Project Statement of Work (SOW)** : describes the business need, high level scope of **deliverables** and strategic plan of the organization, created by the sponsor/initiator/buyer
- **Project Charter** : formally authorizes the project, includes all those from above plus approval criteria, preliminary budget, primary stakeholders, the name of PM, assumptions and decisions etc., usually created by PM (in develop project charter process) and signed by the sponsor, remains fairly the same during project lifecycle, except big changes like sponsor has resigned [*the current sponsor should initiate the change to the charter before he leaves*]
- Project Charter is not a contract
- **Project Management Plan** : **how the project will be performed and managed** - documents assumptions & decisions, helps communication between stakeholders, **goals**, costs & time scheduling (milestones), project management system and subsidiary management plans and documents
- Project Management Plan is NOT a project schedule
- Project Management System: includes a list of project management processes, level of implementation (what actions to take in the management processes), description of tools and techniques, resources, procedures, **change control system** [forms with tracking systems, approval levels]
- **Requirement Traceability Matrix (RTM)** - a matrix connecting deliverables to requirements and their **sources** (for managing **scope**)
- **Work Breakdown Structure (WBS)** - a hierachal chart of decomposing deliverables into work packages
- **Activity List** - a full list of all activities with indication of relationship to the work packages
- **Activity Attributes** - further information (duration, start date, end date, etc.) of all the activities in the list (for **scheduling**)
- **Roles and Responsibilities (RAR)** - a document listing all the roles and description of their responsibilities in the project (often by category)
- **Responsibility Assignment Matrix (RAM)** - a matrix connecting people to work packages/activities, e.g. the **RACI** matrix (responsible, accountable, consult, inform), usually only **one** person is **accountable** for each activity
- **Resources Breakdown Structure (RBS)** - a hierarchical chart listing all the resources by categories, e.g. marketing, design, etc.
- Risk Breakdown Structure (RBS) - a hierarchical chart listing all risks by categories
- Project Information
 - **Work Performance Data** - raw data collected
 - **Work Performance Info** - analyzed in context and integrated data, e.g. some forecasts
 - **Work Performance Reports** - work performance information compiled in report format
- **Sunk costs** - money already spent, **not to be considered** whether to terminate a project, similar to committed cost (often through contracts)
- Direct costs, indirect (shared) costs, Fixed costs, Variable costs
- **Law of diminishing returns** - beyond a point, the more input, the less return

- **Working capital** - assets minus liability, what the company has to invest in the projects
- **Payback period** - a time to earn back capital investment
- **Benefit-cost ratio (BCR)** - an indicator, used in the formal discipline of cost-benefit analysis, that attempts to summarize the overall value for money of a project
- **Depreciation** - straight-line depreciation vs accelerated depreciation (the amount of depreciation taken each year is higher during the earlier years of an asset's life)
- Under **double declining balance**, the asset is depreciated twice as fast as under straight line. Using the example above, 10% of the cost is depreciated each year using straight line. Doubling the rate would mean that 20% would be depreciated each year, so the asset would be fully depreciated in 5 years, rather than 10.
- Under **sum-of-the-years-digits**, the asset is depreciated faster than straight line but not as fast as declining balance. As an example of how this method works, let's say an asset's useful life is 5 years. Adding up the digits would be $5+4+3+2+1$ or a total of 15. The first year, $5/15$ is expensed; the next year $4/15$ is expensed, and so on. So if the asset's cost is \$1000, $5/15$, or \$333.34 would be expensed the first year, \$266.67 the second year, and so on.
- **Economic value added** - the value of the project brought minus the cost of project (including opportunity costs) e.g. for a project cost of \$100, the estimated return for 1st year is \$5, assuming the same money can be invested to gain 8% per year, then the EVA is $\$5 - \$100 * 8\% = -\$3$
- Net present value (NPV) - the sum of the present values (PVs) of the individual cash flows of the same entity
- Present value (PV) - or called present discounted value, is a future amount of money that has been discounted to reflect its current value, as if it existed today (i.e. with inflation, etc.)
- Future value (FV) - is the value of an asset at a specific date
- **Internal Rate of Return (IRR)** - The inherent discount rate or investment yield rate produced by the project's deliverables over a pre-defined period of time.
- **Forecast** (future) vs **Status** Report (current status) vs **Progress** Report (what have been done/delivered)
- **Journey to Abilene (Abilene's Paradox)** - committee decisions can have a paradox outcome, the joint decision is not welcome by either party (because of fear of raising objections)
- when something unusual happens, always refer to the PM Plan/Charter for instruction on how to proceed; if not found, **ask for direction from the management**
- **unresolved issues will lead to conflicts**

02 - 03. Project Management Processes and Knowledge Areas

The Project Management Process Groups (IPECC)

1. Initiating
2. Planning
3. Executing
4. Monitoring and Controlling
5. Closing

Planning and Executing are *iterative*. Monitoring and Controlling is exercised over Planning and Executing.

A phase is not a process group. The 5 processes can happen in 1 phase.

The process groups is not in sequence

The PM should tailor the choices of processes to fit in individual processes (**tailoring**)
deliverables are often incremental in nature

A project/phase begins with the "Initiating" processes, the "Planning", "Executing" and "Monitoring and Controlling" processes may occur in a repetitive manner while the "Closing" processes will be carried out to end the project/phase.

Initiating

- align project purposes with stakeholders' expectations
- assign a project manager
- identify stakeholders and develop project charter
- document business case (created by initiator, maybe well before the initiating process group) and cost-benefit analysis, identify high-level risks, identify project selection criteria
- early in the process, the staffing, costs and chance of success are **low**, risk and stakeholder influence are **high**
- may be performed at portfolio/program level (i.e. outside the project's level of control)

Planning

- create **Project Management Plan** [why the project? what to deliver? who do what? when accepted? how executed?], **subsidiary documents (schedule baseline, cost baseline, performance management baseline, scope baseline (scope statement, WBS, WBS dictionary) and subsidiary management plans** (scope, schedule, budget, quality, human resources [roles & responsibility, organization chart and staffing management plan include the staff need, rewards, safety and training need], stakeholder, requirements, process improvement, communication, change, risk and procurement) - *all are not finalized until a thorough risk management has been performed, need to be approved before work begins*
- all plan and documents can be **formal or informal**, generalized or detailed, depending on needs
- Project Management Plan maybe **continually updated** during the project with *rolling wave planning / progressive elaboration*
- obtain approval of plan from designated **stakeholders**, changes to the project management plan and subsidiary documents/plans need formal procedures described in the change control system
- hold kick-off meeting

- planning process group is MOST important, with over 1/2 of all the 47 process in this group
- may need re-planning when significant changes to the baseline is observed in the executing/monitoring processes

Executing

- to satisfy project specifications
- coordinating human/infrastructure resources in accordance with the project management plan
- updates and re-baselining the project management plan and subsidiary management plans
- normal execution, manage contracts, acquire, develop & manager project team, **perform quality assurance** and manage stakeholder expectation/communication
- direct and manage project work
- continuous improvement process (quality assurance)
- use up the largest share of resources

Monitoring and Controlling

- measure **performance**, address **change** requests, recommend corrective/preventive measures and rectify defects
- usually performed at regular intervals
- **control the quality**, inspection and reporting, problem solving, identify new risks
- reassess control process
- should there be any internal deviance from the stated plan, the PM should make correction (use contingency reserve if necessary)
- monitor and control project work and integrate change control
- make sure only approved changes (through integrated change control) are incorporated

Closing

- either project finished or **cancelled**
- final product verification, contract closure, produce **final report (closeout documentation)**, obtain formal acceptance, archive, release resources, close project
- feedback, review and **lessons learned** (about the process), transition of deliverables to operation
- procurement closure and administrative closure

Product-oriented Processes

- initiating
- planning and organizing
- executing
- closing

PMI Knowledge Areas

- complete set of concepts that made up a professional field/specilization

1. Project **Integration** Management - assemble and combine all parts into a coherent whole
2. Project **Scope** Management
3. Project **Time** Management

4. Project **Cost** Management
5. Project **Quality** Management
6. Project **Human Resource** Management
7. Project **Communications** Management
8. Project **Risk** Management
9. Project **Procurement** Management
10. Project **Stakeholder** Management

04. Project Integration Management

- integration management is needed when processes **interacts**
- to identify, combine, unify and coordinate various processes/activities and manage the interdependencies
- **communication** is most important
- a PM Plan not meeting requirements is a defect

Develop Project Charter	Project SOW Business Case Agreements Enterprise Environmental Factors Organization Process Assets	Expert Judgements Facilitation Techniques	Project Charter
Develop Project Management Plan	Project Charter Outputs from Planning Processes Enterprise Environment Factors Organization Process Assets	Expert Judgements Facilitation Techniques	Project Management Plan
Direct and Manage Project Work	Project Management Plan Approved Change Requests Enterprise Environmental Factors Organization Process Assets	Expert Judgements PMIS Meetings	Deliverables Work Performance Data Change Requests PM Plan Updates Project Document Updates
Monitor and Control Project Work	Project Management Plan Schedule Forecasts Cost Forecasts Validated Changes Work Performance Info Enterprise Environmental Factors Organization Process Assets	Expert Judgements Analytical Techniques PMIS Meetings	Work Performance Reports Change Requests PM Plan Updates Project Document Updates
Perform Integrated Change Control	Project Management Plan Work Performance Reports Change Requests Enterprise Environmental Factors Organization Process Assets	Expert Judgements Meetings Change Control Tools	Approved Change Requests Change Log PM Plan Updates Project Document Updates
Close Project or	Project Management	Expert	Final

Phase	Plan Accepted Deliverables Organization Process Assets	Judgements Analytical Techniques Meetings	Product/Service/Result Transition Organization Process Assets Update
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Develop Project Charter

- formally authorize the project and allow the PM to apply organizational resources
- well-defined project start and project boundaries
- project charter** is a several page document including high level information of the project: project background, business case, goals (S.M.A.R.T. specific, measurable, attainable, realistic, time-bound), who is and the authority of the project manager, budget, risk, stakeholders, deliverables, approval criteria, etc.
- can link the project to other works in the organization through portfolio/program management
- signed off by the **sponsor (the one who supply the money/resources)**
- agreements: either a contract (for external parties), letter of intent, service level agreement, etc. (can be legally binding or NOT)
- a charter is **NOT** a contract because there is no consideration
- PMO may provide the expert judgement
- Facilitation techniques includes brainstorming, conflict resolution, problem solving, meeting, etc.

Develop Project Management Plan

- the project management plan is a **formal written document** on how the project is executed, monitored and closed, including all subsidiary management plans (scope, **requirements, change, configuration**, schedule, cost, quality, process improvement, human resource, communication, risk, procurement) and documents (cost baseline, schedule baseline, scope baseline, **performance measurement** baseline, cost estimate, schedule, responsibility for each deliverable, staff requirements) and some additional documents/plans (selected PM processes and level of implementation)
- the contents to be tailored by the PM (**tailoring**) to suit each project
- created by PM, signed off by destined **KEY stakeholders** (e.g. project sponsor, project team, project manager)
- may be progressively elaborated in iterative phases (outputs from other processes), this must be the **final** process/iteration to consolidate the PM Plan
- when the project management plan is **baselined** (i.e. validated and then **signed off** by key stakeholders), it is subject to formal **change control** and is used as a basis for comparison to the actual plan
- after baselining, the **senior management** must be consulted if these high level constraints are to be altered (whether to use the **management reserves**)
- can be **re-baselined** if significant changes are seen (scope change, internal changes/variances (for the project execution), external factors) <- needed to be approved by sponsors/stakeholders/senior management, must understand the underlying reasons first (built-in costs is not usually a legitimate reason)
- cost** baseline (specific time-phased budget), **schedule** baseline (-> knows when to spend money), **scope** baseline (includes scope statement, WBS, WBS dictionary): whether preventive/corrective/defect repair actions are needed
- the **performance measurement baseline** (PMB) is an **approved** scope-schedule-cost plan for the project work (to use in **earned value management**), it **includes contingency reserve** but excludes **management reserves**
- configuration management** (works with change control management plan), **document all change versions** of project deliverables and completed project components, PMIS includes: **Configuration Management System** (contains the updated

deliverable/project specifications and processes) and **Change Control System** (contains formal documents for tracking changes)

- **configuration management system contains the most updated version of project documents**
- **Kick-off Meeting:** at beginning of the project/phase, participants including project team+stakeholders, element including project review, responsibility assignment matrix, participation of stakeholders, escalation path, frequency of meetings
- *Microsoft Project is considered by PMI as close to a **bar chart**, not an **PMIS***

Direct and Manage Project Work

- create project deliverables, acquire/assign/train staff, manage vendors, collect data for reports, document lessons learned
- implement approved process improvement plans and changes, change requests include **corrective actions**, **preventive actions**, **defect repair** and **updates** (all considered to be change requests)
- if the PM discovers a defect, he/she should instruct the team to make defect repair during this process (need change request but may be approved by the PM only (if stipulated in PM Plan for minor change))
- **approved** change requests - approved in the perform integrated change control, may include preventive, corrective and defect repair actions
- **change requests** may arise as a result of **implementing** approved change requests
- PM should be of service to the team, not a boss
- a work authorization system (part of EEF) defines **approval levels needed to issue work authorization** (to allocate the work) and is used to prevent scope creep as formal approval must be sought before work begins
- **Stakeholder risk tolerance** is part of EEF
- Face-to-face meeting is considered to be most effective
- The PM Plan can be **considered as a deliverable**
- **most of the time of project spends here**

Monitor and Control Project Work

- **validated changes** - actions taken as a result of the approved change requests are validated against the original change requests, to ensure correct implementation
- corrective and preventive actions usually don't affect the baseline, only affect the performance against the baseline
- **defect repair**: considered as **rework**, deliverable not accepted, either rework or scrap, strongly advise defect prevention to defect repair
- the work performance info is fed from all other **control** processes (e.g. control schedule, control stakeholder engagement, control communications, control costs, control quality, etc.)
- **variance analysis is NOT** a forecast method

Perform Integrated Change Control

- the PM should influence the factors that cause project change
- changes arises as a result of: missed requirements, views of stakeholders, poorly designed WBS, misunderstanding, inadequate risk assessment
- all the process is documented in the **change log**
- tracked using a **change management** system, also affect **configuration management** system
- configuration control: changes to deliverables and processes
- change control: identify/document/approve changes
- **configuration management activities**: configuration identification, configuration status

accounting, configuration verification / audit to ensure the latest configuration is adopted and delivered

- for a change request: 1) identify need, 2) **assess the impact, response and alternatives**, 3) create **CR**, 4) Meet with stakeholders, 5) obtain approval from CCB (change control board) or PM as **defined in** roles and responsibility document/PM Plan, 6) request more funding if needed
- customers/sponsors may **need to approve** certain decisions by CCB (if they are not part of CCB)
- **communicate** the resolutions (approve or reject) to change requests to stakeholders

Close Project or Phase

- ensure all procurements are closed (in the Close Procurements Process) before formal closure of the project/phase
- create the project closure documents
- formal sign off by designated stakeholders/customer
- obtain formal approval to close out the project/phase (**administrative closure**)
- obtain approval and deliver the deliverables (maybe with training)
- finish and archive documentations, lessons learnt and update to organizational process asset
- if the contract comes with a warranty, make sure that changes during the project are evaluated against the origin clauses, ensure alignment of the warranty and changes
- **to close a project as neatly and permanently possible**
- for multi-phase projects, this process will be performed once for every phase end and **once** for the whole project (5 times for project with 4 phases)
- litigation can be further pursued after the closure

05. Project Scope Management

- ensure the inclusion of **all and only the work required** to complete the project successfully
- **Product Scope** - requirements needed to be fulfilled to create the product, assessed against the **product requirements and WBS**
- **Project Scope** - activities and **processes** needed to be performed to deliver the product scope, assessed against the scope baseline (scope statement, WBS and WBS dictionary), e.g. including testing & quality assurance, assessed against the **PM plan**
- scope management to prevent **scope creep** (additional requirements added without any proper control)
- The completion of project scope is measured against the project management plan whereas the completion of product scope is measured against the product requirements/WBS
- **gold plating** - additional requirements initiated by the team members to exceed expectation, considered a subset of scope creep
- **Scope Baseline**: scope statement + WBS + WBS dictionary
- **WBS includes only the deliverables/outcomes/results** (not actions)

Plan Scope Management	Project Management Plan Project Charter Enterprise Environment Factors Organization Process Assets	Expert Judgements Meetings	Scope Management Plan Requirements Management Plan
Collect Requirements	Scope Management Plan Requirements Management Plan Stakeholder Management Plan Stakeholder Register Project Charter	Interviews Focus Groups Facilitated Workshops Group Creativity Techniques Group Decision-making Techniques Questionnaire and Surveys Observations Prototypes Benchmarking Context Diagram Document Analysis	Requirements Documentation Requirements Traceability Matrix
Define Scope	Scope Management Plan Project Charter Requirements Documentation Organization Process Assets	Expert Judgements Product Analysis Alternatives Generation Facilitated Workshops	Project Scope Statement Project Document Updates
Create WBS	Scope Management Plan Project Scope Statement	Decomposition Expert Judgements	Scope Baseline Project Document Updates

	Requirements Documentation Enterprise Environment Factors Organization Process Assets		
Validate Scope	Project Management Plan Requirements Documentation Requirements Traceability Matrix Verified Deliverables Work Performance Data	Inspection Group Decision Making Techniques	Accepted Deliverables Change Requests Work Performance Info Project Document Updates
Control Scope	Project Management Plan Requirements Documentation Requirements Traceability Matrix Work Performance Data Organization Process Assets	Variance Analysis	Work Performance Info Change Requests Project Management Plan Updates Project Document Updates Organization Process Assets Updates

Plan Scope Management

- **Scope Management Plan:** how the scope will be defined, validated and controlled
- including how to prevent scope creep, how to **handle change requests**, escalation path for disagreement on scope elements between stakeholders, process for creating scope statement, WBS, processing CR, how the deliverables will be accepted
- **Requirements Management Plan:** how the requirements will be managed, documented and analyzed,
- including how to process requirements, address missed requirements, configuration management, **prioritize** requirements, metrics (and rationale) for defining the product, define the traceability structure (in RTM), authorization level for approving new requirements
- **important:** primary means to understand and manage stakeholder expectations

Collect Requirements

- **Requirement:** a condition/capability that must be met /possessed by a deliverable to satisfy a contract/standard/etc., including quantified/document needs, wants, expectation of the sponsor/stakeholder/customer
- Business requirements - support business objectives of the company
- Stakeholder requirements
- **Solution requirements - functional** (product behavior) and **nonfunctional** requirements (reliability, security, performance, safety, etc.)
- Transitional requirements : **temporary** capability including data conversion/tracking/training
- Project requirements : actions/processes/conditions the project needs to meet
- Quality requirements : quality criteria defined by stakeholders

- **Requirements Collection Tools**
- interviewing (expert interviewing)
- **focus groups** (with SME and pre-qualified stakeholders)
- facilitated workshops (QFD (Quality Function Deployment) - capture VOC voice of customer, translate customer needs into requirements; JAD (Joint Application Design) - facilitated workshop for IT and knowledge workers)
- questionnaires and surveys
- observation (shadowing or Gemba)
- prototypes
- **context diagrams** (diagrams showing input/source and output, to show how people **interact** with the system)
- document analysis
- Product analysis includes techniques such as product breakdown, systems analysis, requirements analysis, systems engineering, **value engineering**, and value analysis
- **Group Creativity Techniques:** brainstorming, **nominal group technique** (to rank brainstormed ideas by voting anonymously), mind-mapping, **affinity diagram** (KJ method - group ideas into larger **categories** based on their similarity and give titles to each group), **Delphi technique** (for experts with widely varying opinions, all participants are **anonymous**, evaluation of ideas funneled by a facilitator), Multi-criteria Decision Analysis (with a decision matrix)
- **Group Decisions-making Techniques:** **Analytic Hierarchy Process** (AHP, for complex decisions, give different weights to factors to build an hierarchy), Voting (unanimous, majority >50%, plurality, dictatorship)
- **Requirements Traceability Matrix** tracks **requirements from origins to deliverables**, including source of requirements and completion status, effective to prevent gold plating (also work with work authorization system)
- **requirement documentation** needs to be unambiguous, traceable, complete, consistent and acceptable to key stakeholders and is approved by the customer and other stakeholders

Define Scope

- **project** & product scope, outlines what will be and what will **NOT** be included in the deliverables, including **details of risks, constraints and assumptions**
- **vs project charter** which includes high-level descriptions
- provides alternatives if the budget and schedule could not meet management's expectations
- **value engineering** is a part of the product analysis technique (**Value Engineering** (value analysis, value management, value methodology) - finding alternatives to constraints to improve product/reduce cost without sacrificing the scope)
- **project scope statement** includes objectives, (project and product) scope, requirements, boundaries, deliverables, acceptance criteria, **constraints**, **assumptions**, milestones, cost estimation, specifications, configuration management requirements, **approval requirements**, etc.
- The scope statement is progressively elaborated

Create WBS

- **the WBS must be created** (if take on a running project without WBS, stop the project and prepare the WBS first)
- WBS is a structured hierarchy created by the organization/stakeholders, can be in an organization chart or table form, based on **the project deliverables (not tasks needed)**
- can be a **template** in OPA

- a higher level above a work package is '**control account**' (control point where scope, cost and schedule are compared to earn value for performance measurement), a work package can have only **ONE** control account
- WBS includes 100% of scope (100% rule)
- **code of accounts**: a numbering system to identify WBS components
- **chart of accounts**: a list of all account names and numbers
- 1.1 for the 2nd level, 1.1.1 for the 3rd level
- WBS is a decomposition tool to break down work into lowest level manageable (time and cost can be estimated, work package can be assigned to a team member) work packages, e.g. by phase or major deliverables
- different work packages can be at different levels of decompositions
- WBS does not show dependencies between work packages, but a WBS dictionary does (WBS dictionary clarifies WBS by adding additional information)
- the major deliverables should always be defined in terms of how the project will actually be organized, for a project with **phases**, the decomposition should begin with the phase first
- scope baseline, an output from Create WBS, is created by the **project team**
- the work packages are broken down enough to delegate to a staff, usu. **8 - 80 hours work**

Validate Scope

- gain formal acceptance of deliverables from **customer/stakeholders** (e.g. obtain customer sign off, requirements validations, etc.) near the **end of project/phase/each deliverable**, e.g. user acceptance test
- **work performance data** tells how the deliverables were created, work performance data includes non-conformance and compliance data
- **change requests** may be an output
- if no formal sign off is received as stipulated, follow the pre-defined process in PM plan, e.g. escalation to management
- often preceded by **Control Quality Process** to give the verified deliverable as input to this process, **verified deliverables** is fed from the **control quality** process
- vs **Control Quality**: the process of monitoring/recording results of executing **quality** activities to assess performance and recommend necessary changes, e.g. unit testing - > high quality vs low quality
- need to **perform even in case of early termination/cancellation** of the project to save any usable deliverables for other projects

Control Scope

- assessing additional requirements by the customer or **proactively overlooking the project scope**
- measure the work product against the scope baseline to ensure the project stays on track proactively, may need preventive, corrective actions or defect repair
- to **prevent unnecessary changes (either internally or externally requested)** to the project
- a documented and enforced change control process
- the **customer** has the ultimate authority to change scope while the senior management can make use of management reserves
- **variance analysis** - method to compare planned (baseline) and actual work and determine the causes/actions e.g. update baseline (keep the variance) or preventive/corrective actions, both need CR
- work performance info - scope variance, causes, recommended action
- may update the **inputs** - requirements documentation & requirement traceability matrix & lessons learnt in OPA

- in general, disagreement should be **resolved in favor of the customer**

06. Project Time Management

Plan Schedule Management	Project Management Plan Project Charter Enterprise Environment Factors Organization Process Assets	Expert Judgement Analytical Techniques Meetings	Schedule Management Plan
Define Activities	Schedule Management Plan Scope Baseline Enterprise Environment Factors Organization Process Assets	Expert Judgement Decomposition Rolling Wave Planning	Activity List Activity Attributes Milestone List
Sequence Activities	Schedule Management Plan Activity List Activity Attributes Milestone List Project Scope Statement Enterprise Environment Factors Organization Process Assets	PDM Dependency Determination Applying Leads and Lags	Project Schedule Network Diagram Project Document Updates
Estimate Activity Resources	Schedule Management Plan Activity List Activity Attributes Resource Calendars Activity Cost Estimates Risk Register Enterprise Environment Factors Organization Process Assets	Expert Judgement Alternatives Analysis Published Estimating Data Bottom-up Estimating PM Software	Activity Resource Requirements Resource Breakdown Structure Project Document Updates
Estimate Activity Durations	Schedule Management Plan Activity List Activity Attributes Activity Resource Requirements Resource Breakdown Structure Resource Calendars Project Scope Statement	Expert Judgement Analogous Estimating Parametric Estimating Three Point Estimates Group Decision Making Technique Reserve Analysis	Activity Duration Estimates Project Document Updates

	Risk Register Enterprise Environment Factors Organization Process Assets		
Develop Schedule	Schedule Management Plan Activity List Activity Attributes Activity Resource Requirements Activity Duration Estimates Project Schedule Network Diagram Resource Breakdown Structure Resource Calendars Project Scope Statement Risk Register Project Staff Assignments Enterprise Environment Factors Organization Process Assets	Schedule Network Analysis Critical Path Method Critical Chain Method Resource Optimization Techniques Modeling Techniques Leads and Lags Schedule Compression Scheduling Tools	Schedule Baseline Project Schedule Schedule Data Project Calendars PM Plan Updates
Control Schedule	Project Management Plan Project Schedule Work Performance Data Project Calendars Schedule Data Organization Process Assets	Performance Reviews Project Management Software Resource Optimization Technique Modeling Techniques Leads and Lags Schedule Compression Scheduling Tools	Schedule Forecasts Work Performance Info Change Requests PM Plan Update Project Document Update Organization Process Assets Update

Plan Schedule Management

- define policies, procedures and documentation for managing and controlling project schedule
- including scheduling methodology, tools, level of accuracy, control thresholds (limit beyond which preventive/corrective actions needed), rules of performance measurement (e.g. earned value)
- lead and lags are NOT schedule constraints

Define Activities

- the scope baseline is used here as it represents the approved (stable) scope
- further decompose work packages into activities for more detailed and accurate estimations
- 'activities' is the PMI terminology for 'tasks' and 'work efforts'
- activity is more related to the **actual work/process to produce the deliverables**
- activity types: level of efforts (support, measured in time period), discrete efforts or

- apportioned effort (in direct proportion to another discrete effort)
- activities have durations while **milestones do not** (zero duration)

Sequence Activities

- WBS is no longer needed, so the **Project Scope Statement** is the input rather than scope baseline
- Precedence Diagramming Method (PDM)** to diagram dependencies
- Network Diagramming Tools are software tools that graphically represent activity sequences
- network diagrams: shows dependencies, duration, workflow, helps identifying critical paths
- precedence relationships** (also known as 'activity on node (AON)' approach): **finish-to-start** (~95%), start-to-start, finish-to-finish, start-to-finish (least)
- Activity on Arrow (AOA) or Arrow Diagramming Method (ADM)** activities are represented as arrows, dashed arrows represent dummy activities (duration: 0) that shows dependencies
- Graphical Evaluation and Review Technique (GERT)** allows for conditional branching and loops
- Network Dependency Types (to be determined during Sequence Activities Process):
- Mandatory Dependency** (hard logic): A must be completed before B begins/ technical dependencies may not be hard
- Discretionary Dependency** (preferred, soft logic): sequence preferred by the organization, may be removed should fast-tracking is required
- External Dependency**: dependency required by external organization
- Internal Dependency**: precedence relationship usually within the project team's control
- Milestones**: the completion of a key deliverable/a phase in the project, as checkpoints/summary for progress, often used in funding vendor activities
- Milestone list is part of i) project plan, ii) project scope statement, iii) WBS dictionary
- Leads**: begin successor activity before end of predecessor, for schedule compression (**fast tracking**) (negative lags)
- Lags**: imposed delay to successor activity, e.g. wait 2 weeks for concrete to cure (FS +14 days)
- Network Diagram Setup : **7-box** method, usually using software tools or 5-box method
- if the **ES** and **LS** are **identical**, the activity is on the **critical path**

Estimate Activity Resources

- closely related to Estimate Cost Process (in Cost Management)
- resource calendar spells out the availability of resources (internal/external) during the project period
- matches human resources to activities (as human resources will **affect duration**)
- effort** (man day, work week, etc.) vs duration vs **time lapsed** (total time needed, including holidays, time off)
- alternative analysis includes make-or-buy decisions, different tools, different skills, etc.
- Activity Resource Requirements may include the basis of estimation

Estimate Activity Durations

- consults SME (subject matter experts, i.e. the one carrying out the actual work) to come with the estimation, not on the PM's own
- Analogous Estimating**: based on previous activity with similar nature (a form of **expert**

judgement), used **when little is known** or very similar scope, works well when project is small, NOT ACCURATE

- **Parametric Estimating:** based on some parameters, e.g. the time for producing 1000 component based on that for 1 component * 1000, use an algorithm based on historical data, accuracy depends on the parameters selected, can be used on [a portion of / the entire] project
- **One-Point Estimating:** based on expert judgement, but highly unreliable
- **Three-Point Estimating:** **best (optimistic)**, **most likely (realistic)**, **worst (pessimistic)** cases, **Triangular** Distribution vs **PERT** (Project Evaluation and Review Techniques, **Beta** Distribution, weighted average using statistical methods [most likely * 4 - 95% confidence level with 2 sigma]), **triangular** distribution (non-weighted average of three data points), uncertainties are accounted for
- In real world applications, the PERT estimate is processed using **Monte Carlo** analysis, tie specific confidence factors to the PERT estimate
- **Bottom-Up Estimating:** a detailed estimate by decomposing the tasks and derive the estimates based on reliable historical values, most accurate but time-consuming
- **Heuristics:** use rule of thumb for estimating
- **standard deviation** (sigma value, deviation from mean, to specify the precision of measurement): 1 sigma: 68%, 2 sigma 95%, 3 sigma 99.7%, 6 sigma 99.99%
- **accuracy** is the conformance to target value
- **contingency reserve:** for known unknowns, owned by PM, may be updated, part of schedule baseline
- **management reserve:** for unknown unknowns, owned by management, included in overall schedule requirements
- update to documents: basis of estimates, assumptions and contingencies
- activity duration estimate may be in a **range**, **don't include lags**

Develop Schedule

- the **schedule baseline** is the approved and signed version of project schedule that is incorporated into the PM plan
- the **schedule** is calendar-based taking into accounts holidays/resource availability/vacations
- vs the **time estimate (work effort/level of effort)** just describes the man hours / man days
- **Slack/Float:** activities that can be delayed **without** impacting the schedule
- **Free slack/float:** time **an activity** can be delayed without delaying the **Early Start** of the successor
- **Total** slack/float: time **an activity** can be delayed from early start without delaying the **project end date (scheduling flexibility)**, can be negative, 0 (on the critical path) or positive
- Project Float: without affecting another project
- **Negative** float: problem with schedule, need schedule rework
- Project slack/float: time the project can be delayed without delaying another project
- **Early Start (ES)** - earliest time to start the activity
- **Late Start (LS)** - latest time to start without impacting the late finish
- **Early Finish (EF)** - earliest time to end the activity
- **Late Finish (LF)** - latest time to finish without impacting successor activity
- **Slack/Float = LS - ES or LF - EF**
- The float is the highest single value along the critical path, **NOT the sum** of them
- **Critical Path:** the longest path that amount to shortest possible completion time (usually **zero** float, activities with mandatory dependency with finish-to-start relationship), can have **more than 1** critical paths (more risks), critical paths may change (keep an eye on near-critical paths)
- activities on the critical path are called critical activities

- Path with **negative** float = **behind schedule**, need compression to eliminate negative float
- **Forward Pass** : compute the early start
- **Backward Pass** : compute the late start
- **Fast Tracking** : allow overlapping of activities or activities in parallel, included risks/resource overloading
- **Crashing** : shorten the activities by adding resources, may result in team burnout
- Scheduling Techniques
- **Critical Path Method (CPM)** - compute the forward and backward pass to determine the critical path and **float**
- **Critical Chain Method (CCM)** - deal with **scarce resources and uncertainties**, keep the resources evenly loaded by chaining all activities and grouping the contingency and put at the end as **project buffer**, for activities running in parallel, the contingency is called **feeding buffer** (expect 50% of activities to overrun)
- Buffer is determined by assessing the amount of uncertainties, human factors, etc.
- **Parkinson's Law**: Work expands so as to fill the time available for its completion.
- Resource Optimization Techniques
- **Resource leveling** is used to adjust the variation in resource loading to stabilize the number of resources working each time and to avoid burnout, may need to extend the schedule in CPM
- **Resource smoothing** is to adjust resource requirements so as not to exceed predetermined resource limits, but only **optimized within the float boundaries**
- Modeling Techniques
- **What if analysis**: to address feasibility/possibility of meeting project schedule, useful in creating contingency plan
- **Monte Carlo**: run thousand of times to obtain the distribution using a set of random variables (**stochastic** variables), use a combination of PERT estimate and **triangular distributions** as end point estimates to create the model to eliminate schedule risks, **the graph is a 'S' curve**
- **Network Diagram**: bar charts with logical connections
- **Hammock activities**: higher-level summary activities between milestones
- **Milestone Charts**: show only major deliverables/events on the timeline
- data date (status date, as-of date): the date on which the data is recorded
- the **Schedule Data** includes **schedule milestones, schedule activities, activities attributes, and documentation of all assumptions and constraints, alternative schedules and scheduling of contingency reserves**
- the Project Calendars identify working days

Control Schedule

- measure result, make adjustments, adjust metrics
- Performance Review includes: Trend Analysis, CPM, CCM, Earned Value Management
- Change Requests generated are to be assessed in the Perform Integrated Control Process

07. Project Cost Management

- **sunk cost** - cost already incurred in the past and cannot be recovered, do **not consider** anymore
- opportunity cost - difference in value between one path vs alternative (= **100%** of value of next best alternative)
- value analysis/ engineering - cost reduction without affecting the scope
- Benefit Cost Analysis (BCA) / Cost Benefit Analysis (CBA) - determine feasibility, bigger benefit/cost ratio (BCR)
- Payback Period - the length of time to recover the investment
- Return on Investment (ROI) - the efficiency of investment = (Gain-Cost)/Cost
- Time Value of Money - Present Value (PV) = value / (1+interest rate)*year, Future Value (FV) = value * (1+interest rate)*year
- **Net Present Value (NPV) = PV of cash inflows - PV of cash outflows (cost)**
- funding for project: self-fund, funding with equity, funding with debts
- discount rate - rate used to calculate present value of expected yearly benefits and costs

Plan Cost Management	Project Management Plan Project Charter Enterprise Environment Factors Organization Process Assets	Expert Judgement Analytical Techniques Meetings	Cost Management Plan
Estimate Costs	Cost Management Plan Human Resource Management Plan Scope Baseline Project Schedule Risk Register Enterprise Environment Factors Organization Process Assets	Expert Judgement Analogous Estimating Parametric Estimating Three Point Estimates Reserve Analysis Cost of Quality Project Management Software Vendor Bid Analysis Group Decision Making Techniques	Activity Cost Estimates Basis of Estimates Project Document Updates
Determine Budget	Cost Management Plan Scope Baseline Activity Cost Estimates Basis of Estimates Project Schedule Resource Calendars Risk Register Agreements Organization Process Assets	Cost Aggregation Reserve Analysis Historical Relationships Funding Limit Reconciliation Expert Judgement	Cost Baseline Project Funding Requirements Project Document Updates
Control Costs	Project Management Plan Project Funding Requirements Work Performance Data	Earned Value Management Forecasting To Complete Performance Index	Cost Forecasts Change Requests Work Performance Info Organization Process Assets Updates

Organization Process Assets	(TCPI) Performance Reviews Project Management Software Reserve Analysis	PM Plan Updates Project Document Updates
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Plan Cost Management

- The Cost Management Plan establishes: i) level of **accuracy** and level of **precision**, ii) unit of measurement, iii) WBS procedure links (to control account (CA)), iv) control threshold, v) **earned value rules of performance**, reporting, funding and processes
- Life cycle costing = **total cost of ownership** : production cost, running and maintenance cost, etc.

Estimate Costs

- similar to Estimate Activity Resources
- look for ways to reduce cost
- ensure the SME to deliver the estimates (more accurate)
- based on WBS
- Cost Types
- **Variable** costs - costs change with the amount of work, e.g. hourly consultants
- **Fixed** costs - costs that are constant, e.g. equipment leases
- **Direct** costs - directly attributed to the project
- **Indirect** costs - shared costs like AC, lighting, etc.
- Cost Estimate Tools
- **Analogous** Estimating (Top Down Estimate) - compare to a similar project in the past (an estimating heuristic/rule of thumb)
- **Parametric** Estimating - use a parameter and repetitive units of identical work
- **Bottom-up** Estimating - detailed estimates of each individual activity from historical data, more accurate and time-consuming
- Type of estimate: rough order of magnitude (-25% to +75%), definitive estimate (-5% to +10%)
- Activity Cost Estimates may include indirect cost and contingency reserves
- **usually in a range of values**
- **Basis of Estimates** - detailed analysis on how the cost estimate was derived (assumptions, constraints, possible range (+/-15%), confidence level of final estimate)

Determine Budget

- **Budget** is more about **when** to spend money
- **Historical Relationships** - analogous/parametric estimation
- **Reserve Analysis** - addresses **Management Reserve** (unknown unknowns) and **Contingency Reserve** (known risks) [not included in calculation of earned value management]
- **Funding Limit Reconciliation** - addresses variance between funding limit (e.g. monthly or yearly limit) and planned expenditure, may require **rescheduling** of work to level of the rate of expenditure
- **Value Engineering** - to improve quality/shorten schedule without affecting the **scope**
- **Project Budget = Cost baseline** (the approved time-phased budget) + **Management Reserve**
- when management reserve is **used** during project execution, **the amount is added to the cost baseline**

- **S-curve** : total project expenditure over project lifecycle

Control Costs

- Check against the **Project Funding Requirements**
- including informing stakeholders of all approved changes and their costs
- Earned Value Calculation
- Index > 1: under budget/ahead of schedule
- Index < 1: over budget/behind schedule
- Estimate at Complete: 1) new estimate required (original flawed), 2) no BAC variance, 3) CPI will continue, 4) sub-standard cost/schedule will continue
- TCPI: **>1** not enough funding remain (**over budget**), **<1** more fund available than needed (**under budget**)
- (Please refer to the PMP formulas section)
- Earned Value Accrual
- **Discrete Efforts** - describes activities that can be planned/measured for output, including **Fixed Formula** (activity given a % of budget of work package at **start** and earn the remaining when completed, e.g. 50/50, 20/80 or 0/100), **Weighted Milestone** (earn value for milestones of deliverables of the work package), **Percentage Complete**, **Physical Measurement**
- **Apportioned Efforts** - describes work that has a direct/supporting relationship to discrete work, e.g. testing, pm activities, calculated as % of the discrete work
- **Level of Efforts (LOE)** - describes activities without deliverables, e.g. troubleshooting, assigned the earned value as scheduled, **without schedule variance** but may have cost variance
- e.g. perform Control Cost weekly during execution where money is spent fastest
- Variance Analysis - to check against the baseline for any variance
- **SPI at end of project must be 1**
- **SPI is NOT telling much information to whether the project is on schedule as the Critical Path must also be investigated to get a meaningful picture**

08. Project Quality Management

- everyone in the organization is responsible for the quality (project team for destined parts while PM for project quality), **PM is ultimately responsible for the project quality**
- **prevention over inspection**
- **outliers** are singular measurements outside the control limits
- continuous improvement to ensure quality (quality assurance)
- some costs of quality will be borne by the organization (organization quality policy, e.g. quality audit, ISO accreditation)
- **Quality**: the **degree** to which a set of inherent characteristics fulfills **requirements**, decrease rework/costs, increase productivity/stakeholder satisfaction
- under 'control': the process is predictable and repeatable
- PM: perform continuous improvement activities (quality assurance), verify quality before completion of deliverables (control quality)
- **Grade** (fit for use or not) vs **Quality** (conformance to stated requirements)
- **Accuracy** (correctness) vs **Precision** (consistency, how closely conforms to target, standard deviation is a measure of precision, smaller standard deviation higher precision)
- Quality Management Concepts
- **Crosby Zero Defects**: identify processes to remove defects, quality is built in to the processes
- **Juran Fitness for Use**: does the product/service meet customer's need? i) Grade, ii) Quality conformance, iii) Reliability/maintainability, iv) Safety, v) Actual Use
- **W. Edwards Deming**: 85% of quality problem is managers' responsibility, develop "System of Profound Knowledge" [system = components working together to achieve an aim] i) Appreciation for system, ii) Knowledge about variation (special cause vs common cause) , iii) Theory of Knowledge (built up by prediction/observation/adjustment) , iv) Psychology
- **Six Sigma**: achieve 3.4/1 mil defect level (99.999%) using DMAIC (Define, Measure, Analyze, Implement, Control) or *[Design for Six Sigma]* DMADV (Define, Measure, Analyze, Design, Validate) approach, **refine** the process to get rid of human error and outside influences with precise measurements, variations are random in nature
- **Just In Time**: eliminate build up of inventory
- **Total Quality Management (TQM)**: ISO 8402 all members to center on quality to drive customer **satisfaction** , refine the process of producing the product
- **Kaizen改善**: implement consistent and incremental improvement, to reduce costs, cycle time, drive customer satisfaction using PDCA (Plan Do Check Act)
- The **Plan-Do-Check-Act** cycle is a way of making small improvements and testing their impact before you make a change to the process as a whole. It comes from W. Edwards Deming's work in process improvement, which popularized the cycle that was originally invented by Walter Shewhart in the 1930s.
- **Capability Maturity Model Integration (CMMI)**: improve overall software quality (design, development and deployment)
- ISO9000: ensures the defined processes are performed in accordance to the plan
- Quality Management processes are so focused on reviewing **EVERY deliverable** - not just the final product, but all of the components, **designs** and specifications too.

Plan Quality Management	Project Management Plan Stakeholder Register	Cost-benefit Analysis Cost of Quality Seven Basic Quality	Quality Management Plan Process Improvement
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	Risk Register Requirements Documentation Enterprise Environment Factors Organization Process Assets	Tools Benchmarking Design of Experiments Statistical Sampling <i>Additional Quality Planning Tools</i> Meetings	Plan Quality Metrics Quality Checklists Project Document Updates
Perform Quality Assurance	Quality Management Plan Process Improvement Plan Quality Metrics Quality Control Measurements Project Documents	Quality Management and Control Tools Quality Audits Process Analysis	Change Requests PM Plan Updates Project Document Updates Organization Process Assets Updates
Control Quality	Quality Management Plan Quality Metrics Quality Checklists Work Performance Data Approved Change Requests Deliverables Project Documents Organization Process Assets	Seven Basic Quality Tools Statistical Sampling Inspection Approved Change Requests Review	Verified Deliverables Change Requests Validated Change Quality Control Measurements Work Performance Info PM Plan Updates Project Document Updates Organization Process Assets Updates

Plan Quality Management

- quality policy (either organizational or just for the project), methods and procedures to meet the objectives and satisfy customer's needs
- identify the quality requirements and document how to achieve
- **Cost-benefit Analysis**: cost of implementing quality requirements against benefits
- **Cost of Quality**: lowest quality cost is prevention, highest quality cost (**poor quality**) is rework and defect repair (as high as 5000 times the cost for carrying out unit testing), lost reputation and sales, **failure cost** may be internal/external (found by customer)
- **Warranty claims are external** cost of quality
- Cost of Quality is the total cost of quality efforts throughout the product's lifecycle
- cost of conformance (prevention cost, appraisal cost) vs cost of non-conformance (failure cost [internal/external])
- **internal/external is reference to the project** (not the organization)
- Poka Yoke (mistake proofing), Zero Quality Control (100% source inspection), Voice of Customer and FEMA (Failure Modes of Effects Analysis) are planning tools for quality management
- **Quality Metrics**: function points, MTBF (mean time between failure), MTTR (mean time to repair)
- Marginal Analysis: ROI of quality measures
- 7 Basic Quality Tools
- **Cause-and-effect / Ishikawa / Fishbone Diagram**: for identifying the cause
- **Flowchart**: (e.g. **SIPOC** diagram) for identifying failing process steps and process improvement opportunities
- **Check Sheets (tally sheets)**: **collecting data**/documenting steps for defeat analysis

- **Histograms**: does not consider the influence of time on the variation that exists within a distribution
- **Pareto Chart**: based on 80/20 principle, a prioritization tool to identify critical issues in descending order of frequency, sort of a histogram
- **Statistical Process Control (SPC) Chart**: determine if a process is stable/predictable using statistical sampling (assessed by **accuracy**[conformance] and **precision**[standard deviation]), identify the internally computed **control limits** (UCL/LCL) and **specification limits** (USL/LSL) **by the customer/PM**
- **run chart is similar to control chart, but without the control**
- **usually +3sigma i.e. a range of 6 sigma**
- a form of **time series**
- if a process is within control limit but **beyond specification limit**, the process is experiencing **common cause variation (random)** that cannot be corrected by the system, management help is needed (special cause can be tackled but NOT common cause)
- **Stability Analysis / Zone Test**: rule of **seven** (7 consecutive on either side of the mean = **out of control**), rule of **six** (six consecutive with a trend = out of control), rule of **ten** (10 as a saw-tooth pattern around the mean), rule of **one** (1 point beyond control limit) [**signal in the noise**]
- **Scatter Diagram**: for trending, a form of **regression** analysis
- **Benchmarking**: compare to past activities/standard/competition
- **Design of Experiments (DOE)**: change several factors at a time for each experiment, **to determine testing approaches and their impact on cost of quality**
 - Additional Quality Planning Tools
 - **Loss Function**: a financial measure of the user's dissatisfaction with product performance
 - Matrix Diagrams: House of Quality (HOQ) used in **Quality Function Deployment** (QFD) (method to transform user demands [VOC] into design quality)
 - **Kano Model**: differentiate features as satisfy, **delight** or dissatisfy
 - **Marginal Analysis**: cost-benefits analysis
 - **Force Field Analysis (FFA)**: reviews any proposed action with proactive and opposing forces
 - Process Improvement Plan: process boundaries, configuration, process metrics/efficiencies, targets for improved performance
 - Quality Checklists: checklist to verify a series of steps have been performed
 - The goal is to refine the process so that human errors and outside influences no longer exist, and any remaining variations are completely random

Perform Quality Assurance

- in the **Executing Process Group**
- **ensures** the quality standards are being followed, to ensure unfinished works would meet the quality requirements
- **by quality assurance department or sponsor/customer not actively involved in the project**
- primarily concerned with **overall process improvement** for activities and processes (rather than the deliverable)
- utilize the data collected in Control Quality Process
- Quality Management Tools
- **Affinity Diagrams**: like a **mind-mapping** diagram, organize thoughts on how to solve problems

- **Process Decision Program Charts** (PDPC): defines a goal and the steps involved, useful for contingency planning
- **Interrelationship Digraphs**: maps cause-and-effect relationships for problems with multiple variables/outcomes
- Tree Diagrams
- **Prioritization Matrices**: define issues and alternatives that need to be prioritized for decision, items are given a priority score through **brainstorming**
- Activity Network Diagrams
- Matrix Diagrams: e.g. 'house of quality' in QFD
- Kaizen改善, Kanban看板: quality assurance methods developed by Japanese
- **Quality Audit**: to verify quality of processes, to seek improvement, identify best practices, reduce overall cost of quality, confirm implementation of approved changes, need **quality documentations**
- **Quality Review**: to review the quality management plan
- change requests are mostly **procedural changes**

Control Quality

- **verify the deliverables** against customer's specifications to ensure customer satisfaction
- **validate the changes** against the original approved change requests
- conditional probability (events somewhat related) **vs** statistical independence (events not interrelated) **vs** mutual exclusivity
- statistical sampling for control quality
- **variable (continuous) data**: measurements, can do maths on e.g. average
- **attribute (discrete) data**: yes/no, no.123, just an identifier, can't do maths on
- QC includes the PM process (lesson learnt, budget, scope)
- **tolerance (spec limits**, deliverables acceptable) vs control limits (process acceptable)
- if within control limit but outside tolerance: **rework the process** to give better precision
- all control and execution processes may generate lesson learned

09. Project Human Resource Management

- Sexism, racism or other discrimination should never be tolerated, no matter what the circumstances. You must separate your team from discriminatory practices, even if those practices are normal in the country where you're working.

Plan Human Resource Management	PM Plan Activity Resource Requirements Enterprise Environment Factors Organization Process Assets	Organization Charts and Position Description Networking Organization Theory Expert Judgement Meetings	Human Resource Management Plan
Acquire Project Team	Human Resource Management Plan Enterprise Environment Factors Organization Process Assets	Pre-assignment Negotiation Acquisition Virtual Teams Multi-criteria Decision Analysis	Project Staff Assignments Resource Calendars PM Plan Updates
Develop Project Team	Human Resource Management Plan Project Staff Assignments Resource Calendars	Interpersonal Skills Training Team-building Activities Ground Rules Co-location Recognition and Rewards Personnel Assessment Tools	Team Performance Assessment EEF updates
Manage Project Team	Human Resource Management Plan Project Staff Assignments Team Performance Assessments Issue Log Work Performance Reports Organization Process Assets	Observation and Conversation Project Performance Appraisals Conflict Managements Interpersonal Skills	Change Requests PM Plan Updates Project Document Updates EEF Updates OPA Updates

Plan Human Resource Management

- plan to organize and lead the project team
- include **roles and responsibilities** (identify resources that can take up the responsibilities) as documented (ownership of deliverables) in **RAM in the form of RACI chart** (matrix) or in a chart/text form, **org charts** - an organizational breakdown structure (OBS) and **staffing management plan** - staff acquisition, release, resource calendar, resource histogram, training, rewards, compliance & safety requirements
- The **OBS displays organizational relationships** and then uses them for assigning work to resources in a project (WBS)
- networking is useful in understanding skills of individuals and the political and

- interpersonal factors within the organization
- org chart indicated the reporting structure of the project

Acquire Project Team

- to acquire the **final** project team
- pre-assignment is the selection of certain team members in advance
- acquisition is to acquire resources from **outside** through hiring consultants or subcontracting
- includes bringing on contractors / consultants
- halo effect**: a cognitive bias (if he is good at one thing, he will be good at everything)
- Multi-criteria Decision Analysis: to select team members based on a no. of factors: availability, cost, experience, ability, knowledge, skills, attitude, etc.
- training is usually paid for by the organization, not project

Develop Project Team

- enhancing and improving overall team performance
- offer feedback, support, engage team members, manage conflicts, facilitate cooperation
- cross-train people
- team performance assessments** : assess team performance as a whole **vs** project performance appraisals: individual performance
- training cost can be set within the project budget or supported by the organization
- PM Authority: legitimate (assigned in project charter), reward, penalty, **expert** (need to be earned), referent (charisma and likable, or ally with people with higher power), representative (elected as representative)
- Expert > Reward** are best forms of power. Penalty is worst.
- Tuckman Model: Forming - Stroming - Norming - Performing - Adjourning
- cultural difference should be considered when determining award and recognition
- recognition should focus on win-win reward for the team (NOT competitive-based)
- team building is important throughout the whole project period
- Motivational Theories
- Maslow's Hierarchy of Needs** - personal needs (Physiological > Security > Social > Esteem > Self Actualization)
- Herzberg's Hygiene Theory** - satisfaction (motivators) vs dissatisfaction (hygiene factors to avoid dissatisfaction but do not provide satisfaction, also called KITA factors e.g. incentives/punishments), hygiene factors include good working conditions, a satisfying personal life, and good relations with the boss and coworkers
- Expectancy Theory - Expectancy** (extra work will be rewarded) **Instrumentality** (good results will be rewarded) **Valence** (the individual's expected reward), for a person to be motivated, efforts/performance/outcome must be matched - will only work hard **for achievable goals**
- Achievement Theory** - three motivation needs: achievement (nAch), power (nPow), affiliation (nAff), best is a balanced style for the PM
- Contingency Theory** - task-oriented/relationship-oriented with stress level (high stress -> task-oriented better)
- Leadership Theory
- including: analytical (with expertise), autocratic (with power), bureaucratic, charismatic, consultative, driver (micromanagement), influencing, laissez-faire (stay out)
- Theory X** - assumes employees are lazy and avoid work, need incentive/threats/close supervising
- Theory Y** - assumes employees may be ambitious and self-motivated, will perform given the right conditions

- **Theory Z** - (japanese) increasing loyalty by providing job for life with focus on well-being of employee (on and off job), produces high productivity and morale
- **Situational Continuum Leadership** - directing/telling > coaching/selling (manager define the work) > supporting/participating (subordinate define the work) > delegating according to maturity/capability of the subordinate

Manage Project Team

- track team member performance, provide feedback, resolve issues
- when managed properly, differences of opinion can lead to increased creativity and better decision making
- **issue log** is fed from Manage Stakeholder Engagement - used to understand who is responsible for resolving specific issues
- **conflict management**: conflicts force a search for alternatives, need openness, not personal, focus on present and future
- **conflicts**: schedule, project priority, resources, technical opinions, administrative overhead (too much administration work), cost, personality
- **conflict resolution**: **collaborate**/problem solve[confrontation of problem] (best), **compromise/reconcile** (give-and-take, temporary/partially resolve), **force/direct** (worst/short-lived), **smooth/accommodate** (emphasis common grounds and **avoid**/touch lightly the disagreements for harmony/relationship), withdraw/avoid (other leads to lose-lose)
- compromise is lose-lose
- **Forcing** would only provide a temporary solution
- Award decisions are made during the process of project performance appraisals
- monitoring and controlling is typically performed by functional managers/HR for functional org

10. Project Communication Management

- assure the timely collection, generation, distribution, storage, retrieval and ultimate **disposition** of project information
- very important to the ultimate success of the project
- message transmission: 7% in word, 38% in vocal pitch, 55% in body language (Albert Mehrabian)
- don't wait to communicate good/bad news
- the **sender has the responsibility** to ensure the receiver correctly understand the message
- if part of the project is procured, more formal written communication will be expected

Plan Communications Management	PM Plan Stakeholder Register Enterprise Environment Factors Organization Process Assets	Communications Requirements Analysis Communications Technology Communication Models Communication Methods Meetings	Communications Management Plan Project Document Updates
Manage Communications	Communications Management Plan Work Performance Reports Enterprise Environment Factors Organization Process Assets	Communications Technology Communication Models Communication Methods Information Management System Performance Reporting	Project Communications PM Plan Updates Project Document Updates OPA Updates
Control Communications	PM Plan Project Communications Issue Log Work Performance Data Organization Process Assets	Information Management System Expert Judgement Meetings	Change Requests Work Performance Info PM Plan Updates Project Documents Updates OPA Updates

Plan Communications Management

- identify the needs for stakeholder communication
- the who, what, when (frequency), why, where and how of communications needs and the persons responsible
- time and budget for the resources, escalation path, flow charts, constraints, guideline and templates
- **Communication Methods:** **interactive** (multidirectional communication, most effective), **push** (active, messages sent without validation of receipt), **pull** (passive, access directly by stakeholders)
- low context vs **high context** (japan, more polite)
- may need to limit who can communicate with whom and who will receive what information

- (**Shannon-Weaver model**)**Sender-Receiver Model:** i) encoded idea, ii) message and feedback, iii) medium, iv) noise level, v) the decoded idea. **The sender to ensure info is clear, complete and the recipient correct understands.** The recipient to ensure complete message is received (to **acknowledge**) and provide feedback/response.
- Effective Listening: feedback, active listening and paralingual (voice expression, nonverbal elements)
- Communication channels: **N (N -1) / 2** // N is the number of team members
- meetings should facilitate problem solving
- PM spends **90%** of their time on **COMMUNICATION** activities, 50% of the time is spent on communicating with the team
- **efficient** communication: only the required messages
- **effective** communication: right timing, right format, right medium

Manage Communications

- create, collect, distribute, store, retrieve and dispose project information according to the Communication Management Plan
- ensures good communications, noises managed, stakeholders may feedback on how to improve
- Communication Barriers vs Communication Enhancers
- **55% message thru body language**, 38% thru paralingual, 7% thru words used
- Types of Communications: Formal Written, Formal Verbal, Information Written, Informal Verbal
- Formal Written: plans, project charter, meeting minutes
- Formal Verbal: presentations, public speeches, keynote addresses
- Informal Written: memos, emails
- Informal Verbal: meetings, ad hoc conversations
- **Performance Reporting**: status, progress, variance, trend, earned value reports and forecasts, summary of changes, risks and issues
- PM Plan Update to show the latest performance (against Performance Measurement Baseline)
- Feedback from stakeholders are to be stored in OPA

Control Communications

- to ensure optimal information flow for effective stakeholder expectation management
- issue log is to document the issues and monitor its resolutions (with **person responsible**)

11. Project Risk Management

- risk identification, management and response strategy impacts every area of the project management life cycle
- everyone is responsible for identifying risks
- **risk has one or more causes and has one or more impacts**
- risk = uncertainty; risk management: **increase** the probability of project success by minimizing/eliminating negative risks (threats) and increasing positive events (opportunities)
- risk attitudes (EEF): **risk appetite** (willingness to take risks for rewards), **tolerance** for risk (risk tolerant or risk averse), **risk threshold** (level beyond which the org refuses to tolerate risks and may change its response)
- **pure (insurable) risk** vs business risk (can be +ve or -ve)
- known risks that cannot be dealt with proactively (active acceptance) should be **assigned a contingency reserve** or if the known risks cannot be analyzed, just wait for its happening and implement workaround (passive acceptance)

Plan Risk Management	Project Management Plan Project Charter Stakeholder Register Enterprise Environment Factors Organization Process Assets	Analytical Techniques Expert Judgement Meetings	Risk Management Plan
Identify Risks	Risk Management Plan Cost Management Plan Schedule Management Plan Quality Management Plan HR Management Plan Scope Baseline Activity Cost Estimates Activity Duration Estimates Stakeholder Register Project Documents Procurement Documents Enterprise Environment Factors Organization	Documentation Reviews Information Gathering Techniques Checklist Analysis Assumptions Analysis Diagramming Techniques SWOT Analysis Expert Judgement	Risk Register

	Process Assets		
Perform Qualitative Risk Analysis	Risk Management Plan Scope Statement Risk Register Enterprise Environment Factors Organization Process Assets	Risk Probability and Impact Assessment Probability and Impact Matrix Risk Data Quality Assessment Risk Categorization Risk Urgency Assessment Expert Judgement	Project Documents Updates
Perform Quantitative Risk Analysis	Risk Management Plan Cost Management Plan Schedule Management Plan Risk Register Enterprise Environment Factors Organization Process Assets	Data Gathering and Representation Techniques Quantitative Risk Analysis and Modeling Techniques Expert Judgement	Project Documents Updates
Plan Risk Responses	Risk Management Plan Risk Register	Strategies for Negative Risk (Threats) Strategies for Positive Risk (Opportunities) Contingent Response Strategies Expert Judgement	PM Plan Updates Project Documents Updates
Control Risks	PM Plan Risk Register Work Performance Data Work Performance Reports	Risk Reassessment Risk Audits Variance and Trend Analysis Technical Performance Measurement Reserve Analysis Meetings	Work Performance Info Change Requests PM Plan Update Project Document Updates OPA Updates

Plan Risk Management

- define and provide resources and time to perform risk management, including: methodology, roles and responsibilities, **budget**, timing (when and how often), risk categories (e.g. RBS), definitions, stakeholder tolerances (a EEF), reporting and tracking
- performed at project initiation and early in the Planning process
- failure to address risks early on can ultimately be more costly
- analytical techniques include stakeholder risk profile analysis, strategic risk scoring sheets
- a **risk breakdown structure** (RBS) (included in the PM Plan) - risks grouped by categories and occurring areas

- key risk categories: scope creep, inherent schedule flaws, employee turnover, specification breakdown (conflicts in deliverable specifications), poor productivity

Identify Risks

- determine all risks affecting the project
- **information-gathering techniques**: brainstorming, **delphi** technique [a panel of independent experts, maintain **anonymity**, use questionnaire, encourage open critique], **root cause analysis** [performed **after** an event to gain understanding to prevent similar events from occurring], expert interviewing, SWOT analysis
- root cause analysis: safety-based (prevent accidents), production-based, process-based (include business process), failure-based, systems-based (all above)
- root cause analysis tools: FMEA, Pareto Analysis, Bayesian Inference (conditional probability), Ishikawa Diagrams, Kepner-Tregoe
- Monte Carlo analysis can identify points of schedule risks
- **Influence Diagram** - graphical representations of situations showing causal influences, time ordering of events, and other relationships among variables and outcomes.
- **Risk Register** (typically not including the risk reserve) details all the aspects of the risk and persons responsible
- The Risk Register may include a **risk statement**
- any risk with a probability of **>70%** is an **issue** (to be dealt with proactively and recorded in the issue log)

Perform Qualitative Risk Analysis

- prioritizing risks for further analysis/action and identify high priority risks
- need to identify bias and correct it (e.g. risk attitude of the stakeholders)
- **qualitative risk assessment matrix** (format described in the Risk Management Plan) which includes the risk, the impact (high, medium, low) and the likelihood (low, medium, high)
- update to risk register and other related documents
- risk register update are output of Perform Qualitative Risk Analysis, Perform Quantitative Analysis, Plan Risk Responses and Monitor & Control Risks
- the scope baseline is used to understand whether the project is a recurrent type or a state-of-the-art type (more risks)
- risks requiring near-term responses are more **urgent** to address

Perform Quantitative Risk Analysis

- the cost, schedule and risk management plan contains guidelines on **establishing and managing risks**
- involves mathematical modeling for forecasts and trend analysis
- data gathering and representation techniques: interviewing, **probability distributions** [normal distribution (**bell shaped** curve)],
- **sensitivity analysis** (using the **tornado diagram** as presentation) for determining the risks that have the most impact on the project
- **Failure Modes Effects Analysis** (FMEA) which documents the "severity", "occurrence" and "detection" of risks
- FMEA for manufactured product or where risk may be undetectable, Risk Priority Number (RPN) = severity (1-10) x occurrence ([0.07%] 1-10 [20%]) X detectability (1-10 [undetectable]), also a **non-proprietary approach for risk management**
- Expected Value / **Expected Monetary Value (EMV)**, probability x impact (cost/effort lost), opportunities (+ve values), threats (-ve values)
- **Monte Carlo Analysis** - by running **simulations many times** over in order to calculate those same probabilities heuristically just like actually playing and recording your results

in a real casino situation, 'S' curve (cumulative distribution) will result, may use PERT/triangular distribution to model data, may use thousands of data points (a random variable), for budget/schedule analysis

- **Decision Tree Analysis** - another form of EMV, branching: decision squares (decision branch - options), circles (uncertainty branch - possible outcomes)

Plan Risk Responses

- plan response to enhance opportunities and reduce threats
- each risk is **owned by a responsible person**
- the **watch list** is the list of low priority risks items in the risk register
- a **fallback plan** will be used if 1) risk response not effective, 2) accepted risk occurs
- risk strategies: 1) prevent risk, 2) response to risk, 3) reduce risk, 4) promote opportunities, 5) fallback if risk response fails
- negative risk strategies: **eliminate/avoid** (not to use, extend the schedule), **transfer (outsource, warranty, insurance)**, **mitigate** (reduce the risk by more testing/precautionary actions/redundancy), **accept** (passive - do nothing or **active - contingency**)
- positive risk strategies: **exploit** (ensure opportunity by using internal resources e.g. reduce cost/use of top talents/new tech), **share (contractor with specialized skills, joint venture)**, **enhance (increase likelihood / impact e.g. fast-tracking, add resources etc.)**, **accept**
- **passive risk acceptance** to be dealt with when the risk occurs
- **Contingency Plan (contingent response strategies)** (plan A) are developed for specific risk (when you have accepted a risk) with certain **triggers** vs Fallback Plan (plan B)
- **Residual Risks** - risks remains after the risk response strategy was implemented, may be identified in the planning process (may subject to contingency/fallback planning) They don't need any further analysis because you have already planned the most complete response strategy you know in dealing with the risk that came before them.
- **Secondary Risks** - risk arises when the risk response strategy was implemented
- Contingency Reserve: known unknowns (determined risk), part of cost baseline
- Management Reserve: unknown unknowns (discovery risk), part of project budget
- The Risk Register is now completed with: risks and descriptions, triggers, response strategy, persons responsible, results from qualitative and quantitative analysis, residual and secondary risks, contingency and fallback, risk budget/time

Control Risks

- when the above risk planning processes have been performed with due diligence, the project is said to have a **low risk profile**
- to check if **assumptions** are still valid, procedures are being followed and any deviance
- to identify **new risks** and evaluate effectiveness of risk response plan
- any need to adjust contingency and management reserves
- to re-assess the individual risk response strategies to see if they are effective
- risk audits deal with effectiveness of risk response and the risk management process
- risk audits are usually performed by experts outside project team for the whole risk management process
- reserve analysis and fund for contingencies apply **only** to the specific risks on the project for which they were set aside
- **workaround**: when no contingency plan exists, executed on-the-fly to address **unplanned events** - still need to pass through normal change control if change requests are needed
- determine the workaround is performed in control risks

12. Project Procurement Management

- Procurement Statement of Work (SOW) is a legal document subject to legal reviews, legal advise should be sought throughout the whole procurement process
- sellers are external to the project team
- need to go through all 4 processes for **each and every** procurement
- contract elements: **offer** (seller offer buyer), **acceptance** (buyer criteria), **capacity** (physical/financial capabilities), **consideration** (seller receive), **legal purpose** (must be legal under law)
- best if contract is signed after PM is assigned
- PM needs to understand terms and conditions, identify risks, include procurement time in schedule and involve in negotiations
- Centralized contracting vs decentralized contracting
- sole source, single source (preferred), oligopoly (very few sellers)
- procurement categories: major complexity (high risk), minor complexity (low risk, expensive), routine purchase (Commercial Off the Shelf Products COTS), goods and services (to perform part of our product)
- a contract is not required to be written, it can be verbal or handshake, for internal projects, **formal contract is best**
- procurement applies to actors (as a service)
- immaterial breach is minor breach
- point of total assumption (PTA) = Target Cost + (Ceiling Price - Target Price) / % Share of Cost Overrun
- contract **change control system** is defined in the procurement management plan but **not in the contract**

Plan Procurement Management	PM Plan Requirements Documentation Risk Register Activity Resource Requirements Project Schedule Activity Cost Estimates Stakeholder Register Enterprise Environment Factors Organization Process Assets	Make-or-buy Analysis Expert Judgement Market Research Meetings	Procurement Management Plan Procurement SOW Procurement Documents Source Selection Criteria Make-or-buy Decisions Change Requests Project Document Updates
Conduct Procurements	PM Plan Procurement Documents Procurement SOW Source Selection Criteria Seller Proposals Project Documents Make-or-buy Decisions Organization Process	Bidder Conferences Proposal Evaluation Techniques Independent Estimates Expert Judgement Advertising Analytical Techniques Procurement Negotiations	Selected Sellers Agreements Resource Calendars Change Requests PM Plan Updates Project Document Updates

	Assets		
Control Procurements	PM Plan Procurement Documents Agreements Approved Change Requests Work Performance Reports Work Performance Data	Contract Change Control System Procurement Performance Reviews Inspections and Audits Performance Reporting Payment Systems Claims Administration Records Management System	Work Performance Info Change Requests PM Plan Updates Project Documents Updates OPA Updates
Close Procurements	PM Plan Procurement Documents	Procurement Audits Procurement Negotiations Records Management System	Closed Procurements OPA Updates

Plan Procurement Management

- determine whether to obtain products/services outside of organization
- identify possible sellers and pre-meeting with them
- identify explicitly what is needed
- **make-or-buy analysis** is a compulsory process, needs to take **risks** into considerations
- carefully written terms and conditions can transfer/share risks
- teaming agreements or joint ventures
- procurement documents: request for proposal (RFP), invitation for bid (IFB), request for quote (RFQ), request for information (RFI), tender notice, invitation for negotiation, seller initial response
- the procurement management plan specifies how a project will acquire goods/services from outside, includes: contract type, risk management, constraints and assumptions, insurance requirements, form and format, pre-qualified sellers, metrics used, etc.
- **Procurement Statement of Work (SOW)** - **performance** (describe what can be accomplished), **functional** (convey the end purpose or result), **design** (convey precisely what are to be done), can be developed by the seller or buyer - detail enough to allow the potential sellers to decide whether they want/are qualified (at a minimum) to pursue the work
- Contract Types:
- **Firm Fixed Price** (FFP) - the price is fixed, specifications are well known, **risk** on the seller
- Fixed Price Incentive Fee (FPIF) - incentives for faster/better than contracted
- Fixed Price with Economic Adjustment / Economic Price Adjustment (FPEA / FP-EPA) - inflation are taken into account
- Purchase Order (PO) - for off-the-shelf goods/services with published rates
- **Cost Reimbursable** (CR) / Cost Plus - buying the expertise (not the products), outcome is not clear, risk on the buyer, little incentive to control costs on buyer, need invoice audits
- Cost Plus Fixed Fee (CPFF)
- Cost Plus Incentive Fee (CPIF) - incentive for performance, sharing of unused money if under/over contracted amount
- Cost Plus Award Fee (CPAF) - award to be given based on agreed criteria, **solely decided** by the customer on the degree of satisfaction
- Cost Plus Percentage of Costs (CPPC) - **illegal for contracts with US Government**

- Cost Contract - not profit, for NGO
- Best Efforts - obligates the seller to utilize best attempts, high uncertainty in meeting the goal
- **Time and Materials (T&M)** - (**hybrid** type) when scope is not known, need constant monitoring to control schedule and cost, simple, for short duration, good for proof-of-concept type projects
- **Point of Total Assumption** - (in **fixed-price** (incentive fee) contracts) in budget overrun, the point at which the seller assumes all additional costs for delivering the product/service
- **PTA = (Ceiling Price - Total Price) / Buyer's Share Ratio + Target Cost**
- target cost = total cost = estimated cost, total price = total cost + total profit
- Request for Proposal (RFP) - cost reimbursable contract, functional/performance SOW
- Invitation for Bid (IFB) / Request for Bid (RFB) - fixed-price contract, design SOW
- Request for Quote - time and material, any type of SOW
- **Cancellation for Convenience** - buyer can cancel and pay up to the point
- **Cancellation for Cause** - default by either party, may result in legal actions
- Escrow - survivability of seller in doubt, put the product in escrow (esp. if seller not give up intellectual properties)
- **Force Majeure** - standard disclaimer refers to 'Acts of God'
- Indemnification / Liability - responsible party
- LOI Letter of Intent - not legally binding
- **Privity** - the contractor may use sub-contractor, no direct contractual relationship with buyer
- Retainage - amount to be withheld to ensure delivery
- Risk of Loss - how the risk is shoulder by the parties
- **Time is of the Essence** - delay in delivery will cause cardinal breach of contract
- **Work Made for Hire** - all work owned by the buyer
- Sole Source vs Single Source (preferred vendor - for long-term relationship)
- **Evaluation Criteria:** risk, understanding of need, life-cycle cost, technical capability, management approach, technical approach

Conduct Procurements

- identify the sellers and award the contracts
- PM may not be the lead negotiator on procurement, but may be present to assist
- may **need** senior management approval before awarding the contracts
- bidder's conference is a Q&A session with bidders, all bidders receive the same information (bidder are careful not to expose their technical approach during the session => may not have many questions)
- NOT to have secret meetings or communications with individual vendors
- may set up qualified sellers lists
- review seller proposals: weighting systems, independent estimates, screening systems (screen out non-qualified vendors), seller ratings systems (for past performance), expert judgement
- Contract Negotiations and Tactics
- **Fait Accompli** - not negotiable terms
- Deadline - deadline for deliverables
- Good Guy/ Bad Guy - one friendly, one aggressive
- Missing Man - decision maker is missing
- Limited Authority - not given authority
- Fair and Reasonable - what is fair?
- Unreasonable - making unreasonable demands

- Delay - esp in critical moments
- Attack - force compliance
- Agreement is legally binding and should include (PM should NOT attempt to write the agreement): statement of work, schedule baseline, performance reporting, period of performance, roles and responsibilities, warranty, payment terms, fees and retainers, incentives, liability, penalties, etc.

Control Procurements

- performed by both seller and buyer
- manage procurement relationships, monitor contract performance, make change and corrections
- the procurement administrator may be **external** to the project team
- may identify early signs and capture details for pre-mature termination of contract
- the claims administration process deals with changes/disputes, disputes is **best to be settled through negotiation > ADR**
- may need Alternative Dispute Resolution (ADR) by 3rd parties in case disputes cannot be settled
- For **Fixed Price** contracts, look out for **Bait and Switch** (replace with cheaper materials), look out for excessive change requests
- For **Cost Reimbursable** contracts, audit all invoices, look out for additional charges, tie payment to milestones, make sure people with the required skill sets are doing the job
- For **Time and Materials** contracts, ensure hours are not padded, follow the milestone dates
- Contract Change Control System: for handling change requests (define who has the authority to approve changes (usually **not the PM, but may be assigned the authority**))
- Work performance data includes: the cost incurred and the invoice needs to be paid
- OPA may include the seller's performance

Close Procurements

- all work are completed, deliverables accepted, claims settled OR terminated by either party
- at completion / termination of contract
- prior to administrative closure of Close Project or Phase
- unresolved claims may be left for litigation **after** closure
- settlement of claims/invoices, audit, archive, lessons learned
- the contract is complete when all the specifications are satisfied, no matter the customer is satisfied with the product or not
- **Procurement Audit** is the structured review of the procurement process from Plan Procurement Management through Control Procurements, is used to capture lessons learned from the procurement exercise
- once a procurement is cancelled, the **next process will be the close procurements**

13. Project Stakeholder Management

- stakeholders are groups/individuals who may **affect / be affected** by the project
- identify stakeholders is a continually process throughout the project lifecycle
- identify stakeholders, communicate and engage them, manage expectations and focus on satisfaction
- stakeholder satisfaction is a key project objective
- the Project Manager is responsible for the engaging and managing the various stakeholders in a project

Identify Stakeholders	Project Charter Procurement Documents Enterprise Environment Factors Organization Process Assets	Stakeholder Analysis Expert Judgement Meetings	Stakeholder Register
Plan Stakeholder Management	PM Plan Stakeholder Register Enterprise Environment Factors Organization Process Assets	Expert Judgement Meetings Analytical Techniques	Stakeholder Management Plan Project Documents Updates
Manage Stakeholder Engagement	Stakeholder Management Plan Communication Management Plan Change Log Organization Process Assets	Communication Methods Interpersonal Skills Management Skills	Issue Log Change Requests PM Plan Updates Project Document Updates OPA Updates
Control Stakeholder Engagement	PM Plan Issue Log Work Performance Data Project Documents	Information Management Systems Expert Judgement Meetings	Work Performance Information Change Requests PM Plan Updates Project Document Updates OPA Updates

Identify Stakeholders

- identify stakeholders and document their importance/influence (=**active involvement** /**impact**/interest/involvement)
- 3 'I's: importance, interest, influence
- stakeholders from **operation** process needed to be included
- determine the stakeholders' hot buttons (what response in specific situations) and develop support strategies
- procurement documents are used for determining external stakeholders such as the seller
- stakeholders have the **greatest influence in the initial stage** of the project
- stakeholder analysis matrix is part of the stakeholder management strategy (output of identify stakeholders)

- **Salience Model:** describing stakeholders based on the **power (influence), urgency and legitimacy**
- **document only influential stakeholders** if there is a large number of stakeholders
- document the impact using a power/influence grid, power/interest grid, influence/impact grid, salience model (stakeholders are classified as "**Monitor**" (**low influence, low power**), "**Keep Satisfied**" (**low influence, high power**), "**Keep Informed**" (**high influence, low power**) and "**Manage Closely**" (**high influence, high power**))
- the Stakeholder Register contains the name, position, role, classification, impact, influence, etc.of the stakeholder

Plan Stakeholder Management

- **management strategies** to engage stakeholders throughout project lifecycle
- Stakeholder Management Plan contains: current/desired engagement levels, scope and impact to stakeholders, interrelationships, communication requirements and forms, how to update the plan
- The distribution of this plan requires precautions as the engagement level of stakeholders is a very sensitive information
- Engagement Level
- **Unaware**
- **Resistant:** resistant to change
- **Neutral**
- **Supportive:** supportive of change
- **Leading:** actively engaged for project success
- **Stakeholder Engagement Assessment Matrix** documents the current level and desired level of engagement of stakeholders

Manage Stakeholder Engagement

- aim: **increase support and minimize resistance** from stakeholders by addressing issues
- the communication requirements of individual stakeholder are recorded in the Project Communication Plan
- PM may call upon sponsor for assistance
- communicate and work with stakeholders to meet their needs/expectations and address issues
- build trust and resolve conflicts, negotiation skills, communication skills
- need to communicate bad news/issues in a timely manner
- **feedback from stakeholders is stored in OPA**
- the Issue Log (Action Item Log): to identify issues/define impacts, **owner (most important element)** and priority/with due date

Control Stakeholder Engagement

- monitor overall stakeholder relationships and adjusting strategies

14. Professional and Social Responsibility

Responsibility

- in the best interest of the society, public and environment
- accept assignments **consistent** with skills and fulfill commitments
- accept stretch assignment when the assigner is fully aware of the skill gaps
- own error and make corrections
- uphold laws and regulations
- report illegal/unethical activities substantiated with facts
- ask for direction should the decision is beyond assigned authority

Respect

- show respect to others
- listen and understand others
- conduct in a professional manner, even if not reciprocated
- resolve conflicts directly
- negotiate in good faith
- do not influence others for personal benefits
- respect others rights

Fairness

- transparency in decision making
- be objective
- provide **equal** access to information, equal opportunities
- disclose any conflict of interests and refrain from making decisions in case of conflict of interest
- do not deny opportunities base on personal considerations
- do not discriminate
- apply rules without favoritism or prejudice

Honesty

- understand the truth and be truthful
- honour commitments
- not to deceive others
- not engage in dishonest behavior for personal gain / at the expense of others

A. PMP Formulas

Name (Abbreviation)	Formula	Interpretation
No. of Communication Channels	$n(n-1)/2$	<p>n should include the project manager</p> <p>e.g. if the no. of team members increase from 4 to 5, the increase in communication channels:</p> $5(5-1)/2 - 4(4-1)/2 = 4$
Schedule Performance Index (SPI)	$\text{SPI} = \text{EV}/\text{PV}$	<p>< 1 behind schedule</p> <p>$= 1$ on schedule</p> <p>> 1 ahead of schedule</p> <p>EV = Earned Value</p> <p>PV = Planned Value</p>
Cost Performance Index (CPI)	$\text{CPI} = \text{EV}/\text{AC}$	<p>< 1 Over budget</p> <p>$= 1$ On budget</p> <p>> 1 Under budget</p> <p>sometimes the term 'cumulative CPI' would be shown, which actually is the CPI up to that moment</p>
Schedule Variance (SV)	$\text{SV} = \text{EV} - \text{PV}$	<p>< 0 Behind schedule</p> <p>$= 0$ On schedule</p> <p>> 0 Ahead of schedule</p> <p>EV = Earned Value</p>

PV = Planned Value

**Cost Variance
(CV)**

$$\mathbf{CV} = \mathbf{EV} - \mathbf{AC}$$

< 0 Over **budget**
= 0 On budget
> 0 Budget
budget

EV = Earned Value

AC = Actual Cost

**Estimate at
Completion
(EAC) if original
is flawed**

$$\mathbf{EAC} = \mathbf{AC} + \mathbf{New ETC}$$

if the original
estimate is based
on wrong
data/assumptions
or circumstances
have changed

AC = Actual Cost

New ETC = New Estimate to
Completion

**Estimate at
Completion
(EAC) if BAC
remains the
same**

$$\mathbf{EAC} = \mathbf{AC} + \mathbf{BAC} - \mathbf{EV}$$

the variance is
caused by a one-
time event and is
not likely to happen
again

AC = Actual Cost

BAC = Budget at completion

EV = Earned Value

**Estimate at
Completion
(EAC) if CPI
remains the
same**

$$\mathbf{EAC} = \mathbf{BAC/CPI}$$

if the CPI would
remain the same till
end of project, i.e.
the original
estimation is not
accurate

BAC = Budget at completion

CPI = Cost performance index

Estimate at Completion (EAC) if substandard performance continues

$$\mathbf{EAC = AC + (BAC - EV)/(CPI*SPI)}$$

use when the question gives all the values (AC, BAC, EV, CPI and SPI), otherwise, this formula is not likely to be used

AC = Actual Cost

BAC = Budget at completion

EV = Earned Value

CPI = Cost Performance Index

SPI = Schedule Performance
Index

To-Complete Performance Index (TCPI)

$$\mathbf{TCPI = (BAC - EV) / (BAC - AC)}$$

< 1 Under budget
= 1 On budget
> 1 Over budget

BAC = Budget at completion

EV = Earned value

AC = Actual Cost

$$\mathbf{TCPI = \frac{\text{Remaining Work}}{\text{Remaining Funds}}}$$

BAC = Budget at completion

EV = Earned value

CPI = Cost performance index

Estimate to Completion

$$\text{ETC} = \text{EAC} - \text{AC}$$

EAC = Estimate at Completion

AC = Actual Cost

Variance at Completion

$$\text{VAC} = \text{BAC} - \text{EAC}$$

< 0 Under budget

= 0 On budget

> 0 Over budget

BAC = Budget at completion

EAC = Estimate at Completion

PERT Estimation

$$(\text{O} + 4\text{M} + \text{P})/6$$

O= Optimistic estimate

M= Most Likely estimate

P= Pessimistic estimate

Standard Deviation

$$(\text{P} - \text{O})/6$$

this is a rough estimate for the standard deviation

O= Optimistic estimate

P= Pessimistic estimate

Float/Slack

LS – ES

= 0 On critical path

< 0 Behind schedule

LS = Late start

ES = Early start

LF – EF

LF = Late finish

EF = Early finish

B. Last Minutes Revision Notes

1. The **contract** between the organization and the vendor supercedes all other work related documents
2. Document **analysis** (collect requirements) vs Document **review** (identify risks)
3. Customers, internal or external, are the most important stakeholders in a project, decisions are made in favor of the customers
4. Project managers manage things, but lead people.
5. Each resource in the project must be accounted for and assigned to a cost category. Categories include the following: Labor costs, Material costs, Travel costs, Supplies, Hardware costs, Software costs, Special categories (inflation, cost reserve, and so on)
6. Five different approaches to conflict resolution:
 - * Withdrawing/Avoiding - Retreating
 - * Smoothing/Accommodating - Emphasizing on agreements than disagreements
 - * Compromising
 - * Forcing – Pushing one's viewpoint
 - * Collaborating – Incorporating multiple view points and driving consensus
 - * Confronting/Problem Solving – Head on with give-and-take policy and open dialogue
7. **Confronting (Problem Solving)** is the **best** problem-solving technique since it meets the problem directly
8. Conflict should be addressed early and usually in private, using a direct, collaborative approach
9. When a project is performed under contract, the contract can serve as the project charter
10. Philip Crosby devised the zero defects theory, meaning do it right the first time. Proper Quality Planning leads to less rework and higher productivity
11. Joseph M. Juran is noted for his fitness for use premise. Simply put, this means the stakeholders' and customers' expectations are met or exceeded.
12. W. Edwards Deming suggested that as much as 85 percent of the cost of quality is a management problem
13. Shewhart = Plan-Do-Check-Act cycle.
14. Organization, Environmental & external assumptions should be addressed by the Project Charter
15. Project Manager must consider "cultural differences" while deciding upon recognition and rewards during team development.
16. Technical inability and poor risk management by the contractor is mostly the reason for the project not to meet the customer expectations
17. Cost Of Quality (COQ) are the cost types in modern quality management: "Prevention Costs", "appraisal costs" & "failure costs", **Internal failure costs** – Failures found by the project team, **External failure costs** – Failures found by the customer (including warranty)
18. Face-to-face meetings are the most effective means for communicating and resolving issues with stakeholders.
19. Detailed Tasks are detailed in "Project Schedule", which is part of Project Plan and note its NOT WBS. **WBS is a "deliverable oriented document"**
20. A '**Planning Package**' is a WBS component below the control account but above the work package. It is used for planning unknown work content that does not have detailed schedule activities
21. Control account Plan (CAP) is a management control point where the integration of scope, budget and schedule take place and where the measurement of performance takes place. These CAPS are placed at the selected management points in the WBS.
22. In decision tree, a circle is a chance, a square is a decision
23. Reporting formats: - Forecast Report (what is expected to happen on a project),-

- Progress Report (what happened since the last report),- Status Report (state of the project at the current time),- Earned Value Report (focuses on Earned Value Management),- Variance Report (what happened vs. what should have happened).
24. The Project Manager ultimately has the responsibility for the Product of the Project and Senior Management is responsible for the Quality of entire Organization
 25. Product analysis includes techniques such as value engineering, value analysis, systems analysis, systems engineering, product breakdown, and functional analysis
 26. The introduction of a new team member will start the formation and development of the team all over again with the forming stage
 27. **Fait accompli** is a tactic used during contract negotiations where one party convinces the other that the particular issue is no longer relevant or cannot be changed
 28. Understand for the exam that configuration management involves - identifying the physical characteristics of the product, service, or result of the project (or its individual components); - controlling changes to those characteristics; and - Documenting changes to verify that requirements are met.
 29. Control process - Configuration identification, - Configuration status accounting and - Configuration verification and auditing
 30. Integrated Change Control, Schedule Control, and Cost Control are all concerned with three issues: - **influencing the things that cause change**, - determining that change is needed or has happened, - and managing the change
 31. Change control systems are documented procedures that describe - How to submit change requests. - They track the status of the change requests, - document the management impacts of change, - track the change approval status, and - define the level of authority needed to approve changes.
 32. Workarounds are unplanned responses. Workarounds deal with negative risk events as they occur.
 33. Close Project - Collecting project documents, - Disseminating final acceptance notice, - Documenting lessons learned, - Archiving project records, - Release resources, - Formal closure
 34. **Hammocks** are summary-level activities or aggregate activities shown as a summary activity on a project schedule network diagram.
 35. "Quality Function Deployment Process" identifies what the customer's needs are (Spoken/unspoken words) and translates those needs into technical requirements. Appropriate for each stage of the product development life cycle
 36. When distributing information, the total message impact from the sender is 7% words, 38% vocal tones and 55% body language
 37. Decision Trees are considered Quantitative while Influence diagram are considered Qualitative.
 38. Influence diagram shows the dependencies among the variables more clearly than the decision tree
 39. A "Bill of Material" (BOM) describes the product in terms of its assemblies, sub-assemblies and basic parts
 40. Project manager must possess following **interpersonal skills**
 1. Leadership
 2. Team building
 3. Motivation
 4. Communication
 5. Influencing
 6. Decision making
 7. Political and cultural awareness and
 8. Negotiation
- Ten most important skills and competencies for Project Managers
1. People skills
 2. Leadership
 3. Listening

4. Integrity, ethical behavior, consistent
 5. Strong at building trust
 6. Verbal communication
 7. Strong at building teams
 8. Conflict resolution, conflict management
 9. Critical thinking, problem solving
 10. Understands, balances priorities
41. **Workarounds** are unplanned responses. Workarounds deal with negative risk events as they occur. As the name implies, workarounds were not previously known to the project team. The risk event was unplanned, so no contingency plan existed to deal with the risk event.
42. **Risk Response**
- Threats**
- Avoid – remove the cause of the risk so that it never materializes
 - Mitigate – reduce the probability and or impact of the risk
 - Transfer – transfer the risk to another party; usually done with insurance and warranties, etc.
- Opportunities**
- Exploit – **make sure** the opportunity occurs, you can add work or make a change to the project
 - Enhance – increase the probability and or positive impact of the risk
 - Share – share the opportunity with a third party to be able to take advantage of the opportunity