Project Planning

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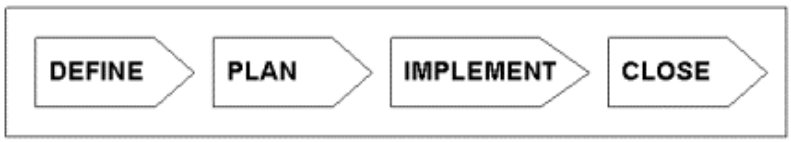
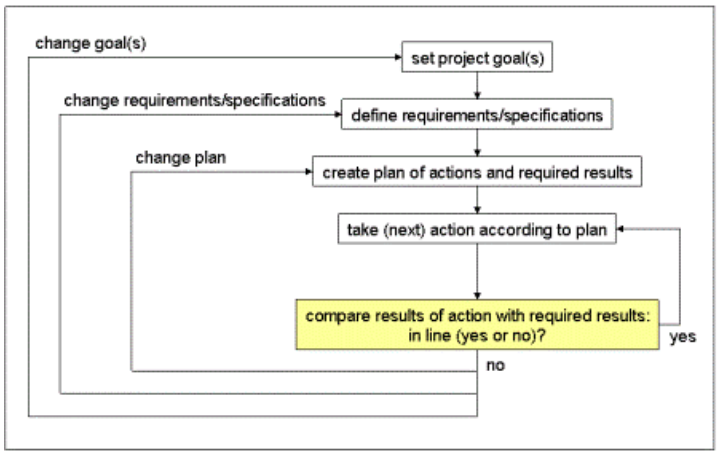
Project Planning

In this paper, we describe how to develop a project plan. Our reference process is the project management process.

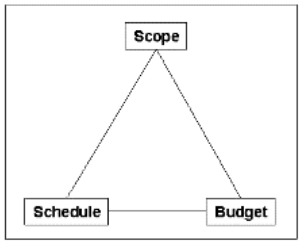


Planning the project means preparing the project management team for best possible performance in implementation and closure phase. To achieve this, the team must remain in control of all project activities, even under the condition of a changing project environment. The project controlling cycle looks like this:



Following the logics of this controlling cycle, we recognize that we need clear project goals as primary prerequisite. Based on this, we can define the requirements and specifications the project result has to fulfill. Only well defined requirements and specifications enable goal-oriented project planning and consequently, goal-oriented actions in implementation and closure phase.

Project planning follows the triple constraint: Project scope, project schedule, and project budget. On this basis, we present the essential project planning tools.



We need to create plans that prepare for optimal controlling of the implementation and closure phase. The questions we are going to answer are:

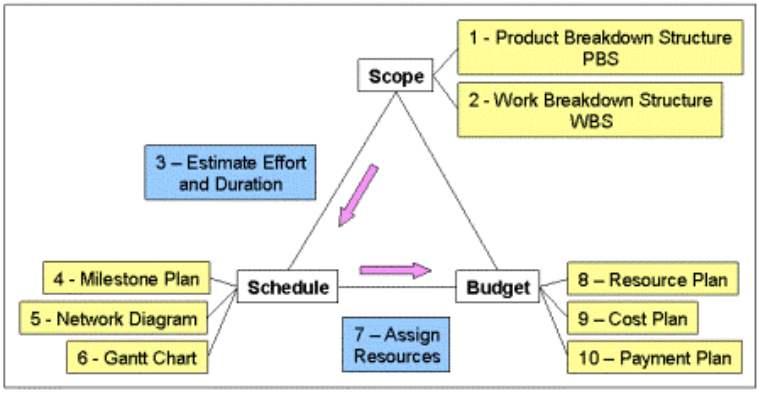
What do we need to plan?

How can we provide sufficient flexibility?

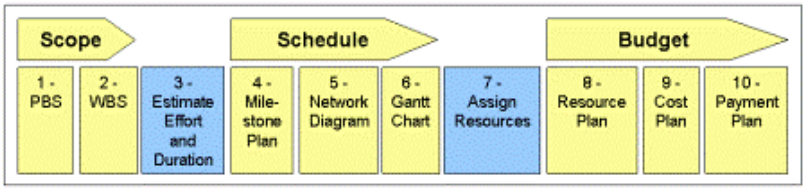
What tools can we use?
How do we document the planning results?

What do we need to plan?

The following picture shows what plans we need, and in what sequence we are going to create them.



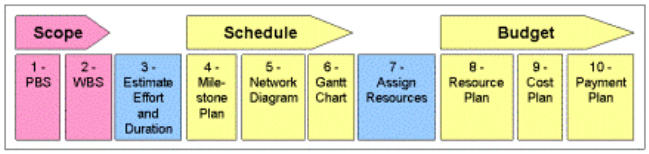
We translate this into the following more process-oriented view.



This picture reflects the basic project planning process we will follow.

Planning the Project Scope – Steps 1 and 2

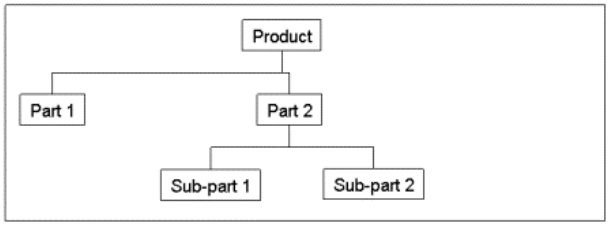
We plan the project scope in two steps, first the product breakdown structure PBS which describes the product or service we are going to create with the project. In a second step, we setup the work breakdown structure WBS that describes all the work that has to be done in order to create that product or service in the form of work packages.



Upon completion of the definition phase we have clear project goal(s), requirements, specifications, and a functional description of the desired project result.

Step 1 – Product Breakdown Structure PBS

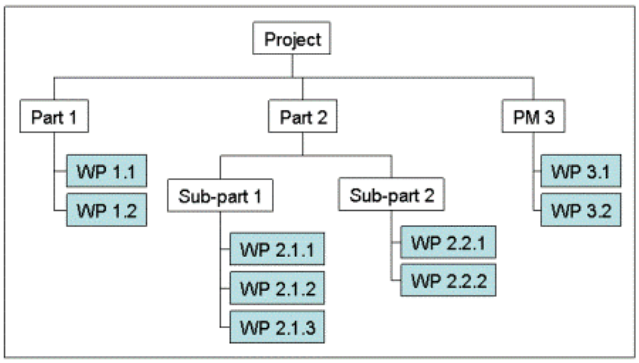
In step 1, we create the breakdown structure of the desired project result, the so-called product breakdown structure or PBS. We ask the question: What is it exactly that we want to create, what is the project result or product, and how should it look like, what are its parts? The PBS is a structured overview over the product and its parts that have to be created by the project. For this we need similar expertise like for setting up the requirements and specifications.



Product Breakdown Structure

Step 2 – Work Breakdown Structure WBS

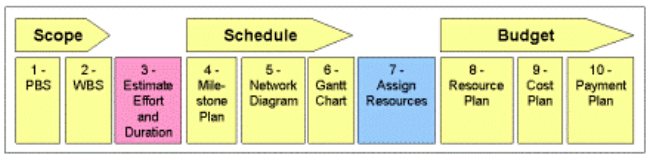
In step 2, we extend the PBS into the work breakdown structure or WBS. We ask the question: What work has to be done in order to create that project result or product and its parts? The answer is a structured overview over all the work packages we have to carry out in order to create the product of the project. Following the principle "verb plus object", each individual work package consists at least of a detailed description of the desired result (the “object”) and what we have to do in order to achieve it (the “verb”).



Work Breakdown Structure

Effort Estimation – Step 3

After setting up the WBS we have to estimate effort and duration of each work package. We do this by asking the work package experts how much of what resources they need, for what period of time, thus obtaining the effort. We recommend combining effort estimation with the first risk analysis into a workshop, with all the experts involved. Then we have better chances to avoid over- or under-estimation, or hidden “security blankets” for the work packages since we can discuss these issues openly with the whole team and address critical items and risks explicitly.



Effort estimation will generate a lot more information than only effort and duration:

- Who will be responsible for each work package?
- What is the work package specification?
- What are the expected results of each work package?
- How is the achievement of the results measured?
- What are the prerequisites for the work package?
- What are the conditions under which the work has to be done?

- What are the required start and end times?
- What and how much material is needed for each work package, at what cost?
- What tools are needed for each work package, at what rates?

Obviously, effort estimation needs expertise on a work package specific level to accomplish this transition.

There are two categories of estimating the effort of each work package: deductive and inductive methods.

Deductive or Top-down Methods

Assume the total cost for the project is given. From there we assign the cost, and thus, the effort of individual work packages based on estimated percentages derived from earlier, similar projects with similar work packages. The advantage of deductive methods is a simple and rapid effort estimation, the disadvantage is that they only work for projects that consist of work packages we already know from earlier, similar projects.

Inductive or Bottom-up Methods

The basic idea of inductive methods is to start effort estimation with the work packages individually, with support of experts, or knowledge of similar work packages of earlier projects, and then summarize bottom up, following the structure of the WBS.

(1) Factor Analysis: For a certain work package, we know all the variables or factors, how they influence the work, and how these factors correlate with each other. Then we can calculate the effort based on a mathematical formula which reflects that influences and correlations.

Effort = f (influencing variables, correlation coefficients).

For example, the effort of a work package "Develop hardware control unit" is influenced by the number of people involved, P=4, the number of interfaces, S=5, the number of functional blocks, B=10. From earlier projects with similar control units we might know the correlation coefficients. For example, cP=2.5, cS=2, cB=1.5, cU=2.0. Our formula could look like this

Effort = cP*P + cS*S*S + cB*B = 10 + 50 + 15 = 75 (working days)

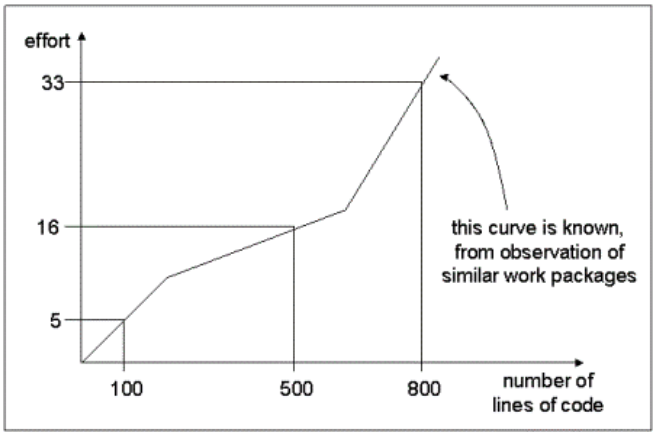
(2) Multiplication Method: If we can divide a work package into a number of equal parts then, we can estimate the total effort by estimating one part and then multiplying this value by the number of parts.

Total Effort = Effort of one part * number of parts.

(3) Analogy Method: This method again applies the knowledge from similar work packages. We interpolate or extrapolate the effort for the work package from a similar one. For example, for the work package “Install electrical wiring in an apartment of 100 sqm” we could guess the effort by interpolation from similar work for apartments of 150 sqm, 10 working days, and 50 sqm, 6 working days:

Effort(100 sqm) = (10 + 6) / 2 = 8 working days.

(4) Function Point Method: For IT or software design related work packages we can apply the function point method. The prerequisite is that we need to have a lot of knowledge about the effort of work packages of similar scope and degree of difficulty, based on observation. Then the experts compile this knowledge into so called “function curves” which we can use to estimate effort for new work packages. In the following example we estimate the effort of work about creating 100, 500, and 800 lines of code. We obtain the effort via the corresponding function points on the function curve, 5, 16, and 33 working days, respectively.



(5) Delphi Method: For most of our work packages we use the Delphi method. We just ask the experts for each work package for their best guess, normal guess, and worst guess. Thus we obtain three figures for the expected effort: $\mathbf{E_{optimistic}}$, $\mathbf{E_{normal}}$ **and** $\mathbf{E_{pessimistic}}$, then combine them with this formula

$$\mathbf{Effort = (E_{optimistic} + 4*E_{normal} + E_{pessimistic}) / 6.}$$

If we can ask ten or more experts, we could even calculate the mean values and apply mathematical statistics with the concept of standard deviation.

Usually, we ask all the experts to join an effort estimation workshop which can be combined with a risk management workshop, of two, three, or more days depending on the number of work packages that have to be estimated.

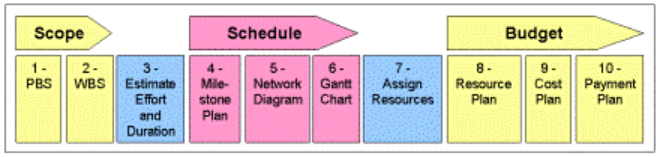
Planning the Project Schedule – Steps 4, 5, and 6

Planning the project schedule comprises three steps: planning the milestones, creating a network diagram of all the work packages, and setting up the Gantt chart. The milestone plan gives us a top level view of the project without the details of all the work packages. In the network diagram we arrange the logical sequence of all the work packages, while the Gantt chart represents the actual time schedule of all the work packages of the project. Network diagram and Gantt chart also show the critical path of the project which we analyze for risks affecting the schedule.

So far, we know

the product and its parts we have to create with our project
all the necessary work for that, in form of work packages
and effort and duration of each work package

With these prerequisites, we continue to follow the project planning process.

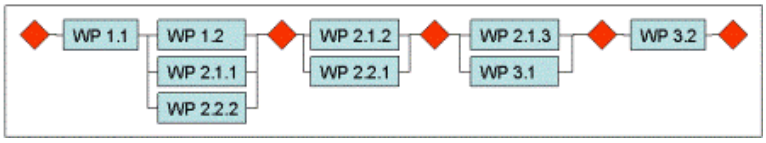


Step 4 – Milestone Plan

We plan major project milestones, the special and most important points of our project time line. In project implementation phase, the project milestone plan will enable us to control the progress on the highest level of schedule.

Step 5 – Network Diagram

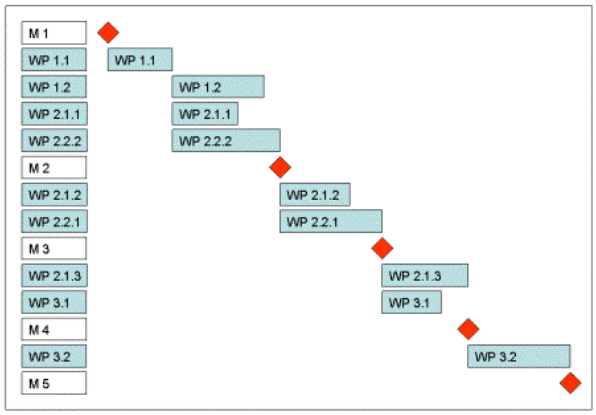
In the next step, we establish a network diagram of all the work packages of our WBS. We essentially ask the question, which work package has to be finished before another one can be started. The network diagram gives a graphical overview over the logical sequence of all the work packages that have to be done and the milestones that have to be accomplished. It will enable us to control project implementation progress on the level of logical work sequence.



Network Diagram Including Milestones

Step 6 – Gantt Chart

To conclude project scheduling we draw a graphic with all the work packages as bars, each one located with reference to a common time line, and with each one's length corresponding to its duration. The Gant chart (or bar chart) gives a graphical overview over the schedule of all the work packages that have to be done and the milestones that have to be accomplished. This will enable us to control project progress work package by work package referring to real time.

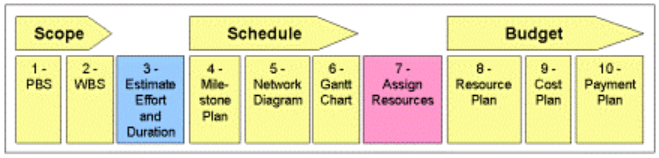


Gantt Chart Including Milestones

Network diagram and Gantt chart are equivalent in the sense that the first one is a mathematical representation (logical sequence) and the second one a physical representation (reference to real time) of the project schedule. In both representations, we usually find several logical paths in parallel, from the beginning of the first work package (project start) to the end of the last work package (project end) of the whole diagram or chart. Now we can add up all the durations along each of those paths. The path with the longest total duration, from project start to project end, we call the "critical path" of the project. Hence, we call this planning method "critical path method" or CPM.

Assigning Resources – Step 7

Having prepared project scope and schedule, we now assign all the necessary resources to each one of the work packages, that is, human resources, tools, and material. Especially, getting all the human resources on board requires some preparation: we coordinate the level of skills and experience of the available people with what is needed; we prepare and discuss their target agreements; we prepare, negotiate, and sign sub-contracts for those work packages that will be provided by external suppliers; we set up and maintain close contact to those resources that are critical; we coordinate the resource planning of our project with that one of others.



We need to plan three different types of resources:

- Human Resources: who will actually do the work, at what work load level?
- Tools and machinery
- Material

Human Resources

Together with the work package experts, we determine the areas and levels of skills and experience necessary to achieve the required results of that work package. Then we identify the people in our organization who have those skills and experience. In case those human resources are not available in our organization we need to decide if we hire or sub-contract to sub-suppliers or freelancers.

For each work package, we create detailed task descriptions that help us to prepare the target agreements for all colleagues who have to contribute to our project. These target agreements include work package specification, expected results, description of how the achievement of the results is measured, prerequisites, conditions under which the work has to be done, required start and end times. They should reflect a mutual understanding of all who are involved: project manager, line managers, and all the colleagues who will do the work. The result will be clarified bookings of the time which those colleagues will spend with our project.

Tools and Machinery

In a similar way, we will book tools and machinery. If not available within our organization, we need to decide about the necessary investment or renting them.

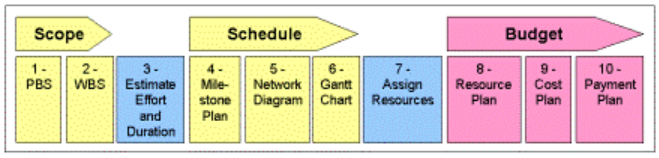
Material

The same principles count for all the material. We plan what we manufacture in our own factories, what we want sub-suppliers to deliver.

For all work packages where we might not have the resources available within our own organization, we need to find external suppliers who can deliver the required results and services. With them we prepare, negotiate, and sign sub-contracts. Thus, we need to provide enough time in the project planning process so that we can carry out these preparations and negotiations without time pressure.

Planning the Project Budget – Steps 8, 9, and 10

Planning the project budget, in another three steps, concludes the project planning process. Having all the resources assigned, we can now allocate hourly rates of human resources and tools, as well as material cost, and integrate all these data with the project schedule on work package level. Thus, we obtain the finalized resource plan, and from that, the (accumulated) cost plan. Together with a payment plan (in case of a customer-contractor based project) or sales plan (in case the project is about product development, marketing, and sales) we prepare the financing plan for our project.



Step 8 – Resource Plan

Now, we combine all this information with our project schedule, i.e. network diagram and Gantt chart. To each work package we assign the resources in terms of

manpower: how many people, on what level of skills, with which work load
material: how much of what kind of stuff
tools: which machinery with what characteristics.

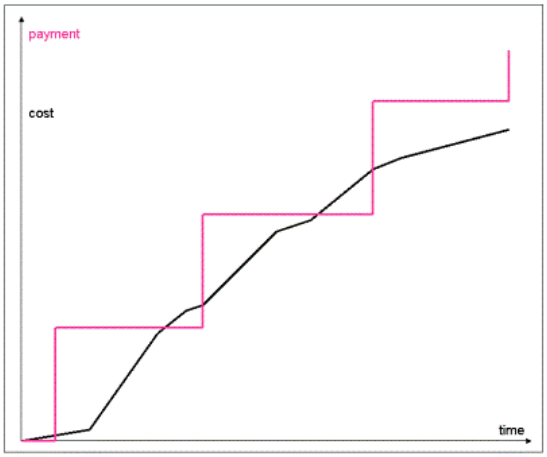
The immediate result of assigning resources to all the work packages will be the resource plan which basically shows when we need whom, what material, and what tools. Another result we obtain is the so-called manpower histogram. It focuses on people only: how many people do we need in which area of skills, on what level of skills, and on what level of work load.

Step 9 – Cost Plan

If we now only add the information of hourly rates for the people working in our project, for the tools we need, and the cost of material, we immediately get the cost plan for the project. The cost plan shows the accumulated cost or planned cost of the project with reference to the project time line.

Step 10 – Payment Plan

With a finalized cost plan, we know when we need to provide how much money in order to cover those costs. Since we usually have a customer-contractor relationship, coverage of the cost is taken care of by customer's payment. So, from the accumulated cost plan, we can derive a payment plan. From the customer's perspective, this payment plan translates into the project financing plan: On basis of the payment plan, the customer is able to determine the overall project budget, and what portions of that budget are needed at what time to fulfill the payment plan.



Accumulative Cost and Payment Plan

In case the project is about developing, manufacturing, and selling a product, the situation is similar: then, we usually need a sales plan instead of the payment plan.

If the project is company or organization internal, then we could interpret the situation as being an informal customer-contractor relationship. I.e., the informal customer could be the CEO of that company or organization, and the informal contractor's role could be plaid by one special department.

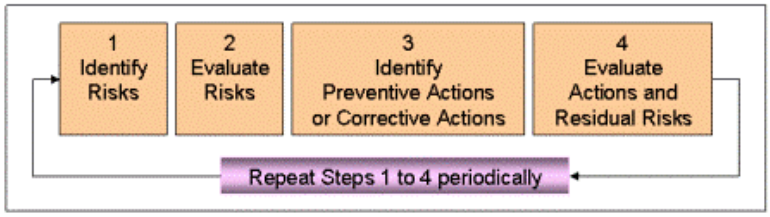
Building these plans,

PBS and WBS
milestone plan, network diagram, and Gantt chart
resource plan, accumulated cost plan, and payment plan

would conclude project planning. But real life holds just too many surprises, and thus, we need to prepare for eventualities.

Project Risk Management

In order to provide flexibility for managing the project implementation phase we need to integrate another important element into project planning: the risk management process. It looks as follows.



When shall we ideally start the risk management process?

We will be able to identify different types of risks only with reference to the different types of plans, for example:

technical risks after setting up the PBS
risks of delays after creating the milestone plan, network diagram, and Gantt chart
risks of missing resources after producing the resource plan.

Thus, it is essential to start the risk management process early in planning phase, e.g. combined with effort estimation, and then, repeat steps 1 to 4 after each step of planning.

Ideally, we combine steps 1 to 4 into what we call “risk analysis”, and we usually carry out this risk analysis in workshops of one to three days, depending on the size of the project.

The results of these risk analysis workshops in planning phase are

(1) Preventive actions, i.e. add-ons to already existing work packages or completely new work packages which we have to integrate into the WBS and all the other planning documents.
(2) Corrective actions, that also add to the WBS or make for decision points in our project plan in the following way. If event X happens then we follow plan A, if X does not happen then we follow plan B.

Preventive and corrective actions together reflect our risk management strategy or risk management plan.

Creating contingencies in form of corrective actions or just in form of budget reserves represents the first important part of keeping our project plans flexible for foreseeable eventualities in implementation phase.

Let us take a closer look at the basic ideas of risk assessment and start with a definition of terms.

What is a risk?

Our daily life language usually refers to risks as events that could have negative impact. A closer look into a dictionary, e.g. Longman, 1998, reveals: A risk is the possibility that something harmful or undesirable may happen. For our purposes, we adopt the definition also used in insurance business. A risk is the probability that an event might occur which could have negative impact. Such an event we call risk event.

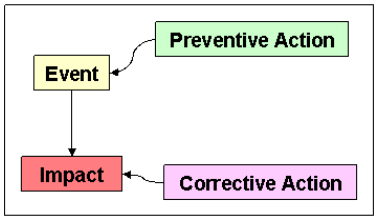
Risk = probability (event with negative impact may happen).

(In a similar way, we can define the term opportunity as probability that an event might occur which could have positive impact. In fact, entrepreneurs of the gambling industry count on that.)

Risk management focuses on the question: What can we do about those events that might impact our project in a negative way?

Principle of Risk Management

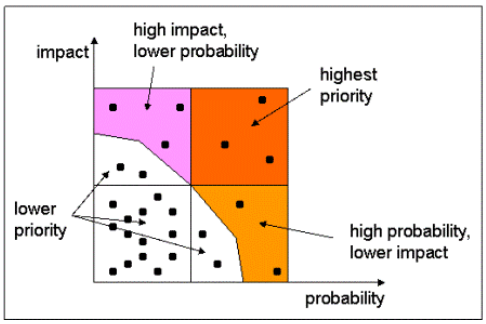
We can prevent some of these events by taking actions which make the event impossible to happen. For most of them we can take actions that decrease their probability. Finally, for those we cannot prevent we can prepare actions that make it easier for us to deal with their impact.



The following form reflects this in a more detailed way.

Project		
Nr. Risk Title		Date
Description of Risk Event	Probability of Risk Event	p
	Impact of Risk Event	I
	Expected Value of Risk	E=p*I
Preventive Action	Cost of Preventive Action	PA
	Residual Probability of Risk Event	pr
	Expected Value of Action	EA=PA+pr*I
Corrective Action	Cost of Corrective Action	CA
Decisions: If EA < E, or p "very high", or I "very high", then integrate **Preventive Action into WBS.** Integrate Cost of Corrective Action CA into **project risk contingency plan.**		
Follow-up Policy		

Following the process, we start with step 1, identifying risks, i.e. identifying as many risk events as possible, usually in a brainstorming session. The result is a list of such events. In step 2, evaluation of risks, we estimate probability (in %) and impact (in $) of each event. By multiplying these figures we obtain the expected value of risk, or just risk value. Risks with high risk value will be high on our priority list. Another way of showing the different priorities of risks is by arranging them in the probability-impact-diagram. Mathematically spoken, the risk value is the statistically expected value of impact or damage that risk event could cause.



It is common practice to include those risks with either very high probability or very high impact into the top priority risks, even if their risk values are low.
Step 3 focuses on identifying preventive or corrective actions, again in brainstorming sessions, and by referring to lessons learned of earlier projects. In step 4, evaluation of actions and residual risks, we estimate the cost of each action. For most events, we cannot reduce the probability of its occurrence down to 0 %. After taking preventive action, we usually end up with a residual probability which, of

course, is lower than the original one. If we now multiply residual probability with impact we obtain the residual risk value. Through adding the cost of action we get the expected value of action.
By comparing risk value with expected value of action we are able to decide if we want to take the action, i.e. integrate it into the WBS or not.
The decision to prepare for corrective actions depends on the company's or organization's accounting principles: it is good practice to include them into the project contingency.
As we proceed through planning phase, and later through implementation and closure phase, we repeat these risk analysis workshops periodically since new risk event can come into our view which we should not miss.

Project Change Management

While risk management can take care of foreseeable eventualities there will be things happening which nobody can plan for. For all unforeseeable events we need to make provisions in a different way. We only know that something is going to happen that will change project scope, schedule, or budget. So, we have to prepare a project change management process that tells us how we are going to deal with necessary changes.

We can think of two different types of situations:

(1) Situations in which we have enough time for finding mutually agreed decisions before implementing any change, without jeopardizing the project goal(s).
(2) Situations in which we cannot wait for mutually agreed decisions before implementing a change.

Project Contract Management

In case we manage a project that is based on a contract we have to integrate a project change management process into that contract in order to take care of the first type of situations, and a project claim management process for the second type of situations. Project contract management comprises change and claim management.

Thus, project contract management as such is the second important part of keeping our project plans flexible for all the unforeseeable eventualities in implementation phase. Here, we describe contract management from the project manager's point of view.

Usually, there are two or more different legal entities or parties involved in the project, normally in customer / contractor or contractor / sub-supplier relationships. These different parties need to sign a contract before starting implementation phase of a project.

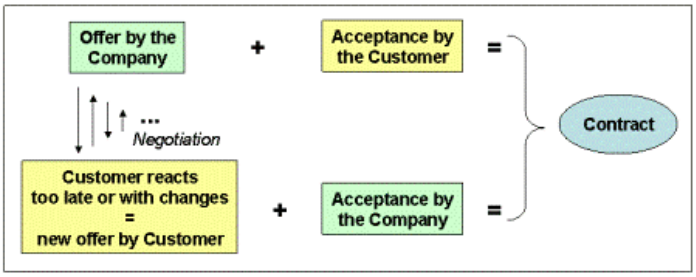
In larger projects with a customer / contractor relationship, on the side of the contractor, a proposal team will own the project management process in definition and planning phase until the contract is signed. Then, they will hand over to an implementation team. So, in the first two phases, a proposal manager is in charge who transfers the project responsibility to a project manager for implementation and closure phase.

What is a contract?

A contract is any agreement between two or more parties where one party agrees to provide certain deliveries or services, and the other party agrees to pay for those deliveries or services.

How do we get a contract between two parties?

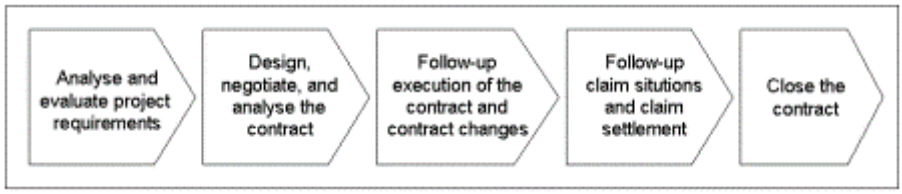
… sometimes, much too easily.



In extreme cases, it just takes an offer by a company and the simple acceptance of that offer by the customer, and we have a contract. Typically, we will see some negotiation going on between the two parties before one of them accepts the last offer of the other party. However, since it is so easy to end up in a legally binding contract situation, the first step, generally the offer by the company has to be prepared very carefully.

What is contract management?

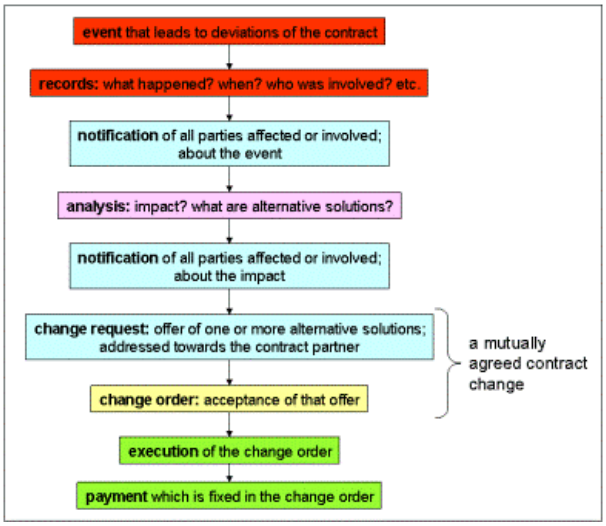
Contract management is a continuous process, starting with analysis and evaluation of the customer's inquiry, and carrying on until contract closure, upon fulfillment of all contractual obligations.



This process overview indicates that contract management activities seem to belong to the responsibilities of the project manager and the whole project team. In fact, they do; however, in larger projects where we have large contracts it is best practice to involve a full-time contract manager who brings in his professional experience, takes responsibility for that process, and ensures the contribution of all team members.

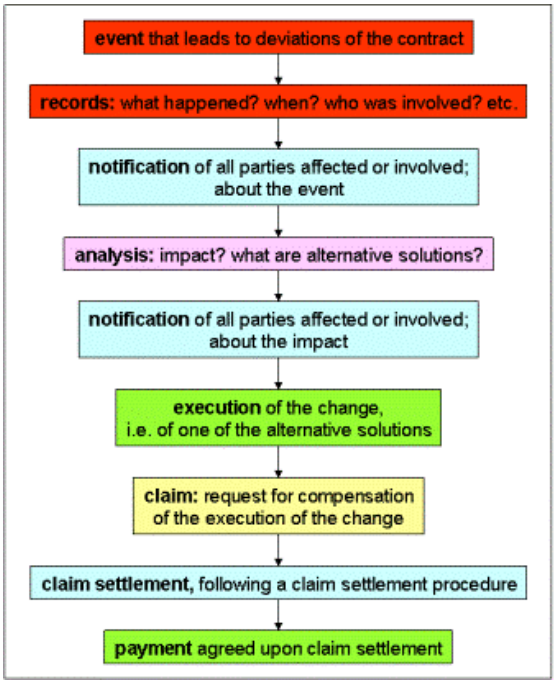
Contract preparation comprises analysis and evaluation of the other parties' requirements, a clear statement of our own requirements, and negotiation in order to reach agreement between the involved parties. After signing the contract, upon handover, the implementation team needs to analyze the contract in order to ensure that they understand what has been signed and needs to be implemented. When preparing and signing a contract in definition and planning phase, we anticipate how we want to implement the required project results, and fix this anticipation in our planning documents. This means that all our project planning is based on assumptions on how the project environment will develop over implementation and closure phase. As a simple matter of life, these assumptions can turn out to be wrong: certain conditions can change, or certain events can happen so that changes or deviations of the plans and of the contract become necessary. Thus, it would be helpful to prepare the project plans and the contract in a way so that those necessary changes can be implemented with mutual agreement of all involved parties.

As a first tool for contract management, we integrate a change management process into the contract.



As an essential result of this change management process we only execute a change to the contract upon successful negotiation and mutual agreement of a change order.

Under certain circumstances (e.g. different interpretations of technical, commercial, or other contractual requirements) this mutual agreement cannot be reached, but the execution of a change takes place anyway, in order to be compliant with higher prioritized project requirements or goals. This we call a claim situation, and we need to integrate a claim management process as a second tool for contract management into the contract. The following picture reflects the general claim management process.



Obviously, claim settlement is the tricky part and needs further explanation.

There are several steps of escalation which we can integrate into the contract as a third tool of contract management. These are the claim settlement or dispute resolution methods.

1. **Negotiation between the two contract parties:**
   In most claim situations, we will be able to settle the case after negotiating with the other party.
2. **Independent expert opinion:**
   The contract parties agree to call a neutral third party for determination of specific contract elements, their interpretation, and an expert opinion on the case.

3. **Executive tribunal or mini-trial:**
   This is a process, sometimes called 'mini-trial', in which the parties make formal but abbreviated presentations of their best legal case to a panel of senior executives from each party, usually with a mediator or expert as neutral chairperson. Following the presentations, the executives meet (with or without the mediator or expert) to negotiate a settlement on the basis of what they have heard.
4. **Dispute review board:**
   The dispute review board is a 'standing' adjudication panel used in major construction contracts. This board is normally appointed at the beginning of the project and stays in close touch with it, adjudicating disputes as they arise.
5. **Conciliation or mediation:**
   Conciliation and mediation are similar. Conciliation refers to a process in which the third party takes a more activist role in putting forward terms of settlement or any opinion on the case between the two parties. While in mediation, the third party provides support to the parties during their negotiation but does not interfere with the content of the case or its settlement.
6. **Adjudication:**
   In this process a neutral third-party, the adjudicator, makes summary binding decisions on contractual disputes without following the procedures of arbitration.
7. **Arbitration:**
   This is a formal process, agreed by the parties, regularly with three arbitrators who are neutral and independent. They make a final and binding decision as first instance. On average, the process duration is two to three years. It follows the arbitration clauses set by the International Chamber of Commerce (ICC), Paris, and it requires the support of external lawyers.
8. **Court trial:**
   After arbitration as first instance, we usually can go for a formal court trial as second and then third instance.

Steps (1) through (6) are not legally binding, but increasingly difficult to ignore or reject. Due to the duration and formal character, arbitration and court trial are the most expensive ways to settle claims. Therefore, it is worthwhile to discuss carefully with the other party before signing the contract which of the first 6 steps could be integrated into the contract.

“The best claim is no claim”

This statement seems to be obvious. If possible we follow the change management process for most of the deviations which we cannot avoid. This requires a common understanding of the contract and the underlying project planning between the contract parties. However, as mentioned above, there might still remain some claim situations.

Planning the Controlling Tools

There is a couple of controlling tools available which support us controlling the implementation phase. It is worthwhile to spend some time to plan which one of those tools we want to use for what kind of work packages. In order to collect all the details we ask our team members who are responsible for the work packages in periodically scheduled project status meetings. Obviously, there must be a high level of trust in each other to obtain the truth about each one of the work packages. This high level of trust is the key to successful project controlling.

The controlling tools, sometimes also referred to project management metrics, comprise:

(1) Measuring Quantities

We measure the progress of a work package in terms of completed parts of the same kind, for example: completed ground area of a building (in sqm), laid cable (in m), number of doors, windows, etc. installed, number of sockets manufactured (in pieces), etc.

(2) 0 – 50% - 100% Method

In case a work package has a result that we cannot express in terms of equal parts we indicate the work progress by

- 0% for “not yet started”,
- 50% for “started, but not yet completed”,
- 100% for “completed”.

This works for most medium size research & development, or engineering & design work packages. The 0 – 100% method is similar, but for very small work packages.

(3) Estimation of the Necessary Remaining Effort and Duration

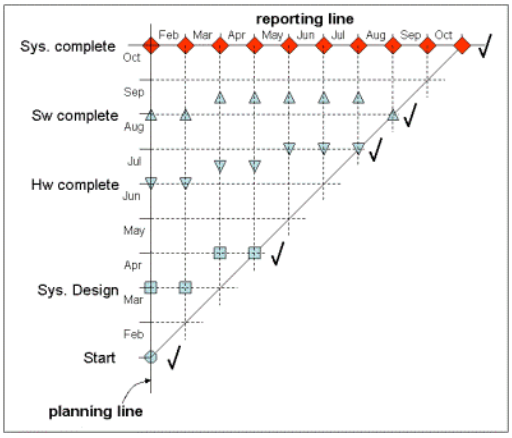
For large research & development, or engineering & design work packages, the 0 – 50% - 100% method would be too inaccurate. In this case, we usually would ask the work package expert for the rate of completion. Additionally, we recommend asking for the portion of work that still has to be accomplished, in terms of estimated necessary remaining effort and duration.

(4) Milestone Trend Analysis (MTA)

MTA represents the most popular project controlling tool. It requires a milestone plan on project level. In general, many work packages lead up to one of the milestones. However, we only focus on the milestone level. On the first day of our project we ask the team members responsible for the milestones for their planning status. In the following example, for these milestones,

- M4: System complete
- M3: Software complete
- M2: Hardware complete
- M1: System Design (complete)
- M0: (Project) Start

we might get this result at the end of the project:

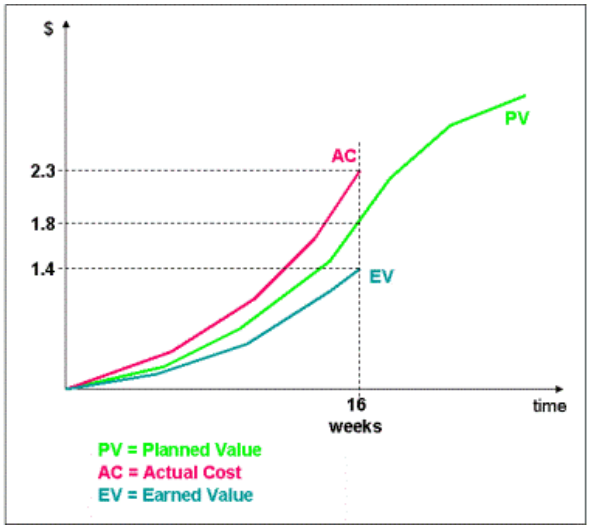


By drawing up the milestones by the end of each reporting period (in our case, monthly), we follow the reporting line, and obtain a trend for each one of the milestones. In case the trend for one particular milestone points upward (as in our case for "Sys. Design", "Hw complete", "Sw complete") we analyze the situation together with the experts of the work packages which contribute to that milestone, and decide on actions in order to achieve a horizontal trend, or maybe even one that points downwards.

(5) Earned Value Analysis (EVA) or Earned Value Management

As another widely used project controlling tool, Earned Value Analysis helps to control cost and schedule in larger projects or sub-projects. The following example shows how it works.
Let us assume we are at the end of week 16 of a small project with 12 work packages, 7 of which are already completed, and another work package has been started.

Our project account shows the actual cost accrued, AC = 2.3 Mill. $, and the work package experts tell us the value of the work accomplished, earned value, EV = 1.4 Mill. $. The project planning documents show that by the end of week 16 we should have accomplished work corresponding to the planned value, PV = 1.8 Mill. $.



In earlier presentations of that matter we find

- Budgeted Cost of Work Scheduled BCWS = Planned Value PV
- Budgeted Cost of Work Performed BCWP = Earned Value EV
- Actual Cost of Work Performed ACWP = Actual Cost AC

We use these values to calculate Cost Performance Index (CPI) and Schedule Performance Index (SPI):

$$\text{Cost Performance Index, CPI} = \frac{EV}{AC}$$

$$\text{Schedule Performance Index, SPI} = \frac{EV}{PV}$$

In our example, we obtain CPI = 0.609 and SPI = 0.778 indicating that we are over budget and behind schedule. Earlier presentations refer to

- Cost Variance CV = BCWP – ACWP = EV - AC
- Schedule Variance SV = BCWP – BCWS = EV – PV

In our example, this would lead to a

- Cost Variance of CV = 1.4 Mill. $ - 2.3 Mill. $ = - 0.9 Mill. $
- Schedule Variance of SV = 1.4 Mill. $ - 1.8 Mill. $ = - 0.4 Mill. $

The two project controlling tools, milestone trend analysis (MTA) and earned value analysis (EVA), summarize the work progress on project level. In case more detailed information is needed we turn to those tools that measure the work progress of individual work packages.

Project Management Communication Plan

The project communications plan tells us who is communicating with whom about what. In the sub-section that covers contract management, we indicated that it is essential to create evidence about anything that is going on in our project in implementation and closure phase:

- Work progress
- Events that interfere with our original project plans
- Necessary changes or deviations to the plans
- Additional work
- Occurred risks and consequences

The best way to create this evidence is to have all our project communications in written reports, notes, or meeting minutes. Some of these documents we create on a regular basis, some just when necessary. All of them go into our project documentation.

It is best practice to plan the project communications in form of a matrix. For the regular work progress it could look like the following example.

from \ to	Project Manager	Project Team Members	Control Board	Customer	Sub-suppliers	Other Stake-holders
Project Manager	X		√	√		√?
Project Team Members	√	X			√	
Control Board			X			
Customer	√?			X		
Sub-suppliers	√	√			X	
Other Stake-holders	√?					X

Obviously, we need this kind of communications plan for every area in which we need reports. These area specific communications plans outline also our agreed plan of escalation. Especially for the events that imply changes to the project plans it is useful to plan that escalation: who should talk to whom first, second, third, and so on, in any problematic situation?

The combination of all of the communications plans with the plan of project meetings and project controlling tools shapes a powerful project information system.

If we store all project plans, the project communications, i.e. all the reports, together with project related correspondence and notes, and all the meeting minutes electronically we obtain a very useful project documentation system, our electronic project handbook. This handbook will serve as source for all the project presentations we have to deliver towards the project management team, control board, customer, sub-suppliers, and other stakeholders.