PMBOK®

Summarized

ABSTRACT
A Remarkably Concise Summary of the PMBOK® 5th Edition

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Introduction to *PMBOK® Summarized*

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This eBook is my attempt to summarize the Project Management Body of Knowledge (PMBOK) 5th Edition in preparation for the PMP® exam.

As it stands, all of the 47 processes have been summarized. However, I still need to backfill the sections on projects, programs, the organization and ethics.

Since this summary draws so heavily on the PMBOK®, a lot of the language may be similar. I attempted to paraphrase but, if the wording looks too similar, the original is most definitely in the Body of Knowledge. The diagrams are all copied from the PMBOK® so those certainly cannot be passed off as my own.

As a summary, this eBook is a study aide and should be used in conjunction with other material. That includes the PMBOK® itself and whatever other books or online resources work best for you. To keep it short, a certain level of knowledge is assumed on the reader's part. Therefore, it is a pretty bad place to start if you are looking for an introduction to Project Management.

The eBook is a work in progress and will be finished when I take the exam or lose interest, whichever comes sooner (*Update: I passed the exam but I will keep working on the eBook until it's perfect or lose interest, whichever comes sooner*).

The book is free to use and reproduce, with attribution, under the Creative Commons license. However, PMBOK® and PMP® are registered trademarks. I am sure the owners of those, the Project Management Institute (PMI), are very fussy about how they are used. The image on the cover was painted by Pieter Bruegel the Elder in 1568, and is called *The Blind Leading the Blind*. Read in to that what you will.

In the meantime, good luck with your PMP® exam and please feel free to give me your feedback.

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Project Management

The PMBOK® definition of a project is “a temporary endeavor undertaken to create a unique product, service or result.” That means a project has a definite beginning and end. It can end by reaching its goals or get terminated. Temporary is not necessarily short. Projects can last for years. The project’s outputs, meanwhile, are not necessarily temporary. They can last for hundreds of years.

Program: A group of related projects or other (sub)programs to get better results than managing them individually.

Portfolio: A collection of projects, operations, programs, other portfolios and *operations* to meet strategic goals.

Organizational Project Management (OPM): Strategy execution framework using project, program, portolio and organizational enabling practices.

A **Project Management Office** (PMO) standardizes an organization’s project governance. It can be: Supportive, Controlling or Directive. It coordinates projects to meet the organization’s strategic objectives. It manages shared resources, coaches and mentors, identifies and implements best practices, etc.

Organizational Structures can be functional, projectized or matrix (a hybrid). A company with a *weak matrix* is most like a functional organization where the Project Manager is more coordinator or expediter. A *balanced matrix* acknowledges the need for a PM but they still do not have full authority. *Strong matrixes* are most like a projectized organization where the PM is full time and has considerable authority.

Initiating Process Group

Project Integration Management Knowledge Area

Develop Project Charter

The project kicks off with Develop Project Charter. This is the process that develops a document that formally authorizes the project and gives the Project Manager (PM) authority to use organizational resources. The key benefit is that we get a well-defined project start, an official record, and a way for senior management to formally commit to the project. For external projects, a contract takes the place of a charter.

A PM is assigned as early as possible — preferably while the charter is being developed and always before planning starts. The charter should be written by the sponsor. Projects are initiated by those external to the project e.g. sponsor or PMO.

Inputs	Tools & Techniques	Outputs
1. Project SOW 2. Business case 3. Agreements 4. Enterprise Environmental Factors 5. Organizational Process Assets	1. Expert judgment 2. Facilitation techniques	1. Project charter

Develop Project Charter Inputs, Tools & Techniques, and Outputs (ITTO)

Inputs, tools and techniques, and outputs (ITTO) to the Develop Project Charter process start with the project statement of work (SOW). This is a narrative description of the products, services or results expected of the project. The SOW draws on the business need, the product scope description and the organization's strategic plan.

Other inputs include agreements, which can be contracts SLAs, etc.; enterprise environmental factors (EEF from now on); and organizational process assets (OPA).

Tools and techniques used to develop the project charter include expert judgment and facilitation techniques. The former can come from stakeholders, consultants, elsewhere in the company, industry groups, etc.

The sole **output** from this process is the project charter itself. It is still very early in the process, but the charter should have project summary and high-level information. This includes things like the project's purpose, measurable project objectives, high-level requirements, assumptions and constraints, high-level risks, project approval requirements and a stakeholder list amongst other items.

Project Stakeholder Management Knowledge Area

Identify Stakeholders

This process identifies anyone who could impact or be impacted by the project. Perceptions count, too. If they think they will be affected, then they are stakeholders. By *project*, we mean anything at all related to the work in hand e.g. decisions, outcomes, activities, etc.

Inputs	Tools & Techniques	Outputs
1. Project charter 2. Procurement docs 3. EEF 4. OPA	1. Stakeholder analysis 2. Expert judgment 3. Meetings	1. Stakeholder register

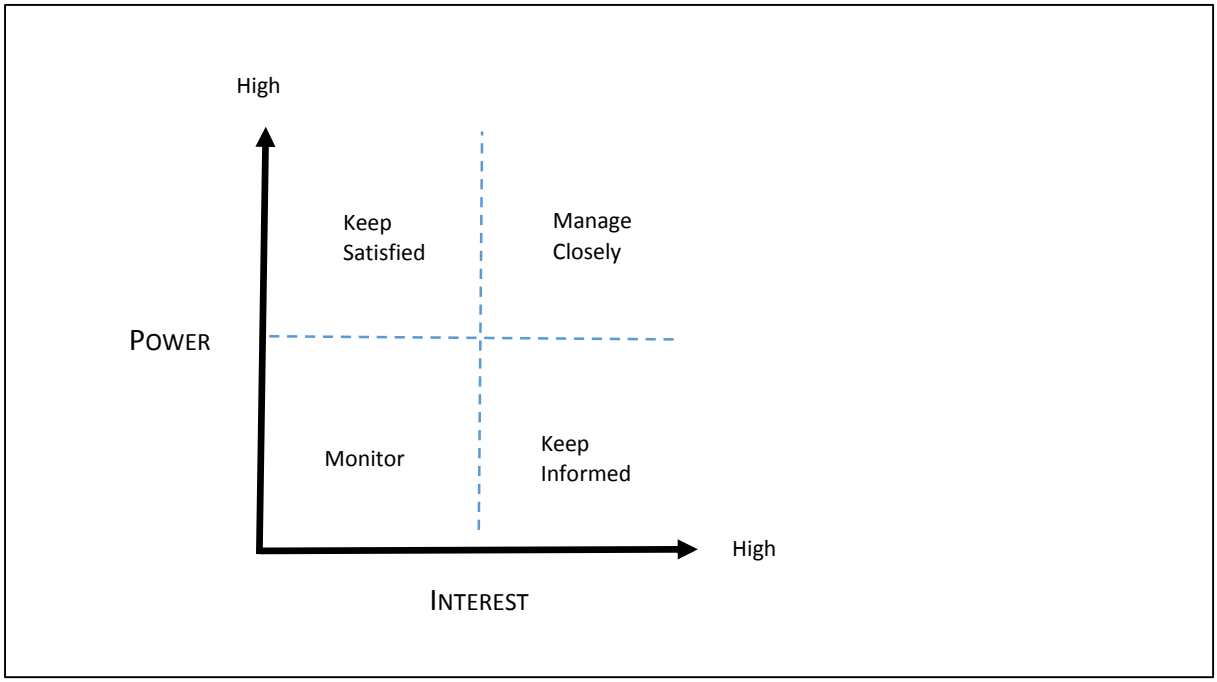
Identify Stakeholders ITTO

It is critical to identify and analyze stakeholders early in the project — hence its inclusion in the Initiating Process Group.

Inputs include the project charter just completed; procurement documents since outside contractors or suppliers are key stakeholders; EEFs and OPAs.

Tools and techniques meetings and expert judgment. It also includes stakeholder analysis, a systematic technique used to identify, and then classify, stakeholders according to roles, expectations, interest and influence on the project.

There are a number of classification models, but the easiest way is probably to draw a 2x2 grid of Power v Interest.



Stakeholder Power/Interest grid

To ensure as comprehensive an identification of stakeholders is drawn up, expert judgment can come from senior management, already identified stakeholders, subject matter experts, PMs who have worked on similar projects, etc. Meetings can also be useful.

The **output** from the Identify Stakeholder process is the stakeholder register. This has identification data such as name, position, locations, project role and contact details; assessment information like main requirements and expectations, potential influence, phase with the most interest; and stakeholder classification such as supporter/neutral/against, internal/external, etc.

The register is updated and consulted regularly as stakeholders change or get identified throughout the project.

Planning Process Group

Project Integration Management Knowledge Area

Develop Project Management Plan

With initiation complete, it is time to start planning the project. This is a huge process group because it contains 24 of the 47 processes.

Falling within the Project Integration Management knowledge area (first of 10), Develop PM Plan is basically the process of developing all your subsidiary plans and integrating them. This Project Management Plan defines the basis of all project work.

Inputs	Tools & Techniques	Outputs
1. Project Charter 2. Outputs from other processes 3. EEF 4. OPA	1. Expert judgment 2. Facilitation techniques	1. Project Management Plan

Develop Project Management Plan ITTO

Inputs include the project charter, enterprise environmental factors and organizational process assets. They also include outputs from other processes such as management plans for HR, Cost, Communications, Risk, etc., etc. Looking at each of those plans, you will see one of their inputs is the Project Management Plan. Clearly this is an iterative process.

Tools and techniques include expert judgment to tailor the process to meet project needs, determine resources and skills required and prioritize work. Another tool is facilitation techniques.

The single output is the Project Management Plan itself. It integrates all subsidiary plans and baselines, and lays out how the project will be executed, monitored and controlled. In addition to the feeder plans, the PM Plan could have the project life cycle, stakeholder communication, change and configuration plans among other items.

PM Plans can have different levels of details depending on the project. Once it is baselined, it may only be changed once a change request is generated and approved.

Project Scope Management Knowledge Area

Plan Scope Management

Inputs	Tools & Techniques	Outputs
1. Project Management Plan 2. Project Charter 3. EEF 4. OPA	1. Expert judgment 2. Meetings	1. Scope Management Plan 2. Requirements Mgmt Plan

Plan Scope Management ITTO

One of the first processes to tackle is Plan Scope Management. It will be the first of four scope processes that take part early in the project. Plan Scope Management lays out how we define, validate and control the project's scope. It is an input to the Project Management Plan which, in turn, inputs in to the Scope Management Plan. The main goal here is to avoid scope creep.

Inputs have already been described elsewhere as have tools and techniques. As expected, an output is the Scope Management Plan itself. This tells how the scope will be defined, developed, monitored, controlled and verified. It is a major contributor to other processes. Elements of this plan could include processes for creation and maintenance of the work breakdown structure (WBS), formal acceptance of deliverables, etc.

Another output is the Requirements Management Plan which does what it says on the tin. It can include the way requirements will be planned and monitored; configuration management; a prioritization process; product metrics, etc.

Collect Requirements

This is finding out, recording and managing the stakeholders' needs for the project. It forms the basis for managing the project's scope. It's hugely important, and, if the PM hasn't been out and about much by now, he or she will be meeting a lot of people very soon. The project's success depends on getting requirements from engaged stakeholders. Requirements need to be in enough detail to become the basis of the WBS. Cost, schedule and procurement decisions are all influenced by requirements.

They can be broken down in to business (from stakeholders) and technical (how the project will be implemented). Or, they can go in to more detail in extra categories such as solution, transition, project and quality.

Inputs	Tools & Techniques	Outputs
1. Scope Management Plan 2. Requirements Mgmt Plan 3. Stakeholder Mgmt Plan 4. Project charter 5. Stakeholder register	1. Interviews 2. Focus groups 3. Facilitated workshops 4. Group creativity techniques 5. Group decision-making techniques 6. Questionnaires/surveys 7. Observations 8. Prototypes 9. Benchmarking 10. Context diagrams 11. Document analysis	1. Requirements documentation 2. Requirements traceability matrix

Collect Requirements ITTO

Inputs include the Scope Management and Requirements Management Plans from the previous section, Plan Scope Management. Another input is the Stakeholder Management Plan, a key component given the importance of stakeholders' input to requirements management. The Project Charter and Stakeholder Register are two other inputs.

There are 11 **tools and techniques** used to collect requirements. Interviews can be formal or informal with both prepared and spontaneous questions. Normally one-on-one, they can have multiple parties. Focus groups bring stakeholders and subject matter experts together. Facilitated workshops are seen as way to get key stakeholders together to quickly define cross-functional requirements or settle stakeholder differences.

Joint application design/development (JAD) are workshops used in software. Quality function deployment (QFD) can help elicit critical requirements.

Group creativity techniques include things like brainstorming, mind or idea mapping and multi-criteria decision analysis. Group decision-making techniques can be subject to procedures such as unanimity, majority, plurality (when there are more than two options) and dictatorship, which is hardly a group technique. But there you have it.

Questionnaires and surveys help gather information from large groups. Observations, or job shadowing, helps with detailed processes or getting details from reluctant stakeholders. Prototypes help get early feedback on the proposed solution. It is part of a process of progressive elaboration.

Benchmarking compares to comparable organizations. Context diagrams draw out the product scope in a business system and how actors interact with it. Document analysis means trawling through agreements, marketing literature, business plans, etc.

The first **output** is requirements documentation. Requirements need to be unambiguous and meet business needs. They should also be measureable and traceable.

The second output is the requirements traceability matrix. This is a grid that tracks requirements from start to deliverable. It also adds value by linking requirements to business and project objectives.

Define Scope

Inputs	Tools & Techniques	Outputs
1. Scope Management Plan 2. Project charter 3. Requirements documentation 4. OPA	1. Expert judgment 2. Product analysis 3. Alternatives generation 4. Facilitated workshops	1. Project Scope Statement 2. Project documents updates

Define Scope ITTO

We now write a detailed description of both product and project. This helps define boundaries by saying what is in and out. This is because all of the requirements just collected may not be included in the project. A detailed project scope statement is critical to project success. It can be iterative.

Inputs include the Scope Management Plan and Requirements Documentation developed in the preceding two steps. The Project Charter is also an input as are organizational process assets.

Tools and techniques include expert judgment that draws on consultants, other business units and professional associations. It's not just your judgment, in other words. Product analysis can be useful where a physical deliverable is involved. This technique includes product breakdown, systems analysis and systems engineering.

Alternatives generation is where as many options as possible are identified. The final tool is facilitated workshops.

The first **output** of Define Scope is the Project Scope Statement. It describes in detail the scope, major deliverables, assumptions and constraints. It pertains to the entire scope. The scope may also explicitly exclude certain work and can therefore help manage expectations.

The Project Scope Statement is different than the Project Charter because it contains more detail and is continuously updated throughout the project.

The second output is project document updates to the stakeholder register, requirements documentation, etc., etc.

Create WBS

This is where we break project work in to smaller, more manageable pieces. For **inputs**, the Create WBS process draws heavily on the previous three outputs: scope management plan, project scope statement and requirements documents. The WBS is hierarchical and covers the work in the current scope statement.

The lowest WBS levels are work packages. When we talk about *work* in the WBS, we mean products or deliverables as distinct from activities. The WBS represents project work. The total at the lowest levels rolls up to the higher levels so that nothing is left out and nothing extra is done – the 100% Rule.

Inputs	Tools & Techniques	Outputs
1. Scope Management Plan 2. Project scope statement 3. Requirements documentation 4. EEF 5. OPA	1. Decomposition 2. Expert judgment	1. Scope Baseline 2. Project documents updates

Create WBS ITTO

One of the key WBS **tools and techniques** is decomposition which divides and subdivides deliverables into manageable pieces. The level this is done to depends on the level of control needed for effective project management.

Expert judgment, meanwhile, can help analyse information. It can also come as templates that provide guidance on decomposition.

A WBS can be shown: Using phases of the project; using major deliverables; or by incorporating subcomponents. Excessive decomposition can waste management time. It may not be possible for deliverables far in the future.

Outputs include Project Document Updates and the Scope Baseline. This is the approved scope statement, WBS and WBS Dictionary. The latter contains detailed deliverable, schedule and activity about each WBS component.

Project Time Management Knowledge Area

Plan Schedule Management

Scoping activities complete for now (it's iterative, after all), we move in to Time Management. First up is Plan Schedule Management, the process of planning how to manage and control the project's schedule. Which is to say, read "plan" as a noun, not a verb, if you get my drift.

Inputs	Tools & Techniques	Outputs
1. Project Management Plan 2. Project charter 3. EEF 4. OPA	1. Expert judgment 2. Analytical techniques 3. Meetings	1. Schedule management plan

Plan Schedule Management ITTO

Tools and techniques include expert judgment, meetings and analytical techniques. The last are strategic options to estimate the project. They can be methodologies, tools or software.

The **output** is the Schedule Management Plan (SMP), which is a major input to the Project Management Plan, which in turn, feeds back to the SMP during iteration. There is wide scope for levels of detail and formality on the SMP. But it should address schedule contingencies.

The SMP can lay out levels of accuracy for activity estimations; units of measure e.g. hours or days; the process used to update project progress; control thresholds; reporting formats; and rules of performance measurement.

Define Activities

Inputs	Tools & Techniques	Outputs
1. Schedule Management Plan 2. Scope baseline 3. EEF 4. OPA	1. Decomposition 2. Rolling wave planning 3. Expert judgment	1. Activity list 2. Activity attributes 3. Milestone list

Define Activities ITTO

Now we identify the activities needed to produce deliverables. We do this by breaking down the work packages so we can estimate and control the project work.

Inputs include the Schedule Management Plan just developed in the previous section. The level of detail there is a key factor. The other inputs were covered earlier.

Tools and techniques include decomposition where *activities* show the effort required to finish a work package. Our outputs here are *activities* as distinct from deliverables in Create WBS. WBS and Activity List can be done in parallel or in sequence but the WBS and its dictionary form the basis for the final Activity List.

Another T&T is rolling wave planning, a form of progressive elaboration and an iterative technique where near-term work is planned in detail but long-term planning is left at high level.

Outputs are the Activity List, a comprehensive list of all the project's schedule activities. It must be in sufficient detail that all team members understand the work. Each activity should have a unique title. Activity Attributes have codes, descriptions, predecessor and successor activities, relationships, lags, etc. They can also identify the person responsible for the work. Unlike activities, which span time, Milestones are significant events in the project. They can be mandatory or optional.

Sequence Activities

We now take our activities and document the relationships among them. This drives project efficiency by outlining a logical sequence of work. All activities and milestones must be connected.

Inputs	Tools & Techniques	Outputs
1. Schedule Management Plan 2. Activity list 3. Activity attributes 4. Milestone list 5. Project scope statement 6. EEF 7. OPA	1. Precedence diagraming method 2. Dependency determination 3. Leads and lags	1. Project schedule network diagrams 2. Project documents updates

Define Activities ITTO

Predecessor connections are with a logical finish-to-start tie, while successors have a logical finish-to-start or finish-to-finish connection.

Inputs come from the preceding processes. We take the activity list, activity attributes and milestone list from Define Activities. The schedule management plan is from the process with the (almost) same name. The project scope statement also feeds in.

Tools and techniques start with the Precedence Diagraming Method (PDM), a technique to graphically model activity sequences. Activity-on-node (AON) is the method used by most PM software. There are four types of PDM dependencies:

- Finish-to-start (FS). Successor cannot start until predecessor has finished. Most common.

- Finish-to-finish (FF). Successor cannot finish until predecessor has finished.
- Start-to-start (SS). Successor cannot start until predecessor has started.
- Start-to-finish (SF). Successor cannot finish until predecessor has started.

The second T&T is Dependency Determination, where they are classified as mandatory/discretionary and internal/external. Mandatory dependencies are also called *hard logic* or *hard dependencies*. Discretionary ones are soft. The project team will make these determinations.

Another very important T&T is the concept of Leads and Lags. A lead is the amount of time a successor can advance with respect to completion of the predecessor in an FS situation. A lag is the time a successor can wait after the start of a predecessor in an SS situation.

Outputs include project document updates and Project Schedule Network Diagrams. This is a diagram showing dependencies.

Estimate Activity Resources

Inputs	Tools & Techniques	Outputs
1. Schedule Management Plan 2. Activity list 3. Activity attributes 4. Resource calendars 5. Risk register 6. Activity cost estimates 7. EEF 8. OPA	1. Expert judgment 2. Alternative analysis 3. Published estimating data 4. Bottom-up estimating 5. PM software	1. Activity resource requirements 2. Resource breakdown structure 3. Project documents updates

Estimate Activity Resources ITTO

This process does what it says on the tin and works closely with the Estimate Costs process.

Inputs include schedule management plan, the activity list, activity attributes and activity cost estimates, the risk register, EEF and OPA. A resource calendar lists working days/shift when people, equipment or material are available. It can include attributes such as skill levels, location, etc.

Tools and techniques include expert judgment and alternative analysis. Published estimating data refers to production rates, unit costs in labor trades in different locations. Bottom-up estimating relies on lower-level components of the WBS.

Outputs are activity resource requirements. The level of detail can vary, and it can include the basis for estimation and assumptions. Another output is the resource breakdown structure, which is a hierarchy of resources and type. It is often a basis for report utilization reports. Finally, there are project document updates.

Estimate Activity Durations

This is where we attempt to gauge how long the work will take, and it is a key input to the upcoming Develop Schedule process.

Inputs	Tools & Techniques	Outputs
1. Schedule Management Plan 2. Activity list 3. Activity attributes 4. Activity resource requirements 5. Resource calendars 6. Project scope statement 7. Risk register 8. Resource breakdown structure 9. EEF 10. OPA	1. Expert judgment 2. Analogous estimating 3. Parametric estimating 4. Three-point estimating 5. Group decision making 6. Reserve analysis	1. Activity duration estimates 2. Project documents updates

Estimate Activity Durations ITTO

This process has many **inputs** (all covered earlier). It is progressively elaborated considering the quality and availability of input data.

One **tools and techniques** is expert judgment. Another is analogous estimating where historical data from similar projects is used. It is often used where there is a limited amount of detailed information available. It is less time consuming, and costly, than other methods. However, it is less accurate. Parametric estimating, on the other hand, derives estimates from historical data and project parameters.

Three-point estimating takes three points to attempt to narrow in on a more accurate answer. Estimates will come from three sources and be classed as most likely (tM), optimistic (tO) and pessimistic (tP). Two different formulas — beta and triangular distributions — can be used:

- Triangular (looks suspiciously like an average): tE = (tO + tM + tP) / 3
- Beta (from PERT technique): tE = (tO + 4tM + tP) / 6

Another technique is group decision making. People involved in execution should be involved. In addition to more accurate estimates, it increases buy-in and their commitment to meeting those deadlines.

Reserve analysis is where uncertainty is accounted for by adding in extra time. As the project progresses, they may be used or discarded as more data becomes available. *Contingency reserves* are built in to the schedule baseline in an effort to handle “known unknowns.” *Management reserves*, meanwhile, are outside of that baseline and are for “unknown unknowns.”

Outputs are Activity Duration Estimates. These are numerical, and do not include lags. They may be qualified by being bracked in a +/- range of days, or be given with probabilities of accuracy.

Develop Schedule

My opinion only, but this is where the rubber hits the road. Develop Schedule is where we generate a schedule model with planned dates for project activities. This is an iterative process with dates subject to review and revision until we zero in on a more realistic schedule.

There are a lot of **inputs**. These include the schedule management plan, activity list, attributes and resource requirements, project schedule network diagrams, resource calendars, activity duration estimates, project scope statement, resource breakdown structure (RBS), EEF and OPA. Two other inputs have not been reached yet in the process: the risk register and project staff assignments.

Tools and techniques are important to know both for the exam and real life. Schedule Network Analysis draws on analytical techniques such as critical path method, critical chain method and others in this section to generate a project schedule model.

Critical Path Method: Estimates minimum project duration and flexibility. It is a Schedule Network Analysis technique that calculates early start, early finish, late start and late finish for all activities. The critical path is the longest sequence of activities through the project, that is, it is the shortest possible project duration. It need not be the project schedule, but it shows how long activities will take.

Inputs	Tools & Techniques	Outputs
1. Schedule Management Plan 2. Activity list 3. Activity attributes 4. Project schedule network diagrams 5. Activity resource requirements 6. Resource calendars 7. Activity duration estimates 8. Project scope statement 9. Risk register 10. Project staff assignments 11. RBS 12. EEF 13. OPA	1. Schedule network analysis 2. Critical path method 3. Critical chain method 4. Resource optimization techniques 5. Modeling techniques 6. Leads and lags 7. Schedule compression 8. Scheduling tool	1. Schedule baseline 2. Project schedule 3. Schedule date 4. Project calendars 5. PM plan updates 6. Project documents updates

Develop Schedule ITTO

Critical Path introduces the concept of float, or the amount of time an activity may be delayed or lengthened without impacting the overall project schedule. The Critical Path, by definition, has zero

float. The Critical Path is calculated by taking a forward pass through an activity diagram and calculating starts and finishes. A backward pass will help identify floats.

Critical Chain Method lets us put buffers on any schedule path to account for uncertainties. A buffer at the end of the chain is known as the project buffer. Feeding buffers are on paths not on the critical chain. The size of these buffers should account for the level of uncertainty.

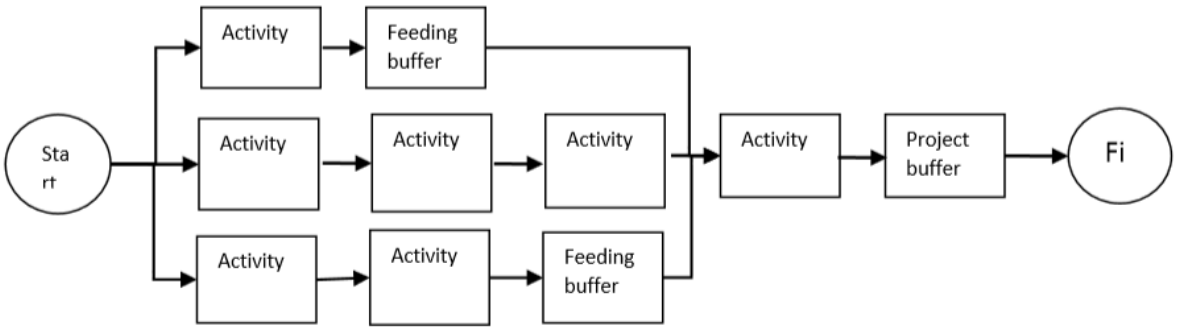


Figure 11: Example of a Critical Chain Method. Heavy line shows Critical Chain

Resource optimization techniques include:

- Resource Leveling where start and finish dates are adjusted based on demand for limited resources such as when a person is assigned to two different activities at the same time.
- Resource Smoothing is where resource requirements are held within certain predetermined levels.

Modeling Techniques include amongst others:

- What-if Scenario Analysis where effects on the schedule are sought based on asking what-if questions.
- Simulation is where multiple scenarios are plotted. This is often done using a Monte Carlo analysis.

Schedule compression techniques are used to shorten the schedule without cutting project scope.

- Crashing is where we shorten the schedule by adding resources. It only works on the critical path and may introduce risk or cost.
- Fast tracking is where phases planned in sequence are done in parallel. It also introduces risk and the possibility of rework.

Other techniques are scheduling tools, and leads and lags.

Outputs from this process are a Project Baseline, the approved version of the project schedule model. This can only be changed after this through the project's change-control procedures. The

baseline is accepted and approved by appropriate stakeholders, and is monitored constantly for variances.

Other outputs are Schedule Presentations such as Gantt charts, milestone charts or project schedule network diagrams in activity-on-node (AON) format. These diagrams should have a planned start and stop date for each activity.

Another output is Schedule Data to help describe and control the project. It should have milestones, activities and their attributes, and all identified assumptions and constraints. We also output a Project Calendar and Project Document Updates.

Project Cost Management

Plan Cost Management

Inputs	Tools & Techniques	Outputs
1. Project management plan 2. Project charger 3. EEF 4. OPA	1. Expert judgment 2. Analytical techniques 3. Meetings	1. Cost management plan

Plan Cost Management ITTO

Scope and Time Planning processes behind us, we move on. Plan cost management produces a Cost Management Plan which provides guidance on how project costs will be managed throughout the project.

Inputs include the project management plan that draws on the scope and schedule baselines among other items; the project charter; and EEFs and OPAs, especially those related to finance and market conditions.

Tools and techniques include expert judgment which can draw on historical information or expertise. Analytical techniques look at funding with equity, debt, build or buy, leasing, etc. Finally, meetings can play a large part.

The sole **output** is the Cost Management Plan itself. It can lay out: Units of measure; level of precision such as rounding; levels of accuracy such as $1,000 ± 10%; control thresholds that indicate when action should be taken; rules of performance measurement.

Estimate Costs

We now try to determine the cost of completing the project work based on what we know at a particular point in time. It is an iterative process and accuracy will increase where estimates are likely to start off with high Rough Order of Magnitude (ROM) ranges that decrease as more

information becomes available. We also look at cost alternatives such as build vs buy, and whether indirect costs should be included.

Inputs	Tools & Techniques	Outputs
1. Cost Management Plan 2. HR Management Plan 3. Scope Baseline 4. Project schedule 5. Risk register 6. EEF 7. OPA	1. Expert judgment 2. Analogous estimating 3. Parametric estimating 4. Bottom-up estimating 5. Three-point estimating 6. Reserve analysis 7. Cost of quality 8. PM software 9. Vendor bid analysis 10. Group decision making	1. Activity cost estimates 2. Basis of estimates 3. Project document updates

Estimate Costs ITTO

Inputs are the Cost Management Plan; the HR Management Plan which has not been developed at this point – hence the need for iteration; the scope baseline; project schedule; risk register which has yet to be tackled; EEF and OPA.

Tools and techniques start with expert judgment. The next four techniques — analogous, parametric, bottom-up and three-point estimating — were all used in Estimate Activity Durations. In three-point estimating, the formula is the same but written differently to account for costs rather than time:

- Triangular (looks suspiciously like an average): cE = (cO + cM + cP) / 3
- Beta (from PERT technique): cE = (cO + 4cM + cP) / 6

Other tools also used in Estimate Activity Durations are group decision making and reserve analysis. It works in the same way in that there are *contingency reserves* for "known unknowns" and *management reserves* for "unknown unknowns."

Other techniques are cost of quality, which will be explored in Plan Quality Management process; project management software, vendor bid analysis and group decision making.

Outputs including the Activity Cost Estimates, a numerical assessment of the project cost. They can be as detailed as you like. Direct labor, materials, equipment, services, IT, cost of finance are all the kind of things included. As mentioned earlier, indirect costs may also be applied. Regardless of the level of detail, a Basis of Estimates should be provided as an output.

Determine Budget

Activity costs prepared, we aggregate them to make a Cost Baseline, which is the approved version of the project budget. However, it does not include the management reserve. The relationships are shown below.

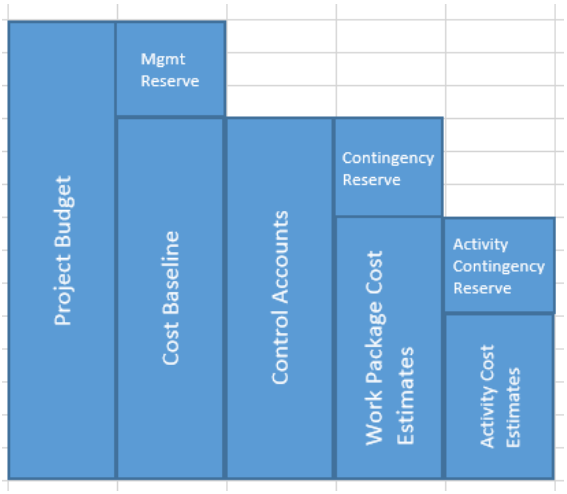


Figure 18 : Project Budget Components

Inputs include the cost management plan which determines how project costs will be managed and controlled; the scope baseline; activity cost estimates along with the basis of those estimates; the project schedule; resource calendars and the risk register, both of which we have yet to tackle; agreements and OPA.

Tools and techniques include cost aggregation; reserve analysis; expert judgment; historical relationships that can make parametric estimates more accurate; funding limit reconciliation.

The first **output** is the Cost Baseline. This is the approved version of the project budget and can only be changed via change control procedures. It is used to compare project performance against actual results. From this, we get our Project Funding Requirements. These may include the source of funding but they should lay out how often the project will be funded e.g. monthly, quarterly.

Inputs	Tools & Techniques	Outputs
1. Cost Management Plan 2. Scope Baseline 3. Activity cost estimates 4. Basis of estimates 5. Project schedule 6. Resource calendars 7. Risk register 8. Agreements 9. OPA	1. Cost aggregation 2. Reserve analysis 3. Expert judgment 4. Historical relationships 5. Funding limit reconciliation	1. Cost baseline 2. Project funding requirements 3. Project document updates

Determine Budget ITTO

Project Quality Management

Quality Management applies to all projects, and there are important risks and trade-offs when it comes quality. There is an important distinction between grade and quality.

- Quality is the degree to which we fulfil requirements
- Grade is a design issue

For example, low-grade software (limited functionality) may be of high quality (no defects) and not be a problem for the user. There are two other differences to be aware of:

- Precision is a measure of exactness
- Accuracy is how correct it is

For example, my digital clock displays 1/100ths of a second (precise). But I never adjusted for daylight savings time — now it's inaccurate.

Quality management approaches to meet ISO compatibility include:

- Customer satisfaction
- Prevention over inspection
- Continuous improvement. The plan-do-check-act cycle forms the basis of many initiatives. The names to remember here are Shewart and Deming. Some initiatives are Total Quality Management (TQM), Six Sigma and Lean Six Sigma. Process improvement models Malcolm Baldridge, Org. Project Management Maturity Model (OPM3), and Capability Maturity Model Integration.
- Management responsibility
- Cost of quality (COQ). Quality has a cost, but this can be in *conformance work* in prevention or inspection, or in *non-conformance work* in rework, repair, etc.

Plan Quality Management

This is the plan that provides guidance on how quality will be managed and validated throughout the project. Quality planning happens in parallel with other planning processes

Inputs	Tools & Techniques	Outputs
1. Project management plan 2. Stakeholder register 3. Risk register 4. Requirements documents 5. EEF 6. OPA	1. Cost-benefit analysis 2. Cost of quality 3. 7 basic quality tools 4. Benchmarking 5. Design of experiments 6. Statistical sampling 7. Additional quality planning 8. Meetings	1. Quality management plan 2. Process improvement plan 3. Quality metrics 4. Quality checklists 5. Project document updates

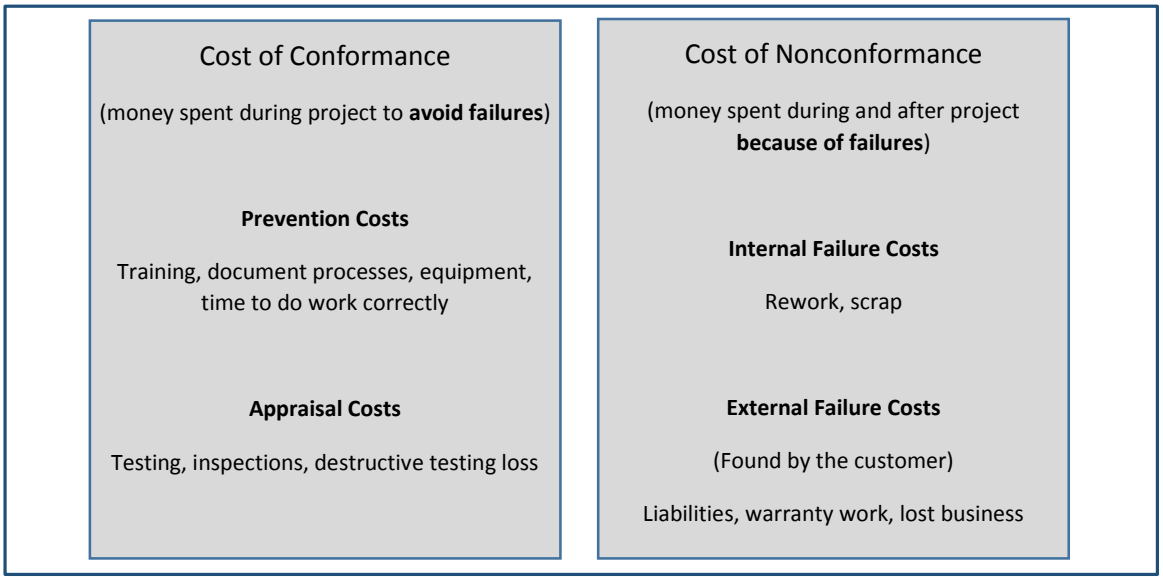
Plan Quality Management ITTO

Inputs include the project management plan, which has the scope baseline and the definition of acceptance criteria. Other inputs are the stakeholder register, risk register, requirements documents, EEF and OPA.

Tools and techniques include cost-benefit analysis and meetings. Benchmarking compares against best practices or other organizations. Statistical sampling means choosing part of a population for inspection. Other tools are brainstorming, force field analysis.

Design of Experiments is where we try to identify which factors influence variables in a process/product. All important factors are changed in an effort to optimize the product or process.

Cost of Quality is broken down below.



Cost of Quality examples

The Seven Basic Quality Tools (aka 7QC Tools) are used in the PDCA cycle.

1. Cause and effect, or Ishikawa, or fishbone, diagrams are used to trace a problem's source.
2. Flowcharts, aka process maps, may help understand and estimate the cost of quality.
3. Checksheets or tally sheets are useful in inspections.
4. Pareto diagrams are a vertical bar chart to isolate the few sources of most of a problem's effects.
5. Histograms
6. Control charts shows whether a process has stable or predictable performance. Upper and lower limits are charted.
7. Scatter diagrams, or correlation charts, show changes in dependent variables.

The first **output** is the Quality Management Plan, a component of the project management plan. It can be formal/informal, detailed or not. It outlines how quality will be implemented. Another output is the Process Improvement Plan. It includes process boundaries, metrics and configuration, and targets for improved performance. Quality Metrics may relate to time, cost control, defects, failure

rates, etc. Quality Checklists are structure tools to ensure required steps have been carried out. Simple or complex, they are often standardized within an organization.

Project Human Resource Management

Plan Human Resource Management

This involves making a staffing management plan to set up roles, responsibilities, and staff acquisition and release. It should plan for what skills are needed, and also include training, team building, rewards and recognition, compliance/safety, and the impacts on staffing elsewhere in the organization.

Inputs	Tools & Techniques	Outputs
1. Project management plan 2. Activity resource requirements 3. EEF 4. OPA	1. Org charts and position descriptions 2. Networking 3. Organizational theory 4. Expert judgment 5. Meetings	1. HR management plan

Plan Human Resource Management ITTO

Tools and techniques for developing the HR Management Plan include organization charts and position descriptions. There are different types of charts, but whichever is used, should establish unambiguously that each work package has an owner.

- Hierarchical charts can be used to show a WBS. They can also be used for a Resource Breakdown Structure (RBS) and matched with the WBS.
- Matrix-based charts include a responsibility assignment matrix (RAM). They can be at varying levels depending on project size. A RACI (responsible, accountable, consult, inform) chart is a type of RAM.
- Text formats are when detailed descriptions are needed.

Networking, inside or outside the organization, is a good way to understand people and politics. Organizational theory looks at how people and organizations behave, and how different structures may react.

The only **output** from this process is the Human Resource Management Plan. Part of the Project Management Plan already started, this can include: Roles and responsibilities; org charts; a staffing management plan that details how long people will be needed and when they will be taken on and let go.

Project Communications Management

Plan Communications Management

This is the process of making a plan on how best to engage with stakeholders. This is key to the success of any project. Communications management should take place very early, and is part of Project Management Plan development. Effective communication is using the right format at the right time for the right people to get the right impact. Effective communication is providing just the information that is needed.

Inputs	Tools & Techniques	Outputs
1. Project management plan2. Stakeholder register3. EEF4. OPA	1. Communication requirements analysis2. Communication tech3. Communication models4. Communication methods5. Meetings	1. Communication management plan2. Project document updates

Plan Communications Management ITTO

Other communications considerations involve confidentiality, information storage, formats of storage, and language and time differences.

Tools and techniques start with a communication requirements analysis that looks at the information needs of stakeholders combined with a review of the value of that information. Only communication that contributes to the success of the project should be done.

The PM should also look at how many communications channels open up as the amount of stakeholders increases. The formula here, where stakeholders are *n*, is:

- ✓ Total channels = n (n-1) / 2

The following can help define communications requirements: org charts; stakeholder responsibility relationships; logistics on who and where stakeholders work.

Communication technology can be influenced by urgency of the need for information; availability of the technology; ease of use; the project environment such as face-to-face or remote work; sensitivity and confidentiality.

A basic communications model consists of encode – transmit – decode – acknowledge – feedback/response.

Communications methods can be *interactive* between two or more parties in person, on the phone, via video, etc. *Push communication* is distributed but there is no guarantee it was read or acted upon e.g. email, voice mail, letter, etc. *Pull communication* is where the recipient seeks the information e.g. intranet, database, etc.

Outputs include Project Documents Updates and the Communications Management Plan. This contains things like stakeholder communication requirements; reason for communication; language, format, level of detail; person responsible for communicating information; escalation process; escalation process, glossary.

Project Risk Management

The objectives of Risk Management are to increase the likelihood of positive events and decrease the likelihood of negative events. Known risks that cannot be managed are assigned a contingency reserve; unknown risks a management reserve. A negative risk that has materialized is an *issue*.

Overall project risk is more than the sum of individual risks since it represents uncertainty on the project as a whole.

There is positive risk, opportunities, and negative risk, or threats.

Risk appetite is the amount of uncertainty we are willing to take.

Risk tolerance is the amount we can withstand.

Risk threshold is the level below which we accept risk. Above it, we become involved.

Plan Risk Management

This process is where we ensure risk management is commensurate with the risks and also the project's importance to the company. The Risk Management Plan is used to communicate with and

Inputs	Tools & Techniques	Outputs
1. Project management plan 2. Project charter 3. Stakeholder register 4. EEF 5. OPA	1. Analytical techniques 2. Expert judgment 3. Meetings	1. Risk management plan

Risk Management Plan ITTO

get support from stakeholders in dealing with project risk. The process should start right when the project is conceived and be done early in project planning.

Tools and techniques include analytical techniques to understand risks and the risk profile of the organization. A stakeholder risk profile analysis could be carried out, and/or a strategic risk scoring. Expert judgment can come from a wide range of senior management, stakeholders, other PMs, industry groups, etc. Meetings can be held with stakeholders, project team, etc., to assess risk and assign responsibilities.

The sole **output** is the Risk Management Plan, a component of the Project Management Plan. It contains a methodology on how risk management will be performed; roles and responsibilities; budgeting; timing on how often RM will be performed; risk categories that can include a Risk Breakdown Structure (RBS); definitions of risk probability and impact potentially including a probability and impact matrix; tracking; reporting formats.

Identify Risks

This process is iterative and all project personnel should be encouraged to contribute to identify risks and to build ownership for risk actions.

There are many **inputs**, most of which are self-explanatory by now. However, the scope baseline (output from Create WBS) is worth mentioning because it contains assumptions that should be revisited. So should all the estimates drawn up to date, for that matter.

Tools and techniques include document reviews. There are several information gathering techniques that can be used: Brainstorming; the Delphi technique to reach consensus among experts; interviewing; root cause analysis.

Other techniques are checklist analysis and assumptions analysis. Diagramming techniques such as cause and effect (Isikawa or fishbone) diagrams, introduced in Plan Quality Management can be used. Other graphics include system or process flow charts, and influence diagrams. Finally, expert judgment and a SWOT analysis can be used.

There is just one **output**: the Risk Register. This contains a list of identified risks and their potential responses. The register will also be updated continuously as the other risk management processes are conducted.

Inputs	Tools & Techniques	Outputs
1. Risk management plan 2. Cost management plan 3. Schedule management plan 4. Quality management plan 5. HR management plan 6. Scope baseline 7. Activity cost estimates 8. Activity duration est. 9. Stakeholder register 10. Project docs 11. Procurement docs 12. EEF 13. OPA	1. Documentation reviews 2. Information gathering techniques 3. Checklist analysis 4. Assumptions analysis 5. Diagramming techniques 6. SWOT analysis 7. Expert judgment	1. Risk register

Identify Risks ITTO

Perform Qualitative Risk Analysis

Risks identified, it is time to examine their probability and impact. Two types of analysis can be done: Qualitative and quantitative. Qualitative risk analysis looks at risks' relative likelihood of occurring,

Inputs	Tools & Techniques	Outputs
1. Risk management plan 2. Scope baseline 3. Risk register 4. EEF 5. OPA	1. Risk probability and impact assessment 2. Probability and impact matrix 3. Risk data quality assessment 4. Risk categorization 5. Risk urgency assessment 6. Expert judgment	1. Project documents updates

Perform Qualitative Risk Analysis ITTO

their impact, responses including time frame and mitigation. This work reflects the views of the project team/stakeholders, and care should be taken not to introduce bias. However, this method is usually fast and cost effective. It is done regularly throughout the project life cycle as laid out in the Risk Management Plan.

Tools and techniques include a risk probability and impact assessment. The impact could relate to scope, cost, quality, etc. Risks and probabilities can be assessed in interviews. The risks are then rated.

A probability and impact matrix lays out the product of impact and probability in a grid. It then color codes the results based on low, medium and high. Risks can be overall to the project or broken out by objectives such as time, scope, etc.

In addition to risk assessment, the quality of the data being used can be examined. This happens in a risk data quality assessment. Risks can be categorized and this can influence work packages and activities. A risk urgency assessment will determine what risks should be tackled sooner.

Outputs include Project Documents Updates as planning continues to be iterated. The risk register is updated as is the assumptions log as new information is uncovered.

Perform Quantitative Risk Analysis

Inputs	Tools & Techniques	Outputs
1. Risk management plan 2. Cost management plan 3. Schedule management plan 4. Risk register 5. EEF 6. OPA	1. Data generation and representation 2. Quantitative risk analysis and modeling 3. Expert judgment	1. Project documents updates

Perform Quantitative Risk Analysis ITTO

This work is done on risks that have been identified in the previous (qualitative) process. However, the process may be constrained by lack of data, or by time and budgets.

Tools and techniques can also take account of fallback plans and secondary risks, where a new risk arises as a result of responding to the first.

Negative risks have four responses:

- *Avoid* the risk completely up to the most radical avoidance of all: shutting down the project completely.
- *Transfer* the risk to another part via work contracts, insurance, guarantees, etc.
- *Mitigate* by taking actions to reduce the probability e.g. changing work practices, more quality controls, etc.
- *Accept* the risk. This can be *passive*, which requires no action except documentation, or *active*, which usually involves setting up a contingency reserve.

Positive risks also have four responses:

- *Exploit* by ensuring the opportunity is realized.
- *Enhance* by increasing the probability of occurrence.
- *Share* by allocating ownership to another party who might be best able to take advantage of the opportunity.
- *Accept.*

Contingent response strategies kick in when certain thresholds have been reached and a risk response is required.

Outputs from this process include Project Management Plan updates. The smaller management plans are updated to reflect changes in process or practise e.g. schedule management plan, cost, quality, HR, etc.

Project Document Updates may also be required.

Project Procurement Management

Plan Procurement Management

This process involves service/product procurement decisions, their documentation and approach, and looking at potential sellers. These arrangements will likely be legal/contractual.

Inputs	Tools & Techniques	Outputs
1. Project management plan 2. Requirements documents 3. Risk register 4. Activity resource req'mnts 5. Project schedule 6. Activity cost estimates 7. Stakeholder register 8. EEF 9. OPA	1. Make or buy analysis 2. Expert judgment 3. Market research 4. Meetings	1. Procurement management plan 2. Procurement statement of work 3. Procurement documents 4. Source selection criteria 5. Make or buy decisions 6. Change requests 7. Project documents updates

Plan Procurements ITTO

Inputs include existing planning work such as the project management plan and, from there, may draw on the scope statement, WBS, etc. Other inputs should be well known by now. However, it is worth discussing organizational process assets (OPA) as they relate to an organization's procurement policy. Contracts can be classified three ways: *fixed price, cost reimbursable, time and materials*.

Fixed price contracts involve setting a, eh, fixed price for the agreed product or service. Sellers are obligated to provide according to the contract, but buyers must specify exactly what they want. Any changes are usually chargeable.

- Firm fixed price contracts (FFP) are the most common. Price and scope are set at the outset.
- Fixed price incentive fee (FPIF) attempt to build in more flexibility where performance targets are set at outset and prices determined later. There is usually a price ceiling, however.
- Fixed price with economic price adjustment (FP-EPA) contracts are like FFP contracts but span many years. Flexibility on pricing is built in to account for changed economic conditions.

Cost reimbursable contracts involve paying the seller for valid actual costs plus a fee. These contracts provide flexibility when the scope is unclear.

- Cost plus fixed fee (CPFF) contracts cover costs plus a fixed-fee, usually a percentage. Paid only for completed work.

- Cost plus incentive fee (CPIF) same as above except there is an incentive for meeting pre-defined goals. However, both parties share any savings or overruns.
- Cost plus award fee (CPAF) contracts work like CPFF but the fee is based on defined criteria. This determination is made solely by the buyer and is not subject to appeal.

Time and materials contracts are a hybrid often used for personnel acquisition where work is not fully proscribed. However, time limits may be implemented to prevent uncontrolled growth.

Tools and techniques include a make-or-buy analysis on internal capabilities, budgets, etc. All direct and indirect costs should be considered e.g. support. Other T&Ts are expert judgment, market research, and meetings.

There are many **outputs** from this process. The Procurement Management Plan will be a component of the Project Management Plan, and it includes information on contract types; procurement standards; evaluation criteria; requirements for performance bonds; etc., etc.

The Procurement Statement of Work is in enough detail to let potential sellers know if they are capable of performing the work. It should be clear, concise and complete. Procurement Documents are used to solicit proposals from vendors. They may be called bids, tenders or quotes when relating to price. When technical approaches are involved, they may be called request for information (RFI), invitation for bid (IIB), request for proposal (RFP), request for quotation (RFQ). These are structured to ensure complete and accurate responses, and to streamline evaluation.

Source Selection Criteria can be objective or subjective, and are used to rate proposals. Factors can include: understanding of need; life-cycle cost; risk; management approach; etc., etc.

A decision that involves procurement normally spurs a Change Request. Other changes may be made to the Project Management Plan or subsidiary plans.

Project Stakeholder Management

Plan Stakeholder Management

We have already identified stakeholders during the Initiating phase. Now we develop a management strategy for effective stakeholder engagement. This is based on an analysis of their needs and potential impact on the project.

Tools and techniques include expert judgment – of the PM and other stakeholders. Different people may be more important at various phases of the project.

Inputs	Tools & Techniques	Outputs
1. Project management plan 2. Stakeholder register 3. EEF 4. OPA	1. Expert judgment 2. Meetings 3. Analytical techniques	1. Stakeholder management plan 2. Project documents updates

Plan Stakeholder Management ITTO

Analytical techniques can be used to track stakeholder engagement and attitudes throughout the project. A *stakeholder engagement assessment matrix* can show current and desired levels. Those are: Unaware, Resistant, Neutral, Supportive and Leading.

Stakeholder	Unaware	Resistant	Neutral	Supportive	Leading
Ernie	C			D	
Big Bird					DC
Oscar		C	D		

Stakeholder Engagement Assessment Matrix

Outputs are the Stakeholder Management Plan, which is a component of the overall Project Management Plan. It will have management strategies for stakeholders; desired and current levels of engagement; interrelationships; communications requirements; information to be distributed, including format, language, level of detail; reason for that distribution; etc. The Stakeholder Management Plan is a sensitive document and should be protected from unauthorized disclosure.

Executing Process Group

We have now walked through the Initiating and Planning process groups, and are more than half way through the PMBOK's 47 processes.

Project Integration Management

Direct & Manage Project Work

Inputs	Tools & Techniques	Outputs
1. Project management plan 2. Approved change requests 3. EEF 4. OPA	1. Expert judgment 2. PM Information Systems 3. Meetings	1. Deliverables 2. Work performance data 3. Change requests 4. PM plan updates 5. Project doc updates

Direct & Manage Project Work ITTO

We now look at overall management of the project work. This process entails doing the work in the Project Management Plan (and approved changes) to achieve the project's objectives. This work also involves dealing with unplanned incidents. During this phase, work performance data is collected, and that becomes an input to the Monitoring & Controlling Process Group. All changes are reviewed and implemented if approved.

Inputs include approved change requests. We haven't dealt with these yet since they are an output of Perform Integrated Change Control in the Monitoring & Controlling Process Group. Change requests can impact any area of the project.

Tools & Techniques include expert judgment and meetings. The Project Management Information System, part of Enterprise Environmental Factors, is a system with scheduling, information collection and distribution, etc.

Outputs include Deliverables. These are unique and verifiable, and can be products, services or results needed for the project to be a success. Work Performance Data are the measurements of work such as tasks completed, KPIs, start and finish dates, number of change requests, etc.

Change requests are a formal way to seek modifications. They come in these flavors:

- *Corrective action*: intentional activity to re-align work with the project plan.
- *Preventive action*: intentional activity to maintain work with the project plan.
- *Defect repair*: intentional activity to fix nonconforming product.
- *Updates*: Changes to controlled documents or plans.

Approved change requests in one area may trigger changes in another.

The last output is Project Management Plan Updates to any of the various plans, baselines, logs, etc.

Project Quality Management

Perform Quality Assurance

This is the process of auditing quality requirements and results to make sure the correct quality

Inputs	Tools & Techniques	Outputs
1. Quality management plan 2. Process improvement plan 3. Quality metrics 4. Quality control measurements 5. Project documents	1. Quality management and control tools 2. Quality audits 3. Process audits	1. Change requests 2. Project Mgmt plan updates 3. Project doc updates 4. Organizational process assets updates

Perform Quality Assurance ITTO

standards and definitions are used. It is different than the *Control Quality* process which looks at results of the running quality activities and assessing performance and necessary changes. On the other hand, this process, *Perform Quality Assurance*, seeks to build confidence that the final result will meet quality requirements and expectations. Prevention and inspection aspects of Perform Quality Management should have a provable impact on the project. It also provides a framework for an iterative means of improving quality on all processes.

Tools and techniques include quality management and control tools. These include:

- Affinity diagrams: like mind mapping
- Process decision program charts (PDPC): To understand a goal relating to steps taken
- Interrelationship graphs
- Tree diagrams
- Prioritization matrices
- Activity network diagrams
- Matrix diagrams

Quality audits are independent processes to see if project activities comply. They can look for good or bad practices, or be used to share knowledge with the project team. Process audits, or analysis, look at the process improvement plan to identify if any steps are needed.

Outputs include Change Requests, Project Management Plan Updates, Project Documents Updates and updates to Organizational Process Assets.

Project Human Resource Management

Acquire Project Team

We have now reached the point where we put the team together. One of our key inputs, naturally, is the Human Resources Management Plan we have already drawn up. The PM team may or may not have control over team selection. However, the PM team should negotiate for the strongest possible team. Factors such as financing, resource availability should be considered during the planning phase.

Inputs include the HR management plan. It has roles, responsibilities, org charts, a staffing management plan, etc. EEF will have data on the organization's existing employee competencies, experience, cost rates, etc.

Inputs	Tools & Techniques	Outputs
1. HR management plan 2. EEF 3. OPA	1. Pre-assignment 2. Negotiation 3. Acquisition 4. Virtual teams 5. Multi-criteria decision analysis	1. Project staff assignments 2. Resource calendars 3. PM plan updates

Acquire Project Team ITTO

Tools and techniques include pre-assignment, or where team members are selected in advance. Another T&T is negotiations with functional managers to ensure appropriate staff are freed up; other PMs to ensure scare resources are available; and external suppliers.

If internal staff are not available, they may be acquired via acquisition. Another T&T may see virtual teams assembled from different locations. Multi-criteria decision analysis is where multiple criteria are used to evaluate potential team members. Factors may include availability, cost, experience, skills, etc.

Outputs are Project Staff Assignments; Resource Calendars; and Project Management Plan Updates.

Develop Project Team

Team put together, we can now start development. This process looks at competencies, interaction and the team environment. The goal is to improve performance. This is a critical skill the PM needs

Inputs	Tools & Techniques	Outputs
1. HR management plan 2. Project staff assignments 3. Resource calendars	1. Interpersonal skills 2. Training 3. Team-building activities 4. Ground rules 5. Colocation 6. Recognition & rewards 7. Personnel assessment	1. Team performance assessments 2. EEF updates

Develop Project Team: ITTO

to have. The team needs to be motivated by feedback, challenging work, opportunities, rewards, recognition, open communication and other tools at the PM's disposal.

Inputs are the HR management plan, and two outputs from Acquire Project Team: Project staff assignments and resource calendars.

Tools and techniques including interpersonal, or soft, skills. Communication, EQ, conflict resolution, negotiation, team building, are among the skills in question. Training is another T&T that is important in enhancing competencies. It can be scheduled, or unplanned in response to performance appraisals.

Team-building activities can be simple or complex – but they should be ongoing throughout the project. The goal here is to help people work together effectively. These strategies can be particularly important when the team is geographically dispersed. There are five stages of team

development. They are usually in order, but the team can become stuck or even regress. They are: *Forming, storming, norming, performing, adjourning.*

Ground rules set up clear expectations and can cover areas such as conduct, communication, working together, etc. Colocation, or "tight matrix," means putting the team in the same location. It can be a team meeting room, or "war room."

Recognition and rewards. Maybe it's just me, but this concept seems so obvious, it's redundant. Nevertheless, some things are worth mentioning: Working with different cultures, it's not all about the money, rewards need to be valued by recipients, opportunities to develop or accomplish are all types of reward.

Finally, personnel assessment tools can give the PM and team an overview of strengths and weaknesses.

Outputs are Team Performance Assessments. The metric here is success in meeting project objectives, schedule and budget. Other indicators could include staff turnover rates, skills acquisition, etc. Any staff competency improvements are fed back in to Enterprise Environmental Factor Updates.

Manage Project Team

Inputs	Tools & Techniques	Outputs
1. HR management plan 2. Project staff assignments 3. Team performance assessments 4. Issue log 5. Work performance reports 6. OPA	1. Observation & conversation 2. Training 3. Proj performance appraisals 4. Conflict management 5. Interpersonal skills	1. Change requests 2. PM plan updates 3. Project doc updates 4. EEF updates 5. OPA updates

Manage Project Team: ITTO

This process tries to influence them team, evaluate team member performance, resolve issues and conflicts if/when they occur. My opinion only, but it's very close on the spectrum to the previous process, Develop Project Team as many of the same skills are involved.

Team management will lead to change requests, input to performance appraisals, HR updates and updates to the lessons learned database.

Most of the **inputs** have already been covered, However, work performance reports come from Monitor & Control Project Work, which has yet to be tackled.

Similarly, many **tools and techniques** have been covered such as observation and conversation, and project performance appraisals.

Conflict management is a technique sure to be used by project managers. Sources can include scarce resources, scheduling, and personal work styles. Steps can be taken to prevent conflict but, if it does happen, team members are initially responsible for resolution. It can be escalated to the PM. It

should be handled directly in private using a collaborative approach. However, formal disciplinary procedures may be required. There are five techniques to resolve conflict:

- Withdraw/avoid by pulling back from the situation
- Smooth/accommodate by emphasizing areas of agreement, conceding your position to maintain harmony
- Compromise/reconcile by getting some satisfaction to all to temporarily or partially resolve the conflict
- Force/direct by pushing your own viewpoint
- Collaborate/problem solve to lead to consensus and commitment

Finally, interpersonal skills are essential. These include *leadership*, especially to communicate and inspire; *influencing*, especially in a matrix environment where PMs have no direct authority; and *effective decision making* to negotiate with and influence the project team.

Outputs are Change Requests when staffing on the project changes. Other outputs are PM Plan Updates, Project Document Updates, EEF Updates and OPA Updates.

Project Communications Management

Manage Communications

This process includes everything from the creation to storage to distribution of communications as laid out in the Communications Management Plan. The aim is an efficient and effective communications flow. It is more than imparting information; it is ensuring the information is

Inputs	Tools & Techniques	Outputs
1. Communications mgmt plan 2. Work performance reports 3. EEF 4. OPA	1. Communication technology 2. Communication models 3. Communication methods 4. Information mgmt systems 5. Performance reporting	1. Project communications 2. PM plan updates 3. Project doc updates 4. OPA updates

Manage Communications: ITTO

appropriate; and that it is received and understood. It should also take account of stakeholder desires for information or discussion. For the PM, there are a number of considerations including: media, writing style, meeting management techniques, listening techniques, etc.

Tools and techniques include communication technology, communication models and communication methods (all covered in Plan Communications Management); and information management systems. These can be hard or soft copy, push-pull, etc.

Finally, performance reporting involves collecting and distributing performance information on the project. This can include status reports, forecasts, etc.

Outputs from this process are Project Communications, and updates to each of the Project Management Plan, the Project Documents and the OPA.

Project Procurement Management

Conduct Procurements

This process involves collecting seller bids, selected a vendor and awarding a contract. This aligns

Inputs	Tools & Techniques	Outputs
1. Procurement mgmt plan 2. Procurement documents 3. Source selection criteria 4. Seller proposals 5. Project documents 6. Make-or-buy decisions 7. Procurement SOW 8. OPA	1. Bidder conference 2. Proposal evaluation techniques 3. Independent estimates 4. Expert judgment 5. Advertising 6. Analytical techniques 7. Procurement negotiations	1. Selected sellers 2. Agreements 3. Resource calendars 4. Change requests 5. PM plan updates 6. Project document updates

Conduct Procurements ITTO

internal and external stakeholder expectations via agreements. This can be an iterative process during large procurements exercises.

Inputs that come from the Plan Procurement Management process are: procurement management plan; procurement documents; source selection criteria; make-or-buy decisions; and the procurement statement of work (SOW). Seller proposals are prepared by potential vendors in response to bids, etc., issued by the buyer.

Tools and techniques: A bidder (contractor/vendor/pre-bid) conference is used to ensure all prospective sellers are on the same page by calling them together to hear the same answers and to ensure no one gets preferential treatment.

Proposal evaluation techniques may be required for complex projects. Independent estimates are where the organization opts to get an outside professional estimator prepare a price that can be used as a benchmark. Expert judgment can be handled by a team with expertise in cross-functional areas.

Negotiations can cover any aspect of the product or service to be delivered. They need not necessarily be carried out by the project manager. For complex procurements, they may even be an independent process.

Outputs include: Selected Sellers and their negotiated draft contracts; Agreements that should meet the needs of the project (this is the PM's responsibility); Resource Calendars; Change Requests; PM Plan Updates; and Project Documents Updates.

Project Stakeholder Management

Manage Stakeholder Engagement

This process works with stakeholders to increase support and minimize resistance to increase the probability of project success. Timing, expectations, and addressing concerns or issues are all involved in this process. Stakeholder influence is typically greatest at the project's initial stages.

Tools and techniques start with communications methods covered in Plan Communications Management. Interpersonal skills are required to build trust, resolve conflicts, listen, overcome resistance, etc. Management skills are required to coordinate and focus the group.

Inputs	Tools & Techniques	Outputs
1. Stakeholder mgmt plan 2. Communications mgmt plan 3. Change log 4. OPA	1. Communication methods 2. Interpersonal skills 3. Management skills	1. Issue log 2. Change requests 3. PM plan updates 4. Project document updates 5. OPA updates

Manage Stakeholder Engagement ITTO

Outputs include the creation, if necessary, of an Issue Log. Project Management Plan Updates are likely, especially to the Stakeholder Management Plan. Other outputs are updates to the Project Documents and OPA.

Monitoring & Controlling Process Group

This process group tracks and reviews, and runs the project. Any changes required are identified, added to the plan and implemented. The project is measured and analyzed regularly, and compared against the plan.

Project Integration Management

Monitor & Control Project Work

Inputs	Tools & Techniques	Outputs
1. Project management plan 2. Schedule forecasts 3. Cost forecasts 4. Validated changes 5. Work performance info 6. EEF 7. OPA	1. Expert judgment 2. Analytical techniques 3. PM information system 4. Meetings	1. Change requests 2. Work performance reports 3. PM plan updates 4. Project document updates

Monitor & Control Project Work ITTO

This process does what it says on the tin. It lets stakeholders understand where the project is regarding work completed, budget, schedule, etc. Monitoring is performed continuously throughout the life of the project. Controlling involves taking preventative or corrective action, or replanning.

Inputs include the Project Management Plan, all its subsidiary plans and associated baselines. Schedule forecasts are an output of the Control Schedule process (yet to addressed). They look at schedule variance (SV) and the schedule performance index (SPI).

Likewise, cost forecasts have yet to be tackled. Those look at estimates to complete (ETC), cost variance (CV), estimate at completion (EAC), budget at completion (BAC) and the cost performance index (CPI).

Validated changes have yet to come, too. Work performance information is another input, as are EEF and OPA.

Tools and techniques: Expert judgment is used by the project management team. Analytical techniques of many different types can be used to analyze and forecast. Other tools are the PM information system and meetings.

Outputs may result in Change Requests. Those should go through the project's integrated change control process. Work Performance Reports and Project Management Plan Updates are also outputs.

Perform Integrated Change Control

Referred to in the previous section, this process involves reviewing all change request, approving changes (not necessarily all of them), managing the change and its impact on the project, and communicating about those changes. This brings structure and a record of change to the project.

The PMBOK says this process "is the ultimate responsibility of the Project Manager." Changes can come from any stakeholder, but they all should be recorded. There should be a pre-defined process to approve/reject requests. This can be done by the sponsor, PM or a Change Control Board (CCB).

Inputs	Tools & Techniques	Outputs
1. Project management plan 2. Work performance reports 3. Change requests 4. EEF 5. OPA	1. Expert judgment 2. Meetings 3. Change control tools	1. Approved change requests 2. Change log 3. PM plan updates 4. Project document updates

Perform Integrated Change Control ITTO

Configuration control looks at both deliverables and processes. Change control, meanwhile, centers around project documents, deliverables or baselines.

Integrated change control involves:

- Configuration identification.
- Configuration status accounting.
- Configuration verification and audit.

Tools and techniques involve meetings or expert judgment. This could be stakeholders on the CCB, for example. Change control tools are used to manage change requests.

The first **output** is Approved Change Requests. These are input to Direct & Manage Project Work, which was looked at during the Executing Process Group portion. The Change Log documents these changes. Rejected changes are also recorded in the log. Finally, updates are likely to the Project Management Plan and Project Documents.

Project Quality Management

Control Quality

This is the process of monitoring results of quality activities. This is done to assess performance and make improvements. The goal is to validate deliverables/work meet the requirements laid down by stakeholders.

Quality Assurance takes place during the Planning and Executing phases, while Quality Control happens during the Executing and Closing phases to formally show that the customer's criteria have been met.

Some terminology to be aware of:

- *Prevention* vs *inspection*: The former keeps errors out; the latter errors out of the customer's hands.
- *Attribute sampling* vs *variables sampling*: The former is a binary conform/non-conform; the latter is on a spectrum measuring degrees of conformity.
- *Tolerances* vs *control limits*: the former is a range of acceptability; the latter shows boundaries of variation

Tools and techniques include inspection. These can happen at any level and typically involve measurements.

Inputs	Tools & Techniques	Outputs
1. Project management plan 2. Quality metrics 3. Quality checklists 4. Work performance data 5. Approved change requests 6. Deliverables 7. Project documents 8. OPA	1. 7 basic quality tools 2. Statistical sampling 3. Inspection 4. Approved change requests review	1. Quality control measurements 2. Validated changes 3. Verified deliverables 4. Work performance info 5. Change requests 6. PM plan updates 7. Project documents updates 8. OPA updates

Control Quality ITTO

Outputs include those listed above in Figure 41. One output, Verified Deliverables, is input to the Validate Scope process. This output measures the correctness of deliverables. Validate Scope formalizes acceptance.

Project Scope Management

Validate Scope

Inputs	Tools & Techniques	Outputs
1. Project management plan 2. Requirements documentation 3. Requirements traceability matrix 4. Verified deliverables 5. Work performance data	1. Inspection 2. Group decision making	1. Accepted deliverables 2. Change requests 3. Work performance information 4. Project documents updates

Validate Scope ITTO

Validate Scope now formalizes acceptance of the completed deliverables. It differs from Control Quality (just covered) in that Validate Scope has to be with acceptance of the deliverables. Control Quality, meanwhile, focuses on correctness of the deliverables. It is usually done before – sometimes at the same time – Validate Scope.

Outputs include Accepted Deliverables. These have met acceptance criteria and have been signed off formally by the customer. This acceptance is then becomes an input to the Close Project or Phase process.

Project Time Management

Control Schedule

This process monitors activities to see if there is any deviation from the project schedule and thus take corrective or preventive actions. It is important to know the actual performance to date.

Inputs	Tools & Techniques	Outputs
1. Project management plan 2. Project schedule 3. Work performance data 4. Project calendars 5. Schedule data 6. OPA	1. Performance reviews 2. PM software 3. Resource optimization 4. Modeling techniques 5. Leads and lags 6. Schedule compression 7. Scheduling tool	1. Work performance information 2. Schedule forecasts 3. Change requests 4. PM plan updates 5. Project documents updates 6. OPA updates

Control Schedule ITTO

However, any schedule changes can only come through Perform Integrated Change Control process.

Tools and techniques include performance reviews such as trend analysis, critical path and critical chain methods (both covered in Develop Schedule), and earned value management (soon to come) that gives indicators such as Schedule Variance (SV) and the Schedule Performance Index (SPI). Other T&Ts have been covered elsewhere at this point.

Outputs are Work Performance Information, Schedule Forecasts based on the information available at the time of the forecast; Change Requests; and updates to the PM Plan (e.g. schedule baseline), Project Documents (e.g. project schedule), and Organizational Process Assets.

Project Cost Management

Control Costs

This is a key process in the PMBOK. There are a number of important concepts and formulas that should be known for the exam. As with Control Schedule, any changes to project costs must be handled via Integrated Change Control. As well as tracking costs, the Control Costs process looks at the value of the work performed to date.

Cost control can include: influencing factors that create cost changes; acting on change requests in a timely manner; ensuring costs do not exceed budget by period or WBS, etc.

Tools and techniques: Earned Value Management (EVM) integrates scope, cost and schedule baselines to form the performance measurement baseline which is used to measure and manage the

Inputs	Tools & Techniques	Outputs
1. Project management plan 2. Project funding requirements 3. Work performance data 4. OPA	1. Earned value management 2. Forecasting 3. To-complete performance index 4. Performance reviews 5. PM software 6. Reserve analysis	1. Work performance information 2. Cost forecasts 3. Change requests 4. PM plan updates 5. Project documents updates 6. OPA updates

Control Costs ITTO

project. It measures three key values for each work package or control account: Planned Value (PV), Earned Value (EV) and Actual Cost (AC).

	Name	Description	Forumula
PV	Planned Value	Work that should have been done at a given moment	
BAC	Budget at Completion	Total PV for a project	
PMB	Performance Measurement Baseline	Total PV	
EV	Earned Value	Value of work performed. Cannot exceed PV.	
AC	Actual Cost	Cost of work performed. Has no theoretical limit.	
SV	Schedule Variance	Measure of schedule performance. Difference between earned value and planned value.	SV = EV – PV
CV	Cost Variance	Amount of spend over or under. Difference between earned value and actual cost.	CV = EV – AC
SPI	Schedule Performance Index	Measure of schedule efficiency. Ratio of earned value to planned value. SPI < 1.0 — less work done than planned SPI > 1.0 — more work done than planned	SPI = EV / PV
CPI	Cost Performance Index	Measure of cost efficiency. Ratio of earned value to actual cost. Most critical EVM metric. CPI < 1.0 — costs over CPI > 1.0 — costs under	CPI = EV / AC

Another important T&T is Forecasting. Done during project work, it looks at Estimate at Completion (EAC) figures that may differ from budget at completion (BAC) numbers. EACs are based on actual costs plus an Estimate to Complete (ETC). The most common method is a bottom-up calculation by the PM and team.

	Description	Formula
EAC	Estimate at Completion	
	EAC at budgeted rate	EAC = AC + (BAC – EV)
	EAC at present CPI	EAC = BAC / CPI
	EAC using both SPI and CPI	EAC = AC + [(BAC – EV) / (CPI * SPI)]

A third T&T is the To-Complete Performance Index (TCPI), which is measures the cost performance needed, with the remaining resources, to meet a specified goal. It is the ratio of cost to finish the work to the remaining budget. It can be based on the Budget at Completion (BAC) or the Estimate at Completion (EAC).

TCPI based on BAC	TCPI = (BAC – EV) / (BAC – AC)
TCPI based on EAC	TCPI = (BAC – EV) / (EAC – AC)

Performance reviews: Variance analysis looks at differences in cost, schedule or completion. Trend analysis determines if performance is getting better or worse. Reserve analysis monitors management and contingency reserves.

Project Communications Management

Control Communications

This process is done to make sure the information needs of the stakeholders are met. It can kick off

Inputs	Tools & Techniques	Outputs
1. Project management plan 2. Project communications 3. Issue log 4. Work performance data 5. OPA	1. Information management systems 2. Expert judgment 3. Meetings	1. Work performance information 2. Change requests 3. PM plan updates 4. Project documents updates 5. OPA updates

Control Communications ITTO

an iteration of the Plan Communications Management or Manage Communications processes i.e. communications is continuous throughout the project.

Despite the huge importance of this topic, there is little new to add at this point in terms of Inputs, Tools & Techniques, or Outputs.

Project Risk Management

Control Risks

This process involves implementing risk responses, tracking risks, identifying new risks, evaluating risk process effectiveness, etc. It can result in choosing alternative responses, taking action or even changing the project plan.

Tools and techniques, therefore, include risk reassessment which can result in the discovery of new risks and the closing of old risks. Risk audits look at the effectiveness of handling risks and their causes.

Outputs are likely to include Change Requests for corrective or preventative actions.

Inputs	Tools & Techniques	Outputs
1. Project management plan 2. Risk register 3. Work performance data 4. Work performance reports	1. Risk reassessment 2. Risk audits 3. Variance & trend analysis 4. Tech performance measures 5. Reserve analysis 6. Meetings	1. Work performance information 2. Change requests 3. PM plan updates 4. Project documents updates 5. OPA updates

Control Risks ITTO

Project Procurement Management

Control Procurements

This process looks at relationships and performance around procurement, and making changes where appropriate. This ensures both seller and buyer meet requirements as laid out in their

agreement(s). This process may integrate with Direct & Manage Project Work, Control Quality, Perform Integrated Change Control and Control Risks, among others.

Inputs	Tools & Techniques	Outputs
1. Project management plan 2. Proejct documents 3. Agreements 4. Approved change requests 5. Work performance reports 6. Work performance data	1. Contract change control sys. 2. Procurement performance reviews 3. Inspections and audits 4. Performance and reporting 5. Payment systems 6. Claims administration 7. Records management system	1. Work performance information 2. Change requests 3. PM plan updates 4. Project documents updates 5. OPA updates

Control Procurements ITTO

By now, we should be familiar with the **inputs** and **outputs**, so there is little need to repeat them. However, some of the **tools and techniques** are new. The Contract Change Control System, for example, is a way to modify and track changes to procurements.

Procurement Performance Reviews are structured to track the seller's progress. Likewise, inspections and audits are often required by the buyer and supported by the seller. They look at work turned in by the seller. Claims Administration handle claims, disputes or appeals. Normally, such procures are set up in the contract and can include arbitration instead of costly legal disputes.

Project Stakeholder Management

Control Stakeholder Engagement

We have now reached the last process in the Monitoring & Controlling Process Group, Control Stakeholder Engagement. This monitors stakeholder relationships and adjusts engagement plans accordingly. It should be continuously controlled throughout the project particularly since

Inputs	Tools & Techniques	Outputs
1. Project management plan 2. Issue log 3. Work performance data 4. Project documents	1. Information management systems 2. Expert judgment 3. Meetings	1. Work performance information 2. Change requests 3. PM plan updates 4. Project documents updates 5. OPA updates

Control Stakeholder Engagement ITTO

stakeholders are likely to come and go, or be identified anew.

Outputs include Work Performance Information. Several times throughout the PMBOK, a distinction is drawn between *data* and *information*. It is done so, again, here to point out that raw data can be misinterpreted whereas information is data that has been analyzed in context.

Closing Process Group

Project Integration Management

Close Project or Phase

Inputs	Tools & Techniques	Outputs
1. Project management plan 2. Accepted deliverables 3. OPA	1. Expert judgment 2. Analytical techniques 3. Meetings	1. Final product, service, or result transition 2. OPA updates

Close Project or Phase ITTO

This process closes all activities to bring the project/phase to a formal close. It also provides lessons learned and the release of resources. Before closing, the Project Manager reviews the scope baseline to ensure objectives have been met. If the project is terminated prematurely, this process has procedures to investigate the reasons. In normal closure, there will also be procedures on how to transfer products/services to production.

Project Procurement Management

Close Procurements

Inputs	Tools & Techniques	Outputs
1. Project management plan 2. Procurement documents	1. Procurement audits 2. Procurement negotiations 3. Records management system	1. Closed procurements 2. OPA updates

Close Procurements ITTO

This process closes each procurement and documents it for future reference. It can happen at whatever stage of the project the procurement applies to. Early terminations of contracts are a special case. However, procedures should be outlined in the relevant section of the contract. Procurement documents, an **input**, are organized and filed, and can be used as lessons learned, an **output** to Organizational Process Asset updates.

Tools and techniques include Procurement Audits to identify successes and failures. Negotiations aim to bring a final equitable conclusion to the contractual arrangements.